Equine Behavior

A Guide for Veterinarians and Equine Scientists

Second Edition

Paul McGreevy

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Equine Behavior

For Sandro and Mary

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A Guide for Veterinarians and Equine Scientists

Second Edition

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Guest contributors

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Preface

The behavior of horses has intrigued horse lovers, since ancient times. The domestication of the horse and subsequent modern use for recreational purposes have led to close observations of and fascination with horse behavior. Whether or not they realize it, those who get the best out of their horses are students of equine behavior. Many opinions exist in relation to what are regarded as normal and abnormal behaviors by horse owners and trainers. Most recently, this has culminated in a renaissance for the 'horse whisperer', who has supposedly mythical powers to commune with horses in their very souls. Undoubtedly, there are individuals who have rare gifts at an intuitive level, in understanding horses and their behavior. Popular interest in the skills of such individuals has accompanied demand for more humane training and handling techniques. Concurrently, the scientific study of equine behavior has been developing, and the purpose of this book is to bring this to the attention of the horse industry.

Equine Behavior: A Guide for Veterinarians and Equine Scientists has been an enlightening labor of love for me and I am honored to have been commissioned to write it. Destiny may have had a hand in my selection, since legend has it that Ireland's McGreevy clan were keen horsemen and, indeed, were notorious for having stolen St Patrick's horses. For their alleged crime the Church forbade them to become priests. I doubt if that would have troubled them, as long as they had horses with which to work. For me the study of equine behavior is the most fascinating occupation in the world. Along with other enthusiasts, I delight in watching horses at work and play, and comparing notes on our observations. The aim of this book is to be a companion for all horse watchers.

Horse lovers are often tempted to conjure interpretations of how horses may process information and to imagine that horses share many of our value systems. On occasion, I have been criticized for failing to consider the rich emotional qualities horses may well possess. Suffice it to say that when we have a scientific way of measuring these qualities – and that time may not be too far away – I will be its strongest advocate, but until then I make no apology for confining myself to what we sometimes call the facts.

The past four decades have witnessed a terrific explosion in equine ethology – the science of horse behavior – so this is an exciting time for horse welfare. This book examines the truth behind modern trends and ancient traditions, by bringing together the latest cutting-edge research and best practice from around the world. The increased availability of data is matched by a growing sensitivity to what horses have been telling us for a very long time. The influence of science has helped to prompt fresh thinking about the relationship between horses and trainers. Science has also shown that horses learn in the same ways as other animals, in accordance with the principles of learning theory. This means that we are better placed to do the right thing by our horses and get the best out of them. The first edition of this book coined the term *equitation science* not as an attempt to objectify horses or undermine the art and skill of outstanding riders, but rather to demystify equitation and to allow more people to achieve better results and to reduce horse wastage.

To understand the impact of human behavior on horses, we need an understanding of the mechanisms that underpin horse training and riding. The nascent discipline of *equitation science* describes the measurement and interpretation of interactions between horses and their riders. By harnessing objective measurement of variables, *equitation science* examines traditional and novel techniques to reveal what works, what does not, and why. Most importantly, it also explores the welfare consequences of training and competing with horses under different disciplines.

As a veterinarian and a qualified riding instructor, I had two related audiences in mind: my colleagues in the veterinary profession and the veterinary students who will soon join us, and equine scientists and graduates in equine studies, who are assuming their place in the industry hierarchy. Veterinary professionals are uniquely placed to benefit from the book's scientific examination of those rare and poorly defined commodities: horse-sense and horsemanship. Owners naturally look to veterinarians for advice on the physical health of their horses, but this book is designed to empower veterinarians to also become a source of enlightened views on the mental health of their patients. Similarly, equine scientists can use the book to support scholarly approaches to enhance the management of horses. I hope this volume is written in a style that makes it accessible to a very wide audience and that it helps the industry as a whole to work with these two stakeholders in designing optimal scientific responses to behavior problems and in developing management and training systems that avoid their appearance.

Although this is a book that can be browsed, I strongly encourage you to digest some of its chapters in sequence. Specifically, the chapter on social behavior should be read before those on the behavior of the mare and stallion. Similarly, the chapter on learning contains material that facilitates understanding of the chapters on training, handling and miscellaneous problems.

The future for our relationship with horses seems bright. As we appreciate how to communicate with them sensitively and consistently, misunderstanding and misinterpretation by both parties will diminish. These advances are likely to be matched by greater sharing of knowledge among practitioners. Gone are the dark days when shamans locked themselves in stables to weave their magic on equine subjects and emerged with impressive results but no intention of divulging the techniques used. Information technology means that, more than ever before, we can disseminate our observations, management innovations, and empirical findings and training successes through scientific abstracts, Internet discussion forums and email chat lists. Although horse enthusiasts are notoriously traditional and resistant to change, there is a pleasing uptake in these methods of exchanging information and an acceptance of new approaches.

I hope you enjoy *Equine Behavior: A Guide for Veterinarians and Equine Scientists* and that it improves your understanding of horses and inspires you to find out more. I warmly invite you to submit suggestions on how to improve future editions of this text. Finally, on behalf of my ancient and far-flung clan, I hope that St Patrick might regard my work as some kind of atonement.

Paul McGreevy
2012

Acknowledgments

Horses deserve the unique place they hold in the hearts and minds of humans, so it should be no surprise that horse behavior as a research domain is populated by some extremely well-motivated and talented people, who have demonstrated their commitment to the species and their great kindness to me by providing invaluable feedback on various chapters of this book. They include Cheri Asa, Francis Burton, Hilary Clayton, Amy Coffman, Sharon Crowell-Davis, Nancy Diehl, Machteld van Dierendonck, Brian Farrow, Jane French, Debbie Goodwin, Caroline Hahn, Alison Harman, Kathe Houpt, Kevin Keay, Cecilia Lindberg, Andrew McLean, Finola McConaghy, Sue McDonnell, Christine Nicol, Kim Ng, Sarah Ralston, Ken Sedgers, Amanda Warren-Smith and Elaine Watson. One colleague, Daniel Mills, distinguished himself by going way beyond the call of duty and reading the entire draft manuscript. I am tremendously grateful to him for his advice and encouragement.

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Introduction

CHAPTER 1

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Evolution and classification

Because the evolution of the horse has been dealt with many times elsewhere, I shall spare the reader detailed descriptions of three-toed forest-dwelling dog-like creatures. Suffice it to say that we have been left with a most remarkable animal that can exploit impoverished grazing niches by foraging on very poor fibrous material and digesting it quicker than ruminants. Various anatomical, physiological and behavioral features of the modern horse mean that it is useful to humans in many ways (Fig. 1.1).

Evolutionary background

A plains feeder that does not disperse and defend territories individually or in pairs as foragers of richer resources tend to, the horse has a long nose that allows it to graze while maintaining surveillance above the sward. As an animal without horns or antlers it relies largely on caution, speed and agility as its chief means of self-preservation. A social herbivore that capitalizes on companions for added safety, mutual comfort and probably enhanced food detection, this is a creature that is likely to feel insecure when isolated. The social skills of horses account for some of the species' pre-adaptation to the domestic context.

To digest material ruminants generally ignore, the horse needs a large fermentation chamber, the cecum. Obliged to carry this voluminous digestive vat, the successful horse must therefore have tremendous muscular power to shift its necessary and considerable bulk from rest to top speed in the event of danger, so it has developed the ability to use minimal physical effort to rest while standing. With its small stomach this 'trickle feeder' is obliged to forage frequently and has not evolved to eat and then ruminate in one spot. Instead it eats and moves and eats and moves. Restricting movement and imposing periods of fasting are therefore likely to be more profound insults to equids than to members of many other species.

Classification of equids

Prior to the beginning of domestication, in the late Pleistocene, long-term geographic isolation of equid populations occurred.[1] This led to the distinct species that exist today (Table 1.1). True horses (*Equus caballus*) occupied

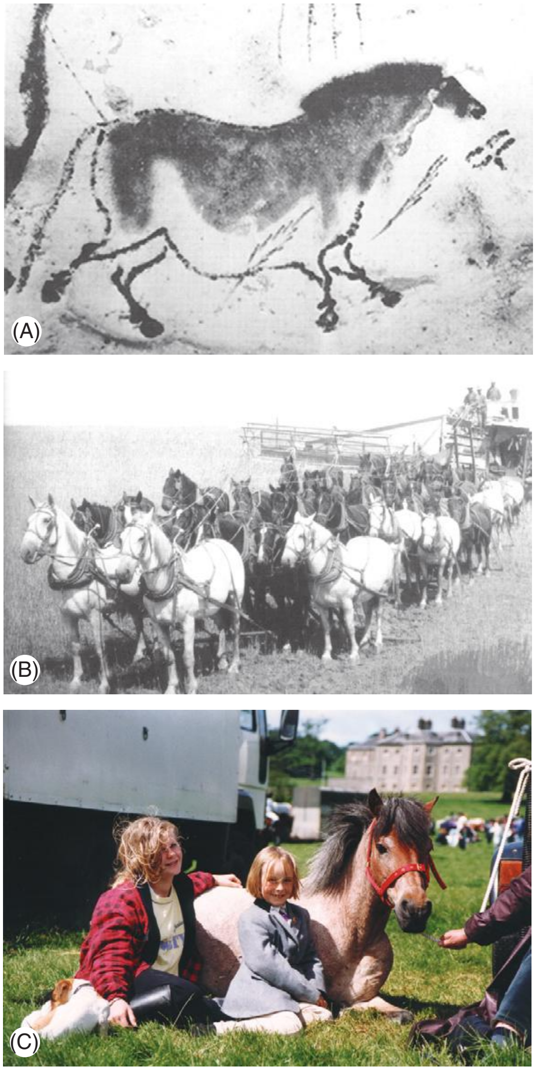

Figure 1.1 Humans and horses have had a long association. From depictions in cave paintings such as in Lascaux, France (A), we know that horses were originally hunted as a source of food, but since then the relationship has been developed through teamwork (B) and companionship (C). *((C) Courtesy of Francis Burton.)*

the Eurasian lowlands north of the great mountain ranges, while the asses occupied the arid zones of Asia. Crosses with asses, zebras and onagers are possible but the hybrids are normally sterile.

Order:	perissodactyla (odd-toed ungulates)
Suborder:	hippomorpha
Super-family:	equoidea
Family:	equidae.

Despite their sometimes great morphological differences, all the breeds, groups and types of domestic horses belong to one species, *E. caballus*. Populations such as ‘mustangs’ and ‘brumbies’ found roaming in North America and Australia are feral representatives of this species. Within the *E. caballus* the occurrence of isolated environmental niches has given rise to the types we see among modern horses. Equine remains found in the Siberian permafrost suggest the presence of two distinct types of *E. caballus*: a small, heavily set type and a finer-boned ‘Oriental’ type of up to 14.3 hands (150 cm). The latter, less sturdy version was probably swifter and most likely the forebear of our modern ‘hot-blooded’ animals (so named because of their adapted suitability to hotter climes), the Arabians and Thoroughbreds. Reactivity and athleticism are the core characteristics of the hot-bloods that have led to their being favored as race, performance and sports horses. To respond rapidly to pivotal stimuli such as the opening of the starting stalls and the impact of the whip, racehorses have been selected for heightened reactivity to environmental changes. It seems likely that this is why they are overrepresented in surveys of abnormal behaviors in stables, behaviors that are seen by many as responses to aversive stimuli. The least reactive equids are the so-called ‘coldbloods’, the heavy horses and solid ponies. In between the two groups are the ‘warmbloods’. These can be described as crosses between hot and cold bloods and are exemplified by European performance horse breeds such as the Hannoverian. The domestication process is ongoing. It is important to recognize that selection for reactivity and speed in modern racehorses and extraordinary gaits in dressage horses may run counter to durability and rideability, respectively.

Equus caballus and *Equus przewalskii*

Mitochondrial deoxyribonucleic acid (mtDNA) studies suggest that a divergence occurred as long ago as a million years,[2,3] between the modern horse (*E. caballus*) and its more numerous and diverse predecessors. The link between them was thought to be the pony-shaped Mongolian Wild Horse, Przewalski’s Horse (*E. przewalskii*). Apart from Caspian ponies that appear to be polymorphic in the diploid number (some having 64 chromosomes while others have 66),[4] *E. caballus* has 64 chromosomes. *Equus przewalskii*, on the other hand, has 66 chromosomes in the diploid state. However, the recent publication of the horse genome[5] has shown that *E. caballus* is not only related to *E. przewalskii*, they are essentially the same species.

Table 1.1 Classification of equidae

Common name	Species	Diploid chromosome number
Przewalski's horse ([Mongolian] wild horse)	*Equus przewalskii*	66
Horse (domestic)	*Equus caballus*	64
African wild ass (and domestic donkey)	*Equus asinus*	62
Nubian wild ass	*Equus asinus africanus*	
Somali wild Ass	*Equus asinus somalicus*	
Asian ass	*Equus hemionus*	56
Mongolian wild ass	*Equus hemionus hemionus*	
Onager	*Equus hemionus onager*	
Indian wild ass	*Equus hemionus khur*	
Kiang	*Equus hemionus kiang*	
Grevy's zebra	*Equus grevyi*	46
Common zebra	*Equus burchelli*	44
Chapman's zebra	*Equus burchelli antiquorum*	
Grant's zebra	*Equus burchelli boehmi*	
Selous's zebra	*Equus burchelli selousi*	
Mountain zebra	*Equus zebra*	32
Cape mountain zebra	*Equus zebra zebra*	
Hartman's zebra	*Equus zebra hartmannae*	

This explains the similarities in their serum proteins and their blood groups and why cross-breeding between *E. caballus* and *E. przewalskii* produces fertile offspring. Geneticists explain that a single fusion mutation in the haploid state (32) could have brought about their differences. Similar intra-species chromosomal dimorphism occurs in the Asian ass *(Equus hemionus)*.[6]

Subsequent isolation of the *E. caballus* and *E. przewalskii* gene pools could perhaps have arisen because of capricious selectivity on the part of Caballus stallions (see Ch. 11) and the retreat of Przewalski herds into regions of the steppe uninhabited by humans.[7] While outnumbered by the similarities between the two species, the differences are fascinating. For example, the striking bistability of hock joints that allows a very rapid switch from one extreme position to the other is much more marked in domestic horses than in Przewalski horses and, for that matter, zebras.[8]

Przewalski horses became extinct in the wild in the 1950s.[9] However, from a nucleus of 11 foundation animals, they survive today in captivity and in successfully re-introduced wild populations, e.g. in Mongolia.[10,11] The survival story of the Przewalski horse is an extraordinary one, and we are indeed fortunate to be able to study them in a variety of contexts. It is fascinating that we now have data to refute the notion that Przewalski horses are socially more aggressive than domestic horses.[12] However, studies of their behavior should be treated with some caution since they have emerged from a shallow gene pool that has been filtered through 20 generations of captivity. Therefore before assuming that present-day Przewalski horses behave as true wild horses, we should bear in mind that some would regard them as survivors of the first stages of domestication. In this text, I have selected examples of feral horse behavior rather than Przewalski horse behavior as benchmarks for what is normal. Discussions of such free-ranging behavior appear in each of the subsequent chapters.

Changing roles

Although initially horses found themselves in the human domain as a food source, their subsequent roles are nearly as varied as those of the other most domesticated species, the dog, and include providing power, leisure and companionship.

Domestication

French and Spanish cave paintings from around 15 000 years ago, depicting hunting for food and hides, represent the earliest record of human use of horses.[13] While early horses would eventually provide their keepers with unprecedented mobility and power, horse herding probably had its origins in the consumption of horseflesh.[14] Hunters favor meat, such as that from horses, that has a high glycogen content. As a source of dietary sugar, this facilitates endurance, which is important for members of hunting cultures. Horses were regularly consumed in favor of other large herbivores. In the Paleolithic, our ancestors may have hunted horses by driving them over cliffs and into traps and pitfalls. They continued to do so for thousands of years to the extent that they had a pivotal effect on population numbers.[15] It is thought that, along with climatic changes, this exploitation contributed to the extinction of wild horses in North and South America. This may be why wild horse remains elsewhere dating from periods since 9000 years ago are rare.[16] Interestingly, it seems the 'true horse' (*E. caballus*) survived in Eurasia but with patchy distribution[17] despite, or perhaps even because of, this predation.

Archaeological evidence of horse domestication dates from 4000 BC (late Neolithic or Bronze Age) in the Eurasian Steppes of the Ukraine.[18] Ancient middens used as dumping grounds for the bony remains of human meals, most notably in a place called Dereivka on the steppes north of the Black Sea, have proved an especially rich source of domestication data. This is where river-valley agricultural economies evolved, relying on the use of stone enclosures to trap large numbers of game. The numbers involved in a draft often exceeded the immediate demand for consumption and prompted the maintenance of surviving herd members, to be slaughtered at a later stage.

From studies of the bone remains found in middens, the first pastoral species seems to have been bovine. A colder climatic shift that affected this region around 3500 BC is thought to have favored equids rather than other domestic or wild herbivores because, being large and long-legged, they were better able to forage in snow. The prevalence of horses in Ukrainian communities underwent a dramatic rise at this time, with horse bones comprising 74% of non-human bones at Dereivka.[19] Evidence of domestication at this site includes this dramatic rise and the predominance of colt skeletons. Analysis of the dental remains of horses in these sites suggests that humans consumed more males than females and that the age range of these animals did not show a normal distribution.

Some authors[15,20] maintain that the relatively high number of colts indicates domestication rather than hunting, which would be more likely to harvest older animals, more often mares. Other workers suggest that

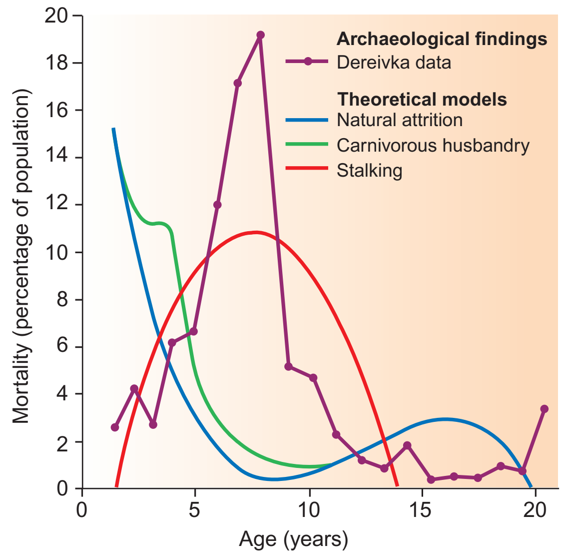

Figure 1.2 Graph of age distribution of remains of 151 horses found at Dereivka, Ukraine. In free-ranging horses death occurs most commonly in the very young and very old (natural attrition model). In populations raised for meat (carnivorous husbandry), the curve is skewed by preferential consumption of 2- to 3-year-olds. Meanwhile, selective hunting of prime-age adults (stalking) produces a different pattern, with a sharp central peak. The age distribution of horse teeth found at Dereivka most closely matches the stalking model.
(Reproduced by permission of Marsha Levine and Antiquity Publications Ltd, from Levine M, The Problems of Horse Domestication in Antiquity *64:727–740.)*

the vast majority of horses at this time were hunted by stalking (Fig. 1.2).[14] Perhaps the age distribution of horse teeth most closely matches what one would expect as remnants of such activity, but it is worth remembering that assessing age by dentition is an imprecise science.[21]

The issue here seems to pivot on whether there is any reason for members of a domesticated population to be selected for consumption at 5–8 years of age. A more traditional farming approach would be to harvest the surplus while they were younger and their flesh was reasonably tender. Although one might also ask why hunters would target animals in a wild group that were undoubtedly in their prime and therefore most fleet of foot, it seems likely that they would be more abundant than adolescents or elderly horses.

The reported preponderance of what we regard as male type canine teeth seems to be crucial here. Could it be that small canines as found in many modern mares were erroneously identified as the teeth of stallions?

Horse remains at Dereivka have been characterized as being from large-headed, short and heavy-set animals,[18]

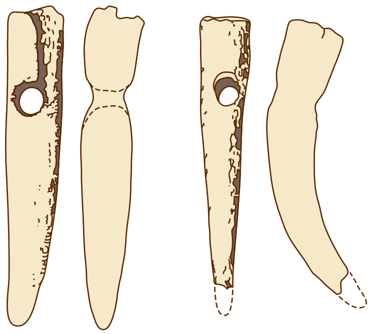

Figure 1.3 Artifact from what is believed to be an early bit fashioned from antlers.[19] A rope would have been held in place in the mouth by the cheek-pieces. *(Reproduced by permission of David Anthony, Dorcas Brown and Antiquity Publications Ltd, from* The Origins of Horseback Riding in Antiquity *65:22–38.)*

a description strikingly reminiscent of the Przewalski horse. When the skull of a male equid was removed from a ritual burial site shared by two dogs and anthropomorphic figurines, it aroused considerable excitement in archaeological circles. Dating from the Copper Age, about 4300 BC, the ritualized nature of the burial suggests profound domestication. Interestingly, in the same grave, excavations revealed antler tines that seemed to have been crafted into the cheek-pieces of a crude bit (Fig. 1.3). By facilitating the comparison of the teeth of modern domesticated and feral horses with those of the so-called Dereivka cult stallion, electron-microscopic analysis of anterior premolar tooth wear has revealed bevels and fractures consistent with the use of a bit.[22] Even though the first bit was not as robust and therefore as damaging as modern hardware, the damage incurred was regarded as being consistent with 300 hours of bridled control. However, before relying too heavily on such comparisons, it is worth considering ways in which the evidence may have been skewed. Freshly domesticated horses may have been very headstrong and early equitation unrefined. Notwithstanding this minor point, the Dereivka stallion is regarded as the first ridden horse and is thought to have predated the invention of the wheel by at least 500 years.[23] The domestication of horses on the steppes may have been repeated in other places. Recent mitochondrial DNA evidence[24] indicates that a large number of founders were recruited over an extended period. This ‘multiple origins’ scenario implies that horses may have been independently captured from diverse wild populations and then bred in captivity as the wild populations disappeared.[24] This suggests that what spread from that equine cradle was not necessarily the horses themselves but the innovation and technology of taming them. That said, the proposed dates for the emergence of bits, saddles and stirrups are still hotly debated.

Although it seems likely that meat production was the first reason for the domestication of horses, their prevailing impact was linked to their use in riding and haulage. When handling an orphan foal, early horse farmers would have appreciated the horse’s ability to pull and the fact that controlling the body depended on controlling the head. A natural progression would have seen the development of harnesses for traction and headcollars for control. It may be that too much emphasis has been placed on the significance of bit wearing as the necessary step that took the use of horses beyond the dining table. It is implied that horses could not have been controlled from behind by anything less than a bit. This is something of a moot point since it precludes riding with bitless bridles. Equally, horses could have been used for non-riding purposes such as traction of non-wheeled haulage devices, or fallen prey for that matter.

Early farmers had to have some means of preventing the usual migratory dispersal of horses but men on foot, even if they were accompanied by trained dogs, would be no match for galloping horses.[25] Only when riding was attempted could horse herding become efficient. Furthermore, while using horses is a matter of taming the individuals as required, breeding them is far more technically demanding.[26] The difficulty of preventing domestic mares from dispersing in search of stallions whenever they were in estrus may have been the reason domesticating the horse took such a long time. For these reasons, horses were domesticated after cattle, pigs, sheep and goats, which were all easier to herd and contain.

Although the horse was one of the last mammals to be domesticated, it has had more impact than most on humans, not least in terms of the dispersion of culture and language.[16,23] Beginning with human migration across the deep steppes of the Ukraine that could not support large human populations prior to the emergence of riding, horses facilitated the spread of human genes. Because riders move two or three times faster and farther than pedestrians, exploitable territories expanded sixfold. At the same time grassland subsistence became more predictable, reliable and productive, and decisive military advantages were secured over more static neighbors.[23] As a consequence, human social groups grew tenfold, conflicts over resources escalated and patterns of trade and theft expanded in range and variety. While riding was established as the prime means of hunting, exploring and herding, the additional use of horses for milk and blood is likely to have peaked at the same

Figure 1.4 Horse being ridden by a stunt rider as a demonstration of use in combat. Equitation improved a warrior's usefulness and chances of survival. *(Reproduced with permission of Gerard Naprous.)*

Figure 1.5 An etching showing the development of haute école training, as archived by Le Baron D'Eisenberg. *(From L'Art de Monter à Cheval, 1737.)*

time. One should not overlook the usefulness of horses in hauling fallen game, firewood, ploughs, produce and physically challenged members of the group. Such was the importance of the horse in the early dispersal of Copper Age humans that horses became one of the chief tradable items.

The emergence of equestrian cultures is also likely to have brought with it an increase in hit-and-run warfare (Fig. 1.4). This suggestion is borne out by the effective use of the horse by native Americans in the 1800s, which resulted in the unprecedented rise in conflicts and accumulation of wealth leading to the tribal supremacy of the Sioux, Comanche and Apache.[27]

Interestingly it was not until approximately 2000 BC that horses arrived in the Middle East and displaced asses and ass-onager hybrids as the favored draft animals for battle carts from which arrows could be fired. A similar displacement took place in mid 19th century Africa when colonists' demand for the social status inferred by using apparently superior riding animals prompted the importation of often poorly adapted horses while the local equid, the quagga (*Equus quagga*), was hunted to extinction by English and Boer farmers.[28]

A new wave of horse-mediated military success emerged when the horse's speed and maneuverability were fully appreciated. In the first place, chariots, as mobile platforms for archers, provided the means of delivering flanking blows to infantrymen,[29] then came the complete development of cavalry warfare. Many authors have discussed the introduction of modern equestrian techniques[30,31] and the development of bits, saddles and stirrups[19,32,33] and the extent to which each lent a military advantage. The invention of the saddle that shifted the rider's weight bilaterally to the lumbar musculature and subsequently the stirrup that facilitated the use of weapons by mounted warriors are thought to have been major steps in the culture of mounted combat. With the increasing sophistication of equine-dependent power that led to the emergence of jousting tournaments and ultimately *haute école* dressage (Fig. 1.5), noblemen came to be judged by, among other things, the quality and quantity of horseflesh in their possession.[34] The role of the horse in colonial success was acknowledged by Cortes after the Spanish invasion of Mexico, when he noted that (next to God) he owed his victory to the horses.

The management of warhorses was often chronicled but the emphasis in these accounts seems to have been upon their training, nutrition[35,36] and medical care[37] rather than their housing. The use of horses by military and invading nations has been marked by considerable wastage. There is evidence that Roman equids in Britain sustained injuries consistent with poor living conditions and gross overwork.[38] Horses continued to serve in battle up until the end of the Second World War, when the Polish cavalry suffered horrific losses from the guns of Russian tanks.

Current status

Horses are regarded as a familiar part of many agricultural idylls but their role as farm animals is now in question. If we compare the life of a stabled riding horse to that of other farm species, some differences are obvious. Unlike most cows, pigs and sheep, horses are generally not kept with a view to productivity in terms of meat or milk and therefore are often on limited food rations. Because they cannot be regarded as production animals, horses are more often these days described as a 'companion animal species'. Unfortunately they do not fit terribly well into this category either, since they do not share living space with humans as do true companion animals such as cats, dogs and caged birds. Their contact with humans is largely restricted to being groomed, fed and ridden.

The key roles of the horse in human activity changed tremendously during the 20th century. The overarching fields in which horses are now used include recreational and social purposes, breeding, sport and competition and to some extent meat production.[39] Huge reductions in the use of horses in military, agricultural and transportation activities have been matched, in developed countries, by increased equine numbers for sport and leisure.[40–42]

Prevalent modern breeds are often used in more than one activity (Table 1.2), and this may help to account for the retention of some diversity. Different breeds are thought to have different temperaments that reflect their original purpose (Fig. 1.6). Happily, horse breed societies have tended to avoid the sort of intense line-breeding that characterizes the bloodlines of many purebred dogs,[43] and very few populations are inbred. Notable exceptions are the horses of the Namib Desert, Namibia[44] and Blue Arabians from the USA.[45] In-hand showing as a sole means of selecting breeding animals removes many performance indicators from the selection process in breeding systems and is therefore short-sighted.

While donkeys are still used by the working classes in many parts of the world, the horse is now a status symbol in Western cultures, a luxury item or an emotional focus. Interestingly, this has done nothing to guarantee its welfare, since many owners of luxury items fail to budget for their maintenance. Despite the emergence of equine insurance policies that have helped to remedy the shortfall, many owners find themselves financially embarrassed, e.g. when invoiced for colic surgery. Financial circumstances have considerable influence on the way horses are managed, as indeed does the value of the horse itself. Sometimes the value of a horse can prove an impediment to optimal welfare.[54]

Although many owners keep their horses in the best possible conditions that money allows,[42] sometimes it seems that when performance is less critical, management standards may drop and welfare may be affected. Ignorance and economies may combine to jeopardize the welfare of hobby-horses. This is not to suggest that high-performance animals always enjoy the best welfare, since, for example, intensive management of racehorses involves some of the greatest alterations in time budgets, some of which can reflect profoundly compromised welfare. It is interesting to contrast the management of a Thoroughbred stallion kept in a mahogany trimmed loosebox with brass fittings near Newmarket, on the one hand, with a child's pony grazing on impoverished land in suburban Dublin. The relative absence of confinement of the latter may well enhance its welfare.

While private owners report increasingly emotional attachments to their horses,[55] large numbers of people work in the equine sector for little or no financial reward. With the shift of horse use from military and utilitarian services, the demographics of horse ownership changed, with women forming the majority.[56] It has been suggested that female horse owners are more affectionate than males.[57] That said, there are interesting reports of an increasing proportion of male riders and an increasing number of older riders.[42] Equestrian sports remain the only Olympic events in which men and women compete on equal terms.

In developed countries, horses kill more humans than any other animal.[58] On the other hand, while there are no published data on the health benefits of horse ownership, there is convincing evidence that riding is a therapeutic activity.[59] Equine practitioners do well to consider the profundity of many human–horse bonds, especially at the time of euthanasia.[60] However, while some cultures have come to regard horses as companion animals, others have retained the pragmatism that leads them to consume young horses surplus to breeding requirements or those too old to be of use as breeders or as a means of conveyance.[39]

Noting the human tendency to forget to appreciate horses for what they are, Rollin[61] highlights our 'unfortunate skill in putting square pegs into round holes'. Compared with close relatives such as zebras that have only very rarely been put to work (Fig. 1.7), horses can be manipulated to behave in many ways and persuaded to cope with a tremendous variety of uses and abuses. The behavioral flexibility of horses is fundamental to their utility in the domestic context. It allows them to tolerate negative reinforcement more than other domestic species but also explains why they are subject to tremendous abuse by clumsy and ignorant handlers (see Ch. 13).

Table 1.2 Some generalizations about the attributes and uses of modern breeds and types

Horse use	Activities	Physical attributes	Behavioral attributes	Leading breeds
Show-jumping	Agility over fences and against the clock	• Tall yet built close to the ground[46] • Powerful hindquarters • Flat pelvis[47] • Forward-sloping femur[48] • Sloping, free-moving shoulders • Long humerus[47] • Large hock angles[47] • Agile • Deep-chested – thought to be associated with optimal lung and heart room	• Obedience • Boldness • Responsivensess • Tendency when jumping to tuck in the forelegs and kick back the hindlegs	• Thoroughbreds • Draft/TB crosses • Welsh Cob/TB crosses • Warmbloods, including Trakehners
Dressage	Controlled and yet demonstrably powerful execution of set maneuvers	• Classic good looks and impressive gaits help to keep the judge's eye on the horse • Powerful limbs • Forward-sloping femur[48] • Neck set on high • Short neck[46] • Long humerus[47] • Long upright phalanges[47] • Small hip angle[47] • Flexible and supple • >14.2 hands high (FEI height rule)	• Responsive • Calm • Classically correct, free, regular paces • Confident	• Draft/TB crosses • Warmbloods including Hannoverians, Dutch Warmbloods, Lipizzaners, Oldenburgs
Eventing	Combined demonstrations of stamina, agility and compliance in the dressage arena	• Generally athletic • Powerful limbs • Neck set on high • High withers • >14.2 hands high (FEI height rule 14 hands 2¼ inches high without shoes)	• Calm • Responsive	• Thoroughbreds • Draft/TB crosses • Australian Stock Horse • Warmbloods, including Trakehners • Warmblood crosses
Endurance	Long-distance riding and ride and tie events	• Stamina and resistance to dehydration • Short strong back • Strong legs • Hard hooves • A long stride and a floating action that helps to conserve energy	• Tendency to bond with humans[45] • Calm • Compliant • Drink readily	• Arabians • Arabian crosses • Paso Finos • Appaloosas • Walers • Australian Stock Horse

(*Continued*)

Table 1.2 (Continued)

Horse use	Activities	Physical attributes	Behavioral attributes	Leading breeds
Children's sport	Junior versions of premier sports and team sports including vaulting and mounted games (gymkhana games), many of which have their origins in latter-day cavalry training, e.g. tent-pegging	• Short backs (except for vaulting horses) • Short legs making turns at speed easier • Agile • Fast over short distances • Athletic	• Tolerant • Calm • Unflappable • Fun-loving • Trainable • Responsive	• Arabian crosses • Ponies, especially Welsh
Racing	Racing: • Flat • Hurdles • Steeple chasing • Arab racing • Quarterhorse racing	• Croup high • Powerful hindquarters • Strong shoulders • Deep chests • Modest abdomens	• Reactive to stimuli • Desire to run • Perhaps a reluctance to be at the back of a group	• Thoroughbreds • Arabians • Quarterhorses
Trotting	Harness racing at the trot	• Tall withers[40] • Open angles at the shoulder and stifle joints[50] • Large girth circumference at the front of the thorax but narrow girth circumference at the lowest point of the back[47]	• Tolerant of harness and handling • Desire to run	• Standardbreds • Cold-blooded trotters
Pacing	Harness racing at a pacing gait	• Elastic fetlock joints[51] • Long sloping shoulders[51] • Long muscular forearms[51]	• Tolerant of harness and handling • Desire to run	• Standardbreds
Ball sports	Polo and polocrosse	• Strong hindquarters that allow the horse to be light on the forehand and therefore easily accelerated • Athletic	• Reliable • Responsive • Hardworking • Agile • Swift to learn	• Polo ponies • Stock horses • Thoroughbreds (small) • Quarterhorses
Working horse competitions	Camp drafting Cutting	• Strong hindquarters	• 'Cow sense' • Reliable • Calm • Quick reaction times[42]	• Stockhorses • Quarterhorses • Draft crosses

(Continued)

Table 1.2 (Continued)

Horse use	Activities	Physical attributes	Behavioral attributes	Leading breeds
Leisure	Recreational trail-riding/trekking/hacking Riding club activities including quadrilles and combined training	• Generally sound • Sloping pasterns	• Adaptable • Calm	• Any riding breed, especially Australian Stock Horse, American Saddlebred, Quarterhorses, Standardbreds, Arabian crosses, colored horses and pony breeds
Hormone, vaccine and anti-venin production	Regular removal of serum or urine for processing into human and animal medications	• Bulky	• Low reactivity	• Draft breeds, notably Percherons
Milk production	Milk production most notably in Russia where fermented mares' milk (koumiss) is a popular food for human infants	• Cup-shaped udders • Long lactation (>200 days)[52] • High yield >1600 kg/lactation)[2] • Fast milk ejection rate (>28 mL/s)[52]	• Tolerant of machine milking and separation from foal	• Bashkir
Meat production	Slaughter for human consumption and pet food; notably: • Spent working animals • Poor young-stock specimens of all breeds • Some purpose-bred animals	Not applicable	Not applicable	• European heavy breeds • Small pony breeds • Feral horses
Draft	• Haulage of produce, wood and water in developing countries • Boutique tourism in developed countries • Ploughing matches	• Compact bodies • Strong, large feet • Strong neck and shoulders • Powerful hindquarters	• Low reactivity • Compliant • Phlegmatic temperament[53]	• Heavy horses including Shires, Clydesdales, Suffolk Punches and Percherons • Donkeys • Mules

(*Continued*)

Table 1.2 (Continued)

Horse use	Activities	Physical attributes	Behavioral attributes	Leading breeds
Exhibition and production	• Showing • Breeding	• Conforming to written breed standard	• Impressive demeanour ('presence') in the show ring • Eye-catching gaits • Adaptable at stud	• Any registered purebreds and registered partbreds, color or types
Hunting and hunter trials	Cross-country riding over natural obstacles and terrain	• Strong hindquarters • Sloping 'jumper's' shoulders • Agility	• 'Bravery'	• Thoroughbreds • Draft/TB crosses • Cleveland Bays
Carriage driving	Dressage and cross-country driving of teams, pairs and singles	• Strong hind quarters • Relatively short, strong legs capable of scrambling, scurrying and turning	• Tough • Compliant • Tolerant of other horses in close proximity • Sure footed • Agile • High hock action	• Welsh ponies and Welsh cobs • Friesians • Gelderlanders • Cleveland Bays • Dales • Fells • Fjords • Shetland ponies • Standardbreds

FEI, Fédération Equestre Internationale; TB, thoroughbred.

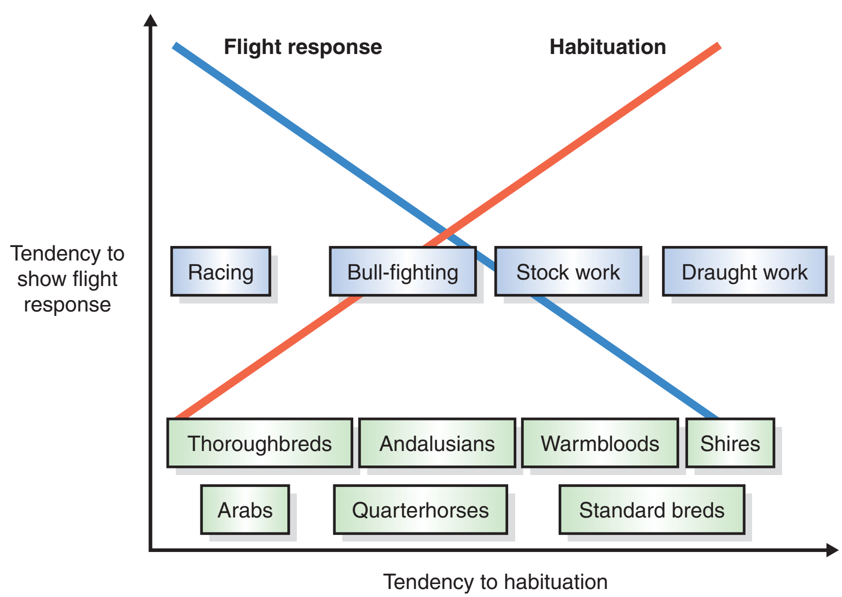

Figure 1.6 Breeds seem to have different tendencies when faced with a potential threat. *(Permission from Paul McGreevy.)*

Figure 1.7 Lord Rothschild and his team of four zebras (*E. burchelli*), circa 1900. *(Reproduced with permission. Copyright Natural History Museum, London.)*

The explosion in the popularity of riding for leisure and in first-time horse ownership has led some veterinarians to bemoan the welfare of some present-day equids, e.g. inner city ponies. Ignorance is a considerable force to be reckoned with. I have encountered novice owners who believed their horses could thrive on remarkable diets, including rabbit food and, on one occasion, cat food.

The horse's future

Information technology should facilitate the education of horse owners and, one hopes, liberate their thinking. The impact of ethology on horse welfare has already been recognized,[62] and there is a growing demand for enlightened approaches to horse handling as evidenced by the success of the modern 'horse whisperers'.[63–66] Unfortunately, for some exponents the emphasis seems to be to placed on shows and the introduction of jargon rather than on education. It is hoped that ethologists will continue to demystify the language of showmen and shamans so that communication with horses can be enhanced wholesale.[67] The growing influence of equitation science suggests that an evidence-based approach to horse-training and riding will ultimately prevail. (Equitation science is considered in detail in Chapter 13.)

The practice of identifying and logging the performance of non-racing sport horses has the potential to enhance the quality and, it is hoped, the depth of the gene pool. For that reason it is particularly good to note the re-emergence of the UK's National Equine Database.

The introduction of novel reproductive technologies such as artificial insemination should allow horse breeders to capitalize on genetic material from overseas in the same way that shuttle stallions, flown in from the Northern hemisphere, have liberated Thoroughbred breeders in the Southern hemisphere. It is anticipated that the publication of the horse genome[5] and the production of cloned horses[68] (Fig. 1.8) will become significant landmarks in the history of domestic horse breeding.

Figure 1.8 Paris Texas, one of the world's first cloned horses. *(Texas A&M University. Reproduced with permission of Eric Palmer.)*

Since it has been shown that crib-biting is associated with a given gene array,[69] it may be that there will emerge a drive to breed from animals that can cope with the stressors of intensive management. Geneticists may also help to improve fertility, one of the most pressing topics in Thoroughbred circles. Globally, the annual reproduction rate for Thoroughbreds is approximately 50%.[40] This compares poorly with other single-offspring species such as cattle, in which 85% is normal.[40] This disturbing trend is certainly not helped by a rise in the rate of twinning, an unfit gene that is passed from one generation to the next almost exclusively by veterinary intervention.

It seems unlikely that, since it has been the single breeding objective for the past two centuries, speed on the track can undergo much further improvement. Mirroring the current focus of human exercise physiologists, the role of lactic acid clearance as a limiting factor in racehorse performance continues to attract considerable attention.[70] It may be that selection of genotypes capable of accelerated lactic acid metabolism may reduce winning times in the longer classic races such as the St Leger and the Oaks.[40,71] Markers of speed may be identified by genome mapping studies but these are likely to combine a number of features, including cardiac output and maximal oxygen consumption.

While there may be initiatives to identify the genes of horses that cope best with intensive management and do so without displaying stereotypies, it is hoped that the technology can be harnessed to improve horse welfare

Figure 1.9 A mechanical horse simulator. *(Reproduced with permission of Racewood Equestrian Simulators.)*

rather than simply to select for tolerance. The worldwide web offers a unique platform for information on the identification and treatment of common ailments and the showcasing of best practice in stable management and evidence-based approaches to training, i.e. equitation science.

Although grazing land will become harder to come by, stabling is likely to evolve to meet more closely the behavioral needs of horses. We may yet identify key elements of established management protocols that can have a deleterious effect on our horses.[72,73] Although these days it is common for owners and trainers to regard the risk of injury in sport horses as being great enough to outweigh the benefits of being turned out,[39] evidence is steadily accumulating to fortify the case for increased opportunities for spontaneous exercise and social contact.[74]

The welfare of riding-school horses is likely to improve as technological advances make it easier to detect those of a novice rider's signals that are particularly confusing and unhelpful. In the UK, electronic riding machines have been developed with all of the paces of a horse (Fig. 1.9). Their predictable action allows the rider to learn, for instance, how to rise at the trot and even jump a fence.[75] With sensors to detect and respond to the rider's signals, the simulator reduces the time required for novices to learn to ride.[76] It is not difficult to see how this technology may advance. It could be programmed to behave less predictably, to be more or less responsive or to demonstrate typical equine conflict behaviors in response to confusing commands.[77] One could even speculate that the welfare of those dependable riding-school horses that always carry novice riders will be of less concern in the future. Currently balance is acquired over weeks of crude education, for example, staying on board by pulling on the reins and therefore the mouth. The numbing effect this has on the horse's mouth reflects the discomfort it must cause. This inelegant and inhumane use of sentient beings in human education may disappear with the growing use of mechanical alternatives.

Digitization of the interaction of elite riders with their mounts may provide for a quantum improvement in the teaching of equitation. Measurement of tensions and pressures applied by the handler's hands, seat and legs can be correlated to observed behavior of the animal and provide an indication of the magnitude of stimulation required to be applied by the handler to modify the behavior of the animal. Logging devices of this sort will also provide teachers with some quantitative means of assessing the handling of an animal under the control of a student. It has been proposed that technologies that decipher the complex physical interactions between riders and horses will facilitate remote coaching and the development of biofeedback systems that permit the use of training templates that can be optimized for each horse–rider dyad.[78]

Stable management

Humans can control horses most effectively by stabling them. This imposes limits on the extent to which horses can meet their behavioral needs and can have profound effects on welfare. Equine behavior undergoes considerable modification when animals are removed from pastured (or feral) environments and placed in a stable.

Traditional stable management

The horses sent over to the British Isles by the Roman conquerors would have included a variety of heavy, 'cold-blooded' and less weather-tolerant, 'hot-blooded' animals. Archaeological evidence[79] suggests that they were all small by modern standards. Evidence of how Roman horses were housed exists but is rather cryptic, with remnants often being limited to urine and manure staining on chalk beds and teeth in feeding channels. However, a site at Hod Hill in Dorset[80] appears to have been particularly well studied. Two types of stable division were noted, and the pattern of chalk-compression and the extent to which hooves had mixed chalk with manure gave the investigators an impression of how the animals were secured within the building. In one type of compartment, measuring 3.6×3.3 m, three horses might have been tethered to the wall, their dung falling into a 2-m channel to the rear. This channel also permitted access by grooms. The other compartment appeared to have accommodated six horses that again were tethered facing the wall. Measuring 3.6 × 5.5 m, this house comprised a central dunging passage that was communal to both rows of horses.

Information regarding accommodation for military horses since that time is limited. Smith[81] indicates that the British Army billeted horses in lines and did not have stables until a program of building barracks and stables began in 1792. Of these stables little is known except that they were not well ventilated and therefore precipitated considerable losses from glanders and other respiratory diseases.[81] Coach horses from the same era were confined to tie-stalls rather than individual boxes that were reserved for saddle horses.

Modern stable management

Just as domestic horses are put to a number of uses, so they are housed for a number of reasons and in stables of varying design. The most common issues around the 'whys' and 'hows' of intensive horse management are considered below.

Reasons for stabling horses

Horse owners throughout the world house their animals for a number of reasons. Among these, the most important is often the need to spare limited grazing areas from damage underfoot, especially in regions of and in times of heavy precipitation. The danger of disease associated with exposure, such as 'rain-scald' and 'mud-fever', in these regions can be reduced by providing field shelters and appropriate prophylaxis. Therefore, the economics of pasture management can prevail over horse welfare when owners consider stabling their horses for the winter.

By stabling their horses, owners eliminate food-stealing by dominant conspecifics and can have more control over food quality and intake. Food and water intakes are easier to monitor, with an eye toward early detection of disease, in the stable rather than the field. During the winter, time spent mucking-out and bedding a horse can be offset by the time saved by not having to groom a thick layer of mud off the horse prior to exercise. Clipping, made more feasible by the fact that the horse is sheltered, adds to this advantage since clipped horses sweat less in response to heavy work than their counterparts in a full winter coat and are therefore easier to clean.

Stabling may be favored by the owners of horses that are difficult to catch when at pasture. The limit on kinetic activity that is imposed by stabling is considered advantageous by trainers of performance horses since they can more easily control the amount of daily exercise taken by their charges. Post-inhibitory rebound in locomotory behavior after periods of confinement[74] may give trainers the impression that horses want to work.

Health advantages may accrue from stabling since injuries can be more effectively rested, worms can be better controlled and flies are less numerous than at pasture. Apparent advantages for the horses of being stabled include shelter (from sun, wind, rain and flies), freedom from bullying and a reduced physical requirement to work (e.g. forage) for food. This book should help readers decide whether these benefits outweigh the costs paid by the horse as it loses choice and control over social and ingestive activities.

Management practices

The time of year and the seasonal nature of some sports such as hunting and eventing influence the way in which horses are managed. Traditionally during the summer, while gymkhana ponies undergo a peak in their use because children are on school holidays, hunters are 'let down' at grass.

Feeding

Horses are notoriously wasteful grazers (see Ch. 8). Many farmers remark that, in wet weather, when one considers the damage done by its unforgiving hooves, a horse is equivalent to the activity of five bovine mouths. The reluctance of owners to allow this damage means that time spent by horses at pasture in temperate climates is often limited during the winter months. While sparing the horses the pain of disorders such as mud fever and dermatophilosis, this intervention often has a deleterious impact on their behavior and nutrition.

Traditionally, horses are fed long fiber from a haynet or hayrack. This is intended to reduce wastage from contamination with urine or feces and possibly to decrease the likelihood of endoparasite transmission. However, there is growing evidence that this unnatural foraging position can have a deleterious effect on the efficacy of the mucociliatory escalator in clearing the upper airways of inhaled particles (Fig. 1.10), especially those inhaled from dried foodstuffs (which are to some extent unnatural in themselves).[82] Similarly, haynets reduce the space available in the stable, may increase the risk of the horse becoming snared (e.g. by trapping its hoof), and elevate the forage so increasing its potential as a source of ocular

Figure 1.10 Dust plumes from a haynet as a horse forages. The position of the food and its contamination with fungal spores are unnatural. The harmful effects on respiratory health are well recognized. *(Reproduced by permission of the University of Bristol, Department of Clinical Veterinary Science.)*

foreign bodies. It is also argued that feeding from a net or rack may adversely affect muscles and nerves in the neck.[83] Perhaps this is why, when financial considerations are almost insignificant relative to the value and maintenance of performance (e.g. in the majority of racing yards[84]) horses are fed roughage, whether it be hay, haylage or silage, from the stable floor.

There are marked seasonal variations in feeding practices according to the weather and the availability of pasture. We do well to remember that the incidence of colic follows a similar pattern, with changes from fresh grass to a dried diet being associated with rises in various enteropathies, especially impactions. The use of concentrated feeds and the periods of fasting with which they are associated have been linked to unwelcome consequences, including increases in gastric acidity that can result in rapid ulceration.[85] Compared with those who ride mainly for competitive reasons, those who ride mainly for pleasure are less likely to feed cereal-based foods according to the manufacturer's recommendations during summer, when grass is available.[86]

Bedding

For a variety of reasons, including availability, ease of disposal and tradition, straw remains the favored bedding for horses.[86] Although it raises concerns for some about the risk of impaction and chronic obstructive pulmonary disease (COPD), straw seems to have the added advantage of being the bedding preferred by horses themselves.[87] It may be worth noting that straw is regularly used as horse food in developing countries.

Depth of various bedding types that is needed to maximize their appeal to horses has not been studied. However, it has been noted that horses lie down on deep litter bedding rather more than do horses at grass or on daily mucked-out beds.[88] The common practice of providing limited bedding to save money can affect choice by reducing the extent to which the horse can comfortably lie down. Houpt[89] notes that if bedding is present but inadequate, horses tend to lie down as soon as more bedding is supplied.

Whereas horses have evolved to be very sociable animals, many owners feel that their charges should be given solitary quarters to make bullying less likely. At pasture, horses choose their affiliates and will spend time interacting with them, for example, while playing, mutually grooming,[63] or settling reasonably minor disputes. On a stable yard, managers tend to dictate the distribution of horses with efficiency of service in mind rather than the associations established between pairs of horses at pasture. It is a shame that there are so few data on the effects of separating horses from preferred companions, or exposing them to agonistic approaches from neighbors whom they would normally avoid.

Watering

While some military horses are still communally watered on a three-times-daily basis, modern textbooks of stable management rarely commend the limited availability of water. However, the maxim that food should not be given before work and that water should not be offered after food probably represents a considerable limitation on the choice that stabled horses can exercise in terms of drinking behavior.[90]

Stable design

There are few publications on the design of stables, and these have been based largely on extrapolations of recommendations for shelter and ventilation of agricultural species. The Universities Federation for Animal Welfare (UFAW)[91] states that for a horse of average size – 500–600 kg bodyweight and 1.5–1.6 m (15–16 hands) – the loosebox should be at least 4 × 4 m and preferably 4 × 5 m. Ensminger[92] states that except for foaling mares and for stallions, there is no advantage in having box stalls larger than 3.6 m square. Evans et al[93] note that the popular size is 3.6 × 3.6 m and that 3 × 3 m is adequate for young horses but suggests that the more time the horse spends in the stall, the larger the stall should be. There are several differences between the housing of horses compared with that of other farm animals. Horses usually have individual living areas, and a much greater labor input per animal is present in stables than in farm-animal housing. A survey of racing stables in the Southwest of England found that floor space varied between 8.76 m^2 and 21.8 m^2 with a median of 12.1 m^2 per horse.[94] This compares favorably with the floor space provided for other agricultural species per unit of body size.[95]

While box designs have been suggested by agricultural engineers and by horse-lore, there appear to be no recommendations in management texts about the amount of time that the occupants of these quarters should spend within them on a daily basis. There are a number of reasons for protracted confinement, including inclement weather, locomotory illness and isolation of contagious pathogens. Episodes of enforced confinement are popularly noted as being contemporaneous with the onset of stereotypies. Given that Evans[93] advocates the provision of more space for animals that are turned out less regularly, it could be argued that the design of all stables should meet the needs of the worst-case scenario that precipitates withdrawal of the daily turn-out period.

The traditional layout of a stable-yard includes the quadrangular enclosure of a central lawned area by boxes whose doors and windows face inwards. Walkways in many yards pass close to these portals and expose stabled horses to the unpredictable and arousing movement of humans, feed-buckets and conspecifics. Therefore, it has been suggested that regimented geometrical accommodation of this sort makes relaxation difficult for the occupants.[63]

Despite similar problems with the distracting effects of activity in the passageways and others to do with air hygiene, barn-style housing (in which horses are housed individually, under one roof, in pens made largely from bars and grilles), which facilitates communication between neighboring horses, is increasing in popularity. Studies on the effect of increasing visual contact with conspecifics on weaving[96,97] (see Ch. 5) suggest that whether a stable, rather than a tie-stall, is acceptable depends on its walls more than its size in that isolation is more of a problem than confinement.[89] Group housing of young horses allows more normal social development[98] and reduces the risk of stereotypies[99,100] when compared with individual housing.

Modern stable management brings with it a number of disadvantages for both owners and horses. For the owner, the disadvantages of keeping their animals in stables rather than at grass revolve around time and money. Time commitments in stable management include bedding and feeding as well as having to exercise the confined horse on a more regular basis than its grazing equivalent in order to maintain a given level of fitness. The disadvantages of stabling from the horse's perspective are considered later.

Behavior

When practitioners are asked to comment on abnormal or unwelcome behaviors, they must first of all appreciate the range of normal behaviors.

Normal behavior in stabled horses

Domestication affects behavior,[101] not least because it limits the amount of space in which stock is able to range. This limitation can be effective from day one of life, since many foals, especially valued Thoroughbreds, are born indoors.[102] Interestingly it has been suggested that myopia may be a consequence for horses that spend too much time in stables[103] (this is discussed further in Ch. 2).

The changes in equine behavior associated with confinement and limited choice merit particular consideration. From the horse's perspective, the ways in which stabling can compromise feeding, social and kinetic behavior and indeed health are considered below.

Feeding behavior

Because behavior is a response to an organism's environment, the more restrictive an environment is, the more limited are the choices available to the organism. It is possible that where choice is limited or eliminated, welfare may be compromised.[104] Choice allows animals to perform the behaviors that are important to them,[105] although the choices they make are not exclusively in the direction of their own welfare.[106] While the debate about the importance of environmental choice in the welfare of animals continues, there appears to be a number of ways in which modern stable management limits choice.

Choice is certainly reduced in feeding behavior when horses are stabled. Feeding behavior in stables seems to show the most marked difference from that at pasture since concentrated rations may be consumed more rapidly than a pure forage diet (Fig. 1.11). While the feral or pastured horse may spend 70% of its day foraging, stabled horses on 'complete diets' may spend only 10% of their time feeding.[107] These diets for competition or

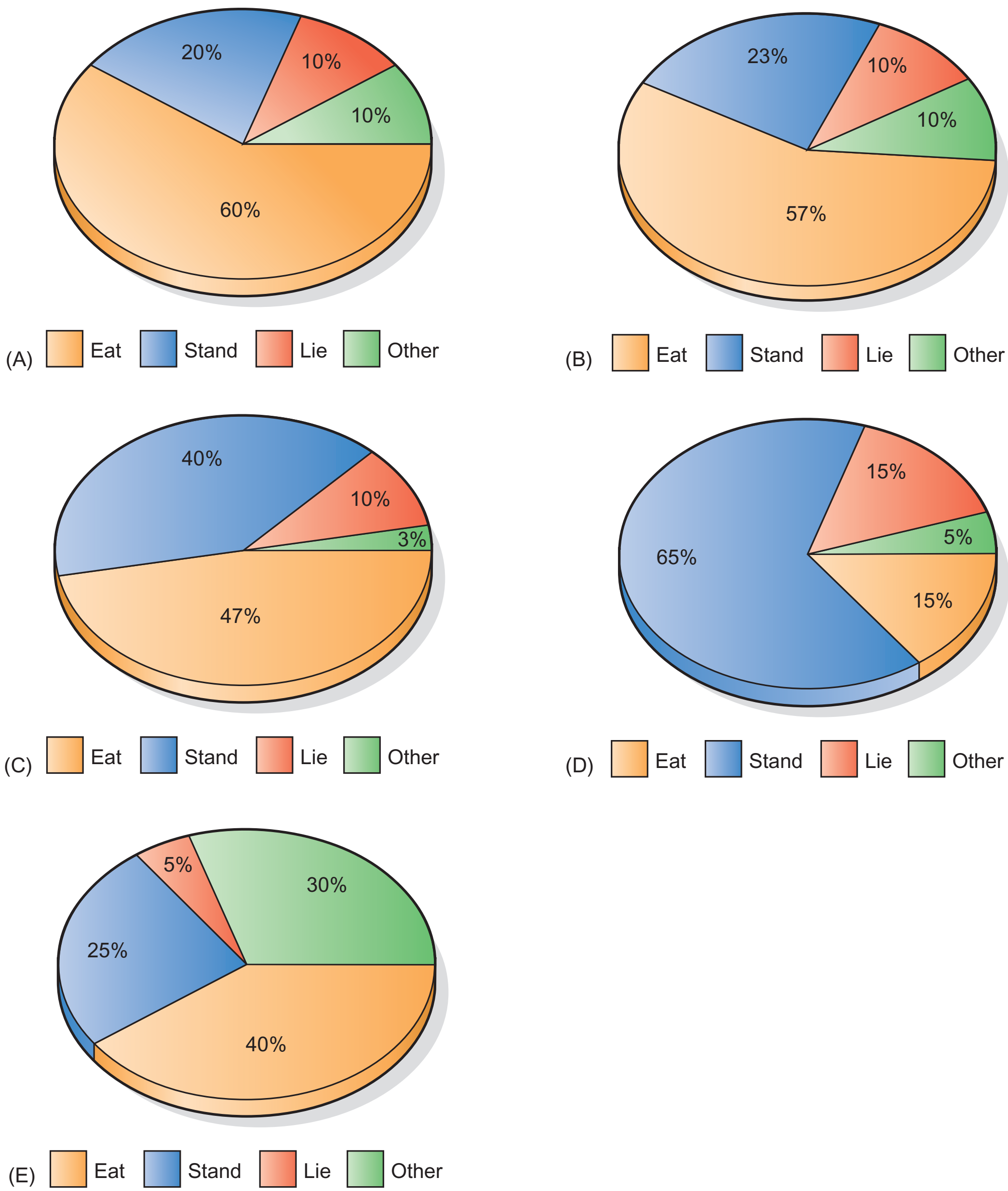

Figure 1.11 Time budgets for horses in a variety of environments: (A) free-ranging Camargue horses, averaged over a year; (B) eight horses housed as a group with ad libitum hay and straw; (C) three horses in individual stables given ad libitum hay and straw and able to see and touch each other; (D) horses fed restricted fiber in stables where they cannot touch each other and only see each other over stable doors; (E) six crib-biters fed ad libitum hay and able to see and touch each other. NB: Crib-biting accounts for 20% of these horses' 'other' behaviors. *(Charts (A)–(D) reproduced with permission of M Kiley-Worthington from* The Behaviour of Horses in Relation to Management and Training.*)*

maintenance can be eaten in less than 2 hours and have removed the feeding behavior of stabled horses even further from its evolutionary origins. In addition, modern diets for the stabled horse can be monotonous. There is compelling evidence that giving stabled horses variety in their forage ration and distributing various forages throughout the stable can help to bring their time budgets closer to normal.[108]

The time at which food is made available often adheres to a strict regime, which may have variable implications for gastrointestinal function. The designation of such feeding times may address the convenience of the operator rather than the needs of the horse. Horses have not been observed to fast voluntarily for more than 3–4 hours[109] but spells of this sort are imposed on many stabled animals.

It has been shown that after 2–3 weeks of continuous access to a single feed, ponies stabilize their bodyweights, consuming 2–3% of their bodyweight in dry matter in a 24-hour period.[110] Despite this finding in support of ad libitum feeding of housed equids, stable managers prefer to control intake, since it is known that to do otherwise is to risk temperamental volatility and metabolic disorders, e.g. laminitis.

There is considerable anecdotal evidence for the effects of diet on behavior in the horse,[1,111] but little has been done to determine the relative importance of factors such as energy, protein and fiber levels. (The relationship between diet and behavior is discussed in more detail in Chapter 8.)

It has been argued that the sleep pattern of a species can be used as an index of adaptation.[112] It is therefore interesting that, while drowsing accounts for 8% of the resting time of stabled horses, this figure has been shown to rise to 14% at pasture.[113] The concomitant dietary differences between intake at grass and in the stable may play a role in this phenomenon since a preliminary study in ponies has shown that, when oats replaced hay in the diet, total rest time increased.[114] This merits further scrutiny (see Ch. 10). Although the number of feeds per day can affect behavior via factors such as disturbances and arousal,[115] it could be that restlessness in horses peaks when stabled animals are fed small amounts of forage and after consuming them are left with little to do in so-called vacuum periods.

Social behavior

The importance of social behavior to stabled horses has yet to be fully quantified with consumer demand studies. However, anecdotes that describe horses performing operant responses, such as undoing bolts with their lips to escape from the stable (Fig. 1.12) may indicate that housed individuals will perform work in order to return to their conspecifics.

It is known that frightened riding horses may bolt in a bid to return to their fieldmates, apparently because of an innate preference for the presence of equine company.[116] There are considerable data to suggest that isolation can be aversive.[117–120] When the choice of equine neighbors in a stable yard is dictated by the manager, bonded affiliates may be separated while individuals with mutually low tolerance may be housed next to one another. Disruption of an established social structure in this way may be associated with heightened aggression, especially at times of concentrated food delivery.[121]

Generally, the opportunities for social interaction with conspecifics, favored or otherwise, are minimized by the individual housing of horses. While olfactory, auditory and visual communication can often occur between stabled neighbors, tactile communication, which is of considerable importance in groups of horses,[122,123] is rarely possible in most stable designs.[94,115] Similarly, interactions such as mutual fly-swatting cannot be performed by isolated horses. These concerns are of particular importance when tie-stalls are considered, with evidence to suggest that they do not sufficiently cater for horses' needs to perform social, recumbent resting and allo-grooming behaviors.[124]

Stables of all sizes when designed for individual horses have the potential to conflict with many of their occupants' survival instincts.[13] While imposing the vulnerability of isolation and an unhelpful concentration of excretory products that may attract predation, they prevent detection of predators and escape. Until we cost out the value of resources or the absence of threats to safety and comfort, it behooves us to consider these impositions from the horses' perspective. For example, while stallions and occasionally geldings create stud-piles of feces in the stable, eliminative behavior in the stable differs markedly from that in the paddock, since the occupants cannot easily avoid contact with their urinary and fecal waste. Because fresh layers of bedding regularly prompt urination in male equids, some consider this a form of marking.[63] So, the extent to which bedding is managed to meet human rather than equine needs bears consideration but it is only one feature of the stabled horse's world that represents a removal of choice. In many ways horses attempt to meet their behavioral needs despite the shortcomings of intensive environments but may fail to do so because of management routines.

Kinetic behavior

Among the prevailing features that arise in intensively managed horses is restricted space. The physical limitations imposed on a horse by stabling mean that kinetic behavior is more difficult to perform than it is at pasture. For example, it has been estimated that an average sized horse needs a 6-m span to roll from one side to another,

Figure 1.12 (A–D) Irish Draft Horse undoing the bolt of his stable door. (E) After a chain was secured across the threshold to prevent his escape, he moved his hay so that he could watch activities on the yard while eating.

so many stabled horses are unable to perform this most basic of maintenance behaviors. The relative lack of space either may prevent the stabled horse from choosing to roll or may precipitate casting. Confinement within looseboxes is common and is an important limitation on the amount of exercise that a horse can take through choice. After periods of confinement, horses show post-inhibitory rebound[74,125] that may explain why unwanted behaviors during training occur more frequently among stabled horses than those at pasture.[116]

It has been suggested[53] that voluntary kinesis indicates that, rather than being simply a substratum for most behavior, locomotory activity has a motivation of its own.[74] However, the possibility of motivation for spontaneous locomotion is a contentious area because there is often difficulty in eliminating motivation to perform other behaviors for which locomotion is a prerequisite, e.g. intrinsic exploration.[127]

Although unacquainted horses from different yards may be mixed on a national and international scale for equestrian competition, isolation is often practiced when new horses arrive on a yard, in a bid to control the spread of pathogens. Should such animals perform an unwelcome behavior pattern, they will often remain in isolation, since stereotypies are traditionally regarded as contagious.

Space is certainly restricted when horses are housed, particularly in the case of tie-stalls. The extent to which stabled horses can see conspecifics is restricted. In a traditional loosebox, this can often be achieved only by looking over the stable door, while many tie-stalls restrict visibility further by having tall dividers between neighboring pens. This view is a contentious one. Marsden[128] maintains that the behavior of horses kept in tie-stalls is similar to that when they are kept at pasture. This was based on the observation that, in tie-stalls, horses showed no significant increase in the time they spent performing abnormal behavior. The proximity of neighboring horses was thought to facilitate social behavior more than is the case in individual looseboxes. It may be that the small sample size (n = 4) could have resulted in the inadvertent selection of horses that were especially unreactive and not predisposed to perform stereotypies. This work did, however, indicate that stalled horses spent significantly less time lying down and moving, with significantly more time standing in stalls than at pasture. Subsequent studies of pregnant mares in tie-stalls have shown their time budgets to be similar to those of free-range horses.[129] It would be interesting to see whether the mares' gravid state influenced this outcome. There is a danger in assuming that, even though horses do not choose to be so confined, tie-stalls somehow meet horses' behavioral needs. Jones & McGreevy[130] have described a framework for judging the impact of and ethical justification for various interventions imposed on horses in the domestic context.

Health

The continual proximity to feces and urine may be aversive to a stable's occupant and may also have an impact on health since humidity and airborne pathogen viability may rise, especially if air-changes per hour are insufficient.[94] An unnatural foraging posture, e.g. eating from a haynet for extended periods rather than from the ground, may compromise the function of the ciliary escalator in the respiratory tract[131] and precipitate pulmonary disease. Rhabdomyolysis[132] and chronic degenerative joint disease[133] are often exacerbated by the physical restriction that accompanies extended periods of stabling. A stable with insufficient or uncomfortable bedding may limit the willingness of its occupant to lie down.[134] This is thought to be associated with the horse's working life being cut short.[135] Stabling has also been implicated as a predisposing cause of one of the most dreaded and frequently fatal equine disorders, colic.[136]

Conclusion

The five freedoms (Box 1.1) have been established as a means of judging the extent to which the needs of domestic and captive animals are met by human carers.[137,138] If we apply this model of good animal welfare to horses, we can highlight areas in which wellbeing may be compromised. For example, we see many ways in which they are denied the freedom to express their normal behavior in a stable. When one considers the social nature of equids, one quickly appreciates the impediment that the isolation of single-horse housing represents to normal equine behavior. Therefore, while it has many advantages for the horse owner, the stable should be viewed not simply as a source of physical confinement but also as a limitation on behavioral choice.

Box 1.1 The five freedoms

To analyze all the factors likely to influence the welfare of farm animals, consider whether the animal has:

1. *freedom from thirst, hunger and malnutrition* – by providing access to fresh water and a diet to maintain full health and vigor
2. *freedom from physical and thermal discomfort* – by providing a suitable environment, including shelter and a comfortable resting area
3. *freedom from pain, injury and disease* – by prevention or rapid diagnosis and treatment
4. *freedom to express most patterns of normal behavior* – by providing sufficient space, proper facilities and company of the animal's own kind
5. *freedom from fear and distress* – by ensuring conditions that avoid mental suffering

Abnormal behavior in stabled horses

Most changes in ingestive, eliminative and social behaviors that follow a horse's move from an extensive to an intensive management system are usually of little concern to the animal's owner. However, behavioral changes that are directly deleterious to the stable or the usefulness and value of its occupant are regarded as abnormal. Tradition maintained that it was a form of disobedience when stabled horses did not behave as their owners required. Such miscreants were said to have 'vices' whether they ate their feces, bit their grooms or refused to lie down.[135] Far from elucidating the reasons for these unwelcome behaviors, this umbrella term tended to put the blame on the horses themselves, as if they had malicious intent.

In 1912, a Captain Moseley, writing in the *Veterinary Record*, described one such 'vice', crib-biting, as 'a form of mental masturbation'. However, while still saddled with a label that implied viciousness, the same behavior in 1959 was recognized by Summerhays[139] as being induced by confinement. Applied ethology has developed since then and serves to examine shortfalls in management that may have prompted such behaviors. Behaviors that have been described as vices[140] are now better categorized as redirected behaviors, learned behaviors, physical problems, stereotypies or the consequence of inappropriate amounts of stimulation.[141]

Displacement and redirected behaviors

Displacement behaviors are regarded as responses that are inappropriate for the current situation. Of course, this rather arrogantly fails to acknowledge that observers may not always know what is appropriate and inappropriate from the horse's perspective. Displacement behaviors are recognized in situations that involve behavioral conflict (see Ch. 13). For example, when a ridden horse is prevented from moving forward for longer than it can readily tolerate, it may start bending its neck laterally in an apparent attempt to groom its flank even though self-grooming is not the most appropriate response to restraint mediated through the bit. In the stabled horse, a similar self-grooming response as a result of frustration may be the kernel of stereotypic self-mutilation.

When a behavior (e.g. an act of aggression) is directed away from the primary target and toward another, less appropriate object, it is said to be redirected.[141] The term must be used with caution since it requires that the observer has correctly identified the primary target. For example, horses that eat their bedding material are thought by some to be performing a redirected behavior that meets their physiological needs for dietary fibre.[110] Others regard this as a form of coprophagia if the bedding is soiled, but since the remedies advocated involve increasing the provision of roughage (which redirects the behavior back to its evolutionary target), the distinction is descriptive rather than functional. Coprophagia is regarded as an adaptive behavior in foals[142–144] but as being an ethopathy in older individuals.[53]

Another common example of redirected behavior in equine husbandry systems is wood-chewing, which is regarded as an ingestive behavior that would be more readily directed toward grass or other palatable fiber were it available.[110] That said, it is known that horses at pasture will chew wood,[145–147] which implies that our understanding of the causes of this behavior is incomplete. It is possible that the ingestion of small quantities of bark may be adaptive as a means of acquiring micronutrients.[110]

Both redirected and displacement behaviors are subject to the rules of operant conditioning (see Ch. 4) and may be reinforced to become established unwelcome responses. For example, many horses paw at the ground or at the stable door prior to being fed. Although this may be a response that would be appropriate for a free-ranging horse that is being kept from its forage by a temporary barrier, such as snow, some would see the targeting of the door as a redirection of the behavior. If the horse is fed during or shortly after pawing the door, and is therefore rewarded, it will be more likely to paw the door in future.

Over-stimulation or under-stimulation of behavioral systems

While lack of stimulation is often cited as a cause of anomalous behavior,[50,148] including apathy, the opposite also merits consideration in the ontogeny of unusual behavioral strategies linked to housing. Kiley-Worthington[88] indicates that too much noise, excitement or exercise can cause over-stimulation, as can the presence of too many horses and humans to mix with socially. Raised levels of arousal in these horses may make them generally more reactive when being handled in the stable.[63] Similarly, inappropriate levels of stimulation are thought to cause psychopathologies such as hyperphagia nervosa[53] and polydipsia nervosa.[149]

Learned behavior

Learning in companion animals is often not recognized and is therefore regularly misinterpreted. This often involves so-called superstitious learning whereby a response is acquired as a result of its accidental link with a reinforcer.[150] Misinterpretation arises because the handlers are unaware of the cues that their presence or actions represent to the animal. Chapter 4 is designed to allow readers to become conversant with learning theory and to understand why the term superstitious learning is virtually redundant, given that animals are learning all the time. Recognizing ways in which animals learn associations unanticipated by their handlers is a cornerstone of behavior therapy. A bizarre example is a case of psychogenic colic that was associated with a demand for human company.[151]

Another example is learned aggression to humans that can evolve as a result of inappropriate associations between agonistic posturing and the unwitting delivery of a food reward. Thus, arrival of the handler prompts hunger-motivated head-threatening behavior that is reinforced by the consequent acquisition of food as the human retreats. This agonistic behavior escalates when punished directly by the handler since his eventual retreat becomes a more valued goal.[152] Other learned responses, including conflict behaviors that arise during horse–human interactions, are considered in Chapter 13.

Physical problems

Problems that arise as a direct consequence of the dimensions of the stable, such as 'refusal to lie down', have been blamed on some deficiency on the part of the occupants rather than the designers of the accommodation. Certainly, the area available influences resting behavior.[153] Other examples of physical problems include habitually getting cast, catching hips on the doorway (often exacerbated by learned fear that prompts faster, though not necessarily better judged, exits through doorways) and getting feet caught in haynets.

Stereotypic behaviors

Stereotypic behavior is characterized by being repetitive, relatively invariant and apparently functionless.[154] Stereotypies are heterogeneous in their causes and their forms. Caged tigers that repeatedly pace up and down in their enclosures raise public concern about welfare in zoos. On a less exotic scale, similar behaviors are performed by horses and ponies. Historically known in horse-lore as 'stable vices' and given specific descriptive labels such as box-walking (stall-walking in the USA), weaving, wind-sucking and crib-biting, these largely irreversible behavior changes tended to cause more embarrassment than concern. Despite this, questions regarding stereotypies (as these unwelcome behaviors are correctly described) have been fielded by behaviorists and vets for decades. In recent times, equine stereotypies have received considerable scientific attention.

Most lay authors on the subject tend to use the blanket term 'boredom' to explain how these behaviors arise, and the remainder imply that it is the fault of the horses themselves. However, the days of dismissive attitudes to behavioral anomalies in horses and ponies would appear to be numbered. Therefore, while there are still those who regard the 'private life' of their stabled horses as being unimportant as long as it does not cause poor performance, others have begun to question the merits of traditional stable management that pushes the horse beyond its limits of adaptation.

Historical accounts of stereotypic behavior

Stereotypic behavior is not described in the earliest text on horsemanship and stable management[155] but archaeologists have used erosion on the incisors of equine skulls as an indicator of crib-biting and therefore domestication. Donkey teeth gathered from what are thought to be ancient sites of worship in Syria have shown signs of wear that have been likened to the erosion one finds in crib-biters.[156] The use of incisor wear to identify Paleolithic horses as crib-biters is not without its critics.[157] The current prevalence of crib-biting in donkeys is negligible and, while it is possible that crib-biting was more common in the past and has been selected out of the population to some extent, it seems strange that three of the five donkeys in this site would have this stereotypy. The use of incisor erosion as a means of confirming that the bearer is or was a crib-biter remains controversial because pre-purchase evidence of erosion is cited in instances of litigation when the vendor fails to declare the behavior.

This link between crib-biting and domestication is made in the belief that stereotyped behavior occurs only in animals that have experienced captivity. Furthermore, the assumption that this wear is invariably the result of an oral stereotypy is not without hazards since sandy soils and particular species of grass may produce similar erosion on the labial surface and the tables of the incisors.

As well as crib-biting and a number of the other so-called stable vices, weaving is described in a number of antique texts on equine husbandry.[158–160]

Characteristics of stereotypic behaviors

Stereotypic behaviors are not recognized in free-living feral horses and are not purely a product of domestication since they are also reported in captive examples of wild equids such as the onager mountain zebra[161] and Przewalski horses.[162] In the horse, these behaviors have therefore been linked to a number of management practices. A number of equine stereotypies have been identified,[88] including:

- chewing
- lip-licking
- licking environment
- wood-chewing
- crib-biting
- wind-sucking
- box-walking
- weaving
- pawing
- tail-swishing
- door-kicking (front feet)
- box-kicking (hind feet)
- rubbing self
- self-biting
- head-tossing

Table 1.3 **Reported prevalence (%) of stereotypies and wood-chewing from studies published between 1993 and 1998**[166]

	Mean	Standard deviation	Median	Minimum	Maximum
Crib-biting/wind-sucking (13 populations)	4.13	2.57	3.66	0	8.30
Weaving (13 populations)	3.25	3.23	1.98	0	9.5
Box-walking (13 populations)	2.20	2.33	3.50	0	7.32
Wood-chewing (6 populations)	11.78	6.12	12.00	5.00	20.00

Reproduced with permission from Nicol.[166]

- head-circling
- head-shaking
- head-nodding
- head-extending, ears back and nodding
- kicking stall (hind feet).

This is an exhaustive list and includes a number of behaviors that are not morphologically invariant and therefore might be regarded as redirected behaviors by other authors. Other behaviors in the above list are difficult to define because changes in form may accompany aging of the stereotypy, e.g. weaving may change from a side-to-side pacing to a stationary head-swing.[163] More than one stereotypy may be performed by an individual horse, e.g. a box-walker may well be seen weaving on occasions.[164] Indeed if a horse has one stereotypy, it has a greater chance of having a second than do normal horses.[165] The results of 13 studies into the prevalence of stereotypies and 6 into that of wood-chewing appear in Table 1.3.[166]

Since many stereotypies are popularly regarded as being transmissible by mimicry[134] and some are associated with health and performance problems, horses exhibiting them are often isolated. Some (such as box-walking, weaving and wind-sucking) must be declared at auction and tend to lower the value of affected animals. These are dealt with more thoroughly in Chapters 5 and 8.

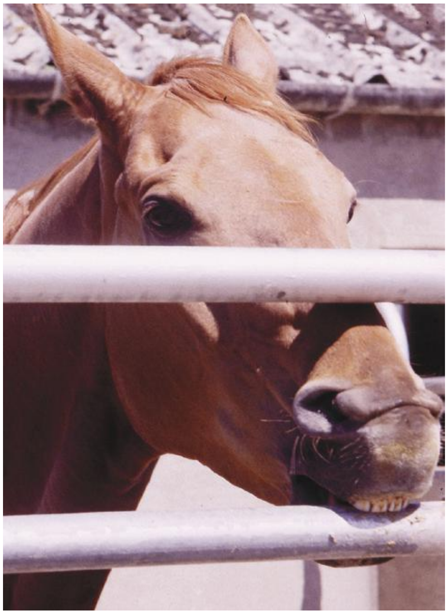

Figure 1.13 Horse crib-biting on metal substrate. Although horses prefer to grasp wood rather than metal (perhaps because it cushions their teeth), they will crib-bite on metal if no other substrate is available. This helps to demonstrate a considerable behavioral need to perform the stereotypy. *(Reproduced by permission of the University of Bristol, Department of Clinical Veterinary Science.)*

The functional significance of stereotypies

There has been much recent debate about the functional significance of stereotypies performed by captive domestic animals.[167–169] One influential theory is that stereotypies enable animals to cope with stress.[170–173] However, experimental studies to examine the effects of preventing animals from performing stereotypies in order to assess the validity of the stress-coping hypothesis have produced equivocal results.[174–178] Nevertheless, transient decreases in heart rates have been demonstrated in association with bouts of crib-biting (Fig. 1.13).[179,180] Furthermore, efforts to prevent the performance of equine stereotypies are linked to some increases in physiological stress parameters.[177,178] It has also been suggested that crib-biters may have higher basal sympathetic activity because they have been found to have higher overall mean heart rate.[180]

Stereotypies could help a horse cope with suboptimal environments or bring direct and immediate rewards that make the behaviors intrinsically gratifying. Endorphins have been implicated as a possible source of reinforcement for crib-biting[181] because opioid antagonists can reduce crib-biting by 84%, suggesting that at least one of the perceived benefits of crib-biting (from the horse's perspective) is mediated by opioid receptors at some point. However, because resting behavior in crib-biters was also significantly increased by opioid antagonists, it may be that the reduction in crib-biting was linked to a generalized sedative effect. The effects of opioid antagonists on weaving are extremely variable, with reports of both decreases[182,183] and increases.[178] While it is possible that weaving may also be opioid mediated, further work with larger numbers of weavers would be required before there can be a clearer understanding of the mechanisms involved.[178] Recent studies on the brain of stereotypic horses indicate altered dopamine activity.[184]

A further suggestion is that a given stereotypy may retain a function within the motivational system from which it is derived.[88] Thus, an oral stereotypy such as crib-biting may provide a route to normal feeding and digestive activity within an environment that severely limits normal forage intake (e.g. an intensive training program characterized by the provision of high concentrate: minimal roughage diets).

Persevering with non-functional behaviors or previously trained but currently unrewarded responses is a characteristic of stereotypic animals.[185,186] There is evidence that stereotypic horses may have developed a general inability to suppress non-functional behavior.[187] While this may have important repercussions for the trainability of stereotypic horses, it should also be borne in mind when equine scientists select subjects for studies of learning.

Management factors and abnormal behaviors in stabled horses

It is clear that the prevalence of crib-biting and weaving is greater in Thoroughbreds than in other breeds.[188,189] The prevalence of box-walking, wind-sucking/crib-biting and weaving in UK Thoroughbred populations has been estimated at 1.1%, 4.2% and 2.8%, respectively ($n = 1033$)[190] and in Italy at 2.5%, 2.4% and 2.5% ($n = 1035$).[191] Data from 4468 UK Thoroughbred horses in training showed the total prevalence of all three of these stereotypies to be 10.8%, similar to the prevalence of lameness.[192] Estimates of the combined prevalence of all stereotypies are more difficult; for example, when lip-licking, pawing, tail-swishing, head-tossing, head-nodding and box-kicking were included, the prevalence on some yards reached 26%.[88] However, it remains difficult to dissect the effects of management and breed because Thoroughbreds are generally raced and therefore managed intensively.

In other species, cage-design,[193] isolation-rearing[194] and food-deprivation[195] have been implicated as proximate causes of stereotypic behavior. Arousal, generated by frustrated motivation, is a possible shared underlying cause,[196] although others emphasize the possible heterogeneity of the cause and effect of different stereotypies.[154] Despite much work on farm and laboratory species, the proximate causes of stereotypic and redirected behavior in the horse have yet to be verified. However, the possible causal factors associated with oral and locomotory stereotypies are discussed in Chapters 8 and 5, respectively.

The role of genes and environment

Although they have failed to control for variability in management factors, studies into the role that heritability plays in stereotypy frequency have consolidated the view that certain family groups are more likely than others to demonstrate stereotypic behavior.[107,191,197] More recently, it has been demonstrated that crib-biting at least is a canine oral stereotypy associated with certain gene arrays.[198] Meanwhile a growing branch of the literature identifies the importance of management factors that might frustrate motivation in the horse.[115,166] In horses bred for Flat racing, these include the amount and type of forage, the bedding type, the number of horses on the yard and the amount of communication that is possible between neighboring horses.[115] A parallel study in dressage and eventing horses demonstrated that the amount of time spent in the stable correlated with the likelihood of stereotypies being reported.[199]

Although feeding practices tend to have a greater effect than housing practices on the incidence of abnormal behavior,[128] a single causative factor is rarely to blame. For example, wood-chewing increased when high-protein rations were fed, because of a concomitant reduction in the total fiber content,[109] and when exercise was withdrawn.[146] Many authors have suggested other possible causes of anomalous behaviors, including factors associated with weaning, social contact, crowding, feeding, housing and/or training practices.[88,200]

Some authors[135,164] emphasize the importance of mimicry rather than environmental deficits, believing that exposure to a stereotypic neighbor may increase the likelihood of stereotypy development or performance. Such social influences, known in voles,[201] may also affect stereotypy levels in horses,[202] but the evidence that horses can learn by observation is so far rather limited[203–206] Even if observational learning is not involved, we should not rule out the possibility that having a stereotypic neighbor may

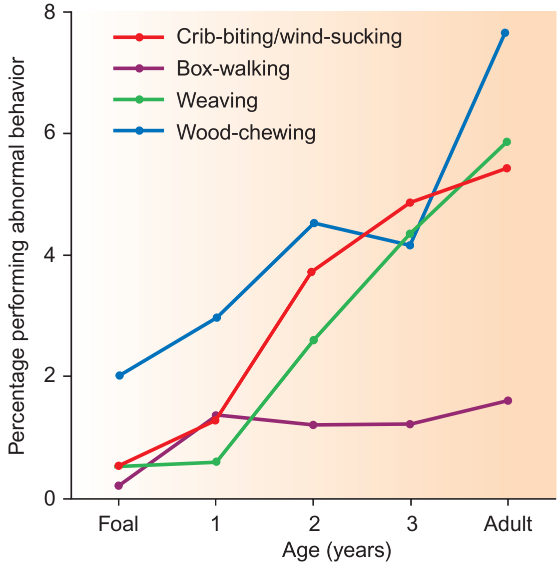

Figure 1.14 The percentage of Thoroughbreds reported as showing stereotypic and redirected behaviors from a sample population of 1023 foals, 746 yearlings, 1001 2-year-olds, 711 3-year-olds and 6250 adults.

Figure 1.15 Two horses crib-biting at pasture. Since they have one another's company and optimal foraging opportunities they provide a useful example of emancipation. *(Reproduced by permission of the University of Bristol, Department of Clinical Veterinary Science.)*

simply increase the arousal of observing horses and therefore predispose them to developing stereotypic behavior.

An exhaustive study of abnormal behavior on Thoroughbred studs gathered data on more than 11 000 horses, which suggested that, as a result of emancipation (where abnormal behaviors become detached from their initiating causes and thus less responsive to environmental enrichment), the prevalence of stereotypies tends to rise with age (Fig. 1.14).[192] Therefore, it seems likely that few horses are ever 'cured' of these behaviors. This implies that once these behavioral anomalies are established, they persist to an extent, despite attempts to improve any potentially causative deficiencies in the horse's management (Fig. 1.15). The continual reinforcement of stereotypic behaviors contributes to their resistance to therapy. That said, in one study effective treatment of crib-biting was offered as a possible reason (along with euthanasia) for the largest percentage prevalence in crib-biting rates being found in foals.[207]

Fundamentally the possibility of emancipation means that it is better to implement environmental enrichment prophylactically rather than therapeutically. Notwithstanding its effects in maintaining normal behavior in youngstock,[208] it is also likely to increase learning ability[209] while at the same time promoting musculoskeletal health.[210]

The process of emancipation also means that stereotypic foals are better research subjects than mature stereotypers. Studies on cohorts of foals from neonates to 4-year-olds have yielded fascinating results. For example, time-related patterns for the development of oral behaviors differ from those of locomotory behaviors.[207] This seems to emphasize that a single process such as 'boredom' could never fully explain the full spectrum of equine stereotypies. The results of these and other recent studies on oral and locomotory stereotypies are discussed in more detail in Chapters 8 and 5, respectively.

The future holds tremendous promise for sympathetic and productive understanding of equine stereotypies and the responsibility we must take for their emergence and effective management.

Management of stereotypies

Detailed therapeutic approaches to individual stereotypic behaviors will be considered in later parts of this book, but it is worth noting some overarching principles that apply to many of these ethopathies. Of all of the anomalous behavior patterns in horses, stereotypies seem to have proved most insoluble to horse owners. Work on other species by different groups[169,174,211–213] often appears contradictory and has highlighted heterogeneity in stereotypies.[167] Since the study of equine stereotypies is still in its infancy and because information from other species can be applied only with caution, it is perhaps not surprising that hippologists have found vices so mysterious and frustrating and have met with so little success when attempting to modify these behaviors.[135]

As the data demonstrating increasing prevalence with age suggest, stereotypic behaviors can become emancipated from their initiating causes.[214] Therefore, while stereotypies may arise in response to adverse management, they may persist in more enriched environments. Despite this, owners of stereotypic horses often feel responsible for their charges' behavioral anomalies. The behaviors are therefore unwelcome not least because they are a potential source of embarrassment to owners.

Stereotypic horses are considered undesirable for many reasons. Generally diminished performance in stereotypers has been identified by some authors,[88,215] while health problems associated with these behaviors have been highlighted by others.[116,134,216–219] Furthermore, it has been suggested that stereotypic horses in tie-stalls spend less time interacting with neighboring horses.[129] Prevention of crib-biting, involving physical or surgical approaches,[1,134,220–224] is less commonly attempted presumably because of considerable variation in rates of success. Certainly surgery is falling out of favor as the causes of stereotypies become better understood.

There is recent empirical evidence that observational learning can occur in horses, but this is so far confined to a simple, following response, quite unrelated to the complex and covert oral maneuvers required in, say, crib-biting. Nevertheless, the belief that behaviors can be learnt or copied continues to affect the management of stereotypic horses. Physical prevention of the behaviors is the prevalent response, while isolation of affected horses from other horses is also common (Table 1.4). If these behaviors are not as functionless as assumed, e.g. if they constitute a coping response to a suboptimal environment, the common practice of preventing stereotypic behavior may be of welfare significance. Conversely, managing stereotypic animals so that they are subjected to minimal frustration, e.g. by feeding and exercising before other horses on the yard, is very helpful.

The need to prevent stereotypies for aesthetic and occasional health reasons has prompted searches for permanent cures. A remedy that is effective for every cribbiter remains elusive (but readers are directed to Chapter 8 for a discussion of current humane approaches). The resourcefulness of horses in satisfying their motivation to perform this behavior seems to overwhelm humans' ability to physically prevent established forms of the behavior. In the light of evidence of brain chemistry differences in affected horses,[184] physical and surgical prevention attempts seem especially crude.

Environmental enrichment, often mentioned in the context of captive exotic species, is no less important in the horse. Turning stabled horses out to pasture offers a dramatic illustration of the effects of enrichment. However, for some owners this is not an option. While many owners reach for the blanket term 'boredom' to describe the problems faced by the stabled horse, some are beginning to explore ways to increase complexity of stables.[226] For example, using a chain in place of the stable door is a surprisingly effective means of increasing the visual stimuli that enter a stable (see Fig. 1.12E). The key with any environmental enrichment is to ensure that the intervention is relevant and unlikely to provide a focus for simple redirection of abnormal behaviors, an outcome that is quite unsatisfactory. By studying this book, and most notably Chapters 5 and 8, readers will be well placed to design enrichment strategies that are likely to meet the behavioral needs of all horses, especially those that exhibit under-stimulation and frustrated motivation.

Table 1.4 Attitudes among professional horse owners to stereotypic behaviors[a]

	Racing stables	Riding schools	Competition establishments
Source of concern about stereotypic behaviors			
They reduce the performance of the animal	31	30	27
They have adverse clinical effects on the horse	52	55	56
They reduce the monetary value of the animal	45	59	31
Responses			
Remove causal factors	35	43	36
Physical prevention	77	67	79
Isolation	39	30	48

[a]*The results of a telephone survey conducted with the owners of 100 racing stables, 100 riding schools and 100 competition establishments (n = 8427 horses).*[225]

The web site http://research.vet.upenn.edu/HavemeyerEquineBehaviorLabHomePage/ReferenceLibraryHavemeyerEquineBehaviorLab/LabPublications contains a tremendous amount of information and advice on the behavior and management of stallions. Before attempting to modify the sexual responses of stallions, e.g. for semen collection purposes, readers are advised to visit this site and study the research papers it offers.

Introduction to evaluating behavior problems

Many behaviors labeled abnormal are simply normal but unwelcome. It is the veterinarian's job to distinguish normal and learned behaviors from those with organic origins. Owners and grooms generally know their horses better than the consulting clinician and therefore it is important to keep one's counsel until a thorough case history has been taken.

Care should be taken to translate horsey jargon when taking a history. Various terms may be used to describe the same behavior: for example, depending on the observer, a reactive horse may be variously described as sharp, keen, fizzy or flighty.[11,227] A survey of horses described by their owners as 'head-shakers' identified some that were simply nodding their heads.[228] Depending on their professional background, equestrian industry stakeholders seem to have different criteria when identifying horses in behavioral conflict.[229] That said, there is evidence that even among a large group of amateurs the use of a human personality inventory achieves high inter-correlations in the ranking of horses, with especially strong agreement being achieved for neuroticism and extraversion.[230] The reliability of these assessments increases the legitimacy of everyday use of psychological terms to describe animal behavior.[230] It is also encouraging to note that when confined to the use of objective descriptive definitions, riders score horses' temperaments with significant agreement and that their scores correlate significantly with objective measures from temperament tests.[231]

Although clients tend to be impressed by shortcuts in history-taking, experience shows this tempting path to be more hazardous than worthwhile. Acquiring only half the salient facts means one is half as likely to emerge with a correct diagnosis and successful therapy. More than dog and cat owners, horse owners tend to seek advice from each other before calling out the veterinarian, so it is often the case that horse-lore has been applied unsuccessfully in the past. At the end of a complete case history, one should have all the benefit of hindsight and therefore make intelligent suggestions based on what is known of previous attempts to remedy the problem. Given the priority that most owners give to ridden horse behavior and the putative link between activities under-saddle and those outside work,[232] behavioral practitioners who do not themselves ride may unfortunately lack some authority in equine behavior therapy consultations.

How to take a case history

Behavioral consultations can be considered under two main headings; the background and management details, which constitute a behavioral profile, and the unwanted behavior. Although entirely a matter for personal preference, it seems good practice to establish details of the horse's management before exploring details of the unwanted behavior. This is because, having acquired a picture of the way the horse sees its world, one can better understand the motivation it may have to deploy unwelcome counter strategies. Box 1.2 gives an example of factors constituting a typical behavioral profile.

Because such potentially dangerous behaviors as bucking and rearing can be both expressions of joie de vivre and evasions from pain, veterinarians undertaking behavioral consultations should begin by performing physical examinations to eliminate somatic causes before embarking on a program of behavior therapy. This book explores the normal behavior of horses in considerable depth so that practitioners are equipped to consider the adaptive significance of many signs that present as behavioral problems. Horses that shy provide a useful example in that they should undergo ophthalmological examinations that are complemented by information regarding the frequency and variability of shying, and the spatial relationships of objects at which they tend to shy.

Problem behaviors, especially those under-saddle, can be acquired as a result of unfortunate experiences but may also reflect ongoing pain. To some extent it is a shame that the veterinary profession is called upon only as a last resort when a horse starts refusing jumps it is capable of clearing. As a result, lower limb pain is probably under-diagnosed as a cause of such problems.[233] The application of various gadgets and escalated coercion often come *before* a full clinical examination.

Recognition of pain ranks as an extremely important feature of the examination in a clinical case with behavioral manifestations. Houpt[234] suggests that a visual appraisal may help to indicate chronic pain, with the

Box 1.2 Behavioral profile

Name
Family includes
Address
Tel no
Animal's name
Breed
Age
Sex
If gelded, age at castration
Other surgical and medical history

Early history and education
Origin?
Was dam's behavior observed?
Since what age has horse been in present ownership?
Why was the horse obtained?
Is it still used for this purpose?
If there has been a change, why?
Previous owners and trainers?
Any 'imprint' training?
Circumstances at early rearing (numbers, ages and gender of companions, housing, exposure to humans)?
Age at and method of weaning?
Methods of training? (primarily operant vs classical)[a]
Do related horses have similar problems?
Do other horses that were raised or trained at the same yard have similar problems?

Environment
Type of housing (loosebox, pasture, run-out shed)?
Exercise?
a. Hours per week ridden or driven?
b. Hours per week in pasture or paddock? Size of enclosure?
c. Hours per week lunged?
d. Other?
Other horses in environment and its relationship with them (any recent changes)?
Other animals in the environment and its relationship with them?
Persons involved with the horse and its relationship with them?

About the horse's day
When fed?
What fed?
Where fed?
Who feeds?
Who feeds titbits?
Who can take food away from the horse?
Does he/she like to be groomed?
Is the horse head-shy?
Who grooms?
Where?
How often is the horse turned out?
What is the horse's response to being caught when at pasture?

[a] See Chapter 13.

affected horse typically having a loose lip but clenched masseter muscles. Meanwhile, there may be a facial expression suggestive of 'concern', with decreased mobility of the eyes, puckering of the eyelids, backward inclination of the ears[233] and dilation of the nostrils.[53] As social herbivores, horses might not be expected to demonstrate signs of pain more overt than teeth-grinding, since to do so may single them out for predation. However, it is proposed that when vocalization accompanies pain, it generally takes the form of a squeal if the pain is of somatic origin and a grunt if visceral.[233] While reduced locomotion and postural attempts to shift weight away from the seat of pain can be spotted from a distance, guarding of muscle groups may be appreciated during palpation.

Although the role of neuropathic pain is now recognized in the etiology of headshaking (see Ch. 3),[235] it remains unclear why some horses headshake most when being ridden in certain ways, e.g. with a flexed poll. Sometimes the role of pain in emergent unwelcome behavior is not revealed without analgesics. While one horse that is slow to leave from and quick to return to its yard may have become overly bonded to a companion, another may refuse to leave the yard until placed on a course of anti-inflammatory drugs. The latter would be one of those horses that have learned that being ridden, especially on resilient surfaces, is reliably painful and therefore should be avoided.

In behavioral terms, donkeys are not small horses. Behavioral peculiarities in the donkey are sometimes of clinical significance. Compared with horses, donkeys give fewer overt signs of pain, tending instead to lie down or stand still with their heads lowered. Sweating and hyperpnoea are more common responses to abdominal pain than rolling and flank-kicking (Jane French, personal communication). Even during intestinal strangulation or rupture, donkeys rarely lie down and roll but instead show little more than inappetance, a mildly elevated heart rate and a vague reluctance to move.[236]

Because behavior modification relies on being able to redirect motivation that has prompted unwanted behaviors, it pays to clarify the specifics of any behavior that seems to have departed from the norm. For example, if the animal is described as aggressive, considerably more information is necessary before the motivation to demonstrate agonistic behaviors can be understood. One should establish whether the horse is aggressive to other horses, other domestic species, humans or all of these. Aggression toward specific targets merits further questioning. For example, aggression toward humans can be investigated further with questions such as:

- Under what circumstances is the horse aggressive?
- Does the horse avoid personnel or is it actively aggressive?
- Does the horse target particular individuals or types of people (male, female, large, small) or all people?

The unwanted behavior and the way it has evolved to its current form need to be clearly defined (Box 1.3). Given the apparent inconsistencies in the terminology and interpretation of equine behavior,[237] practitioners are commended to equine ethograms designed to establish standard nomenclature for equid behavior.[238] That said, there remains a need for a working horse ethogram that offers robust definitions on which the majority of experienced observers can agree.[229] Because of the possibility of inconsistent labeling of behaviors,[192,235] direct observation or video material is certainly preferable to an oral account of the behavior. Problems in the ridden horse can be fully appreciated only if the patient is ridden saddled and unsaddled and, if feasible and safe, with and without a bit, preferably on more than one occasion by different riders.

With a clear picture of the ontogeny and motivation of the unwelcome behavior, the development of an effective, tailored strategy to remove any reinforcement of the behavior and redirect the horse's motivation is likely to emerge.[239–242] This is behavior modification. Although a number of case studies are presented in this book, readers may find more exhaustive accounts of behavior modification elsewhere (for a series of 60 cases, see *Why does my horse…?*[54]). Even when consistently applied, the results of behavior modification programs are rarely immediate in the horse, because of its innate resistance to extinction,[88] but they are usually impressive. There have often been years of inconsistent and inappropriate handling which leave habits that must be surmounted before the slate is clean enough for fresh lessons to be learned. It is therefore worth reminding owners that, because horses have excellent memories, 'quick fixes' are generally a rarity in equine behavior therapy. Behaviors with their origins in fear are especially prone to re-emerge in response to historic triggers. Some apparently expeditious solutions may mask pain, so they should be used with tremendous caution and only after the role of discomfort has been assessed.

In the following chapters, we will explore the variety of innate and learned behaviors seen in horses. Given this information, the success of behavior therapy depends largely on the versatility of the practitioner and the compliance of the owner.

Box 1.3 The unwanted behavior

- Description of what specifically happens
- Where does the behavior occur?
- When does the behavior occur?
- When was it first detected?
- What was the owner's reaction?
- What advice has the owner received to date?
- What problems has the owner encountered with any attempts at correction?
- Has there been any change in the frequency or appearance of the problem?
- What will be done with the horse if its behavior does not improve?

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Perception

CHAPTER 2

Chapter contents

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Horses have been described as being among the most perceptive of animals.[1] By studying the sensory perception of horses, we gain valuable insights into their behavior, but we should also be reminded of the care we must take to be consistent in the subtleties of our body language when handling and training them. The differences between human and equine perceptions of the external environment can be explained, in part at least, by the differences in their sensory structures. The horse's adept perception has allowed it to be constantly aware of changes occurring in its surroundings and this has played a pivotal role in the success of the species. An appreciation and understanding of the horse's well-developed sensory system are valuable tools, particularly when attempting to understand distinctive aspects of equine behavior.

Vision

The equine eye is among the largest, and held by some to be the largest, in terms of absolute dimensions, of any terrestrial mammal.[2,3] Leaving aside the aesthetic appeal of this, it suggests that the horse relies heavily on visual information about its environment. With large retinae and a relative image magnification that is 50% greater than that of humans,[4] the horse's eyes allow it to visualize a wide panorama of the horizon and also the area ahead where feet will be placed and fodder will be selected. As a herbivorous flight animal, the horse has good distance vision, allowing it to scan widely for danger and, despite being relatively poor at accommodation, with a vertical field of 178°,[4] it is able to visualize the ground immediately ahead while grazing.

Horse eyes occupy a lateral position on the head, affording a panoramic view in front and on both sides, with only a narrow blind area to the rear (Fig. 2.1). The narrow blind zone at the back of the horse of approximately 20° for each eye,[5] can be unveiled by a slight turn of the head. For example, when kicking with its hindlegs, a horse may turn its head to ensure that its target is no longer in the blind area. The width of the blind zone is determined by the level at which the head is carried. As most practitioners appreciate, the blind zone can be effectively increased by cupping one hand around the lateral canthus, an intervention which pacifies many horses that have learned to anticipate aversive stimuli as part of veterinary intervention (see Ch. 14).[5]

The price horses pay for having laterally placed eyes is that the muzzle gets in the way of forward vision. Depending on the carriage of the head, the particular breed and the setting of the eyes, there is a blind zone extending almost 2 m directly in front of the horse. When the head is down the horse's binocular field is located down the nose in the direction of grass. Therefore horses can see where they eat especially well. This is why, if they do want to see directly in front rather than down the nose,

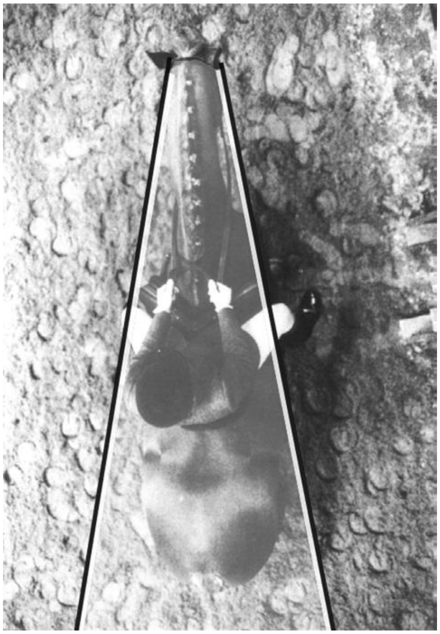

Figure 2.1 Aerial view of a horse showing the blind spot to its rear. The width of the blind spot is influenced by the horse's head carriage. *(Adapted, with permission, from photograph 6.1A in* Equestrian Technique *by Tris Roberts, London: JA Allen; 1992.)*

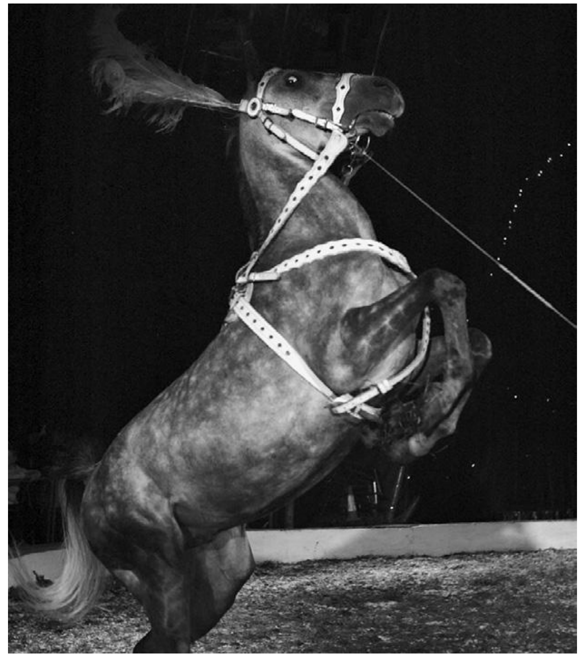

Figure 2.2 Rearing horse showing the white of its eye. *(Reproduced with permission of the Captive Animals Protection Society.)*

horses have to lift up the nose and point it at the object of interest.

The exposition of more sclera is often noted in anxious animals (Fig. 2.2) because the eyes are opened wider to take in more visual information that may help them resolve the situation, while a fixed eye may be associated with reasonably chronic distress. It is widely believed that the extent of oscillation of eye movements and the amount of sclera shown can be helpful in assessing the disposition of horses,[6] but, if the horse has a relatively small iris, that may detract from the reliability of this effect.

Acuity

There are a number of aspects of vision that can be measured. Visual acuity describes the ability to distinguish the fine details of an object. Clearly, the nearer an object is to the eye, the finer the detail that can be distinguished. Horses' eyes are geared to be focused largely on more distant features and, like those of many mammal species, appear to have limited accommodation, i.e. the ability to focus on very close objects less than about 1 m away. Animals that have been trained to discriminate between panels painted gray and those bearing black and white stripes can expose their species' acuity. As panels with ever finer stripes are presented to the observer, the discrimination task becomes more difficult (Fig. 2.3). The point at which the lines blur together and appear to be gray (the limit of acuity) is marked by a failure to discriminate. Most birds that have been tested excel at this task. They can distinguish extremely narrow stripes that occupy as little as $\frac{1}{100}$ th of a degree of their visual field. Horses can perceive stripes that fill about $\frac{1}{20}$ th of a degree.

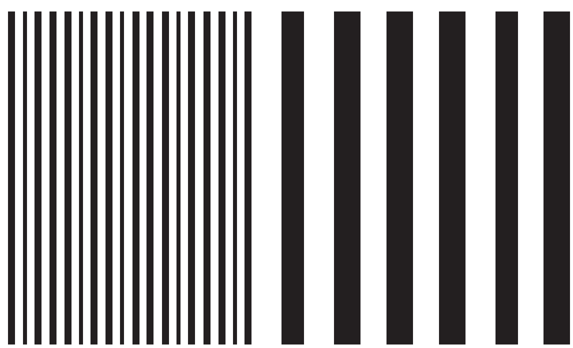

Figure 2.3 A system of vertical lines can be presented progressively closer to one another to measure visual acuity. *(Reproduced with permission of Alison Harman.)*

Figure 2.4 (A) The visual field in front of a horse when allowed to carry its head naturally. (B) The blind area in front of a horse when over-bent. *((B) Reproduced with permission of the Captive Animals Protection Society.)*

An interesting way of expressing the horse's acuity is in comparison with normal human vision, as 20/33. This indicates that a horse can only discern at 20 m what a human can at 33 m,[7] and this compares favorably with the dog (20/50) and the cat (20/100).[7] Horses' eyes are extremely sensitive to movement in all areas of their visual field, but human peripheral vision is considered a good approximation of the visual detail horses can appreciate.[8]

The visual field is affected by the corpora nigra, which are found on the upper margin of the pupillary aperture, possibly as an anti-glare device.[9] The corpora nigra contain an intricate network of blood vessels, which suggests that they might also be used to oxygenate the anterior chamber of the eye (Alison Harman, personal communication 2002). For horses to see through their narrow pupils, they adjust their head position up and down or side to side. Best frontal vision of the ground in front is achieved when the horse flexes slightly at the poll. Horses commonly hold their heads in this position when they are moving in slower gaits. This was thought to improve focus and enhance images of the ground ahead.[6] However, when over-flexed so that the nose is behind the vertical, the horse cannot see the space in front of it and so, when being ridden, may occasionally collide with objects, people and other horses if not directed (Fig. 2.4).

A functionally important blind spot is created when a horse is ridden with its nasal planum behind the vertical. The blind spot is formed to the front of the horse, and is believed to be as wide as the body. Thus, when a horse is being ridden in such a fashion it cannot see directly in front of itself. Hyperflexed horses are said to be showing signs of submission and 'listening to their riders', but it is possible that compromising a horse in this way makes it more reliant on the rider to avoid obstacles and such that it seems more biddable. Before using physical constraints, such as tie-downs and standing martingales to keep the head down or overchecks to keep it up, one should consider the effect of these restraints on the horse's ability to convey itself safely over rough terrain and most especially over jumps. The effect on vision is subject to current debate since Bartos et al[10] drew attention to the ability of the horse to rotate its eyeball to maintain the pupil in a horizontal position. These authors claimed that the horse maintains the 'horizontal eyeball position regardless of head position', suggesting that this rotation overcomes any deficit in vision that might otherwise arise from the horse having its nose pointed caudally by the rider. However, they did not report the head positions they examined, and their photos seemed to imply that the nose was always somewhat in front of the vertical. They were not concerned with forward binocular vision and

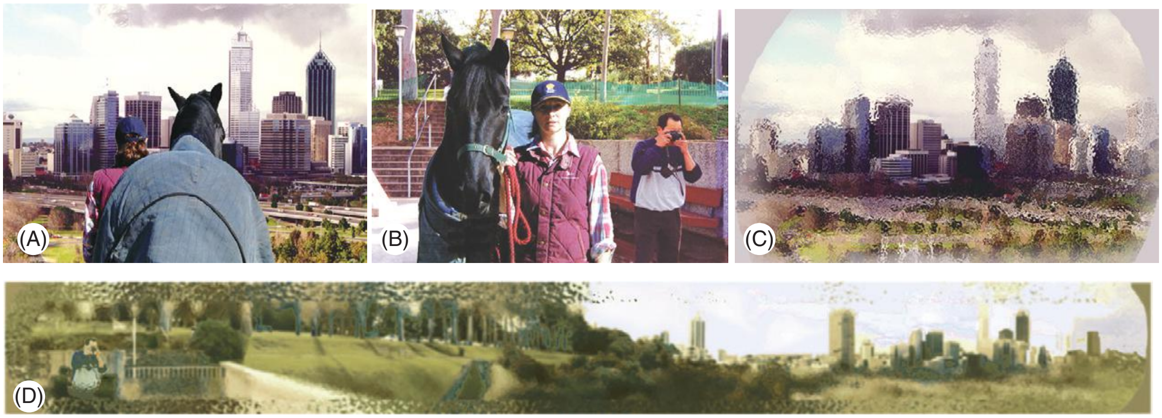

Figure 2.5 The visual field of one eye of a horse. Horse and human – (A) rear view, (B) front view – are standing looking out over Perth from a viewpoint in Kings Park. So in front of them they see Perth and to the back of them is a man taking a photo of Perth. The human view (C) is of Perth itself and not much more, since our vision is so frontal. Also we see just the very middle in high acuity. The horse (D) by contrast, sees Perth and everything else simultaneously right back to the man taking the photograph. *(Reproduced with permission of Alison Harman.)*

did not use any technique such as ophthalmoscopy to determine visual field[11] or alignment of the pupil relative to the corpora nigra, so it is difficult to comment on their findings. Some recent data counter the generalization that pupil rotation can overcome all changes in head position, indicating that in extreme head positions the pupil is not parallel to the ground[12], but further work is needed to confirm this.

The horse has mostly monocular vision, i.e. each eye sees a completely different field of view. However, horses have a small binocular field at the front of the monocular fields. Therefore, the horse can adjust its view to overlap the visual fields of both eyes and achieve a binocular view (Fig. 2.5). This binocular field of view allows the horse to observe the ground in front with both eyes.

To see objects at a greater distance, the horse rotates its nose upwards because its binocular overlap is oriented down the nose (Fig. 2.6). It is believed that when focusing on objects to the fore, horses may momentarily lose the ability to observe from the rear and to the sides.[7] That said, when taking off for a jump, horses sometimes tilt their head sideways, using their lateral vision to get a better look at jumps as they get up close. Perhaps this is why blinkers have found little favor in show-jumping circles, the traditional source of a multiplicity of gadgets. Blinkers are most effective in preventing shying and have been favored by carriage drivers because they make horses less likely to attempt to turn in the shafts or bolt. It is also suggested that blinkers can render a horse more responsive to voice commands used to increase speed because they prevent it from seeing when the driver is neither carrying nor about to use a whip (Les Holmes, personal communication 2002). Blinkers on racing animals bring rather different benefits – especially, it seems, when used for the first time. It has been suggested that, if it is a generally low-ranking animal, a racehorse that sees another horse approaching from behind is more likely to defer to the challenger if not wearing blinkers. This assumes that more high-ranking horses are more motivated to take the lead in a galloping herd, a hypothesis that has yet to be tested.

It has been shown that the horse's eye has a visual streak (Fig. 2.7). This linear retinal region contains high concentrations of ganglion cells, while low concentrations appear in the peripheral regions. Concentrations in the visual streak reach 6100 cells/mm^2, with the peripheral regions ranging between 150 and 200 cells/mm^2.[11] It is worth noting that the distribution of ganglion cells within the visual streak of horses depends on skull shape. Long-skulled (dolichocephalic) breeds, such as the Standardbred, have less centralization of their ganglion cells than the short-skulled (brachycephalic breeds), such as the Arabian, and are therefore thought to have better peripheral vision[13] (Fig. 2.8).

Depth perception

It was long believed that animals with laterally placed eyes and extensive monocular visual fields did not have

Figure 2.6 (A, B) Show jumper approaching a jump with the horse's head either (A) up or (B) down. Visual field is indicated. (C–E) A view of what a horse sees when approaching a jump with head (D) up or (E) down. (D) shows that the horse sees the jump and also a lot of other things out to the side. (E) shows that if you hold the head down it sees its foot and knee and a bit of the world out to the side. Perhaps this is why a horse may be more compliant when its head is held down, since it is unlikely to make much sense of the visual world. (C) Shows what a human sees over the jump (remember we only really see the middle of our visual field in high acuity). *(Reproduced with permission of Alison Harman.)*

stereopsis – the ability to see in stereo and perceive depth. However, studies[14] have demonstrated that the horse's binocular field is an arc of approximately 60° in front of the head, affording good stereopsis and thresholds of depth detection comparable to those of cats and pigeons. These findings indicate that larger interocular distances, as found in the horse, may provide useful depth judgment. This may have arisen because the horse has evolved to make judgments over a range of several meters, whereas ground-feeding birds, such as pigeons, with an extremely small interocular distance, have to focus at a distance of only a few centimeters. Horses also use monocular depth cues to judge distance.[4] This makes sense because they spend so much of their day with their heads to the ground, a position that makes stereopsis redundant.

Harman et al[11] suggest that when a horse lifts its head the binocular area of vision is directed at the horizon, enabling scanning and depth perception. In this position monocular lateral vision is compromised. However, when the head is lowered and the binocular vision is directed at the area directly in front of the head, the lateral monocular fields afford good lateral horizon vision.

Effective use of the binocular field is required when a horse attempts to discern an object that is close and low. The horse is best able to use its binocular field of view by arching the neck and rotating the head. It can focus on the object by simultaneous rotation of the eye downward to optimize orientation of the visual streak (see p. 37).

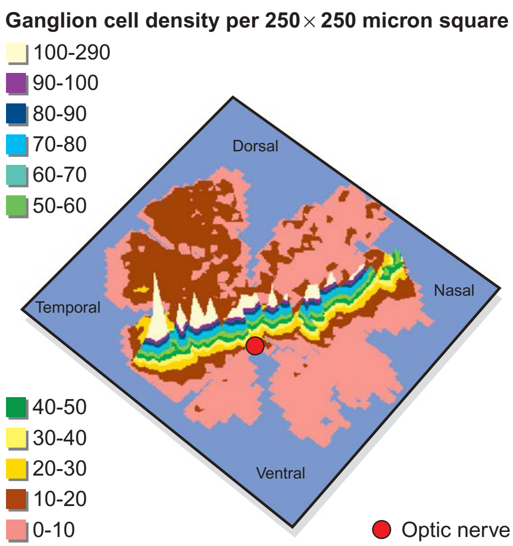

Figure 2.7 The distribution of ganglion cells on a flat-mount of a horse retina. High concentrations are represented by the peaks. *(Reproduced with permission of Alison Harman.)*

Stimulus visibility

Factors that affect the visibility of a stimulus for a horse include size of the object, contrast and environmental illumination. When a moving horse spots something underfoot, it not only looks at the stimulus, but is also likely to change speed.[15] The level of arousal plays a part in the recognition of stimuli, an outcome that may be influenced by the horse's age and training because

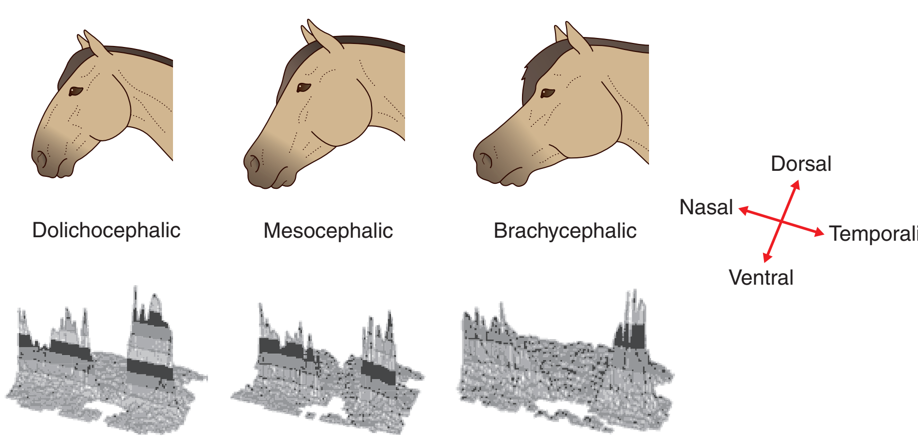

Figure 2.8 Retinal ganglion cell density maps from horses of three breeds showing the dorsal part of the retina is in the background, ventral is in the foreground, nasal is to the left, and temporal is to the right. Each shaded band represents 400 cells/mm^2. Studies of the retinae of horses with different skull shapes have shown that (at least some of) the neural tissue of morphologically diverse breeds differs.

recognition of distant stimuli on the ground is facilitated by carrying the head at a lower angle. Saslow[15] found that younger animals tend to carry their heads higher and therefore may not notice stimuli as readily as older horses, especially those that have been trained not to carry their neck straight and head high.

Saslow[15] also found that horses were able to discern stimuli better in overcast rather than bright sunny conditions. This suggests that the equine rod-dominated eye may not find bright conditions as favorable as dull conditions. That said, naïve horses are often reluctant to make the transition from a well-illuminated area into relative darkness. This is part of the challenge that trailers (floats in the USA) represent. The high proportion of rods to cones (generally 20:1)[16] gives the horse excellent night vision but insufficient to make them innately fearless of areas that are poorly lit. As we will see in Chapter 4, horses will work to keep a stable illuminated, and this further explains the aversiveness of small dark spaces, including trailers (Fig. 2.9). A reflective layer of cells behind the retina, the tapetum, enhances vision in poor light. Acting like a mirror, the tapetum reflects light back on to the retina, enabling further light to be gathered. The downside of this arrangement is that image quality is somewhat compromised. Because several receptors may be stimulated by incoming light, acuity can be reduced and the image becomes fuzzy. This effect has been likened to the pixelation of a low-resolution digital image.[4]

Accommodation

Horses have a small degree of ciliary accommodation,[17] which relies on the contraction of ciliary muscles and contractile fibers that extend into the corpora nigra. However, despite weak lens muscles, horses' optics allow them to see, on the whole, between about 1 m away and infinity, with little need to vary the lens. Accommodation is required if there is a need to see even closer than that with high acuity. Horses rarely need to do that; indeed because the eye's proximity to objects is generally limited by the length of the nose,[18] things very close are felt via the skin and vibrissae of the muzzle, so highly focused vision is not essential.

According to what was originally referred to as the 'ramp retina' theory, it was believed that the distance from the nodal point of the eye to the retina varied so that the dorsal retina was farther away than the more central and ventral regions. This theory was supported by the observation that horses are likely to exhibit characteristic head-moving behavior when looking at things. For example, the head may be raised unusually high and the nose pointed forward when observing an object of interest to the fore. The horse may arch its neck sideways (cock its head) to look at an object of unusual interest beside it (Fig. 2.10).

First refuted by Sivak & Allen,[19] the ramp retina theory has fallen out of favor. By demonstrating that, except for the far dorsal and far ventral retina, the distance

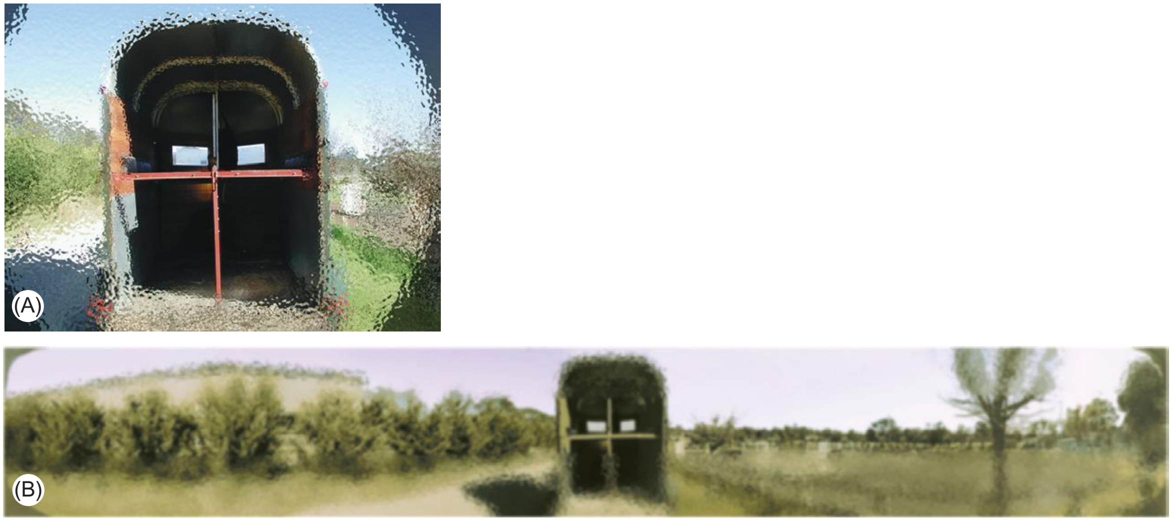

Figure 2.9 (A) Human and (B) horse visual fields when looking into a trailer (float in the USA). *(Reproduced with permission of Alison Harman.)*

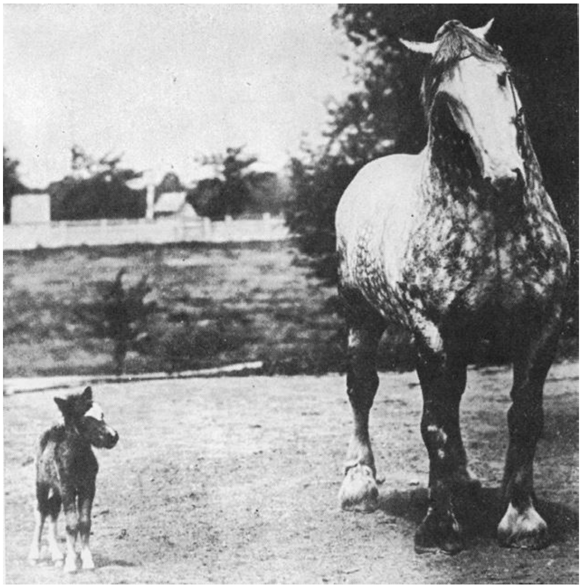

Figure 2.10 Horse raising and tilting its head to look at a pony foal. *(Reproduced with permission of Animal Science Dept, Iowa State University.)*

between the retina and lens was the same at all points on the retina, Harman et al[11] confirmed the absence of any ramp. Therefore, because movement of the head would not alter the focus of the image on the retina, they inferred that the horse has dynamic accommodation ability.

The arrangement of its visual streak gives the horse a very narrow, but panoramic view. The reason the horse cocks its head sideways is to 'look' at an object with the visual streak. Movement of the head may bring into focus images that originally fell onto the regions of low acuity, in the same way that we may see movement in our peripheral visual field and turn towards it to see, with our high-acuity retinal region, what is the cause of the movement. The horse sees a movement in the peripheral visual field and reacts defensively. This may explain why a horse will suddenly raise its head and shy away from an object that has suddenly entered its field of view.

Accommodation in the horse appears to be no more than one diopter (light-bending power) in either direction.[11] In optical terms, horses are emmetropic with limited accommodation, which means they can see everything well but cannot focus close up. The normal horse's eye appears to be correctly focused with a tendency to long-sightedness (hyperopia) when older. It has been suggested, though, that domestication, inbreeding and constant stabling may lead to horses becoming myopic.[11] Though yet to be tested, the hypothesis (derived from work in human infants exposed to night lights while asleep) is that if a young horse has limited possibilities to focus into the distance and instead looks only at close objects (because the stable is often a visually limited environment with dim light), then it may have a tendency to be shorter sighted (Alison Harman, personal communication 2001).

Color vision

Leblanc & Bouissou[20] showed that mares, when presented with their own and an alien foal, used visual recognition from a distance to identify their offspring. However, when the mare was presented with foals of similar coat color, other sensory responses were required for identification. Notwithstanding this interesting exception, horses have relatively little need for color vision. The equine retina does, however, provide both morphological and electrophysiological evidence for color vision. Although rods dominate, both cones and rods are present in the retina, and there is clear functional duality of responses indicative of cones and rods.[21]

It has been suggested that, like all mammals (with the exception of primates, some of which are trichromats), horses are dichromats[22] and that they struggle to discriminate between green and grays of similar brightness. Smith & Goldman[21] suggested that the color discrimination of the horse has no neutral point at which color can be distinguished from gray. Their horses responded to blue, green, red or yellow versus gray at any brightness.

Different colors, from the short-wavelength purples and blues, through the spectrum to the long wavelengths can be tested using color boards arranged in pairs. If the horse distinguishes between colors correctly it finds that it can push the board to reveal a food reward (see the case study at the end of this chapter). However, the problem is to ensure that one adequately controls for brightness or luminance.[23] Early studies on color vision in horses trained horses to choose between a colored stimulus and a gray one.[21,22] In an attempt to eliminate brightness cues, several gray stimuli were used for comparison with each color. Conflicting results from these studies suggest problems with methodology and raised the possibility that horses may be better than humans at discriminating between gray panels of different luminance.

Investigations of equine responses to color discrimination tests can be further thwarted by lack of motivation in the horses. Horses have been trained to use the color of a central panel to signal a correct (left or right) lever-pressing response.[24] However, discrimination performance

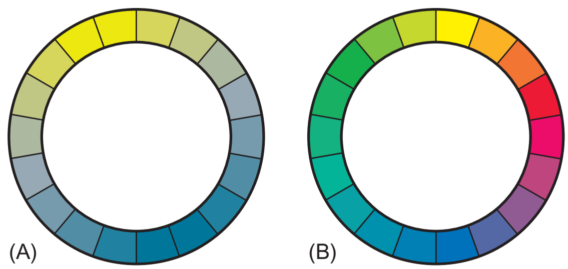

Figure 2.11 The differences between (A) the dichromatic color vision of the horse and (B) that of trichromats, such as humans, are most notable in the number of different colors seen.[24] *(Reproduced with permission of Joseph Carroll.)*

was better when the combinations were differentially reinforced by two types of food than when by a single reinforcer. Interestingly, the stimulus color of the preceding trial interfered with discrimination performance on a given trial.

The most recent behavioral studies seem[25,26] to confirm that horses have only dichromatic vision, similar to red-green color deficiencies found in some humans[27] in that they fail to discriminate the color red as easily as they discriminate the other colors from grey. The continued exploration of equine vision, and perhaps even the painting of obstacles for horses in competitions, including show-jumping, should take account of these findings. Retrospective studies of the competition performance of 72 show-jumpers attempting to jump a total of 343 obstacles showed that the number of faults at a particular obstacle depended on obstacle-type, height and arrangement but also color. For example, obstacles of two contrasting colors were jumped without fault more often than those of one (light or dark) color.[28]

Given that cones are maximally sensitive to particular wavelengths of light as determined by their opsin content, analysis of pigment provides the clearest evidence for dichromatic vision in horses. Microscopic studies of the retina support evidence from recent behavior studies[29] by showing that there are two peaks in the spectral sensitivity of equine cones at 428 nm and 539 nm.[30] This translates into two basic hues: pastel blue and yellow. It is important to remember that, for dichromats, there are no intermediate hues as there are in the visual world of trichromats, such as humans. Instead, when colors from the two ends of the dichromatic spectrum are mixed, the result is a desaturated version of one of the basic hues or an achromatic region (white or gray). These differences are represented most clearly by the color wheels in Figure 2.11.

Foal vision

Consistent visual stimulation during neonatal life is required for proper development of the visual pathways.[4] When a foal is born the eyes are open and it is assumed that there is some degree of visual function. Important functions of the visual system develop after eye opening. In humans or cats, for example, limited or no input to one eye renders it amblyopic or functionally blind, since no allocation is made for its input in the visual cortex. Similarly, the development of a binocular field, i.e. when both eyes are in register, takes place some time after birth (up to several weeks in cats, 5 years in humans). This is the 'critical period' during which the input to the visual cortex becomes fixed. We do not know what this period is in equids, but by extrapolation from cats and humans, it probably occupies the first few months (Alison Harman, personal communication 2002).

It has been suggested that neonatal foals are short-sighted because the muscles used in accommodation are relatively weak.[6] This may account for their apparent reliance upon tactile and gustatory exploration, and their occasional collisions with objects, including fences. Exploring ways in which the eye of the neonatal foal is functionally different to that of the mature horse, Enzerink[31] found that foals developed a menace response (avoidance of a hand raised up suddenly to the level of the horse's eye – a crude indication of ophthalmic health) several days post-partum. It is suggested that with open eyelids and the lack of a menace response, foals could be predisposed to eye trauma. However, the absence of a menace response does not provide sufficient reason to stable foals in the first weeks post-partum for fear of globe trauma. Newborn foals are generally well protected by the mare, and globe trauma is not a common finding in healthy foals. The pupillary light response is evident from birth; however, a functional visual cortex is not required to initiate the response and, therefore, a positive response does not exclude a visual deficit.[31]

Problems with vision

Horses with partial blindness are potentially more dangerous than those that are fully blind, because they may suddenly see objects and react with surprise. Horses with impaired vision often flick their ears rapidly during locomotion and show excessive sensitivity to sounds. Extraorbital causes of impaired vision may include lesions in the brainstem, cerebral cortex, optic nerve or superior colliculi as well as electric shock, serum hepatitis, or poisoning (for example with hypericum, lead and selenium). On the other hand extreme sensitivity to light is noted in recurrent uveitis, equine viral arteritis and riboflavin deficiency.

Chemoreception

In the horse, smell and taste are linked neurologically as they are in many other species.

Smell

Horses familiarize themselves with foreign objects by smelling them. There is evidence that horses investigate urine odor for information that may help them to discriminate between conspecifics on the basis of broad categories, such as sex or reproductive status.[32] Social exchange by sniffing one another's breath usually, but not always, with a closed mouth, represents an important part of greeting rituals between horses. Forced exhalations help to drive air from the nasal cavity in advance of deep inhalations that allow the horse to sample odor molecules. Rarely do humans allow sufficient time for horses to gather much of this sort of information. At the same time, we should remember that because of the combined effect of bathing, using soaps, changing clothes and manipulating all sorts of materials with our hands, our odors are likely to change over time in a way that thwarts their reliability for horses. Horses use odors to recognize familiar foods and those for which they have a particular need.[33] The strategic use of agents, such as peppermint essence, that mask the flavor of food and water can overcome capriciousness when horses are presented with novel resources, for instance, as a result of transit, competition or sale.

Olfactory receptors that generate the sense of smell are found in the upper part of the nasal cavity within the mucous membrane. Odorous molecules bind with these receptors and initiate the neural signals that may be processed into strong associations, some social and others sexual. Having a long nose, the horse has a predictably large area of olfactory mucosa (see Ch. 3).

In addition to the conventional olfactory system, the horse contains an accessory olfactory system in the form of the vomeronasal organ (VNO, also known as the Organ of Jacobson). This paired tubular organ is also present in many other animals. It is found inside the horse's nose within the

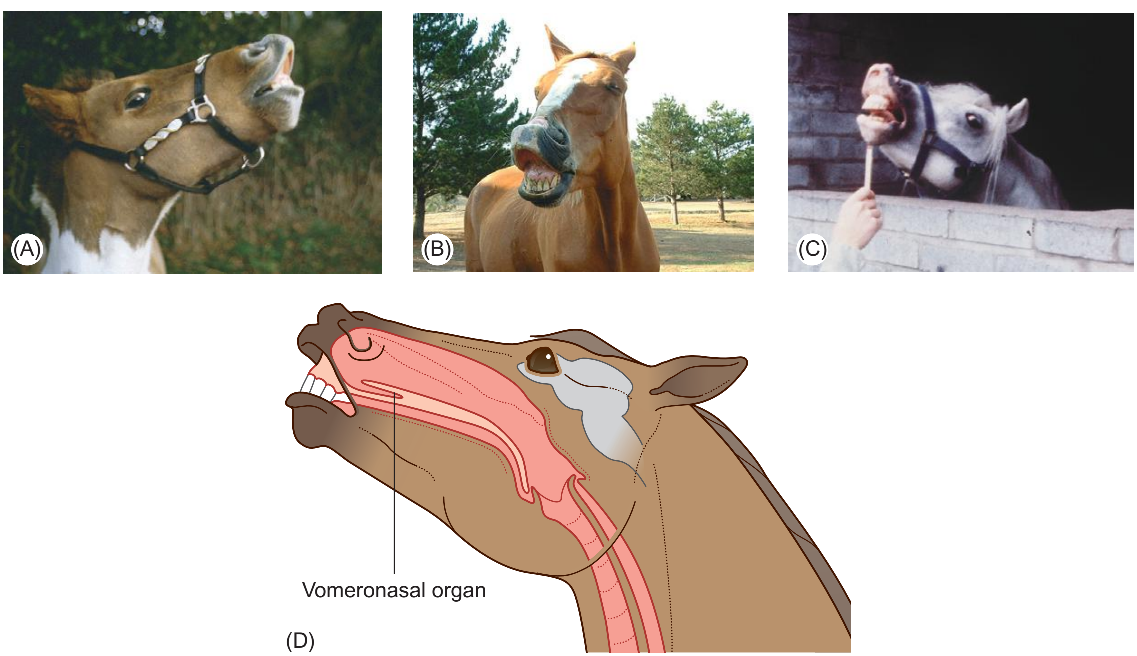

Figure 2.12 Flehmen response seen in adult and juvenile horses of both sexes but most commonly observed in mature stallions, especially in response to estrous mares. The typical response includes (A) elevation of the head, rolling back of the eyes, rotation of the ears to the side and (B) eversion of the upper lip. It may also involve (C) some flicking of the tongue and lateral rolling of the head. (D) Section of horse's head showing position of vomeronasal organ during flehmen. *(Reproduced with permission of: (B) Jo-Anne Rooker; (C) Francis Burton. (D) Redrawn from Waring 1983[40] with permission.)*

hard palate and is used to detect pheromones in urine and other moderately volatile odors. The horse uses its VNO during the flehmen response in which it raises its head and rolls back its upper lip (often anthropomorphically labeled a laugh), forcing smell-laden air through slits in the nasal cavity into the VNO (Fig. 2.12). The response is often seen in horses conducting a thorough investigation of other horses' urine and feces but may also occur when they encounter novel flavors and nasal irritants. Although gravity assists in this sampling procedure, it has been shown that the lumen of the tubular portion of the VNO alternatively expands and contracts to pump its content in the direction of the accessory olfactory bulb.[34] In contrast to many other species, the VNO of the horse does not open into the oral cavity.[35] Rather than being restricted to exhibition of flehmen only after direct contact of the lips or tongue with urine, horses are unique in that they can flehmen in response to volatile substances borne in the air.[35]

Colts show more flehmen than fillies but intriguingly foals of both sexes show the response more often than do their mothers.[35] This suggests that the response has a role in the development of both sexual surveillance and pheromone processing. That said, foals do not appear able to discriminate between estrous and non-estrous urine.[36] As yet, the importance of pheromones in triggering maturational change in adolescent horses can only be inferred from studies in other species. The flehmen response offers a powerful signal to observing horses and seems to have an important role in courtship. Stallions can discriminate between estrous and non-estrous mares, but their ability to do so seems to depend on supportive visual and auditory cues rather than on olfactory stimuli alone.[37,38]

The recent emergence of a commercial equine appeasing pheromone (EAP), a synthetic analogue of the esters found in the skin of a lactating mare's udder being marketed as a calmative, offers a fascinating insight into the importance to horses of various volatile molecules that humans cannot detect. EAP may facilitate habituation to acute stressors or to stressful situations. For example, it has been reported to reduce restless behaviors in foals at the time of weaning and in reactive horses presented with stimuli associated with clipping.[39] The treatment effects of EAP were said to persist after six weeks.

Taste

Taste, like smell, is a result of interactions of chemical stimuli with receptors on a mucous membrane. These receptors are papillae found on the tongue (Fig. 2.13).

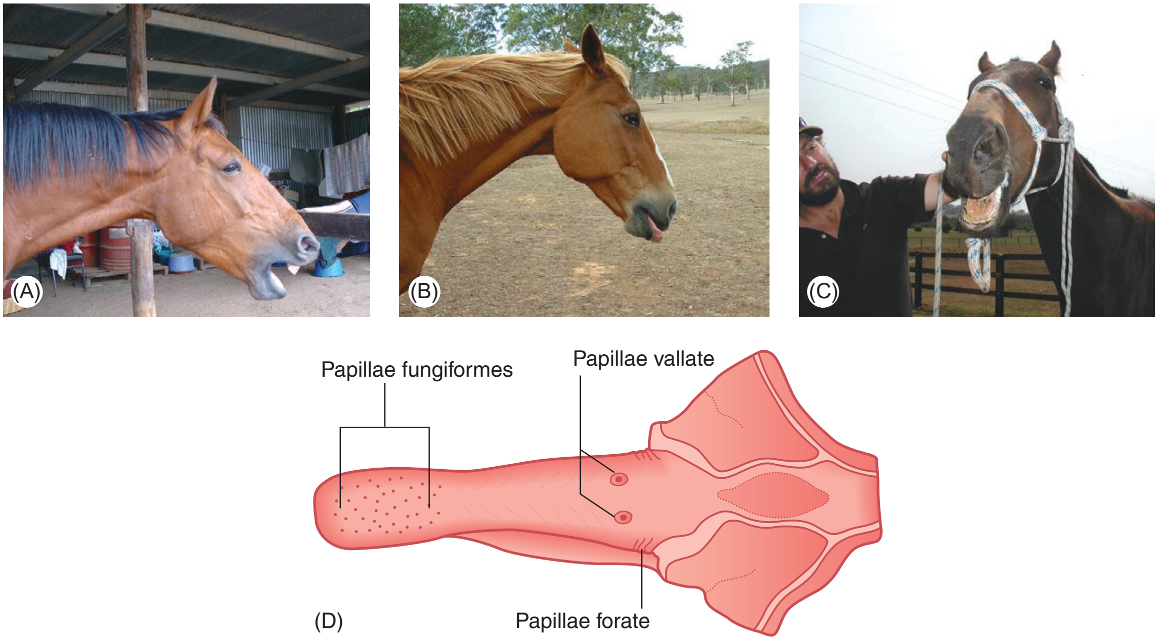

Figure 2.13 (A–C) Horses often attempt to get rid of foul-tasting materials (including many oral medications) from their mouths. (D) Distribution on the equine tongue of the papillae that house taste. *(Reproduced with permission of: (A, B) Jo-Anne Rooker; (C) Tanya Grassi. (D) Redrawn from Waring 1983[40] with permission.)*

The taste sensations perceived by the horse are presumed to be gradations of salt, sour, sweet and bitter.[40] Umami has not been tested.

Just as it is pivotal in the early bonding of a mare with her foal, taste may be used when two horses groom one another.[41] Taste may also help horses to determine the caloric content of foods, as well as allowing animals to discriminate among different foods and exercise their preferences.[42] Studies have shown that horses will learn to avoid a food associated with illness.[43] Gustation may also provide nutritional information about food. For example, if the horse's diet is deficient in salt, it may preferentially select feedstuff higher in salt content over another not so high.[44]

While the sense of taste may also provide information about the toxicity of food, this faculty is far from foolproof.[41] It appears that horses differ individually in their ability to avoid bitter additives and *Senecio* species, including ragwort.[45] This may have practical implications in deciding which horses may safely graze on pastures infested with toxic plants.

Taste also regulates digestive processes that initiate further processes such as enzymatic secretions. A normal appetite in the horse is determined primarily on the basis of pre-gastric stimuli such as taste, texture and smell.[46] The regulation of feed intake is also greatly influenced by taste, and this is of importance in maintaining the body's normal chemical balance. Habituation by gradual exposure to increasingly concentrated solutions of innately aversive chemicals has been reported in horses as an adjunct means of modulating water intake in performance horses.[47]

Hearing

The equine sense of hearing is very well developed. The horse's funnel-shaped ears can move in unison or independently of each other. Using 10 muscles, the ears can be moved around a lateral arc of 180°, enabling accurate location of the source of the sound.[48] Horses with impaired hearing may show more drooping of the ears. The direction in which the ears point helps to indicate in which direction a horse's attention is focused (Fig. 2.14). This seems particularly useful when horses, as group animals, may have their vision obscured by the bodies of their companions. As such, ear direction may contribute to social referencing in horses. When outdoors, horses seem to be able to use body positioning in sound detection, e.g. it is suggested that, if they position themselves appropriately, horses can amplify sounds by bouncing them off their shoulders.[6] Horses are able to locate the source of a sound within an arc of approximately 25°. This compares poorly with hunting species such as dogs and humans that are accurate within a degree. However, it seems that horses are well-equipped to hear faint noises. For example, they can respond to sounds from up to 4400 m away.[49]

Figure 2.14 The direction of the ears of this horse in a roundpen indicates that it has its attention on the handler.

Horses are better than humans at discriminating between noises of similar loudness. Horses can also protect their ears from very loud noises by laying them flat. The aversive effects of a combatant's squealing during a fight may be tempered by this response. In comparison with the human, the horse is able to hear higher-pitched sounds. A human's range of hearing is between 20 Hz and 20 kHz while a horse's is 55 Hz to 33.5 kHz,[50] being most sensitive to sounds in the range 1–16 kHz, a broader range than most mammals. Horses can therefore hear high-pitched sounds that we cannot, but not some of the lower frequency sounds that we can hear. This is thought to arise from the shorter interaural distance horses have compared with humans.[51] Equine sensitivity to ultrasound helps in determining the source of noises. It may be that we should become more sophisticated in our exploitation of this difference, for example in the development of training aids and secondary reinforcers. There seems to be an interaction between visual and auditory perception, with an especially interesting correlation across a number of mammalian species between sound localization ability and the width of the field of best vision.[52] Species with small foveae or areae centralis have good localization thresholds while those with large fovea have poor localization thresholds. With its characteristic visual streak the horse falls into the latter category, having a long narrow field of good vision that most probably allows it to pinpoint the likely source of a sound without needing accurate identification of the auditory locus.[29]

There is some suggestion that horses can respond (with nervousness and vocalization) to sounds of very low frequencies, such as geographical vibrations preceding earthquakes.[53] It is thought that they do not 'hear' as such, but can detect the vibrations through the hoof.

Studies have shown that there is no difference in hearing ability between adult mares and geldings.[54] However, there is a significant difference between 'adult' horses and 'old' horses, suggesting that the ability to hear sound of a higher frequency decreases with age.[54]

We do well to talk to horses with whom we seek to form a bond. Unlike the visual and olfactory properties we provide, our voice is constant and is therefore a more reliable cue for recognition.[55]

Touch

The sense of touch is variable over different areas of the horse's body. The withers, mouth, flank and elbow regions are very sensitive areas. Some horses dislike their ears, eyes, groin and bulbs of the heels being touched. As herd animals it is important that they are sensitive to the presence of others at their sides. This may help them to move as a cohesive social group in times of danger and to initiate bouts of mutual grooming (see Fig. 2.15 and Chs 5 and 10). When riders use their legs to move horses beneath them they are capitalizing on this innate sensitivity and do well to preserve sensitivity to pressure signals from their legs. But, by the same token, from early foundation training we usually expect horses to habituate quickly to relentless pressure from the girth in virtually the same region.[56]

The vibrissae around the eyes and muzzle have a rich afferent nerve supply.[57,58] The apparently disorganized beard of vibrissae in the neonatal foal is thought to facilitate location of the teat.[6] Vibrissae inform the horse of its distance from a given surface and may even be able to detect vibrational energy (sound). Together with the lips, they gather tactile information during grazing and head-rubbing. Horses are said to test electric fences with these whiskers before touching them. It has been suggested that the inability to detect fixed objects is a contributory factor to facial trauma in horses subjected to road transport subsequent to whisker trimming (Amy Coffman, personal communication 2002). Because vibrissae can be identified as anatomically different from normal hair coat, the trimming of whiskers has been outlawed in Germany (Andreas Briese, personal communication 2002).

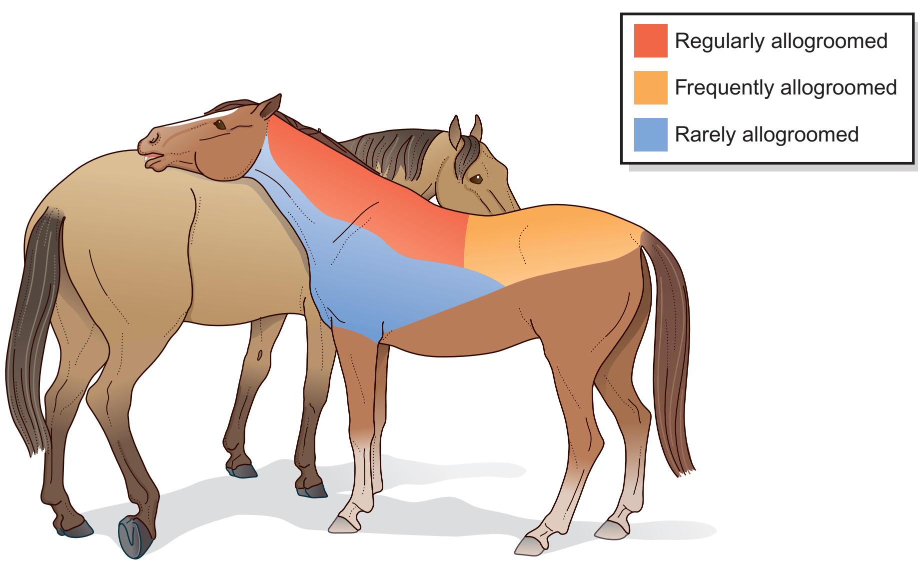

Figure 2.15 Mutual grooming map. *(Redrawn after Feh & de Mazieres 1993[59], with permission from Elsevier Science.)*

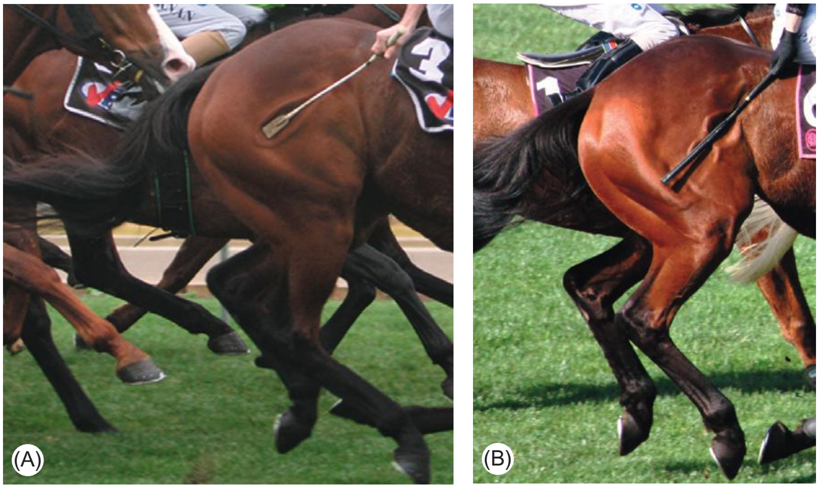

Figure 2.16 Unpadded (A) and padded whips (B) are likely to cause comparable pain if they cause similar indentations in the skin and if unpadded sections of padded whips impact upon the skin. *(Reproduced with permission of Liss Ralston.)*

In the mouse, it has been shown that each vibrissa has its own small region of sensory cortex, a so-called whisker barrel, one per whisker, each of which can be clearly seen in brain sections (Alison Harman, personal communication 2002). This dedication of a portion of the cortex to each vibrissa indicates that they must be extremely important sensory instruments which should not be removed for cosmetic purposes.

Pain results in the release of pain mediators that act on the specific nociceptors. The nociceptors generate electrical potential in response to traumatic stimulation such as tissue-damaging pressure, intense heat, irritating chemical substances and skin abrasion.[60] As the severity of the stimulus intensifies, there will be an increased frequency of action potential generation. The sensory cortex in the brain (see Ch. 3) creates the perception of pain and makes the horse aware of the strength and position of the pain stimulus. In response to pain there may also be activation of the sympathetic nervous system, causing a range of physiological responses. A painful stimulus also gives rise to a behavioral response and an emotional component that may include fear and anxiety.[61] It seems naïve to imagine that whipping horses as is traditional in racing does not cause pain. Padded whips are now required in both Australia and the UK and there are clear rules about how these can and cannot be used. However, for these devices to be effective they must activate mechanoreceptors in the horse's skin and, despite the padding, deformation of tissues remains a consequence (Fig. 2.16). The justification for whipping tired horses is now being questioned in the scientific literature.[61]

Sensitivity of the skin varies according to the thickness of the horse's coat, thickness of its skin and receptor density in different areas. There are distinct receptors in the skin that respond to heat and cold (thermoreceptors), touch, pressure and vibration (mechanoreceptors) and pain (nociceptors). It is worth noting that a common feature of all skin nociceptors is that they often become less responsive if the stimulus is repeated at frequent intervals[60] (see Habituation in Ch. 4).

The distribution of different types of sensory end organs changes in different parts of the body. When practitioners twitch their patients' upper lips (see Ch. 14) they are capitalizing on the fact that this area is rich in three types of nerve endings that detect touch, pressure and pain. The mechanism by which this helps to pacify fractious animals is discussed further in Chapters 3 and 15. It is worth remembering that the buccal mucosa is as sensitive as the skin to tactile stimuli. The discriminative ability horses show when they empty their mouths of fine inedible material taken in during grazing, accounts for the rarity of intestinal foreign bodies in horses compared with, say, cattle. We have exploited this sensitivity by using oral discomfort to control horses. We should respect this sensitivity and avoid the heavy-handed rein-pulling that ultimately destroys it. The growing debate about ethical equitation[62] will undoubtedly force us to examine the merits of severe bits (Fig. 2.17) and the use of constricting nosebands that reduce the behavioral manifestations

Figure 2.17 Severe bits frequently cause oral conflict behaviors, if the horse is not stopped from opening its mouth by a jaw-clamping noseband. *(Reproduced with permission of Julie Taylor.)*

of oral pain in competition horses.[63,64] Given the importance of tactile stimulation for communication both within human–horse dyads and among horses, it is surprising that this topic has not been more thoroughly explored by equine scientists.

SUMMARY OF KEY POINTS

The horse has:
- almost 350° vision
- a caudal blind spot that accounts for a proportion of startle responses
- dichromatic color vision (i.e. like a color-blind person)
- a sense of taste that discriminates between safe and toxic plants with variable accuracy
- highly developed accessory olfaction
- the ability to hear within and beyond the range of human hearing
- predictable zones of very sensitive cutaneous sensation.

Case study

Rascal, a 9-year-old cob, is one of a group of horses at Brackenhurst College, UK, being taught to select certain colors in chromatic pairs as part of an investigation of perceptual ability. He can differentiate between white and yellow.

The animals in this study chose between two boxes that were identical, except for the color of a card displayed on the front of each. In Rascal's case a yellow card was on the 'correct' box, which opened to allow the horse to gain the reward, and a white card was on the 'incorrect' box, which was locked. Once successful, a horse can quickly learn *some* other pairs of colors, unless it cannot distinguish between them, or if a color choice has been used in a previous pairing during training. Horses have excellent memories, so they do not easily learn discrimination reversals, even after long breaks.

The horse was first led into the testing arena and helped by the trainer to open the boxes so that the boxes were associated with hidden food rewards (Fig. 2.18). Next day, the horse was allowed to investigate the boxes itself with the trainer walking alongside. Next, the horse learned to approach the devices without being led by a human. It was released from a start line about 6 m from the boxes and allowed to explore alone. Five training sessions, each lasting for about 15 minutes, were given over a period of 3 weeks. Eventually, using only the visual cues, 70% of trained horses confidently selected the 'correct' box every time.

In shaping the final behavior, the trainer randomly assigned the 'correct' choice to a left or right position (with a maximum of three consecutive trials in the same position). This was to make sure that the horse was using the colored card to make a choice and not the position of the box, since spatial cues seem stronger than visual ones for equids.

At first, the horse was encouraged to investigate both boxes to discover that only one of the pair of boxes would open and contained the reward. Later, after obtaining the reward, the horse was not allowed to investigate the other (locked) box, because this negatively punished incorrect selection. If the horse made the 'wrong' choice, it was then allowed to change its choice and go to the other 'correct' box. After four consecutive 'wrong' choices, the horse was guided to the 'correct' box.

As training progressed, the horse was no longer allowed to swap, but was led back to the starting line to

Figure 2.18 The training of a horse to undertake a visual discrimination task.

try again after an incorrect choice. This increased the 'cost' of failure, making it more important for the horse to get it right first time, and so improved learning.

As opposed to those occasional (often nervous) animals that appear to have no primary motivation to investigate the devices, relaxed horses are most suitable for this type of training. Interestingly, some horses primarily trained as riding animals seem to have preconceptions about being led by humans and do not readily take the opportunity to make choices in the presence of humans. These individuals were reluctant to take the lead and had to be removed from the experimental group.

Clearly, we need more of this type of research because, among other outcomes, it helps to remind us that horses are more than simply draft or riding animals. Many novice observers and even some with equestrian experience are surprised to see horses doing something other than being ridden.

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Behavior and the brain

Caroline Hahn

CHAPTER 3

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Introduction

> *From the brain, and from the brain only, arise our pleasures, joys, laughter and jests, as well as our sorrows, pains, griefs and tears ….*
>
> (Hippocrates ~500 BC)

Only relatively recently has it been accepted that the 'mental state' of humans and animals, the emotional, instinctive and cognitive foundations of behavior, are inseparable from their somatic aspects. This artificial schism between psychology and neurology began more than four centuries ago when the philosopher René Descartes was trying to study the human body. The Catholic church expressed its dissatisfaction with this study of God's handiwork, and in response Descartes struck a deal with the church – human existence was divided into two realms: the physical body, which he would study, and the mental/spiritual realm, which would remain the exclusive domain of the church. This artificial construct dividing the mental and physical has guided much of scientific and medical thought ever since, to the detriment of human and animal patients.[1] Increasingly powerful molecular tools are being used by neuroscientists to elucidate the relationship between anatomy, physiology and specific functions in perception, thought and movement. Classic psychiatric diseases are not (yet) clearly defined in horses, but an appreciation of basic neuroanatomy and neurophysiology is fundamental to understanding the influence of neuropathology and psychopharmacology on equine behavior (Fig. 3.1).

Fundamentals of functional and behavioral neuroanatomy

The nervous system processes external stimuli into neuronal impulses resulting in neurotransmitter release, and integrates these with motivations and emotional stimuli to direct the actions of motor units. These enable the animal to react to its environment and influence the behavior of others. The function of the nervous system fundamentally depends on a group of specialized cells called neurons – polarized, elongated cells that are uniquely capable of extremely rapid, intercellular communication. Neurons have a receptor region (the dendritic zone), a cell body (soma) containing the nucleus, and an axon conducting impulses from the dendritic zone to synapse with other neurons (Fig. 3.2).

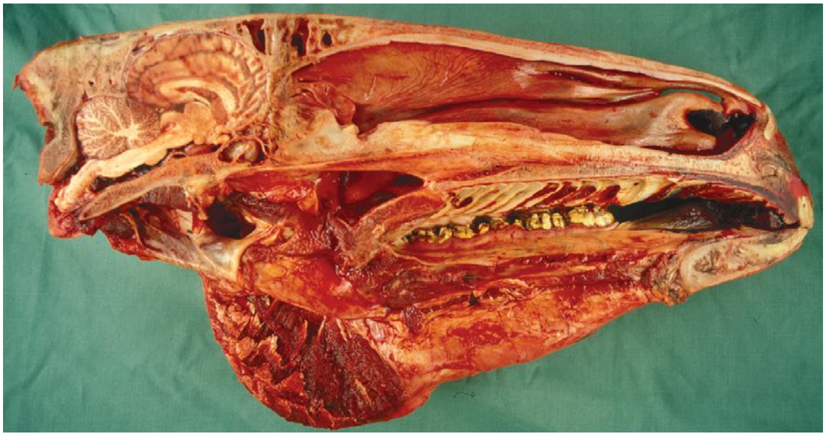

Figure 3.1 Photograph of a sagittal section of the equine head. The equine brain weighs about a third of the human brain (or about 0.1% of the horse's bodyweight). *(Photograph courtesy of Keith Ellis.)*

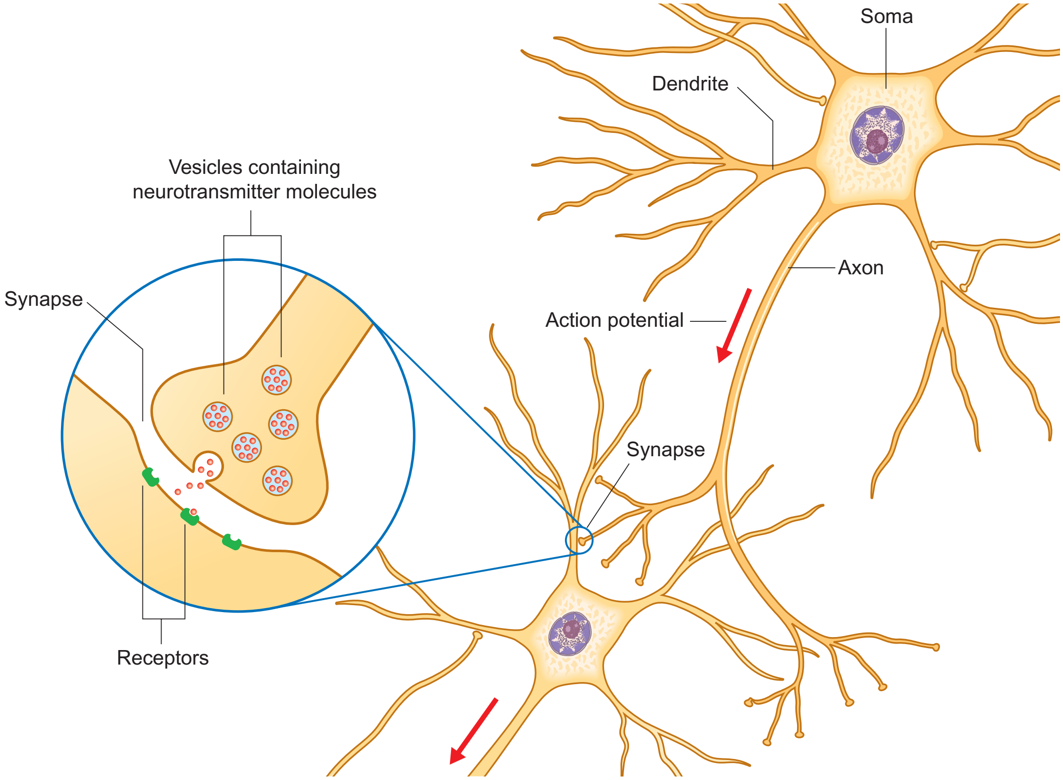

Figure 3.2 Diagram showing the basic structure and function of neurons.

The cell bodies collectively make up the ‘gray’ matter of the central nervous system (CNS), whereas the axons are found in ‘white’ matter. The shape, size and position of the soma as well as the length and branching of the proximal and distal processes differ greatly between neuronal populations. Brainstem axons may have a length of only a few micrometers, whereas the recurrent laryngeal nerve (the nerve that supplies the larynx) is over 3 meters long! Axons often project in groups or bundles that collectively form tracts in the CNS and nerves in the peripheral nervous system. Neurons make up only a small proportion of the total number of cells in the nervous system; the majority are neuroglial cells [Gr. *glia,* glue] such as astrocytes, cells with important supportive and metabolic functions.

Major components of the central nervous system

This section serves to introduce the fundamentals of neuroanatomy, a subject that has been comprehensively addressed by de Lahunta[2] and reviewed by Kaplan & Sadock[3] and Behan.[4] The CNS consists of the brain and spinal cord (Fig. 3.3). The brain includes the two cerebral hemispheres, which are roughly mirror images of one another, and the brainstem, a narrow structure through which all the pathways entering and leaving the two hemispheres must pass and which comprises the centers that control breathing, heart rate, eye movement and many other critical functions. Caudal to the cerebral hemispheres is the cerebellum, a structure that helps to control movement and balance. The caudal part of the brainstem flows into the spinal cord, the point of exit for nerves on their way out to innervate muscles and the point of entry for sensory fibers returning from the body’s sensory organs. All the nerves outside the central nervous system are collectively called the peripheral nervous system. The two cerebral hemispheres are built around a connecting system of hollow spaces called the ventricular system. The ventricles are filled with cerebrospinal fluid (CSF). This clear fluid also bathes the surface of the CNS, providing mechanical support to the CNS, and playing an important role in maintaining a constant chemical environment. CSF is produced by modified blood vessels known as the choroid plexus located inside the ventricles.

There are four major divisions of the CNS:

- forebrain, composed of the cerebral hemispheres, basal nuclei, hypothalamus and thalamus
- brainstem, composed of the midbrain, pons and medulla oblongata
- cerebellum
- spinal cord.

Neurons of similar function are grouped together in ‘laminae’ in the cortex, ‘nuclei’ in the brainstem and ‘columns’ in the spinal cord. Axons from sensory and motor nerves enter and leave the CNS as spinal nerves from the spinal cord and cranial nerves from the brain.

Forebrain

Cerebrum

The cerebrum is the most rostral (forward) division of the brain and is divided into two cerebral hemispheres

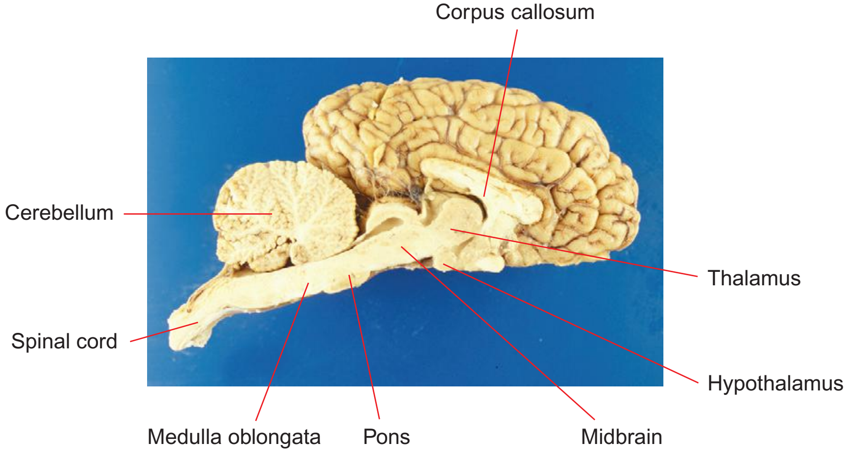

Figure 3.3 Sagittal section of equine brain outlining the major components of the brainstem. *(Photograph courtesy of Keith Ellis.)*

(Fig. 3.4). Cell bodies of the neurons in the cerebrum are located in two general areas: on the outside surface of the cortex (folded into gyri and sulci) and deep to the surface in the basal nuclei (Figs 3.5 and 3.6). Evidence from human studies suggests that the cerebrum is the region of the brain responsible for perception, emotion, voluntary movement and most learning. These functions will be considered in more detail later.

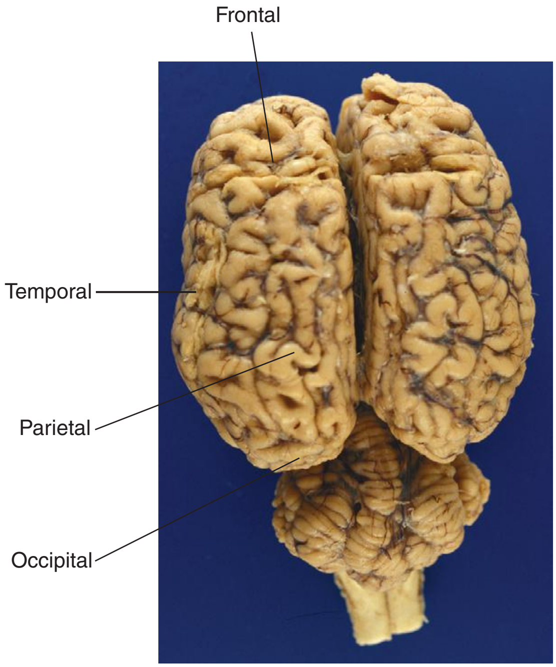

Figure 3.4 Cerebral lobes.

The tremendous number of neurons in the cerebrum have axons arranged in large fiber bundles. Notably the internal capsule serves as the major projection pathway to connect the cerebrum with the brainstem, and the corpus callosum consists of axons connecting the left and right cerebral hemispheres across the midline. Only one cranial nerve (Table 3.1) – the olfactory nerve, which transmits sensations of smell – is associated with the forebrain (this really is not a 'nerve' at all; in the horse it is a relatively large structure, and it probably received its name on account of its diminutive nerve-like appearance in the human brain).

Thalamus and hypothalamus (diencephalon)

The most prominent components of the diencephalon are the thalamus and the hypothalamus. The thalamus functions as an integrating system to relay pathways to and from the brainstem and higher centers in the cerebrum. With the exception of impulses from the olfactory nerve, all impulses heading to the cerebrum must synapse in the thalamus; reciprocal fibers there play a critical role in the filtering of sensory input, and in abnormal states they may generate false signals or inappropriately suppress sensation. The thalamus may also serve directly as the site of conscious perception of some sensations[5]

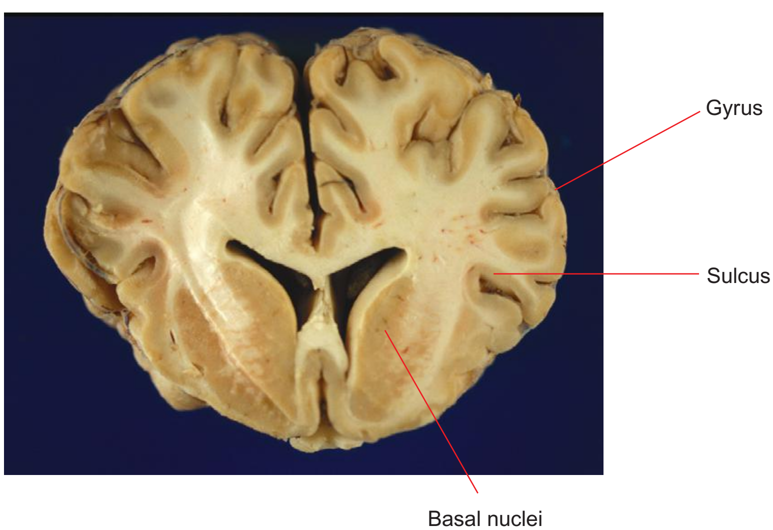

Figure 3.5 Transverse section of cerebrum at the level of the basal nuclei. Neurons in the forebrain are aggregated on the surface of the cortex and in the basal nuclei.

and plays a pivotal role in maintaining consciousness, focusing attention, and initiating sleep.[6]

The hypothalamus is the higher center for regulation of autonomic motor activity. It functions without direct voluntary control, but is influenced by the cerebral cortex. There is evidence that stimuli associated with emotionally relevant events may have a significant effect on hypothalamic hormonal regulation. These hormonal consequences seem to influence further behavior and responses in relevant situations, especially aggression and sexual behavior.[7] Seasonal polyestrus behavior of mares is initiated by stimulation of the pineal gland

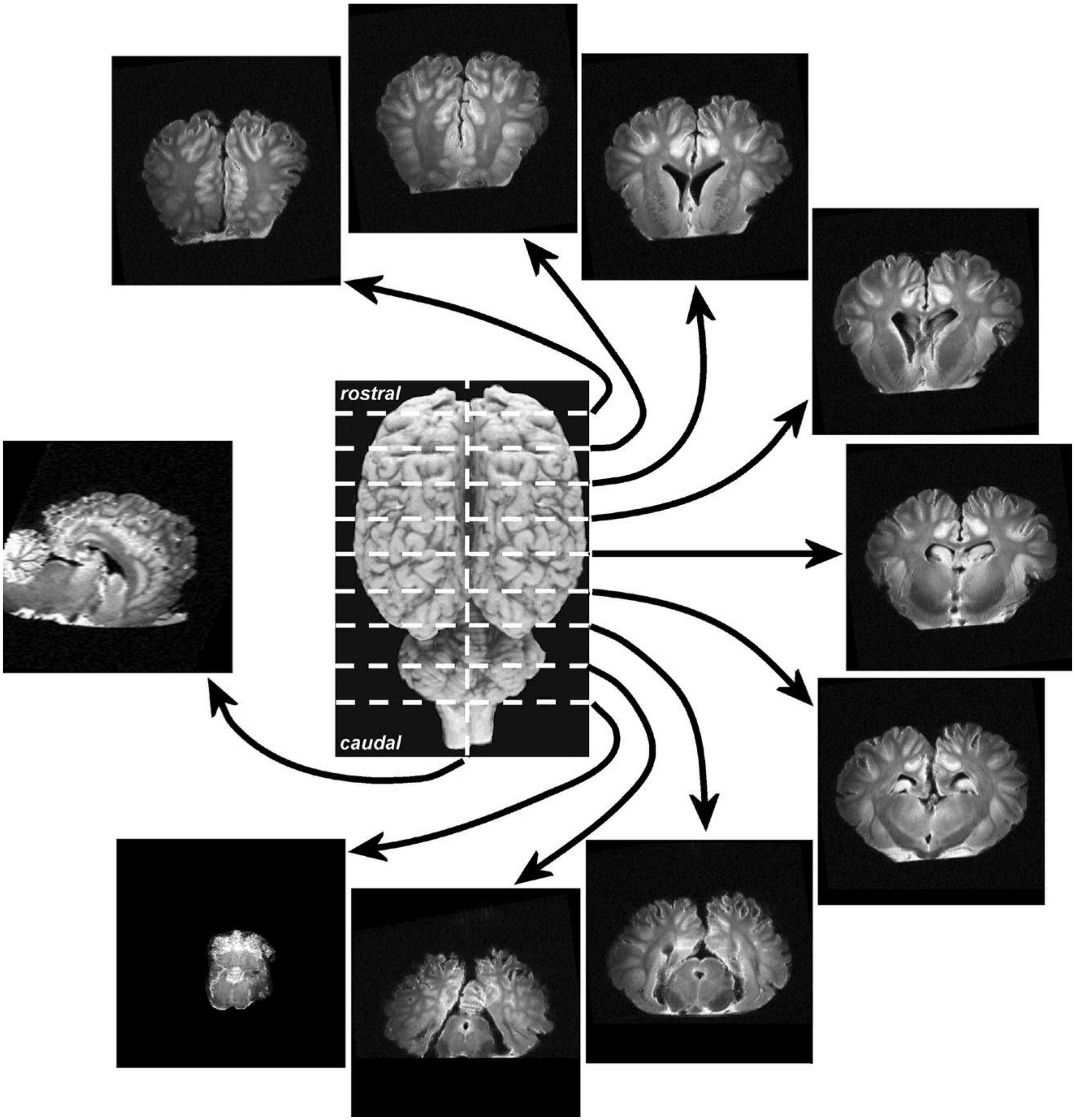

Figure 3.6 One sagittal and nine transverse sections of a T2-weighted proton density magnetic resonance imaging (MRI) scan of an equine brain. *(With permission of Luke Henderson, Kevin Keay and Paul McGreevy.)*

Table 3.1 Cranial nerves

Number	Name	Brain division	Major function
I	Olfactory	Cerebrum	Smell
II	Optic	Diencephalon	Vision
III	Oculomotor	Midbrain	Eye movement, pupillary constriction
IV	Trochlear		Eye movement
V	Trigeminal	Pons	Sensory from head, muscles of mastication and temporal muscles
VI	Abducens	Medulla oblongata	Eye movement
VII	Facial		Facial movement
VIII	Vestibulocochlear		Balance, hearing
IX	Glossopharyngeal		Taste and pharyngeal movement
X	Vagus		Muscles of larynx and control of viscera
XI	Spinal accessory		Muscles of neck
XII	Hypoglossal		Tongue movement

by light, either natural or artificial, causing a reduction of melatonin secretion. This in turn allows gonadotropin-releasing hormone (GnRH) to be secreted by the hypothalamus, ultimately resulting in the secretion of estrogen and estrus behavior (the exact connection between decreased melatonin production and increased GnRH concentrations is not yet understood).

Brainstem

Despite its small size, the brainstem is arguably the most important part of the nervous system. It is the link between the cerebral cortex and the spinal cord and it contains the nuclei of most of the cranial nerves and the regulatory centers for cardiac and pulmonary function.

Midbrain

The midbrain is the most rostral portion of the brainstem and contains the pathways connecting the brainstem and cerebrum. It contains the red nucleus, an important nucleus containing 'upper motor neurons' that initiate the gait of horses (these are neurons in the brain that innervate and control the lower motor neurons in the brainstem or spinal cord). Two of the three nuclei controlling eye movement – cranial nerves (CNs; see Table 3.1) III (oculomotor) and IV (trochlear) – are found in the midbrain. The dorsal components of the midbrain (rostral and caudal colliculi) are linked with reflex functions such as blinking and, in concert with other structures, reacting (shying) to visual or auditory stimuli.

Pons

The pons lies caudal to the midbrain. The pons is the portion of the brainstem that contains the motor neurons of the trigeminal nerve (CN V), responsible for the muscles of mastication (CN V is also the afferent system for facial sensation, but those neurons are distributed throughout the brainstem).

Medulla oblongata

All of the ascending and descending pathways (directional terms that strictly speaking are only correct for upright primates) between the spinal cord and the brain pass through the medulla oblongata, and the nuclei of the last seven cranial nerves (CNs VI–XII) as well as the sensory nuclei involved in proprioception are located there (Fig. 3.7).

Cerebellum

The cerebellum lies dorsal to the pons. It modulates the tone and relative degrees of contraction of opposing muscles needed for smooth motion, by integrating complex inputs from the brainstem, cerebrum and spinal cord. The reason for the 'jerky' movement of foals is because the cerebellum is still developing (but is far,

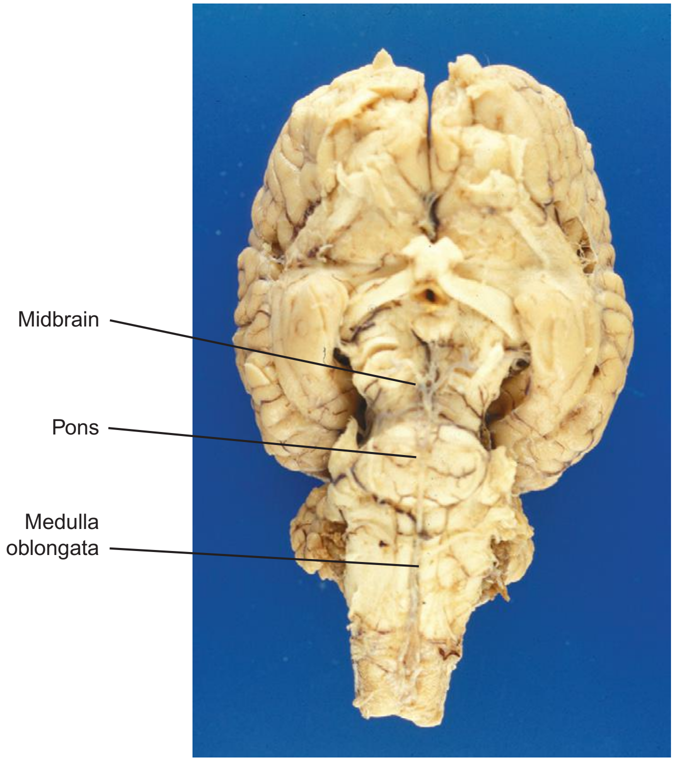

Figure 3.7 Ventral surface of equine brain outlining prominent cranial nerves. *(Photograph courtesy of Keith Ellis.)*

far more developed than the neonatal human brain!). Functional imaging studies in humans have shown the cerebellum to be active during mere imagination of motor acts.[8] Foals suffering from a degeneration of the cerebellum, 'cerebellar abiotrophy', are strikingly uncoordinated, with strong, jerky movements and prominent tremors, particularly of the head, just before initiating a movement (intention tremors).

Spinal cord

The spinal cord is the most caudal part of the central nervous system. It receives and processes sensory information from the viscera, skin, joints, limbs and trunk, and controls movement of the body, parasympathetic outflow to urogenital structures and sympathetic outflow to the entire body. Neural networks in the spinal cord, referred to as 'central pattern generators', produce the rhythmic movements of specific gaits such as trotting, pacing or galloping, even when isolated from the brain and sensory inputs. Supraspinal sensory, and neuromodulatory influences, modulated by training, interact with the central pattern generators to shape the final motor output.[9] The gray matter containing the neurons has a roughly H-shaped outline in the center of the spinal cord. Motor neurons are found in the ventral horn, while sensory neurons are present in the dorsal horn. Ascending sensory information passes along fiber tracts (funiculi) to sensory nuclei in the brainstem and cerebellum. Upper motor neurons in the brainstem control movement by innervating lower motor neurons in the ventral horn of the gray matter of the spinal cord, resulting in muscle contraction.

Behavioral neuroanatomy

One organizational principle of the nervous system is the use of parallel processing, in which sensory, motor and cognitive functions can be served by more than one pathway.[10] Simplistically, the brainstem and thalamic reticular activating system provide arousal and initiate attention; the caudal part of the forebrain integrates perceptions and, at a conscious level, the frontal cortex initiates voluntary movement and executes plans.

The cerebrum

The cerebral cortex has achieved maximal prominence in humans where, were it spread out flat, it would measure about 45 cm^2. In order to fit within the confines of the skull, the cortex of phylogenetically advanced animals such as primates and horses is folded into grooves (sulci) alternating with prominences (gyri). The brains of more 'primitive' mammals, such as rodents, have a smooth surface. The neuronal layers of the cortex form the gray matter, while the underlying white matter is composed of axons traveling to and from the gray matter.

The cerebral cortex is divided into two hemispheres, which have a contralateral relationship with the body – for example impulses originating in the left hemisphere affect the right half of the body. Within the cortex, human studies have suggested a hemispheric dichotomy of emotional representation, with the left hemisphere housing the analytical mind and the right hemisphere appearing to be dominant in functions involving emotion.[11] This may well apply to horses to some extent.

The hemispheres are somewhat arbitrarily divided into four lobes (see Fig. 3.4) named for the overlying bones: frontal, occipital, parietal and temporal. There is a rough correspondence between these loosely defined anatomical regions and their function, a relationship that is most obvious in humans but appears to hold reasonably well for horses. The parietal lobe contains primary somatosensory and motor areas, while the occipital lobe is almost exclusively committed to visual processing. The temporal lobe includes the primary auditory cortex in addition to structures involved in memory, including the hippocampus and the amygdala. The temporal and frontal lobes influence emotions, and epilepsy of the temporal lobes can manifest solely as behavior alterations, such as unprovoked aggression and extreme irrational fear, hyposexuality and tail chasing in small animals.[12,13] Temporal lobe epilepsy has not been shown to occur in the horse, but one could reasonably expect that it does.

The frontal lobe, and particularly the prefrontal cortex, plays a very significant role in the coordination of goal-directed behavior and evaluates the effect of such behavior via reinforcement/punishment outcomes. The frontal lobe also allows the conscious initiation of movement (although once a gait is 'initiated' it is controlled largely by the brainstem and spinal cord of the horse). In most behaviors, sensory systems project to association areas where sensory information is interpreted in terms of memories and motivations. Training horses would not be possible without this system.

Evolutionary brain divisions

A further, and rather more functional, classification recognizes three divisions of cerebral cortex: the archicortex, paleocortex and neocortex. These are distinguished on a developmental evolutionary basis and by the number of layers of neurons.

The archicortex and paleocortex are phylogenetically old regions and consist of three layers of cells (laminae) as opposed to the six laminae that characterize the neocortex. The archicortex is composed of medial structures included in the limbic system, such as the hippocampus and amygdala, and is involved mostly with emotion or behavior. The paleocortex is represented by one lobe on both sides of the brain, the piriform lobes, concerned with smell. The neocortex comprises the rest of the cerebral cortex and includes somatosensory and motor areas, visual and auditory cortical areas, and the association cortex. The association cortex is devoted to the collection of information, prioritization of its relative importance and decisions about suitable responses. Horses have representatives of each type of cortex.

In humans, the association cortex appears to be responsible for the ability to think, create, conceptualize and problem solve, and in comparative neuroanatomical studies, the massive size of the frontal lobes is the main feature that distinguishes the human brain from that of other primates. It has been proposed that cognitive abilities of particular species are directly correlated with the challenges of securing food, and that grazing ungulates are to some degree removed from the evolution of higher mental abilities in terms of food procurement. This is reflected in the relatively small size of the equine forebrain compared with that of social carnivores and primates. In terms of solving problems, horses are considerably slower to solve novel problems through rule-learning abilities than species such as primates and higher carnivores.

The limbic system

The components of the limbic system are hard to define, as various authors include different structures and areas in their definitions. It is usually agreed that it consists of those structures forming the border ('limbic') of the rostral end of the brainstem. This includes subcortical nuclei such as the hypothalamus and amygdaloid complex as well as the hippocampus, [Gr. *hippocampos,* sea-horse] an ancient, horseshoe shaped, rolled-up gyrus located within the temporal lobes. In amphibians and reptiles the limbic structures are devoted in large measure to processing olfactory input, a role superseded in mammals by important functions in memory, learning and social and emotional behavior.[14]

Olfaction remains an important sensory system, and olfaction receptor genes are the largest family of genes currently known to exist. Each receptor protein in the nasal mucosa is highly selective and will bind only a select group of odorants. Horses have a large and well-developed olfactory system which plays a role in appetite and food intake, sexual desire, mating, recognition of friends and foes and the accompanying emotional changes associated with these experiences. An associated sensory apparatus is the vomeronasal organ (VNO), an elongated pouch-like structure ventral to the rostral nasal meatus and lined with olfactory receptors. Scent information, particularly from pheromone molecules, is detected in the VNO (assisted by the 'flehmen' response; see Ch. 2). Olfactory signals do not synapse directly in the thalamus but project directly to the frontal lobe and the limbic system. The strong association between odors and memory is rooted in this ancient function of the limbic system.

One nucleus in the limbic system, the amygdala, receives fibers from all sensory areas and appears to assign emotional significance to memories as well as mediating the expression of emotions associated with self-preservation, such as fear.[14] Surgical removal of the amygdala results in a loss of fear, changes in social behavior and aggressiveness.

The reciprocal connections between the amygdala and the neocortex could provide the means by which conscious thought and learning can suppress reflex emotional responses such as fears. Certain sensory inputs may trigger a very strong reaction, the flight response, which has evolved as a protection from predation. Horses' ability to hear a wider range of high-frequency tones, such as the sound of twigs broken by the paws of a stalking predator, are naturally linked to an evasive (bolting) response. This is highly relevant to the training of horses, in which natural fearful responses have to be overcome.

Memory

Learning mechanisms and memory are fundamental to how the brain processes information (see Ch. 4). There is no universally agreed model of how memory works, but it is agreed that a memory is a set of encoded neural connections. Encoding can take place in several parts of the brain, and neural connections are likely to be widespread. Genetically determined positional cues probably steer growing fibers toward the general target with which to synapse, but fine-tuning of the pattern of projections is accomplished by activity-dependent mechanisms. Synaptic relationships are constantly being remodeled through increases or decreases in the size and strength of individual synapses, as well as the formation of new synapses and the elimination of unnecessary ones. This plasticity of cortical representation may not only underlie learning but may allow for recovery from brain lesions.

A widely held hypothesis is that learning occurs through 'long-term potentiation', and this has recently been confirmed in rat models.[15] Long-term potentiation produces changes in synapses that are necessary to acquire and store new information. Synapses become increasingly sensitive so that a constant level of presynaptic stimulation becomes converted into a larger postsynaptic output. Certain forms of long-term potentiation have been shown to depend on the activation of NMDA receptors (see following sections). Long-term potentiation can be demonstrated in vitro by recording electrical potentials of single hippocampal neurons, and can be prevented by applying NMDA receptor antagonists to the preparations.

The three brain regions that appear to be critical to the formation of memories are the medial temporal lobe and certain thalamic and basal forebrain nuclei. Aside from sensory projection areas, specific areas of cerebral cortex can be damaged with little specific change in learned behavior. Thus these neural substrates are not necessarily the locations in which memory representations are stored but are areas thought to be critical to the normal functioning of the system. It is by modifying the synaptic connections between neurons that processors for most brain functions, including emotion, motivation and motor function, are built.[16]

Two basic time-scales of learning have been identified: short-term memory and long-term memory (some classifications also include an additional two time scales: immediate and intermediate memory). Neural activity related to short-term memory has been observed in many brain areas, but the mechanism by which this activity can outlast a transient sensory stimulus is still unknown. The transfer of short-term memory (which is easily disrupted) to long-term memory (a more stable anatomical or neurochemical change in the nervous system) depends on the hippocampus and related structures in the medial temporal lobe. Damage to the hippocampus results in an animal's inability to store recent memories but does not interfere with memories already consolidated before damage occurred.

Cognitive psychological studies have suggested that there are two further distinctions within the domain of long-term memory: the conscious recall of information (explicit memory), and the unconscious use of information about motor skills and procedure (implicit memory). Explicit memory relies on a set of structures in the medial temporal lobe, particularly the hippocampus, diencephalon and gyri in the temporal lobe. The learning of motor skills, allowing movements to be made more quickly and accurately with practice, requires constant feedback from the sensory and association areas for completion but, with practice, these become encoded within a number of cortical areas as well as the basal nuclei and the cerebellum.[17] The learning of basic strides by foals as well as the complex responses we expect from horses following sensory cues from the rider, require the formation of long-term implicit memory traces.

Neurophysiology and neurochemistry

Neuroanatomy does not in itself explain how the brain controls behavior. Insight into the effect of neuropathology on behavior, as well as the action of neuropharmacologic drugs, requires an appreciation of the function and underlying physiology of the nervous system.

Electrophysiology

Emotions and behavior are ultimately determined by the release of specific neurotransmitters (reviewed in the following sections), which influence the activity of other neurons. Their release is made possible by the electrophysiological activity of excitable cells in the nervous system. Regardless of cell size and shape, transmitter biochemistry or behavioral function, almost all neurons receive and convey information using electrical signals, the so-called action potentials. Action potentials are rapid, transient all-or-none impulses caused by sodium ions entering the axon and potassium ions rushing out. This changes the difference in electrical potential between the inside and outside of the axon. In most neurons the essence of neuronal processing occurs in the regulation of whether or not an action potential is generated. Action potentials are generated at a specialized trigger region within the origin of the axon, and from there are conducted down the axon in one direction only at rates of 1–100 m/s (360 km/hour!). Near its end, the tubular axon divides into fine branches that form synapses, with other neurons and with effector organs, such as muscle.

The ease with which an action potential can be initiated in an individual neuron depends on the relative difference in concentration of sodium and potassium ions inside and outside the axon. The difference is maintained by the action of ion pumps and ion channels. Variation in the resulting electrical difference results in neurons having various thresholds, excitability properties and firing patterns. In the resting state ion channels are closed, but they open in response to the binding of a number of specific molecules at the synapse, or secondary to changes in the membrane potential. Excitatory neurotransmitters act to open cation channels and increase the likelihood of the generation of an action potential. Inhibitory neurotransmitters on the other hand, open anion (chloride) channels that reduce the electrical difference between the inside and outside of the axon membrane and decrease the likelihood of the generation of an action potential. The modulation of the Na^1/K^1 pump is believed to be one of the fundamental mechanisms for learning,[18] by manipulating long-term potentiation.

At the distal end of the axon, the action potential influences other neurons by affecting the synapse. When an action potential reaches the presynaptic terminals of the appropriate synapses, neurotransmitter-containing synaptic vesicles fuse with the presynaptic membrane and release their content into the synaptic cleft. The neurotransmitters bind with specific molecules in the postsynaptic membrane, the receptors, which cause an alteration in the transmembrane potential to either increase or decrease the likelihood of an action potential being generated by the postsynaptic cell.

A single transmitter can produce several distinct effects by activating different types of receptors, and there is now considerable evidence that synapses can be modified functionally and anatomically during development by experience and learning. Training (‘schooling’) of laboratory animals has been shown to produce measurable changes in synaptic interactions.[15]

Neurotransmitters

Neurotransmitters are classically defined as substances that are synthesized in a neuron, released into the synaptic cleft and then exert a defined action on the postsynaptic neuron by modulating cellular excitability. They are absolutely cardinal to the normal function of the nervous system, and it is worth spending a little bit of time reviewing their function. Their physiology and pharmacology have been well reviewed by Kaplan & Sadock[3] and Dodman et al.[12] Abnormal levels of neuropeptides have unequivocally been shown to be involved in human psychiatric disorders, and it is also clear that the relative amount and location of neurochemicals can all influence ‘abnormal’ behavior. Rarely if ever can a solitary and unambiguous shift in one neurochemical cause these conditions. Instead, changes in the action of several neurotransmitters or their interaction with receptors are necessary.

Three classes of neurotransmitters classically transmit information in the nervous system: biogenic amines, amino acids and neuropeptides (Table 3.2). Recent data have led to the identification of several novel classes of neurotransmitters, including nucleotides, prostaglandins and gases such as nitric oxide. Some neurotransmitters have in addition been shown to influence gene expression. The field of neurochemistry has breached the bounds of the mere study of chemical mediation of nerve impulses and has developed into a broad discipline that overlaps neuroanatomy, developmental neurobiology and behavioral genetics.

It is appropriate at this stage to review the classification and function of some of the principal neurotransmitters that are known to have a role in modifying behavior.

Biogenic amines

The biogenic amines are bioactive amines, derivatives of ammonia (NH_3) in which one or more hydrogen atoms have been replaced by hydrocarbon groups. This includes dopamine, adrenaline (epinephrine), noradrenaline (norepinephrine), serotonin, acetylcholine and melatonin. A common feature of all biogenic amine neurotransmitters is that they are initially synthesized in the axon terminal by enzymes produced in the cell body and transported down the axon. After release, a significant amount of noradrenaline, serotonin and dopamine in the synaptic cleft is taken up again by a presynaptic transporter protein to be repackaged into vesicles, or degraded by the enzyme monoamine oxidase. A number of psychopharmacologic agents affect amine reuptake, synthesis or degradation.

Adrenaline and noradrenaline Adrenaline and noradrenaline, along with dopamine, are classified as catecholamines and are synthesized from the precursor tyrosine in a common biosynthetic pathway. Although adrenaline is in higher concentration in serum and is the catecholamine that causes the sweating and increased heart rate when horses are stressed or excited, noradrenaline is more abundant in the brain. Noradrenergic

Table 3.2 Classification of neurotransmitters[a]

Neurotransmitter class	Components	Neurotransmitter
Biogenic amines	Quaternary amines	Acetylcholine, histamine
	Catecholamines	Adrenaline (epinephrine) Noradrenaline (norepinephrine) Dopamine
	Indolamines	Serotonin, melatonin
Amino acids	Excitatory	Glutamate
	Inhibitory	GABA
	Inhibitory and excitatory	Glycine
Neuropeptides	Calcitonin gene-related peptide	
	Substance P	
	Vasoactive intestinal peptide	
	Opioids	Endorphins, enkephalins
	Hypocretin	
	Many others	
Nucleotides	Adenosine	
Prostaglandins	Arachidonic acid	
Gases	Nitric oxide	
	Carbon monoxide	

[a]There is no clear consensus on the classification of neurotransmitters, and the list of examples is not exhaustive. Additional neurotransmitters are constantly being added.

neurons in the medulla project to the hypothalamus and control cardiovascular and endocrine functions, while equivalent neurons in the reticular formation of the pons mainly provide projections to the spinal cord that modulate autonomic reflexes and pain sensations. A further group in the locus ceruleus in the dorsal part of the pons has wide projections to the rest of the CNS. Although the exact function of the locus ceruleus is unknown, increased activity in this region is associated with anxiety, and it is particularly active in animals undergoing stress. Noradrenergic activity in humans is correlated with aggressive behavior, and specific adrenergic receptor blockers have beneficial effects in violent patients.[19] Antidepressant drugs such as the tricyclic antidepressants and monoamine oxidase inhibitors increase levels of noradrenaline by blocking its reuptake and catabolism. Their use is indicated in narcoleptic horses (see following sections), but potentially serious adverse effects may be seen with large doses.[20]

Dopamine Dopamine-secreting neuronal groups in the substantia nigra in the midbrain send major ascending dopaminergic inputs to the forebrain, including the cerebrum, limbic system and basal nuclei. An important role of dopamine in human medicine concerns the control that dopamine receptors in the basal nuclei have on the initiation of motor responses and the regulation of movement (affected in Parkinson's disease and Tourette's syndrome). The significant association between Parkinson's disease and depression suggests that the dopamine nigrostriatal tract is involved in control of mood as well as motor control. The only example of selective basal nuclei pathology in horses is equine nigropallidal encephalomalacia following ingestion of yellow star thistle (*Centaurea solstitialis*). Pan-necrosis of the basal nuclei results in devastating dystonia and rigidity of the muscles of mastication in affected horses.

Pathways to the frontal and temporal cortices have been implicated in emotion, thought and memory storage. A strong association has been found between high levels of detachment and a particular subtype of dopamine receptor, D_2 receptors.[21] Drugs that selectively bind D_2 receptors have anti-aggressive effects in human patients.[22] Lesion studies indicate that dopaminergic systems innervating the basal nuclei contribute to feeding, drinking and other motivated behaviors in a crucial way, and their pharmacologic blockade impairs feeding behavior. [23,24]

The dopaminergic systems may be particularly involved in the brain's reward system, leading to addiction, not only to abused drugs such as nicotine, amphetamines and cocaine, which directly increase dopamine levels, but also to the biochemical rewards associated with equine stereotypic behaviors. There is evidence that high levels of dopaminergic activity within the basal ganglia play an important role in many stereotypies.[25] Dopaminergic activity is modulated by many neurotransmitters, including endogenous opioids and glutamate, and exogenous NMDA receptor blockers have been shown to suppress crib-biting in horses.[26]

Serotonin Serotonin is principally produced by neurons in the rostral pons and midbrain. It is synthesized from the amino acid tryptophan, and oral intake of tryptophan supplements may increase serotonin levels in the brain. It has been used to 'sedate' horses and may have a very mild effect; however, other work indicates that tryptophan may actually stimulate horses rather than having a sedative effect.[27] Serotonin (5-HT) – or its precursor, 5-hydroxytryptophan (5-HTP) – may induce sleep and, importantly, appears to reduce anxiety. The 5-HT system is the mediator of learned and sustained fear responses, and decreased 5-HT levels have been associated with violent psychopathological behavior in humans.[28] Potent hallucinogens such as lysergic acid diethylamide (LSD) are structurally similar to 5-HT. It has been argued that serotonin plays a role in the behavioral facilitation system that initiates responses to the environment, and the behavioral inhibition system that arrests ongoing behavior. A decrease in serotonergic transmission leads to an inability to adopt passive or waiting attitudes, or to accept situations that necessitate or create strong inhibitory tendencies. This is particularly relevant to frustrating situations such as encountered by horses kept in what are essentially unnatural environments. Stereotypic behavior patterns in human medicine, often grouped in a classification known as obsessive–compulsive disorders, appear to be partially attributable to decreased 5-HT and abnormal endorphin metabolism. Parallel examples of ritualistic and stereotypic behaviors, including wind-sucking and crib-biting in horses are recognized in veterinary medicine.[29] Many antidepressants, discussed further in the following section, such as the tricyclic antidepressants and fluoxetine (Prozac®) block serotonin reuptake transporters, thus increasing the amount of serotonin in the synaptic cleft.

Acetylcholine This is a very prominent neurotransmitter in both the central and peripheral nervous system, as it is the major neurotransmitter of the parasympathetic branch of the autonomic nervous system as well as the preganglionic synapses of sympathetic neurons. Neurons in nuclei of the thalamus and brainstem project to the cortex and limbic system and affect behavior patterns.

Acetylcholine, one of the principal neurotransmitters involved in the propagation of aggressive, predatory behavior, is important in regulating wake and sleep cycles and has been shown to increase the strength of synaptic connections in the hippocampus. Cholinergic enhancement has been shown to improve memory performance in humans.[30]

Amino acids

Amino acids are molecules containing both an amine and a carboxylic acid group. Amino acid neurotransmitters are the most abundant in the brain. The major excitatory neurotransmitter is glutamate, opposed by the major inhibitory neurotransmitter gamma-aminobutyric acid (GABA). A simplified way to look at brain biochemistry is as a balance between those two neurotransmitters alone, with all other neurotransmitters simply being involved in modulating that balance.

GABA GABA is the primary neurotransmitter in intrinsic neurons that function as local mediators for inhibitory feedback loops. Major tranquilizing and anticonvulsant agents, including benzodiazepines (e.g. diazepam) and barbiturates act primarily through GABAergic mechanisms. A further inhibitory neurotransmitter, which is predominantly active in the spinal cord, is the amino acid glycine.

Glutamate It is now generally agreed that glutamate is the major excitatory neurotransmitter in the brain, and it is believed that 70% of the fast excitatory CNS synapses use glutamate as a transmitter. There are five types of glutamate receptors of which *N*-methyl-D-aspartate (NMDA) is the best understood because it may play a crucial role in learning and memory as well as in aggressive and defensive behavior.

Glutamate has recently gained unparalleled prominence in the field of excitotoxicity (for review see Hahn & Mayhew[31]). Oxygen metabolism results in the generation of free-radical molecules, which can result in considerable subcellular damage. Neurons appear to be at particular risk of free-radical damage, and excitotoxicity is now thought to be a potential contributor to the pathogenesis of a large number of diseases, including equine motor neuron disease.[32]

Peptides

An ever-growing list of neuroactive peptides, such as calcitonin gene-related peptide (CGRP), substance P, vasoactive intestinal peptide (VIP) and hypocretin (see subsection on narcolepsy), act as neurotransmitters or, more commonly, modulate pre- or postsynaptic transmission. Nevertheless the actual molar concentration of any given peptide in the brain is maximally two to three orders of magnitude lower than that of the biogenic amines, acetylcholine and amino acids. Unlike classic neurotransmitters that are synthesized at the synapse, neuropeptides are synthesized in the cell body, from where they are transported down the axon. Neuropeptides thus take a comparatively long time to replenish, cannot be recycled, and have a longer duration of action than the amino acids or biogenic amines.[33]

Opioids Opioids are a prominent member of the neuropeptide group. The opium poppy was cultivated in lower Mesopotamia in 3400 BC, where it was referred to as the 'joy plant', but it was not until the 1970s that this large family of neuropeptides, the endogenous opioids (endorphins), were isolated from brain extracts. Four classes of endogenous opioids are now recognized, and they are principally involved in the regulation of stress, pain and mood, in addition to potentiating effects on adrenergic and glutamatergic neurotransmission. They are known to have a major role in social affiliation and caring behavior in humans, and there is good evidence for opioid peptides mediating defensive and defeat responses during conflict. Opioid receptors are found closely associated, both functionally and anatomically, with dopaminergic and serotonergic neurons, and are distributed in regions such as the limbic system, hypothalamus and basal nuclei. Endorphin systems are probably involved in the effectiveness of the twitch (see Ch. 14), since its action is blocked by naloxone and its application increases plasma concentrations of beta-endorphin.[34] A tandem role of endorphins and serotonin has been suggested in stereotypies and has received considerable attention in the study of crib-biting, not least because it may contribute to the phenomenon of emancipation (see Ch. 8).

Equine psychopharmacologic agents

The availability of chemical restraint has revolutionized the number and type of procedures that can be performed on standing horses. The following is a summary of a few of the commonly used behavior-modifying pharmacologic agents used in horses (Table 3.3).

Phenothiazines

Phenothiazine tranquilizers were introduced into clinical veterinary medicine in the 1950s. Phenothiazines

Table 3.3 Doses and schedules of administration of selected equine psychopharmacologic agents

Agent	Psychopharmacologic use	Dose and schedule[a]	Comment
Phenothiazine (acepromazine)	Minor tranquilizer	0.02–0.1 mg/kg i.v.	Care: hypotension, paraphimosis
α_2-agonist (xylazine)	Sedative/analgesic	1.0–2.0 mg/kg i.v.	
Opioid (butorphanol)	Analgesic/sedative	0.05–0.1 mg/kg	Care: excitement, particularly if used alone
Benzodiazepine (diazepam)	Sedative/anticonvulsant	Foal: 5–15 mg i.v., may repeat in 30 min Adult: 0.2 mg/kg i.v.	
Reserpine	Long-term sedative	2–5 mg p.o. once ***or*** 0.5 mg i.m., repeated 1 week later	Erratic behavior, obtundation and anesthetic deaths
Phenobarbitone	Anticonvulsant	2–4 mg/kg b.i.d. for long-term therapy	
Cyproheptadine	Headshaking	0.3 mg/kg b.i.d. q12 h then, after 7 days, 0.4–0.5 mg/kg q12 h	Responses very variable
Carbamazepine	Headshaking	20–30 mg/kg q6 h	Half-life is around 90–100 min so horses should be test exercised within 2 hours of any particular dose. If not effective, can try in combination with cyproheptadine, but with care: sedation

[a]The doses are derived from reference material and should be modified according to veterinary clinical assessment. A number of the drugs have additional applications at different doses not discussed in this text.

such as acepromazine (and older compounds, including chlorpromazine and promazine hydrochloride) interfere principally with the central actions of dopamine but also affect noradrenaline and adrenaline, resulting in mild brainstem depression. This class of drugs is no longer used to sedate animals heavily, but their calming effects have been valuable in calming unfriendly and apprehensive animals. Individual responses are extremely variable, and there is generally a markedly reduced effect on excited horses. Acetyl promazine maleate given at 0.03–0.1 mg/kg i.v. or i.m. has reduced some stereotypies (by reducing all activity?), and the same drug at higher doses eliminated suspected opioid-induced pacing postoperatively.[35] They interfere with the central actions of the excitement-producing catecholamines, adrenaline, noradrenaline and dopamine.[36] Phenothiazines, however, have no analgesic properties and they decrease gastrointestinal tone and secretions due to CNS depression and anticholinergic actions. Priapism and paraphimosis (penile protrusions) are a recognized risk of using phenothiazines in geldings and particularly stallions. The mechanism is unknown but is attributed to a blockade of adrenergic and dopaminergic receptors centrally and peripherally.

α_2-agonists

Agonists of the α_2 subgroup of adrenoreceptors were developed as antihypertensive agents for use in humans, and are now far more commonly used for veterinary procedures in horses than are phenothiazines, because they result in more consistent and profound sedation. The behavioral effects of α_2-agonists such as xylazine (Rompun™), detomidine and romifidine are dose related and vary from subtle calming to profound sedation accompanied by head drooping and ataxia. Exaggerated reflex kicking responses have been associated with their use, even in profoundly sedated horses, an effect that is reduced when α_2-agonists are combined with opiates such as butorphanol. The α_2-agonists are commonly used with ketamine, a dissociative anesthetic, to induce anesthesia. Pharmacologically they are classified as analgesics as well as sedatives[37] and result in sedation by binding to central and peripheral presynaptic inhibitory α_2-receptors. These are inhibitory to the release of noradrenaline and thus act to hyperpolarize the postsynaptic neuron.[38]

Opioids

Opioids are exogenous substances that bind specific subpopulations of central and peripheral opioid receptors, and at standard doses have analgesic properties without loss of proprioception or consciousness. The classification of opioid drugs has changed as the molecular pharmacology of opioid receptors has been clarified, but it has traditionally been based on their action on the three main classes of receptors: m, k and d. Thus morphine, fentanyl, codeine and heroin are classed as 'agonists' while butorphanol (Torbugesic™) is categorized as an agonist-antagonist compound due to its effect on k and m receptors, respectively. The agonist-antagonist agents have fewer undesirable side effects such as excitation.

Opioid agonists and agonist-antagonists are used in equine medicine for their sedative and analgesic action, and common practice is to mix them with an α_2-agonist or phenothiazine, particularly to prevent the α_2-associated 'reflex' kicking. An example of a pure opiate antagonist is naloxone, notably used in veterinary medicine in trials designed to establish whether endogenous opioid blockade will result in diminished stereotypic behavior. Naloxone administered i.v. had a dose-related effect on eliminating crib-biting for up to 2 days, but it also resulted in abdominal distress.[35] However, resting behavior was also significantly increased in crib-biting horses, and it may be that the stereotypy reduction was due to a sedative effect of the opiate antagonist.

Benzodiazepines

The most prominent benzodiazepine is diazepam (Valium™), a drug noted for its anxiolytic, sedative, anticonvulsive and muscle-relaxing properties. It is used frequently for sedation in foals and is the drug of choice for the treatment of status epilepticus. Benzodiazepines, along with barbiturates, open axonal chloride channels thus hyperpolarizing membranes and leading to inhibition of CNS function.[39] Along with barbiturates they potentiate GABA receptors and increase mean GABA channel opening times.[40]

Phenobarbitone

Phenobarbitone is a long-acting barbiturate used in the management of seizures and occasionally as a tranquilizer. The primary mechanism of the action of barbiturates is to increase inhibition by acting indirectly as GABA agonists, increasing the neuronal threshold of electrical excitability. It is the initial drug of choice for treating seizure disorders in horses and can initially result in profound sedation.

Reserpine

Reserpine is an alkaloid extracted from the root of *Rauwolfia serpentine*, a climbing shrub indigenous to India. It was introduced into veterinary medicine in the 1950s and its calming properties were exploited for management and training purposes. It has essentially been dropped from clinical use as a tranquilizer. Reserpine causes depletion of biogenic amine concentrations in the brain, including serotonin, noradrenaline and dopamine. Because noradrenaline is an excitatory neurohormone in the brain, its depletion explains the calming or tranquilizing effect of reserpine in the horse.[41] It is still available in oral and injectable preparations as an antihypertensive and antipsychotic drug in human patients, and is on occasion used to calm nervous horses. There is apparently a large variability in the pharmacokinetics of reserpine in horses, and adverse reactions, including erratic behavior and obtundation, and anesthetic deaths due to hypotension, have been recorded. Reserpine should be avoided in stallions and should not be administered prior to surgery.

Fluoxetine

Folk medicine has long used extracts from the flower and leaves of St John's wort *(Hypericum perforatum)* to treat mild depressive disorders, but it is only recently that the ability of St John's wort to inhibit serotonin and dopamine reuptake has been recognized. The antidepressant and anti-obsessional actions of fluoxetine (Prozac®) are similarly thought to be linked to its ability to block presynaptic uptake channels and act as a selective serotonin reuptake inhibitor (SSRI). Fluoxetine has fewer of the anticholinergic, sedative and cardiovascular side effects than the classic tricyclic antidepressant drugs, probably because of comparatively lower opiate, catecholamine and dopamine membrane receptor binding.[42] It is the most commonly used specific 5-HT reuptake blocker in companion animal medicine, and is used in an oral preparation to treat stereotypies, aggression and fear, and anxiety.[43,44] Fluoxetine has not been thoroughly evaluated in horses, but its use is likely to increase given the prominence of the drug in human and small-animal medicine.

Cyproheptadine

Cyproheptadine is a specific serotonin receptor antagonist with histamine receptor blocking and anticholinergic and sedative effects. It may also stimulate ACTH secretion and has a role in altering pain sensations. It is used in human medicine for treatment of severe anorexia nervosa, and encouraging results have been reported in the use of cyproheptadine for the treatment of horses with hyperadrenocorticism[45] and headshaking,[46] a condition that may involve altered pain perception.

Carbamazepine

Carbamazepine is a tricyclic anticonvulsant that increases serotonin levels by blocking the neuronal serotonin transporter.[47] It can be used in the treatment of most types of human epilepsy, although its anti-seizure mechanism of action is incompletely understood. Carbamazepine in humans is increasingly being used for its anti-aggressive effects and to treat a variety of neuropsychiatric disorders. It has been successfully employed as a treatment of trigeminal neuralgia in humans, an effect that may explain its efficacy in ameliorating the signs of headshaking.[48] There are a great many reports in the literature of paradoxical and severe side effects of this drug in human patients,[49–51] and care is advised in its use in veterinary medicine.

The neurological examination

The first steps in evaluating behavior cases involve obtaining a detailed history and performing a medical examination to rule out any underlying clinical condition. The behavior changes noted as abnormal by the owner may be associated with pain, metabolic changes, weakness or sleep attacks. A systematic neurological examination is considered fundamental to a psychiatric investigation of human patients presenting with recent-onset psychosis or acute changes in mental status.[52] Similarly, it is appropriate to have an appreciation of diseases of the equine nervous system known to alter behavior of the horse. A detailed neurological examination, including assessment of mentation, cranial nerves and sensory and motor systems, should be included in the investigation of any horse presented with a history of a recent change in behavior, or suspected of having an altered state of mentation.

The physical examination is designed to disclose signs of general disease or pain that may have an influence on behavior, while the objective of the neurological examination is to determine if the change in behavior could be explained by an underlying neurological deficit, and to define the anatomical portion of the nervous system responsible for the clinical signs. This is an absolute prerequisite to allow reasonable differential diagnoses to be formulated. Readers are referred to Mayhew[53] for a detailed description of how to perform and interpret the neurological examination of the horse.

The neurological examination consists of a careful evaluation of behavior, mental status, cranial nerve function, gait and postural reactions. Because the clinician is unable to ask for voluntary responses, the neurological examination of the horse involves testing simple and complex reflex pathways and interpreting the site of the lesion in light of the anatomy of the reflexes tested. A simple reflex arc consists of a sensory neuron, one or more interneurons and a motor neuron that innervates muscles effecting the response. Reflexes occur without connections from ascending or descending central tracts, although input from higher centers classically inhibits excessive reflex movement. Discrete areas of the nervous system are extremely specialized and, by accurately localizing clinical signs, the anatomical location of a lesion can be determined. This requires an assessment of all the principal components of the nervous system, and abbreviating the neurological examination is discouraged. If it is determined that neurological deficits other than a subtle change in behavior are present, then it is appropriate to proceed with further diagnostics before initiating protocols to treat a primary behavioral problem.

Behavior and mental status

As explained in the introductory chapter, the owner of the horse should be questioned about the onset of the behavioral change, the nature of the signs, and any previous or associated clinical problems. The signalment of the animal has to be taken into consideration, and the presence of possible external triggers, such as auditory or tactile stimuli, should be explored (see Ch. 1). Importantly, the mental status of the animal must be assessed, since neuropathological lesions inducing a change in behavior can also be expected to affect the general function of the cerebral hemispheres as well as neural activity in the brainstem and diencephalon.

The various terms that describe alterations of mental status in horses include obtundation, stupor, coma, hyperactivity and aggression. Further signs of a subtle change in sensorium comprise continual yawning, asymmetric drifting or circling and, in foals, lack of recognition of the mare. More severe forebrain disease may lead to head pressing (Fig. 3.8), head deviation and propulsive walking or circling, aggression and self-mutilation, adopting bizarre postures and leaving food in the mouth. These signs usually reflect disturbances in the diencephalon and forebrain, and often implicate some portion of the limbic system.[2] Large, space-occupying lesions in the cerebral hemispheres may result in locomotor or postural disturbances. If the lesion is unilateral the animal may circle toward the side of the lesion (because, for that patient, the spatial field contralateral to the lesion 'ceases to exist'?). Lesions of localized regions of cortex, for example the occipital lobe, can result in a specific sensory loss such as blindness with normal pupillary light responses (central blindness). Lesions of the frontal lobes may result in behavioral changes such as lack of recognition of familiar people or objects, while damage to the temporal lobe can result in changes in eating behaviors, sexual habits, and temperament.

Seizures are a clinical sign strongly indicating the presence of forebrain disease. They result from multiple, synchronous discharges from a population of neurons producing a variety of undirected, uncontrolled, unorganized movements or changes of mentation. The seizure may be preceded by an aura (actually a part of the seizure but one that does not include involuntary movement) in which the horse is distracted from its environment or is restless. The actual seizure is called the ictus, and in horses is expressed by involuntary changes in muscle tone or movement. The wave of abnormal neurophysiological activity can remain in one region causing, for example, rhythmic movement of muscles of the face, or can spread to the other cortical hemisphere. If there is a generalized excitation, lower motor neurons in brainstem and spinal cord can become involved, resulting in a generalized seizure with rigidity, recumbency and tonic and clonic limb movements (Fig. 3.9). The animal loses consciousness during a generalized seizure, but recovers in a few minutes. This may be followed by a post-ictal phase of obtundation and temporary blindness, which can last for hours or, in the case of foals, days.[53]

Figure 3.8 Horse showing intermittent somnolence and head pressing as a result of liver failure and hepatoencephalopathy caused by pyrrolizidine alkaloid (ragwort) toxicity. *(Photograph courtesy of Joe Mayhew.)*

Cranial nerves

Because of the close anatomical relationship between the forebrain and the brainstem, diseases affecting the prosencephalon often also result in dysfunction of one or more cranial nerves. The examination of cranial nerves consists of the evaluation of a series of reflexes and responses involving one or more cranial nerves (see Table 3.1).

The head should be initially examined for asymmetries of posture, facial expression or muscle mass. A head tilt (lateral deviation of the poll), suggests the presence of a vestibular disturbance, and this can be emphasized by applying a blindfold. Ptosis, weak eyelids on palpation, pulling of the muzzle to one side or decreased ear tone are signs of facial nerve (CN VII) paresis. Temporal or masseter muscle atrophy is seen with pathology of the motor branch of the trigeminal nerve (CN V). Atrophy or severe weakness of the tongue is caused by hypoglossal (CN XII) paresis. The function of the sensory branches of CN V is tested by reflex responses to light pricking of the ears, lips or nasal mucosa. Animals with diffuse cerebral dysfunction or focal parietal lobe pathology may show signs of nasal hypalgesia even when CN V is not affected.

The eyes deserve close attention as the ocular muscles are innervated and controlled with great precision. Vision requires intact eyes, optic nerves (CN II) and central visual pathways. Most of the objects viewed with one eye are perceived in the contralateral occipital lobe,

Figure 3.9 Horse with a *Streptococcus equi* cerebral abscess in early tonic phase of generalized seizure. *(Photograph courtesy of Joe Mayhew.)*

but impulses subsequently cross to the opposite hemisphere via the corpus callosum.[54]

Vision is assessed by making a threatening gesture towards each eye, resulting in blinking (the menace response). Care must be taken not to stimulate the cornea or the palpebrae with air current. While the precise central relay of this reflex is not known, it is thought to include several different brain regions, including the visual pathways, as well as the motor cortex, pons, cerebellum, facial motor nucleus, facial nerve and orbicularis oculi muscle in the eyelid. The menace response is probably mediated by subcortical neural circuits as suggested by work on both rodents[55] and human[56] and nonhuman primates.[57] Suddenly appearing, 'looming' visual stimuli activate midbrain circuits that produce conjugate eye, head and neck movements away from the source of the stimulus.[55] Foals up to 2 weeks of age, and animals affected by cerebellar disease, may not respond to this test of vision by blinking. They should nevertheless react to a menacing stimulus by retracting the eyeball, resulting in a brief protrusion of the third eyelid, and/or by pulling away the head.

Eye movement is assessed by moving the head from side to side and looking for normal nystagmus, with the fast phase occurring in the direction of movement. Abnormal, horizontal or vertical nystagmus indicates a lesion in the vestibular system, which influences the cranial nerves innervating the external muscles of the eye: CNs III, IV and VI. Strabismus (abnormal eye position) in horses is rarely due to dysfunction of the latter nerves and is more likely to be caused by mechanical interference with eye movements, but ventral strabismus noted after raising the head is common with ipsilateral vestibular disease.

The pupils should be observed for size and symmetry, and the pupillary light response (CN II and III) assessed by observing pupillary constriction after shining light into the eye. Consensual responses are difficult to evaluate in horses, due to the lateral placement of the globes, and instead the light is swung briskly from eye to eye, observing for a further constriction of the pupil when the light is directed into the pupil previously constricted by the consensual response. Normal pupillary light responses in the presence of blindness suggests pathology of the occipital cortex (central blindness).

The obvious presence of the nictitating membrane is notable, and could indicate the presence of enophthalmos, such as can be caused by sympathetic denervation (Horner's syndrome) or, classically, tetanus.

Gait and postural reactions

CNS disease resulting in behavioral changes may also cause gait and postural reaction deficits if the brainstem and associated ascending and descending tracts are affected. Ataxia (lack of coordination due to a deficit in proprioception pathways) and weakness (due to upper motor neuron pathology) can underlie changes in gait that cannot be explained by a musculoskeletal lesion.

Figure 3.10 Hydrocephalus in a foal. *(Photograph courtesy of Joe Mayhew.)*

Ataxia is assessed by determining the responses to postural reactions, maneuvers designed to accentuate more subtle deficits. The horse should be examined when walking in a straight line, circling tightly, being led up and down a slope with the head extended. Stepping on the opposite foot, pivoting on a limb, increased or decreased joint movement and excessive circumduction of a limb may be signs of neurological disease. Laterally pulling on the tail while walking is a sensitive test for weakness caused by the interruption of the connection between upper motor neurons in the brain and lower motor neurons in the spinal cord, so called upper motor neuron weakness. Hopping the horse, by flexing one thoracic limb and pushing the animal to the opposite side, can accentuate both ataxia and weakness of subtle thoracic limb signs.

Neurological diseases with behavioral signs

Diseases diffusely affecting the forebrain can be associated with changes in behavior. However, this is highly unlikely to occur in the absence of further clinical signs such as failure to recognize familiar companions, continual yawning, facial twitches (partial seizures) and drifting to one side when blindfolded. More severe disease can, in addition, be expected to result in circling toward the affected side, obtundation, head pressing and generalized seizures. Focal lesions in the midline of the brain affecting the ventromedial hypothalamic nucleus or rostral hypothalamus, or bilateral damage of the hypothalamus or limbic systems, may further cause aggression or disturbances in eating, drinking or sexual behavior.[7] It should be remembered that CNS neoplasia is extremely rare in the horse! The following is a brief discussion of diseases of the horse that result in clinical signs which include changes in behavior, but readers are urged to further consult more comprehensive texts.[53,58,59]

Hydrocephalus

Hydrocephalus is a condition marked by an excessive accumulation of CSF resulting in dilation of the cerebral ventricles and raised intracranial pressure. It may result in enlargement of the cranium (Fig. 3.10) and atrophy of brain parenchyma. This can be secondary to some obstruction of normal CSF circulation or the site of CSF absorption into the venous system. On occasion hydrocephalus, even with a severe loss of cortical tissue, is found as an incidental finding in foals with apparently normal behavior. Hydrocephalus is uncommon in adult horses compared with other domestic animals, as neoplasia is exceedingly rare in the brain of this species. It can be associated with massive cholesterol accumulation in the choroid plexus, cholesterinic granulomas, believed to result from choroid plexus congestion and hemorrhage.[60] These can be massive structures and surgical removal has not been reported.

Infectious diseases

Bacterial meningitis

This is rarely seen in adults but is not uncommon in foals, in which it is usually associated with failure of passive transfer of immunoglobulins. Physical and neurological examination findings can include fever, obtundation, ataxia, aimless wandering, abnormal vocalization, collapse and seizures. The prognosis is poor. Attempted therapy consists of long-term antibiotic administration and intensive nursing care.

Diffuse encephalomyelitides

Numerous viruses across the world cause encephalitis or, more commonly, encephalomyelitis (inflammation of the brain and spinal cord), in horses. Most are caused by arboviruses (*ar*thropod-*bo*rne viruses), which include viruses from a number of families using an insect or tick vector. Most but not all occur in warm climates, as the vector can survive through the winter. The most prominent of these are the alphaviruses (Eastern, Western and Venezuelan viruses), which are found in the Americas. A variety of other arboviruses such as Semliki Forest, Japanese B, St Louis encephalitis, equine infectious anemia and equine encephalosis viruses, however, also result in cerebral disease in horses.[59] Aujeszky's disease (pseudorabies) has occasionally been reported to cause disease in horses,[61] and Borna disease,[62] Hendra virus[63] and West Nile virus have recently received attention.[64] Clinical signs vary in severity depending on the virus, but the majority result in clinical signs attributable to diffuse disease, which may include fever, blindness, ataxia, seizures and hyperexcitability. The prognosis depends on the specific virus involved and is especially poor for Eastern and Venezuelan encephalitis.

A rare virus that deserves additional mention because of its public health significance is rabies, a disease that accounts for thousands of human deaths worldwide each year. The disease can initially cause diverse clinical signs in horses, including lameness, colic, tetanus and peripheral neuropathies.[65] In a group of experimentally infected horses the most frequently observed clinical sign was muscle tremors, with pharyngeal spasm or pharyngeal paresis, ataxia and lethargy or somnolence also being commonly observed.[66] The virus passes from the tissues at the bite wounds via peripheral nerves to the CNS by retrograde axoplasmic flow. Once in the CNS the virus disseminates widely in the brain and spinal cord, resulting in a variety of clinical signs. In the brainstem ('dumb') form, obtundation and dementia with ataxia, drooling and pharyngeal paralysis occur, while the cerebral ('furious') form is characterized by vocalization, photo- and hydrophobia, hyperesthesia and seizures, as well as changes in behavior marked by aggressive and destructive behavior. The behavioral changes are believed to be principally due to pathology of the limbic system, and reflect a strategy by the virus that serves to enhance the likelihood of transfer of the agent.[67] Viral pathology centered on the spinal cord results in ascending paralysis, and this forms, more often than the cerebral and brainstem forms, seems to result in asymmetric self-mutilation.

Diffuse disease with cerebral signs has also been reported due to bacteria such as the spirochete *Borrelia burgdorferi,* which causes Lyme disease.[68] Protozoal diseases, including equine protozoal myeloencephalitis in the Americas[69] and trypanosomiasis in tropical and subtropical countries,[70] can on occasion present primarily with forebrain disease.

Brain abscess

Primary brain abscesses in horses are rare but do occur following a history of strangles (*Streptococcus equi*, subspecies *equi*) or during an acute septicemic infection in foals (Fig. 3.11). A thorough physical examination may

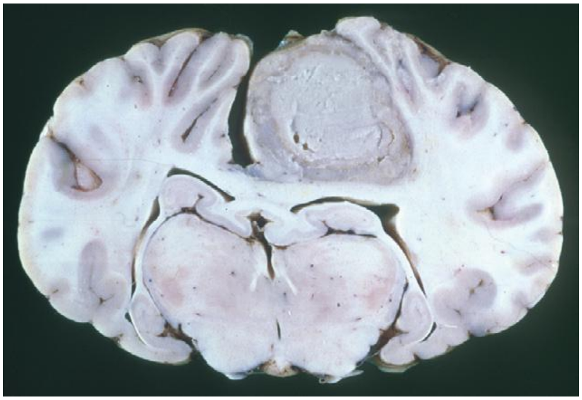

Figure 3.11 Transverse section of equine brain at the level of the thalamus. Cerebral abscesses in the cingulate gyrus are due to *Streptococcus equi* infection (strangles). *(Photograph courtesy of Joe Mayhew and Alexander de Lahunta.)*

determine whether pyogenic disease or multiple foci are present, and cerebrospinal fluid often has increased inflammatory cells and mildly increased protein concentrations. Displacement and compression of the neural tissue by the abscess, and the resulting disruption of the vasculature and creation of secondary vasogenic edema, leads to brain swelling and increased intracranial pressure. Compulsive circling, obtundation, symmetric or asymmetric central blindness and gait changes often follow. Treatment with antimicrobial therapy is rarely rewarding, and surgical drainage should be considered if the abscess is found to be accessible following a computed tomographic scan.

Parasitic encephalomyelitis

Verminous encephalomyelitis can be due to the aberrant migration of an endoparasite normally found in horses, or due to the presence of a parasite not usually present in horses. Clinical signs usually reflect the random migration of the organism, classically *Strongylus vulgaris*, in the brain or spinal cord. Some nematodes, such as the filarioid *Setaria* spp. and the rhabditoid *Halicephalobus gingivalis*, can result in diffuse forebrain disease with behavioral signs such as blindness, circling, obtundation and head pressing. In addition to the direct tissue destruction caused by the migrating parasite, the presence of the organism (usually *Strongylus vulgaris*) in the brachiocephalic arteries can result in a thromboembolic shower to the ipsilateral cerebrum. The resulting acute-onset seizures, obtundation and changes in mentation can be severe. The diagnosis is made on the basis of the history and neurological examination findings and may be supported by serum and CSF neutrophilia or eosinophilia. Treatment is based on anti-inflammatory and anti-parasitic therapy, and the prognosis depends on whether clinical signs were caused by the thromboembolic shower or actual parasite migration (worse prognosis).

Metabolic disorders

Hepatic encephalopathy

Liver failure is a prominent cause of cerebral dysfunction in the horse and can be due to primary hepatic pathology or, rarely, shunts bypassing the liver; these connect the portal circulation from the intestines to the systemic circulation (portosystemic shunts) in foals.[71] Liver pathology can be acute following Theiler's disease (serum hepatitis), acute toxicosis with mycotoxins or pyrrolizidine alkaloids (found in plants such as ragwort), liver abscessation, suppurative cholangitis or cholelithiasis. Horses with acute liver failure classically present with obtundation, anorexia, and with CNS derangements such as head pressing and aimless wandering (see Fig. 3.8). Icterus and elevation of liver-specific serum biochemistry values are normally a feature of acute liver failure. In chronic liver failure, hepatic insufficiency occurs because hepatocellular compromise is such that the functional reserve of the organ is exceeded.[72] Weight loss is often the most prominent feature of chronic liver failure, and icterus and elevated serum liver enzymes may not be prominent. The most common cause of chronic hepatic failure is exposure to hepatotoxic plants, particularly those containing pyrrolizidine alkaloids (e.g. ragwort). See Savage[73] and Barton & Morris[74] for detailed discussions of the etiologies of liver pathology in horses.

The clinical manifestations range from minimal changes in behavior and motor activity to overt obtundation, anxiety and coma, consistent with a global depression of CNS function. This appears to arise as a consequence of a net increase in inhibitory neurotransmission due to an imbalance between GABA and glutamate receptor agonists.[75] Of the many compounds that accumulate in the circulation principally as a consequence of impaired liver function, ammonia is considered to play an important role in the onset of hepatic encephalopathy.[76] Ammonia is excitotoxic, as it is associated with impaired reuptake of glutamate into nerve endings and astrocytes. This increases the concentration of glutamate in the synapse, ultimately leading to a down-regulation of NMDA receptors and decreased activity of this essential excitatory neurotransmitter (see subsection on aminoacid neurotransmitters, above). At the same time, increased inhibitory neurotransmission occurs, due to increased brain levels of benzodiazepines and GABA receptors and the direct interaction of ammonia with one of the GABA receptors. In addition astrocyte metabolism of ammonia to glutamine facilitates plasma-to-brain transport of aromatic amino acids such as tryptophan and tyrosine, direct precursors of the inhibitory neurotransmitters serotonin and dopamine.

Central nervous system energy deprivation

Hypoxia, ischemia and hypoglycemia result in a fall of intracellular energy levels and neuronal necrosis. Neurons in specific anatomical areas in the forebrain and brainstem, including specific populations in the cerebral cortex, hippocampus, amygdala, thalamic nuclei and cerebellum, are especially vulnerable. Excitatory neurotransmitters, principally glutamate, are important final mediators of neuronal death in hypoxia and ischemia.[77]

Hypoglycemia

Significant hypoglycemia produces transient behavioral signs such as confusion and obtundation. In adults it can be associated with hepatic failure, or hyperinsulinism due to inappropriate administration of insulin in treating hyperlipemia or pancreatic neoplasia. Hypoglycemia is more prevalent in foals and can be found secondary to septicemia, potentially due to depletion of glycogen stores, impaired gluconeogenesis and increased peripheral glucose utilization. It is also found in foals with a decreased milk intake, particularly while in intensive care, and is associated with seizures.

Anesthetic hypoxia/anoxia

Respiratory or cardiac failure during anesthesia can lead to hypoxic brain damage. Central blindness and obtundation can be immediate sequelae. If such animals are euthanized, they are found to have an encephalopathy that can be mapped to those areas of the brain sensitive to energy deprivation of neurons[58] such as the superficial cortical laminae.[78] Long-term nursing can be rewarding, and aggressive therapy with the free-radical scavenger dimethyl-sulfoxide is appropriate.

Hypoxic ischemic syndrome

Hypoxic ischemic (neonatal maladjustment) syndrome is a well-recognized but poorly understood disorder of neonatal foals (Fig. 3.12). It affects full-term foals with normal maturity, although a very similar syndrome may be present in full-term, dysmature foals.[79] Affected individuals typically are normal immediately after birth but within a few hours to days postpartum become disinterested in nursing, may wander aimlessly and rarely make peculiar vocalizations, so-called ‘barking’. Further deterioration is marked by recumbency, seizures and obtundation leading to coma and death. The neuropathological findings vary with the duration of clinical signs but typically include ischemic neuronal necrosis and patchy, focal and diffuse hemorrhages, sometimes accompanied by edema in specific sites of the brain and occasionally spinal cord. The pathogenesis is unknown but the lesions suggest an hypoxic and/or ischemic insult around the time of birth,[80] such as premature breakage of the umbilicus when mares rise from the ground in response to human interference. Therapy involves controlling any seizures with diazepam and extended, intensive nursing care.[53] Diagnosis is complicated by concurrent septicemia and hypoglycemia.

Figure 3.12 Foal with hypoxic ischemic syndrome having a partial seizure. The foal eventually recovered. *(Photograph courtesy of Joe Mayhew.)*

Leukoencephalomalacia

Long-term ingestion of corn affected by the fungus *Fusarium moniliforme* can result in single cases or outbreaks of leukoencephalomalacia. Liquefactive necrosis of cerebral white matter classically leads to acute onset of signs of dementia, obtundation, central blindness, incoordination, facial paralysis and death in a few hours to a day. Mildly affected horses that recover may have permanent cognitive deficits. The toxins responsible are secondary metabolites of the fungi, principally fumonisin B1,[81,82] causing vascular lesions in the white matter of subcortical regions as well as in the cerebellum, brainstem and spinal cord. Hepatic disease frequently coexists.[58] Confirming the source of an outbreak is complicated by the fact that corn samples commonly contain fungal spores.

Epilepsy

Seizures, transient and involuntary changes in behavior or neurological status due to abnormal electrical discharges in forebrain neurons, may be related to the syndromes discussed above. In small animals, seizures can manifest as anything from a subtle alteration in alertness to a generalized tonic–clonic event. Subtle behavioral changes may be manifested during auras, while profound behavioral alterations, including hysteria, rage and 'fly biting', can be the primary clinical sign during some forms of seizures (partial complex seizures) depending on the seizure focus.[13,83] In humans and dogs partial complex seizures are based in the limbic system, and the amygdala is known to be particularly sensitive to seizure activity. Horses have a relatively high seizure threshold and, unlike in humans and dogs, idiopathic juvenile-onset epilepsy in which no brain lesion can be identified has not been shown to occur. Recurring seizures have been reported in adults, associated with organic lesions, and particularly in foals that may have benign epilepsy that they grow out of.

Seizures have a tendency to occur when the horse is undisturbed, and the first indication of epilepsy in a horse may be unexplained injuries that occur overnight. Any episode that compromises the awareness of an animal as large as a horse must be considered extremely dangerous, and it is strongly recommended that a horse not be ridden unless it has been seizure free without medication for at least 6 months.

Narcolepsy

Narcolepsy is an incurable, non-progressive sleep disorder characterized by striking transitions from wakefulness into rapid eye movement (REM) sleep without passing through slow wave sleep (see Ch. 10). In humans the clinical features include overwhelming episodes of sleep, excessive daytime somnolence, hypnagogic hallucinations, disturbed nocturnal sleep, cataplexy (sudden loss of muscle tone) and sleep paralysis. A syndrome that has the clinical appearance of narcolepsy has been noted in older horses (usually when undisturbed, e.g. in the back of a paddock) and Shetland and miniature horse foals.[84] The clinical signs can range from buckling at the knees, usually when the horse is quiet, to total collapse and areflexia with maintenance of some eye and facial responses and normal cardiovascular function.[53] The syndrome resolves in some foals. Demonstrating the existence of narcolepsy in horses by classical electroencephalographic techniques may prove to be very difficult, as ongoing work (Colette Williams, personal communication) indicates that horses, unlike humans and dogs, may normally be able to go into REM sleep directly from a period of arousal. This may make eminent sense for a prey species as it would enable the horse to inspect its surroundings before becoming recumbent and losing muscle tone in REM sleep. In humans, some breeds of dogs and miniature horses, an hereditary background has been demonstrated. Canine[85] and human[86] narcolepsy is associated with dysfunction of a group of neurotransmitters involved in sleep regulation and satiety, the hypocretin system. In narcoleptic foals, narcoleptic episodes are often associated with nursing, and it is intriguing that the hypocretin system is involved in the regulation of sleep as well as appetite. The tricyclic antidepressant imipramine has resolved the signs of narcolepsy in horses for many hours[87] but is rarely indicated for long-term management.

Headshaking

Headshaking is a condition in which the horse shakes its head in the absence of obvious external stimuli, and with such frequency and violence that it becomes difficult to ride, or the horse appears to be distressed. Headshaking is most often noted in middle-aged horses during spring or summer and is anecdotally associated with horses asked to use gaits with sustained neck flexion, such as dressage animals. The syndrome appears to be progressive in many cases, with increases in severity and loss of the characteristic seasonality. A great deal of research has been applied to this frustrating condition, but the etiology is far from clear.

Several causes have been suggested, including middle-ear disorders, ear mites, cranial nerve disorders, guttural pouch mycosis, dental periapical osteitis, allergic rhinitis and vasomotor rhinitis; however, only very rarely can it be shown that correction of the abnormality leads to elimination of the headshaking.[88] Clinicians in California examined the role of light on headshaking behavior of horses and determined that the condition appeared to be light-stimulated in approximately 60% of the horses. It was suggested that the close association of the optic and trigeminal nerves in the midbrain may allow optic stimulation to cause referred itching, tingling or electric-like sensations in areas innervated by branches of CN V, a condition similar to 'photic sneezing' in man.[46] The majority of horses with idiopathic headshaking showed some improvement or resolution of signs after oral administration of cyproheptadine.[89] This contrasts with studies performed in Great Britain,[48] in which a photic etiology could not be established and where cyproheptadine alone was ineffective; 65% of those cases however showed a 90–100% improvement following local anesthesia of the root of the maxillary branch of CN V, and combination therapy of cyproheptadine and carbamazepine resulted in very significant improvement in the majority of cases.

It was concluded that a trigeminal neuritis or neuralgia may be the basis of the underlying etiopathology of idiopathic equine headshaking. The etiology, just as in the human equivalent, is not known. The sodium channel-blocking effects of carbamazepine[90] are used to make a diagnosis of trigeminal neuralgia in humans, where similar clinical signs of sporadic or persistent mild to extreme facial pain is associated with the distribution of the trigeminal nerve. In the human condition, 'trigger factors' are a consistent feature; this may correspond with the intermittent seasonal nature of the equine disorder. Human trigeminal neuralgia has a much greater prevalence in multiple sclerosis patients,[91] and the disease may be associated with demyelination, but so far no direct clinical evidence for this has been established.[92] In spite of exhaustive studies on the peripheral portion of the trigeminal nerve, ganglion and sensory trigeminal nucleus, however, no consistent detectable pathology has been identified (Derek Knottenbelt, personal communication 2001).

There are currently no consistently useful therapies, and, although a particular case may respond to single or multiple management or therapeutic measures, the prognosis for cases of idiopathic headshaking is poor. The reported efficacy of the antihistamine hydroxyzine in some headshaking cases[93] may be attributed to the fact that rhinitis due to an allergic response may be the trigger factor rather than the specific pathology underlying this disorder. Furthermore, hydroxyzine does possess some sodium channel-blocking effects,[94] so it is difficult to establish whether decreased histamine release or sodium blockade is producing the benefit in these isolated individual cases.

There is much research remaining to be done to understand this distressing disorder that regularly results in euthanasia of otherwise healthy horses.

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The author would like to thank Professor Joe Mayhew for many years of instruction, and Mr Keith Ellis for remarkable tolerance and exceptional photography.

SUMMARY OF KEY POINTS

- Major components of the central nervous system are the forebrain (cerebral hemispheres and thalamus), the brainstem (midbrain, pons and medulla oblongata), the cerebellum and the spinal cord.
- The brainstem and thalamic reticular activating system provide arousal and set up attention; the caudal part of the forebrain integrates perceptions, and the frontal cortex initiates voluntary movement and executes plans.
- The parietal lobe comprises primary sensory and motor areas; the occipital lobe is concerned with visual processing; the temporal lobe includes areas devoted to memory and hearing; the hippocampus and the amygdaloid nuclei are involved with memory and emotion; the frontal lobe is concerned with planning and control of movement.
- The limbic system is involved with memory, social and emotional behavior.
- Brain regions that appear to be critical to the formation of memories are the medial temporal lobe and certain thalamic and basal forebrain nuclei.
- Behavior is based on neurons receiving and conveying information using action potentials that trigger the release of neurotransmitters.
- The main neurotransmitter classes are the biogenic amines, amino acids, neuropeptides, nucleotides, prostaglandins and gases.
- Psychopharmacologic agents act by modifying neurotransmitters.
- The neurological examination is carried out to determine whether the change in behavior could be explained by an underlying neurological deficit, and to define the anatomical portion of the nervous system responsible for the clinical signs.
- A number of neurological diseases affecting the forebrain produce changes in behavior.

Case study 1

The author has examined several horses with recent changes in behavior such as becoming 'hot', difficult to ride, unwilling to move forward or being prone to frequent and sudden bucking and bolting. A neurological consult was sought, usually because the owner was concerned that the horse may have a 'brain tumor'. Careful neurological examinations did not reveal changes in mentation or other neurological signs in any of these cases. Several of these horses were euthanized and a postmortem examination further failed to determine morbid neuronal pathology.

Case study 2

An adult Thoroughbred mare known to be 'difficult' was brought to a farrier for corrective shoeing. During shoeing she became very belligerent, pushing through handlers, not standing still and acting aggressively. She was dealt with as a 'difficult' and 'badly behaved' horse by the farriers until, after about one hour of this, the experienced groom realized that the behavior was pathological. She was examined by a veterinary surgeon who found severe icterus. STAT liver enzyme analysis confirmed the diagnosis of acute liver failure and she was euthanized.

(Courtesy of Professor Joe Mayhew.)

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CHAPTER 4

Learning

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Learning theory

Equids can learn remarkable behavioral responses (Fig. 4.1), but if we are to consider principles in horse-training from a rigorous scientific perspective, there is an abiding need to demystify traditional horse-training jargon and couch the following discussion in the language of learning theory. This unifying language explains what happens at a mechanistic level in all effective training systems.[1] Using this approach veterinarians and equine scientists can be agents of change by counseling owners and trainers on effective and humane techniques in training and retraining. A glossary of equestrian terms appears at the end of this book, so this chapter avoids any such esoteric labels. The original rules of what we call learning theory were first set down by psychologists and behaviorists who used clinically controlled, some would say sterile, stimuli. These days the study of animal learning is increasingly the pursuit of cognitive ethologists. These are the behavioral scientists who, when considering the way in which a member of a species processes information, emphasize the importance of the environment for which that species evolved and determine how the biology of a species can influence its behavior.[2]

The definition of learning

Broadly speaking, a stimulus is any detectable change in an animal's environment. A response is any behavior or physiological event. The usual technical definition of learning or conditioning, as it is often called, is any relatively permanent change in the probability of a response occurring as a result of experience. Importantly, this refers to a response and not a cognitive outcome, such as knowledge.

Not all changes in behavior are consequences of learning. The reference to a 'relatively permanent

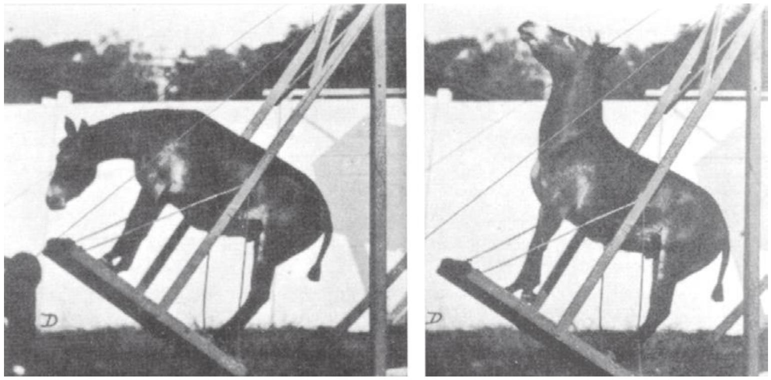

Figure 4.1 Denver, the swinging mule, changing his head and neck position to shift his center of gravity and swing a platform.

change' is added to exclude modifications of behavior by motivational factors, physiological variables or fatigue. A thirsty horse that drinks despite having refused water some hours earlier has changed its behavior but is not considered to have learnt anything in the interim. Instead, its motivation to drink has changed as a result of shifts in variables such as blood volume and the concentration of sodium in body fluids. Similarly, fatigue can change behavior, transforming a rearing colt into a weary slug, but its effects could not be described as relatively permanent.

Sufficient reflexive responses cannot possibly be built into each foal to meet every challenge throughout life, so learning enables young horses to use their experience to update their behaviors according to their developing circumstances. Although only cursorily studied in any empirical sense, it is likely that horses are particularly attentive when learning to do what they fill most of their days with – grazing. Foals sample their mothers' feces when learning to select safe vegetation types, while adult horses retain the ability to review preferences in diet according to the proximate consequences of consumption.[3]

Intelligence

The intelligence of animals is difficult to assess. Intelligence may be shown when the animal learns to ignore irrelevant stimuli, just as it also learns to react to significant stimuli. This permits the behavioral developments that make discrimination possible. The horse's integration with its domestic environment is facilitated by this ability to compare and contrast. Most horses can accurately discriminate between stimuli and evaluate them, e.g. they can differentiate sounds, visual features of special significance, the identities of people, and so on.[4]

Veterinarians are often asked to comment on the intelligence of horses. For example, some owners are intrigued to know whether they should credit their horses with the cognitive talents of dogs. Attempts to compare brain to bodyweight to arrive at a quantitative comparison between species are rarely well received by horse lovers since, using this measure, the horse approximately equates with the turtle. Furthermore the same ratio credits the shrew with more brain power than the human. One of the core problems here seems to lie in the definition of intelligence, because it is a nebulous construct. It may be preferable to speak of the ability to learn, but even that approach may be flawed when experimental designs fail to select naïve subjects. We should bear in mind that conclusions about equine reasoning abilities (or lack thereof) may be biased because they have been based on observations that appear to have been made almost exclusively with horses that have been trained by negative reinforcement (Amy Coffman, personal communication 2002). It is possible that this may have affected their performance, e.g. by reducing their willingness to risk making mistakes.

Several attempts have been made to compare learning abilities in horses with those of other species and to compare the ability of different breeds of horses.[5,6] All of the tests between species are confounded by the differences in physical ability and sensory acuity between species, as these may account for the differences in perceived 'intelligence'. Add to this the species' differences in motivation and the variation in salience of a single type of apparatus and one begins to see how such comparisons are inherently flawed. One can see how difficult it is to devise a test that two species can undertake with equity. Experimenters have yet to make the necessary adjustments to stimuli so that members of two species can detect and respond to them with equal ease, speed and motivation. The same criticism can be leveled at experiments that compare the problem-solving ability of breeds within a species or, for that matter, bloodlines within a breed.[7] Selection of breed traits can impair or enhance performance in various ways, including emotionality.

Imprinting and socialization

Some neonate animals show evidence of imprinting in a special category of learning that occurs during a highly sensitive period in their development, generally at the time of their first stimulation from the outside world. Spalding[8] was the first to make systematic observations of this phenomenon, reporting that shortly after hatching, young chicks followed any moving object. Later, Lorenz[9] made the topic popular among behavioral scientists. He described imprinting as a unique process in precocial birds occurring exclusively in a sensitive period during which 2–3-day-old hatchlings begin to studiously follow a 'mother figure'. Typically, this figure is the hatchlings' real mother, but Lorenz recognized that, during their growth period, they would follow almost *any* moving object. Lorenz posited that imprinting was irreversible and, given that birds hatched by another species often court and attempt to mate with the foster species, that it determined future mating partners.

For equine practitioners, the questions are: does imprinting occur in horses; and, if so, is it the same as in precocial birds; and is it of any use in training and management? Veterinarian Robert Miller[10] introduced the term imprinting to describe the behavior of young foals and suggested that the sensitive period for foals, when the 'following response' is learned, is within the first 48 hours of life. At this time the foal's mother is usually the nearest large moving creature in its world and it is to her that the foal bonds.

Imprinting is mediated by the sense of sight, but sound and olfaction are also involved. Having described imprinting as a process in foals, Miller also introduced the prospect of *imprint training* as a viable methodology for modifying the behavior of newborn foals in a bid to reduce the prevalence of aversive reactions and defensive aggression while at the same time sensitizing the foal for pressure release.[10,11] Miller's observations about the phenomenon of imprinting are noteworthy, because like gallinaceous birds, horses are precocial and are mobile soon after birth. If Miller's claims are correct, we should spend time imprint training foals rather than schooling larger, stronger and more dangerous youngsters.

Imprint training as recommended by Miller is an exhaustive process, requiring habituation of the foal to common stimuli as well as sensitization to other salient stimuli. It involves between 30–50 interactions, which Miller calls 'stimulations', of each body region of the foal. Imprint training begins with drying the foal and cutting its umbilical cord. On day one, habituation begins with the foal being held securely before it stands. The holding persists until the foal relaxes and ceases to resist. Then it is rubbed all over its body until it again shows relaxation. Beginning with the ears (including ear canals), face, upper lip, mouth, tongue and nostrils, this rubbing is repeated. Rubbing the eyes, neck, thorax, back, legs, feet, rump, tail, perineum and external genitalia follows.

The next steps are rather controversial because they seem to amount to flooding with novel aversive stimuli, including artificial devices such as clippers and a rectal thermometer, as well as sham rectal examinations. Further habituation to unusual stimuli follows, with the handler rubbing a piece of crackling plastic over the foal's entire body until 'panic subsides'. Gunfire, hissing sprayers, whistles, loud music, flapping flags and swinging ropes are also included in the imprinting program. Habituation to pressure around the girth region follows with the handler's arms surrounding the foal and compressing rhythmically until any resistance abates.

After habituation, sensitization to pressures for leading via the headcollar is undertaken. This is not exclusively part of so-called imprint training, but is really the first step in negative reinforcement training. Training the foal to lead at an early age, as long as it does not compromise foal safety or the mare–foal bond, can be justified because it enhances foal and handler safety during any veterinary intervention before foundation training.

The increase in popularity of imprint training over recent years has triggered interest in the process from scientists, not least because of the possible implication of flooding and learned helplessness in techniques revolving around restraint and aversive stimuli. The ensuing research suggests significant limitations to Miller's schema. Concerns have been raised for the well-being of foals that undergo significant human interventions shortly after birth. Henry et al[12] noted that foals separated from their dams for just one hour went on to show patterns of strong dependence on their mothers, little play, social withdrawal and aggressiveness. The perceived need for persistence in application of restraint as part of the Miller regime remains a contentious issue. Restraint may increase latency to stand, but such delays are not accompanied by any accompanying increase in the latency to nurse.[13] However, because restraint of

Table 4.1 Results of imprint training

Authors	Imprint age	Repetitions	Age at testing	Test
Mal and McCall 1996[15]	24 h	Daily for 42 days	85 days	Halter, lead[a]
Jezierski et al 1999[23]	14 days	Until 24 weeks	6, 12, 18, 24 months	Hoof lead approach[a]
Spier et al 2004[21]	10 min	24 h	90 days	Restraint, halter, worm, vaccinate, hoof[a]
Lansade et al 2005[24]	6 h	Daily for 14 days	16 days, 3 months, 6 months, 1 year	Halter[a], hoof lead[b]
Mal et al 1994[25]	Birth	Daily for 7 days	120 days	Approach stimuli
Simpson 2002[13]	2–8 h	Daily for 5 days	4 months	Approach stimuli[a]
Williams et al 2002[19]	45 min	12, 24, 28 h	1–3 months	Approach stimuli

After Houpt 2007.[123]
[a]*Significantly better than non-handled.*
[b]*Three-month results.*

struggling foals may increase their risk of injury, veterinarians should consider this outcome carefully before advocating the Miller system. Similarly, as we shall see, they should be mindful that there is insufficient evidence to demonstrate that handling at later ages could not have similar results.[14]

The suggestion that foals be stimulated until they appear sleepy rather than reactive is central here. We cannot assume that sleepiness indicates emotional acquiescence. There is a need for surveillance of foals' physiological response to this intervention, which may allow us to assess any deleterious effects of elements of the training program and refine the entire approach.

The sensitive period during which foals can acquire any special learning remains elusive. Mal & McCall[15] concluded that handling throughout the first 42 days of life improved performance in a halter-training task compared with handling from days 43 to 84. Concurring with Miller about the likely existence of a critical period, they suggested that this period lies within the first 42 days of life.

Heird et al[16] reported that when moderately handled from weaning until 18 months of age, foals showed enhanced problem-solving abilities. Extensively handled horses were slower navigating through a maze than minimally handled horses, but faster than unhandled horses. That said, we should consider the possibility that the aversiveness of confinement within the maze was greatest in the unhabituated, unhandled foals and that problem-solving in and therefore progress through the maze may have been hampered simply by fear. On the other hand, the extensively handled horses, having been trained to wait for cues, may have been more dependent on human signals to advance through the maze. Heird et al[16] also reported that horses which had been extensively handled were less emotional, showed a higher maze-learning performance and were more trainable for riding than those that had received less early handling. This evidence supports handling protocols that reduce flight response through habituation, approaches that do not necessitate imprint training *per se*.

Most of the recent literature suggests that imprint training of foals does not correspond to any natural analogue in the equid ethogram and that, during imprint training, the foals frequently resist strongly and are distressed.[17] Whether this early stress can be justified in terms of later benefits is still subject to debate.[18] Williams et al[19,20] showed that handling foals at birth and/or 12, 24 and 48 hours after birth, had no beneficial effect on their later behavior when tested at 1, 2 and 3 months of age[19] or at 6 months of age.[19,20]

The distinctions among habituation, any equine analogue of filial imprinting (as described in birds) and the more radical elements recommended by Miller are far from simple. This explains why some studies have shown some positive effects of imprint training. For example, foals handled early tend to approach familiar humans[12] and accept foot handling[21] more readily than unhandled ones. However, aversive stimuli were not rendered more tolerable by imprint training. For example, at 3 or 4 months of age, fitting halters or clipping was as disturbing for handled foals as it was for unhandled foals.[13,19,21] Significantly, foals that had been imprinted and then went without regular later handling were as difficult to approach as controls[22] (Table 4.1).

Handling after the putative sensitive period seems to have only transient benefits.[24] While Mal et al[25] found no beneficial effects when foals were handled (stroking, haltering or picking up feet) during the first 7 days, subsequent evidence has emerged to suggest that, when subjected to similar handling at 14 days of age, foals were more tractable at 3 months than non-handled foals. However, differences between the handled and unhandled foals were less apparent when tested at 6 months of age and had disappeared completely by one year of age.[22]

Higher trainability[16] and easier handling,[26] has been reported in foals handled regularly from weaning. Similarly, Hausberger et al[18] proposed that any benefits of early handling rely on regular repetitions of handling. Compared with unhandled foals, handling foals 5 days per week (including catching, leading, picking up feet, grooming and being approached by an unfamiliar human) until they are 2 years of age improved manageability at 12, 18 and 24 months.[23] The optimal duration of the handling period is still unclear, but the optimal time for handling seems to be at weaning since, in contrast to imprint training, this would reduce the chance of interfering with the mare–foal bond. It should be followed up with regular handling.

Hausberger et al[18] point out the absence of evidence in foals for the existence of a sensitive period in development that assists in the formation of a foal–human bond. They emphasize that the affiliative qualities of human–horse interactions may be more important than when the interactions occur. Certainly, prior to weaning, foals seem to find being scratched highly reinforcing and humans may be better at scratching some body parts than other horses are.[2] In a similar vein, Søndergaard & Halekoh[27] proposed that unhandled 2-year-olds become as familiar as handled animals, probably because humans bring food.

Given that foals learn from their dams, it is worth noting that the reactions of the mare during handling have an impact on the foal's behavior. Sigurjonsdottir & Gunnarsson[22] found that the mare's nervousness correlated positively with the imprinted foal's resistance to capture, haltering and leading at the age of 4 months. In essence, they demonstrated that the calmer the mare, the easier the foal was to handle. This finding could simply reflect social learning or the inheritance of flightiness. However, more direct activities, such as brushing and hand-feeding of the mare in the presence of the foal had a lasting, positive effect.[28] One year later, without any handling in the interim, foals handled in this way were more easily approached in the paddock and stroked by a familiar or unfamiliar human, whereas controls showed greater resistance to capture and to the presence of humans. Hausberger et al[18] concluded that establishing

Figure 4.2 Early exposure to humans can be achieved without compromising the mare–foal bond.

a positive human–dam relationship may therefore be critical in creating a durable improvement to the manageability of foals. At the same time as offering such lessons with the dam, handlers should interact gently and consistently with the foals themselves since, as long as they cause no flight response and they do not disrupt the mare–foal bond, regular training activities that fully align with learning theory and, in particular, pressure release contingencies, can be learned at an early age (Fig. 4.2).

The research on imprint training seems to underline the difficulty in dissecting any equine analogue of filial imprinting from habituation and socialization. Socialization involves giving foals opportunities to become acquainted with stimuli they will spend time with in later life. This principle is the core of the lessons foals can learn from watching their dams calmly interacting with humans. They also learn from their peers and require a rich social environment to develop normal social skills, low adult–young ratios being associated with subsequent aggression in foals.[29] Intriguingly, it has been reported that foals of high-ranking dams remain closer to their mothers during socialization.[30] Although foals reared without peers are bolder with humans,[31] it is possible for them to learn to become too familiar with handlers. Grzimek[16] separated a neonatal foal from its own species for 64 days and found that it developed a fear of conspecifics and a social preference for humans over equids. Similarly, Williams[32] noted that artificially reared foals failed to respond to the social signals of conspecifics and sought human company rather than that of other horses. The socialization benefit is an important reason that fostering orphan foals on to nurse mares is preferable to hand-rearing (see Ch. 12).[33] It is not clear how labile the unwelcome consequences of mal-imprinting are in later life. Some owners speak of foals that have mal-imprinted as having a lack of ‘respect’, e.g. ‘because they have no fear, they climb on top of you’. As with any training, the key to finding the best course is to be consistent. If you do not want a horse that takes dangerous liberties in later life, then do not allow it to practice such responses as a foal and certainly never reward it, however inadvertently, for doing so. Familiarity does not necessarily breed contempt. However, just as a mare disciplines her foal before and during weaning by punishing behavior she finds unacceptable, so the human handler might be justified in doing the same to avoid the youngster growing up with a litany of inappropriate responses and no ‘respect’ for humans. The problems with punishment are discussed later in this chapter but in brief it is safe only when accurately timed and as subtle as possible. For these reasons, it demands experienced horsemanship. Novices rearing orphan foals rarely strike the right balance between adequate physical contact and consistent use of pressure-release training. Sensitization in early handling programs is important as a precursor to negative reinforcement. It trains the foal to move away from exogenous tactile stimuli as it must to become a safe and responsive working animal in later life.

In a novel object test, the cardiac responses of Dutch Warmblood youngsters with regular training were compared with youngsters that had received additional training from the age of 5 months onwards. The animals were tested at 9, 10, 21 and 22 months of age.[34] The regular youngsters showed greater increases in mean heart rate that could not be entirely explained by the physical activity and decreases in HRV measures. Because these horses showed individual consistency of these heart rate variables at all ages, the authors suggested that non-motor cardiac responses might be useful in quantifying certain aspects of a horse’s temperament.[34] Data of this sort strongly imply that individualized attention to the behavioral conditioning of young stock pays dividends throughout their lives.

In conclusion, while noting the helpful efforts of researchers in this domain, we should accept that a great deal of confusion prevails about best practice in the formative years of a horse’s life. This highlights the need for experimental designs to provide data that are more readily applicable to the needs of horse producers and equestrians.

Non-associative learning

Imprinting aside, there are two major categories of learning: non-associative and associative. In non-associative learning the animal is exposed to a single stimulus to which it can become habituated or sensitized, while in associative learning, a relationship is established between at least two stimuli. There are two subdivisions under the umbrella of associative learning. These are classical conditioning and operant conditioning. The latter, as we will see, is important for animals to be able to solve novel problems in their environment. The central tenets of learning theory merit detailed consideration by those embarking on behavior modification in practice because the ontogeny and resolution of inappropriate behavior patterns can be explained with reference to learning theory. If we can appreciate how a horse finds benefits from aggressive responses to humans, we can understand why meeting such responses with violence rarely, if ever, helps. If we can understand how to train a horse to bow, we can apply similar techniques to modify the behavior of a horse that has learned to avoid being loaded onto trailers.

The most basic form of learning involves cumulative experience of stimuli by themselves. This gives the horse data about the relevance of stimuli in its environment.

Habituation

Habituation is said to have occurred when repeated presentations of a stimulus by itself cause a decrease in the response (Fig. 4.3). It is really the simplest form of learning. Consider the training of a police horse (see case study below) that must be gradually exposed to more and more of the potentially frightening stimuli that it will later encounter when out on patrol. The people delivering these stimuli in training are familiar to the horse and started their disturbances at a considerable distance from it. Only when the horse ignores the

Figure 4.3 Horse with tarpaulin.

rumpus at a certain noise level and a certain distance are these variables made more threatening and proximate. Similar approaches are used to train stunt horses for film and exhibition work (Fig. 4.4).

The likelihood of habituation and its rate are dependent on the nature of the stimulus, the rate of stimulus presentation and the regularity with which it is presented. When habituating a horse to a stimulus, it is essential that the stimulus be repeated well past the point of habituation. To stop prematurely can teach the animal exactly the opposite of what is desired. Habituated responses show spontaneous recovery when stimulation is withheld. This means that exposure to the relevant stimuli must continue at intervals to prevent the original response (e.g. a flight response) from recurring.

Habituation is central to horse taming and pivotal in early handling regimens. Recent work by Jezierski et al[23] using Konik horses, confirms that habituation to handling can reduce reactivity. Konik horses are a primitive breed unlikely to have been selected to be easily managed by humans.[35] Horses exposed to daily handling (10 minutes per day over 5 days per week) from 2 weeks of age displayed a reduced heart rate and enhanced manageability compared with horses born and reared up to weaning age in a forest environment free from human contact.[23] The early handling intervention made horses much easier to manage than non-handled foals

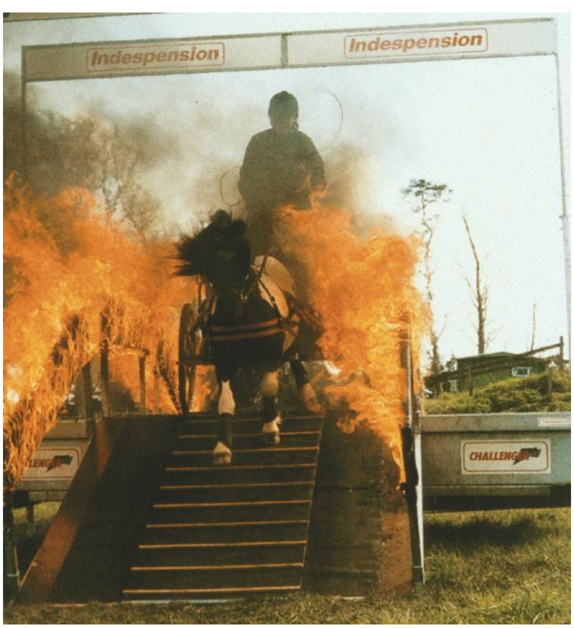

Figure 4.4 Stunt pony, Mr Pie, galloping through fire. *(Photograph courtesy of Amanda Saville-Weeks.)*

in a variety of tests given at 6, 12, 18 and 25 months. Again, it pays to consider the extent of any moderating influence from these foals' dams, that were exposed to humans as part of the experimental procedure.

Desensitization and counter-conditioning

In behavior modification, the step-by-step process of weakening an unwelcome fear response to a given stimulus or set of stimuli to the point of extinction is often labeled systematic desensitization. If the horse is relaxed when exposed to barely perceptible measures of the causative factors one at a time, it can learn to behave passively rather than fearfully. The emphasis in this approach has to be on the gradual introduction of increasing aliquots of the problematic stimuli. Too fast an advance is marked by a return to the fearful response or an alternative evasion. If this arises, exposure to the stimuli must be returned to the level to which the horse had successfully habituated.

If, rather than simply habituating horses to aversive stimuli, we expose them to pleasant coincidental consequences, counter-conditioning may occur. This helps to facilitate the emergence of an alternative, more appropriate response to the aversive stimulus. Despite encouraging data to support the use of this approach,[36] this is a sadly under-exploited strategy in the management of horse behavior. Any veterinarian who appreciates the motivation most equids have to feed should be able to harness this drive to train appropriate behaviors. For example, if one is required to administer eye drops to a horse one can either struggle with it as it wrestles its head away or condition an appropriate head posture using food. The principles of learning theory that apply when horses learn to tilt their heads to nuzzle in the pockets of owners and find titbits can be used for veterinary purposes. For sustained performance, the rewards must outweigh the costs and, because horses learn to avoid aversive stimuli more than some other domestic species such as the dog,[37] this means that the daily value of the reinforcements must eclipse the aversiveness of the total daily dose of eye drops. Unfortunately, for some veterinarians and owners, simple habituation to periorbital palpation is too time consuming and therefore counter-conditioning holds even less appeal. Because they are reliable sources of ocular discomfort, these are the people whom equine ophthalmic patients learn to avoid.

It is important to recognize that simply offering food in the presence of a fear-eliciting stimulus is an inadequate approach since the horse may be chewing a mouthful of food and therefore gaining gratification from it while demonstrating a flight response. Rather than allowing the fearful horse to stuff his head into a bucket of grain during exposure, a simple gratifying distraction, effective trainers use valuable rewards that are small enough to be consumed quickly. These rewards are used when the horse that tends to run away with an elevated head posture offers approximations of a more appropriate response such as turning towards the stimulus and lowering its head.[38] By waiting for the horse to offer the appropriate response rather than forcing it to 'behave' with aversive stimuli, such as buccal discomfort where rein pressure is used, the trainer allows the horse to learn the consequences of its own actions in bringing about a reward. This elegant approach, which allows the horse to have some control over the situation, requires all the features of good training practice, including sensitive shaping technique (see p. 96) and, above all, consistency.[39]

A less sophisticated approach to fearfulness in horses that may, at first glance, seem expeditious, is flooding, which involves the over-exposure to the causative stimuli until the response disappears. A familiar example of flooding is seen in traditional horse 'breaking' when a saddle is strapped to a naïve horse that is then allowed to buck in an attempt to rid itself of the saddle until it gives up. Driven by the belief that the horse is not responding because it is no longer fearful, many misguided handlers reach for this approach to all manner of fear-elicting stimuli. Unfortunately the horse has no control over the situation and can learn that it is simply helpless to respond. Where this learning is context specific (see below), the lessons are only partially learned and the horse may emerge with extreme fear responses in slightly different circumstances. Trainers of police horses generally do not use flooding because the horses must offer learned responses in a very wide variety of contexts (see case study at the end of the chapter). Flooding in combination with physical restraint and muscle relaxants such as succinylcholine chloride has been described, with warnings about the dangers of the subjects damaging themselves as they struggle or collapse to the ground.[40] Flooding that leads to apathy may be justified in certain aggressive horses, as an alternative to euthanasia, but for some it remains questionable on welfare grounds.

Sensitization

Sensitization is the opposite of habituation in that there is an increase in a response after repeated presentations of the stimulus by itself. The stimulus has to be intrinsically unpleasant or aversive. Sensitization usually happens when an individual cannot escape or make an avoidance response to prevent repeated exposure to a stimulus that is intrinsically unpleasant or aversive. This is particularly likely if the subject is highly aroused. If one recalls the magnified unpleasantness of a dripping tap when searching for sleep, the effect of sensitization becomes clear. Stimuli over which the horse learns it has minimal control (e.g. bot flies) are those to which it can become most rapidly sensitized and sensitization can override habituation. For example, if while completing his training, the police horse described above is involved in a road traffic accident every day for a month, he would reliably become sensitized to motor vehicles and perhaps even become phobic so that just the sound or sight of them might be sufficient to send him into a flight response.

Associative learning

When horses make links between stimuli and responses or, to use training terms, cues and outcomes, they are undergoing associative learning.

Classical conditioning

Classical conditioning is the acquisition of a response to a new stimulus by association with an old stimulus. It involves coupling a stimulus with an innate behavior or physiological response. It is also labeled Pavlovian conditioning because it has its origins in primarily unrelated saliva collection experiments conducted by Ivan Pavlov.

Pavlov had spotted his experimental dogs salivating when they heard his technician tinkling a bell as he approached the kennels to feed them. To determine how accurately a dog could develop such associations, Pavlov decided to replace the sound of the bell with more easily varied sounds made by a buzzer (and later a metronome). He surgically implanted a tube to collect saliva from each dog to measure its rate of production (Fig. 4.5). Pavlov used this apparatus to demonstrate the strength of the links between a novel stimulus (the buzzer), to a physiological stimulus (food in the mouth) and a response (salivation). The dogs quickly began to salivate in response to the buzzer, a new stimulus that had previously been irrelevant or neutral. The labels Pavlov created for the elements in this process are still used today. Before the learning experience, only meat

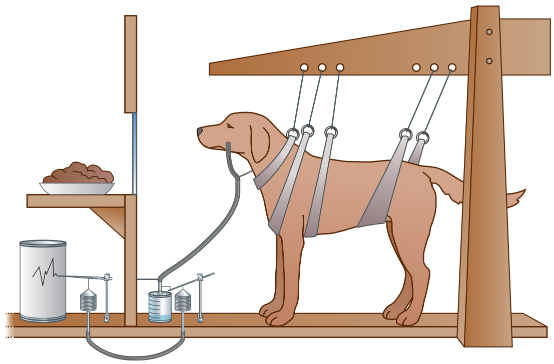

Figure 4.5 Illustration of one of Pavlov's dogs in its experimental apparatus used for measuring the rate of salivation as an indicator of the strength of associations between conditioned stimuli and food.

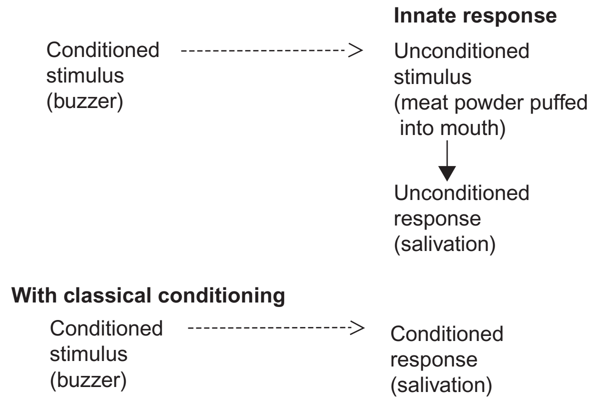

Figure 4.6 Conditioning rather than leadership qualities provides a more plausible explanation of leading behaviors. A horse will lead forward from pressure even from a well-trained dog.

powder, the *unconditioned stimulus* (US), produced salivation as an *unconditioned response* (UR) (Fig. 4.6). After learning, the buzzer became a *conditioned stimulus* (CS) and the salivation response to the conditioned stimulus became the *conditioned response* (CR, also known as the learned response).

Crucially, in classical conditioning, the sound of a buzzer was followed by the delivery of food to the mouth, regardless of what the dog might have done when it heard the buzzer. Classical conditioning enables the animal to associate events over which it has no control. This increases the *predictability* of an environment. The more frequently and consistently the neutral stimulus is paired with the unconditioned stimulus, the more rapidly the association will be made. In some cases, usually involving the most fundamental pain or pleasure, the association is formed with a single experience.[41] We know that fear-related responses are particularly resistant to extinction[42] and that single-trial learning of flight responses can persist for years.[43]

A good example comes from horse-breeding units. Learning about sex seems especially likely as a consequence of classical conditioning. Some stallions get aroused when they hear the sound of the bridle used to control them in the service pen. Their excitement increases when they are led to the service barn – hence, through classical conditioning another reliable environmental cue becomes associated with copulation. Racetrack grooms use classical conditioning when they whistle each time they see their charges urinating. Once the association between the whistling and urination is made, the horses urinate on cue for post-race urine tests (see Ch. 9). Riders use classical conditioning when they replace pressure cues from the bit and the rider's legs with previously neutral signals such as changes in their position (seat).

Pavlov recorded an interesting footnote to his studies: he noted that his dogs would race ahead of their handlers to get to the experimental area. They would not wait for a stimulus that made their mouths water, they would actively try to put themselves into situations and perform activities that led to rewards. This was a result of trial-and-error learning and brings us neatly to the other important category: operant conditioning.

Operant conditioning

An operant response is a voluntary activity that brings about a reward. In operant conditioning, the buzzer might still be presented but the dog must make a particular response before food is consumed. In other words, there is a special link (what learning theorists call a contingency) between a particular behavioral response and a food reward. Operant conditioning underpins most of the techniques that work well in equestrian contexts (Fig. 4.7).

While Pavlov was concentrating on the physiological responses of dogs in harnesses, Thorndike[44] was studying the behavioral responses of cats in puzzle boxes. Instead of delivering food independently of behavior whenever a signal had been presented, Thorndike delivered it once his animals had responded. In a body of work intended to discredit the notion that animals are capable of reason, Thorndike[44] described the behavior of a naïve cat in a specially designed box (Fig. 4.8).

Figure 4.7 Conditioning rather than leadership qualities provides a more plausible explanation of leading behaviors. A horse will lead forward from pressure even from a well-trained dog.

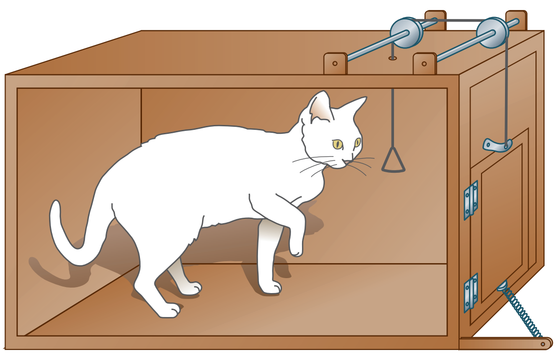

Figure 4.8 Illustration of one of Thorndike's cats in a puzzle box.

Without any food or other home comforts, life was rather dull and unsustainable in the puzzle box. The cat could get out – but only by pulling a trigger. Motivated to access food outside the box, Thorndike's cats would eventually learn to escape by operating the trigger that released the door latch. Once out of the box, they would get their food. Thorndike called this trial-and-error learning, but this label has largely been replaced by the terms instrumental learning and operant conditioning. The animal sees a cue (the trigger), performs a response (pulling) and gets a reward (liberty and food). In any horse-training or retraining situation, trainers should challenge themselves to be clear about the horse's perception of the same three critical elements: cue, response and reward.[45] The effect of the reward is to strengthen the correct response. This is known as reinforcement. The term reinforcement refers to the process in which a reinforcer follows a particular behavior so that the frequency (or probability) of that behavior increases.

On successive occasions in his free-operant studies (see below), Thorndike noted that the cat's latency to escape fell but only very gradually. The absence of a sudden drop in the latency to learn was sufficient evidence for Thorndike to assert that his cats were not using thought or reason to solve the problem. Thorndike's work was followed by that of Skinner,[46] who maintained that almost any response could be learned by an animal that is given opportunities to operate within its environment to obtain a desired outcome.

Rocky, the 8-year-old Irish Draft horse in Chapter 1 (see Fig. 1.12), learned within 4 weeks of being at a new home that unlocking the bolt on his stable door allowed him to enrich his environment. He learned that the behavior had a pleasant result. However, he does not attempt to escape if a chain is slung across the threshold of his doorway and loosely tied with a single strand of twine. It appears that the open door affords him a better view and, for the time being at least, satisfies his motivation to observe the activity on the yard.

Operant or instrumental conditioning consists of presenting or omitting some reward or punishment when the animal makes a specific response.[47] The likelihood of an association arising depends on the relationship between the first event and the second via stimulus–response–reinforcement chains. Operant conditioning enables an animal to associate events over which it has control. This increases the *controllability* of the environment, which represents the crucial difference between classical (Pavlovian) and operant conditioning. Operant conditioning can have potential benefits for horse welfare by improving choice. In classical conditioning, rewards become associated with stimuli, while in operant conditioning they become associated with responses.

Operant conditioning has been studied experimentally in two types of situations: 'discrete trial' situations and 'free operant' situations. In a 'discrete trial' situation, a subject is exposed to the learning task, required to make a response, and then withdrawn from the situation. For example, a horse may have to choose one of two directions, left or right, in a simple T-maze. In a 'free operant' situation, on the other hand, the subject is allowed to operate freely on its environment. For example, a horse placed in a paddock and free to do whatever it likes, can be conditioned by reinforcement under a given set of contingencies. Horses such as those that open their stable doors or dunk their own hay are good examples of free-operant conditioning. Like Thorndike's cats and the rats that pressed levers in Skinner's laboratory, they work within their environment to effect a reward. In equine contexts, there are many examples of individuals

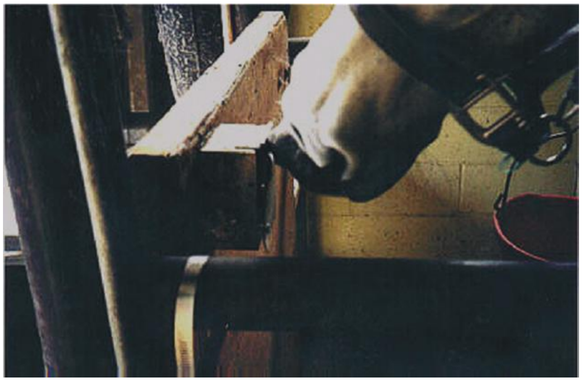

Figure 4.9 Horse performing an operant task: pressing a button with its muzzle. *(Photograph courtesy of Katherine Houpt.)*

acquiring a response to avoid an aversive outcome. Several studies suggest that lack of control over aversive events can bring about major behavioral and physiological changes. For example, after being exposed to uncontrollable electric shocks, rats have increased gastric ulceration, increased defecation rates and are more susceptible to certain cancers when compared with individuals that retain control over comparable shocks.

Operant devices can be used to determine the preference animals have for certain environmental parameters. Horses have been trained to break photoelectric beams to turn on lighting in their accommodation and, using this device, have demonstrated a preference for an illuminated environment.[48] Others have been trained to nuzzle buttons to access resources (Fig. 4.9).

Conditioned horses have been used to study the effects of psychotropic pharmaceuticals. In one example, horses were trained to interrupt a light beam for a reward of oats.[49] They developed their own individual response rates, which remained stable at between 5 and 35 responses per minute for each horse over a period of months. Reserpine (5 mg/ horse, i.v.) depressed the response rate in all horses tested. This depression was maximal between 3 and 5 days after treatment and lasted for up to 10 days. In part, the lasting nature of the drug accounts for its appeal to those seeking to modulate equine flight responses, especially during traditional breaking (2.5–10 mg s.i.d. or b.i.d. orally for up to 30 days[50]) (see also Ch. 3).

Training and behavior modification

Learning allows animals to use information about the world to tailor their responses to environmental change. By avoiding pain and discomfort, animals can make their life more pleasant. Even invertebrates such as flies, slugs and ants show impressive forms of learning when avoiding unpleasant stimuli. When animals cannot evade pain or aversive stimuli, they become distressed; but if this is chronic in nature, they develop learned helplessness and fail to make responses that were once appropriate.

We manipulate animals' experience to train them. Training generally means drawing out desirable behaviors and suppressing undesirable innate behaviors to institute novel responses.

In training horses we have exploited their need as prey animals to avoid discomfort and, for that matter, threats of discomfort.[37] Crudely speaking, we apply pressure to attain the desired response and remove it when we get the desired response. The aim of training is to install signals (cues) that result in predictable behavior patterns. When the association between pressure, response and timely release becomes highly predictable, a habit emerges. If a habit does not develop, it could be that the animal has learned that there is no response that can reliably cause the pressure to be released. This may reflect inconsistency on the part of trainers. Unfortunately, it is possible to identify many horses in all spheres of ridden and draft work that have developed such learned helplessness and are often labeled 'stubborn' (see Ch. 13).[51]

The ability of horses to learn is one reason humans find them useful and valuable.[47] The changing role of the horse demands a greater emphasis on humane treatment and the development of more sophisticated research into horse education.[45] In this context, veterinarians and equine scientists can play an important role as innovators countering traditional horse-lore that resists technological advances.[52]

Training naïve animals is generally preferable to training animals with inappropriate experience.[53] If an animal is pre-exposed to a conditioned stimulus for a number of trials before structured conditioning commences, i.e. before reinforcement, the acquisition of a conditioned response to that stimulus will be retarded. The animal has simply learned to ignore the stimulus because it has no important consequences.

With a sound grip on learning theory, all practitioners can apply therapeutic behavior modification programs that identify the motivation, remove the rewarding aspects of the unwelcome behavior and reinforce a more appropriate alternative. If the strategy does not work, one can be sure that training has been insufficient to establish the new associations or that the reinforcement for the new response is insufficient to overcome gratification from the existing behavior. Due consideration of equine ethology usually serves to explain failures of this sort. If the salience of a cue or the value of a reward is insufficient, no amount of training expertise will effect a desired response.

Training horses, whether under-saddle or in-hand, stabled or in the paddock, basic, advanced or remedial, usually involves operant principles. Before giving a reward, the trainer must wait until the animal produces or begins to produce the desired activity. Rewarding the desired behavior relates to the law of effect, which states that whatever behavior immediately precedes reinforcement will be strengthened.

Reinforcers and punishments

Be it positive or negative, reinforcement will always make a response more likely in future. Conversely, positive or negative punishment will generally make a response less likely in future (Table 4.2).

Both punishment and negative reinforcement can be applied as consequences of behavior and so are central to operant conditioning. Many trainers claim not to use negative reinforcement but are instead simply confused by a term that may have unpleasant connotations.[54] In this context, negative is used in the mathematical sense and refers to removing (subtracting) something from the animal's world. Similarly, positive refers to adding. So when trainers reinforce a behavior by removing something unpleasant, they make the behavior more likely in future. For example, if a trainer stops tapping a horse with a whip (see case study in Ch. 13) when it moves in the desired direction, he makes the horse more likely to move away from the whip when the tapping resumes, i.e. the 'move away' response has been negatively reinforced. 'Positive' and 'negative' when applied to reinforcement are not value judgements, as in 'good' or 'bad', but arithmetical descriptions of whether the behaviour is reinforced by having something added or something taken away, e.g. pressure (Fig. 4.10). For example, when

Table 4.2 Punishment versus reinforcement – effect of the treatment

Response becomes more likely in future	Response becomes less likely in future
Positive reinforcement – titbit reinforces begging	Positive punishment – applying tension on the rein increases discomfort in the mouth
Negative reinforcement – easing tension on the rein reduces discomfort in the mouth	Negative punishment – complete removal of food extinguishes begging

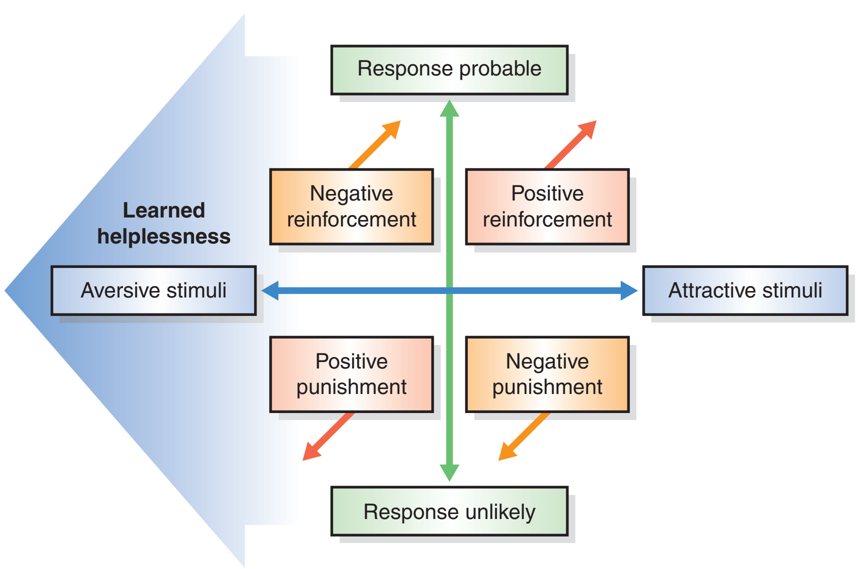

Figure 4.10 The likelihood of a horse in training offering a particular response is a result of the level of aversiveness or attractiveness of the stimulus. Within this structure lie all forms of reinforcement.

the horse responds to a turn signal and the rein pressure is immediately released, negative reinforcement has been applied.

Negative punishment or omission forms an important part of our attempts to improve or modify responses. Most readers will agree that a horse being encouraged to perform a new behavior in the *manège* will first attempt to use an established response. The absence of reinforcement at that point makes repetition of an unwanted established response less likely. If reinforcement has been omitted, the horse has been negatively punished. This forces any horse labeled as having either any talent or even a temper to try new solutions to its problem. An educated horse has learned that it can use a variety of responses to solve the problems presented by hand and leg signals. It is consistency in both the presentation of such problems and the provision of consequences that distinguishes good trainers.

In the interests of clarity, I encourage all trainers and animal educators to consider carefully their use of these terms. Punishment is not in itself a dirty word. Nor is negative. Both negative punishment and positive punishment can be extremely mild. That said, it is easier to resolve problem behaviors that reflect training errors in positive reinforcement than those that emerge from punishment.[55] The degree to which one relies on either reinforcers or punishers and the consistency with which one applies them are what matter to the animal.

Using reinforcers

A reinforcer is anything that increases the frequency of the particular behavior that it follows. A response will increase in strength when followed by a reward. The merit of a reinforcer can be measured only in terms of the degree to which it makes the behavior more likely in future. If a trainer's saying 'good boy' in response to a horse's leg-yielding has no effect on the horse's future behavior then, according to this definition, reinforcement has not occurred. The trainer's words have had a neutral or even confusing effect. The definition does not describe how or why some events act as reinforcers. Whether some event is called a reinforcer is purely a matter of the effect it had.

Consideration of the type of reinforcer is important. Discrimination performance in horses improves if there is a differential outcome in reward.[56] In a discrimination task where the color of the center panel signaled that either a left or a right lever response was correct, horses performed best when different reinforcers (food pellets for one lever; chopped carrot for the other) were linked with each lever, than when reinforcers were randomly assigned or identical.[56] Therefore *many* different contextual features associated with both stimuli and reinforcers can be integrated to maximize differentiation and thus enhance performance.[35] However, in ridden horse contexts, only a limited variety of reinforcement is available. This generally involves the removal or release of pressure.

Palatable foods are generally more reinforcing if they are not normally part of the horse's diet. Horses that have been exposed to these foods may perform with a higher level of consistency for this type of reinforcer. Because they can recognize these types of food as highly palatable and receive them infrequently, they seem more motivated to work for them. However, this is less effective in naïve horses because of neophobia (literally, fear of the new).

Significantly, horses work to avoid negative reinforcement, even when this interferes with their access to positive reinforcement.[35] In practical terms, this has meant that although such rewards appear frequently in experimental protocols, little attention has been paid to the merits of reinforcing desirable behavior under-saddle with positive reinforcers. The problem is that it is difficult to deliver food immediately after the horse offers a desirable response. Therefore devices that instantly deliver rewards to the mouth allow the time between performance of the desired behavior and its reinforcement to be minimized, effectively enhancing the speed of learning. Preliminary research into such devices has produced encouraging results.[57] That said, since the horse has evolved to stop moving when it finds pleasing food, such devices may not necessarily align well with ridden work since this relies more heavily on chains of locomotory rather than postural responses.[57]

Food is not the only reward that can be used. The other obvious one is water, when given to subjects that have been kept thirsty. For example, although questionable on humane grounds, this approach is acknowledged as one of many effective means of motivating a horse to enter a trailer.

Reinforcers can be either primary or secondary. Primary reinforcers are any resources that animals have evolved to seek. If the animal's motivation is correctly predicted, food, water, physical contact, sex, play, liberty, sanctuary and companionship can all be used as primary reinforcers. Secondary reinforcers are stimuli that are not intrinsically rewarding but that have become associated with the kind of primary resources listed above. These associations make great sense in evolutionary terms since an auditory, olfactory or visual cue that has become reliably linked with a primary reinforcer will hold an animal's interest much longer than a neutral stimulus.

Consider the way horses are often praised with tactile stimuli: they can either be scratched at the withers or patted on the neck. Horses have evolved to find grooming one another rewarding. Indeed, when horses indulge in the familiar 'I'll scratch your back if you scratch mine' occupation, reduced heart rates suggest that they may be gaining pleasure or stress reduction from the stimulation. So, a scratch on the correct part of the withers can represent a primary reinforcer. By comparison, the far more common practice of patting horses on the neck is reinforcing only if the owner has coupled the pat with something pleasant.[4] Because horses have not evolved to be motivated to behave in certain ways for pats on their necks, the intervention has to be conditioned as a secondary reinforcer (e.g. by patting immediately before feeding).

Reinforcement schedules

Until a behavior is firmly fixed as a conditioned behavioral response, the trainer must be consistent in applying signals and in granting rewards. If consistent reinforcement is not provided for correct responses, the horse's behavior becomes unpredictable. As we see in Chapter 13, this is especially important when using pressure/release pairings. Horses cannot be expected to learn well if exposed to delayed reinforcement, as they do not relate the reinforcement to the behavior. Immediate comfort or immediate relief from discomfort is what works for horses.

Once a behavior is consistently elicited as a conditioned response, it can be enhanced by means of a variable reward schedule. The desired behavior can then be rewarded unpredictably. It is also necessary to obtain the same results in multiple locations in order for the behavior to become generalized and for context specificity (see later) to be overcome. As will be discussed in Chapter 13 on Training, this step is sometimes labeled 'proof' (i.e. that the learning is no longer context specific).[58]

Myers and Mesker[59] showed that a horse could respond to different fixed-ratio positive reinforcement schedules (in which partial reinforcement is delivered on the basis of the number of correct responses made) and fixed-interval positive reinforcement schedules (in which reinforcement becomes available again only after some specified time has elapsed). They reported that few reinforcements were required under each new presentation schedule to get predictable response rates from the horse. Their results ranked horses' responses to the different reinforcement schedules as similar to the responses of tropical aquarium fish, guinea pigs and octopi.

Shaping behavior

Although Skinner's findings with his lever-pressing rats may seem to represent common sense, his school of thought has produced some intriguing principles. Perhaps one of the simplest yet most powerful of these is shaping. This is the concept of reinforcing successive approximations to the final (desired) response. The technique allows a trainer to move from a situation where it is impossible to reinforce a desired response (because that response never occurs) to one where the targeted response is occurring, being reinforced, and increasing in reliability. If trainers wish to reinforce particular responses, they can either wait for the behavior to occur spontaneously, which can be readily reinforced if the behavior occurs frequently, or they can shape the behavior pattern. In seeking to train complex behaviors or those that occur uncommonly in an animal, the trainer will usually opt to reinforce successive approximations of the final behavior (Fig. 4.11).

Crucially, shaping relies on sparing and grading the reinforcement so that the animal does not stagnate. So, for example, when training a horse to approach a target (in so-called target training) a reward is given only when the horse travels closer to the paddle or stick (or whatever is being used as a target) or does so with more speed than on previous occasions. A common characteristic among good trainers is their ability to recognize an opportunity to reinforce improved 'approximations'. While poorer trainers complain that their animals fail to understand what is being asked of them and feel that the animals have peaked in their training, superior trainers have the sense and patience to capitalize on each tiny improvement as the only way of moving toward the final response.

While shaping a new behavior or, for that matter, modifying an existing one, it is important to reward target behaviors as soon as they happen. Any delay in rewarding the improvement will lessen the effect of that reward. This may be because it allows the subject to perform another response during the delay interval and it is then potentially this response that is reinforced.

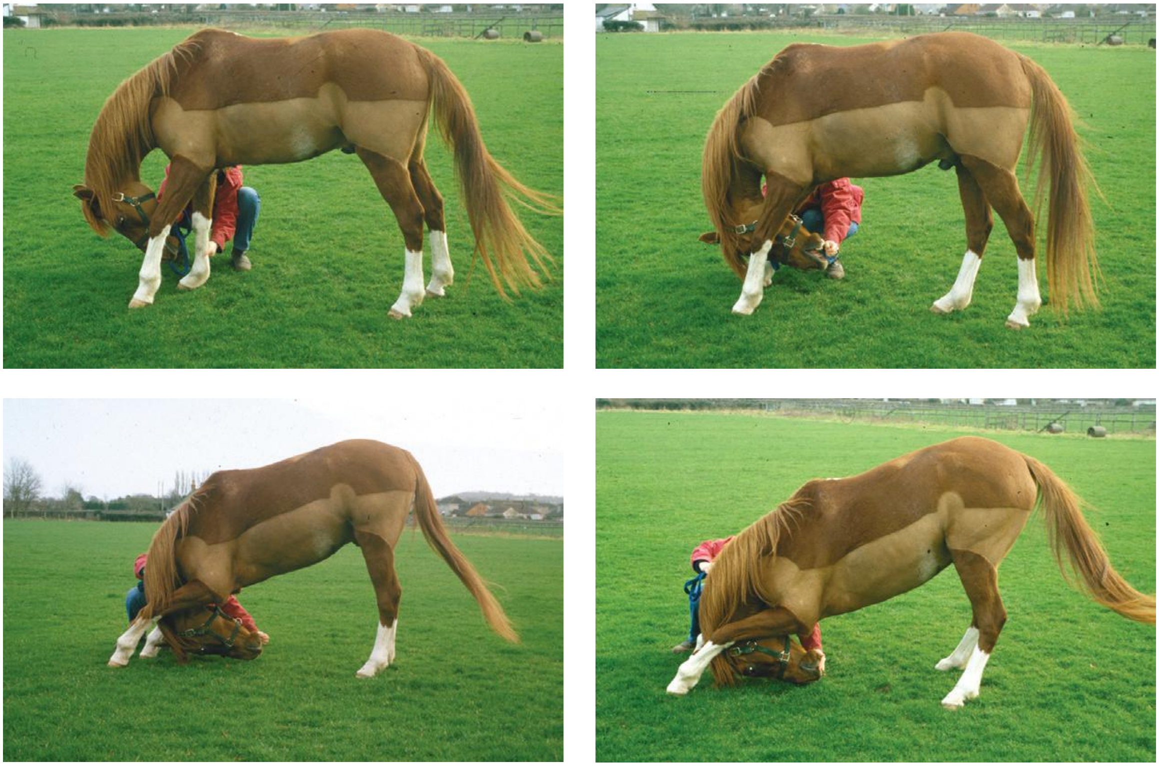

Figure 4.11 Arabian gelding being shaped to bow. Generally, at each successive iteration of the behavior, the reward is withheld until the horse shows an improvement on its previous best. *(Reproduced by permission of the University of Bristol, Department of Clinical Veterinary Science.)*

An example might be rewarding a horse for jumping a fence very cleanly by giving him a sugar cube. To administer the sugar while riding, you would have to bend forward and place it in front of the horse's mouth. Since this could not be achieved safely at speed, you would probably slow down or even halt. Instead of learning to jump ever more cleanly, the horse would predictably learn to slow down and halt, these being the behaviors closest to it receiving the reward.

Clicker training

Perhaps the most popular example of a secondary reinforcer is the sound made by a so-called 'clicker', the handy device used by thousands of trainers worldwide.[60] Clickers develop an association for the animal that allows the trainer to *bridge* the gap between the time at which an animal performs a response correctly and the arrival of a primary reinforcer (most commonly a food reward). Essentially the clicker comes to mean 'Yes, that's good – expect a reward any second now'. When a clicker is first used, the correct association is established by making the sound just before giving a delicious reward. Through classical conditioning repetition assures the animal of the signal's reliability.

As discussed in subsequent chapters, clicker training can be extremely helpful in remedial behavior modification. Moreover, after traditional negative reinforcement based conditioning has established desirable responses, clicker training is suitable for refining them (Fig. 4.12). The benefits of positive reinforcement as applied in clicker training should not be underestimated. There are many impressive accounts of successful clicker training, including the use of the device to train a sour dressage horse to work with its ears pricked forward. It would be interesting to examine the effect of such a cosmetically palliative approach on the physiological stress responses in such animals. If nothing else, clicker training may be more humane than traditional negative reinforcement training. With clicker training, 'what you click is what you get', therefore if your observations and timing are not perfect you will inadvertently shape some behaviors you do not want. So a trainer's poor timing can make

Figure 4.12 Pony being clicker trained to perform Spanish Walk.

clicker training ineffective. In contrast, poor timing in traditional negative reinforcement training can amount to abuse (see Ch. 13).

Any secondary reinforcer can be instituted in this way. The only significant feature of a commercial clicker device is that the sound it makes is sharp and distinctive. The brevity and clarity of a clicker facilitates precise reinforcement of brief behaviors, such as the bringing forward of the ears. Being pocket-sized or attachable to keyrings, clickers are convenient, but by no means unique. Indeed, as long as they cannot be confused with words that appear in common parlance, human vocalizations (so-called clicker words) are even more readily available. Some horses are fearful of the click per se and are therefore candidates for alternative secondary reinforcers such as a whistle. The use of clicker training principles for shaping and modifying unwanted behaviors, such as reluctance to load, merits serious consideration. By deconstructing a response into its constituent parts and rewarding the horse for successful completion of each, we can demonstrate to the horse that its fears of undertaking the complex behavior as a whole may have been unjustified.

Secondary reinforcers are most effectively established when presented before or up until the presentation of a primary reinforcer. Simultaneous presentation of a reward and a novel secondary stimulus is less likely to work because the primary reinforcer will block or overshadow the new stimulus. Similarly, presentation of the secondary stimulus *after* the primary reinforcer is unproductive, because although an association will exist between the two, it does not help the animal to predict the arrival of a reward.

The speed or strength of learning increases with the size and attractiveness of the reinforcer. This is why horses will learn to run faster to the sound of a rattling bucket than they will to the rustling of a haynet. Many horses respond well to carrots as the primary reinforcer in a clicker training protocol but only if carrots are not routinely offered in regular meals. The relationship between motivation and the reinforcing value of any food should be considered here. However, as we have seen, a degree of familiarity is altogether desirable since some horses will not work for novel foods regardless of their apparent suitability. So when selecting primary reinforcers, experienced trainers observe the horse's responses to determine the reinforcing value of a novel reward.

Horses show a rapid decline in interest in responding for the secondary reinforcer only, and the temporal link between primary and secondary reinforcers is also critical.[60] Thus the fundamental rules of learning theory apply, and trainers who build the firmest association between the primary and secondary reinforcers by ensuring that the 'clicker never lies' (i.e. it always predicts the arrival of a primary reinforcer) can most effectively shape desirable behaviors. The use of secondary reinforcement seems to increase a horse's interest in performing novel tasks,[60] and this creativity in the horse's approach to problem solving accounts for the growing appeal of clicker training in behavior modification programs, especially where traditional remedial approaches have failed (see Chs 13 and 15).

When shaping alternative responses, practitioners find that continuous reinforcement schedules rapidly increase the response rate of new behaviors.[60] However, once the behavior has been shaped and is under stimulus control (see below), intermittent reinforcement can be used (with a resultant increase in the resistance to extinction). That said, during intermittent reinforcement each click must be 'honored' with a reward since failure to do so weakens the reinforcing effect of the click.

Contiguity

The principle of contiguity states that temporally close events will become associated. Giving a sugar lump to a horse two minutes after a pat on the neck will not develop a useful association with the pat. The lump has to arrive within seconds of the pat if the latter is to become reinforcing. The time interval between stimuli is not necessarily the most important criterion in establishing an association. Events far apart in time can still be associated as long as there is a high predictive link between them. The best example of this is food aversion learning that helps animals to avoid food items that have previously made them ill. Novel flavors are more likely to be associated with later sickness and therefore the horses may be alert to this possibility when they consume novel foods.

Operant conditioning has been used to indicate the behavioral effects of drugs. Since the reward is usually food, a decrease in the rate of responding suggests that the drug administered is either a depressant or an anorexic agent. Food aversion learning has also been used by scientists interested in the consequences of proprietary drugs on horse welfare. The aversive effect of drugs can be calibrated by the degree to which food associated with it is subsequently avoided.

Punishment

Horses can learn from both unpleasant and pleasant experiences. Haag et al[61] found that there was significant correlation between a pony's rank in learning ability to navigate through a maze for a food reward and its rank in learning ability to avoid mild electric shocks. When shocks are used to teach a horse how to navigate through a maze, subjects take significantly longer to make their choices than horses who were not punished and simply found their way through by trial-and-error. So punishment can stifle creativity and impede a horse's innate problem-solving skills.[55] One should bear this phenomenon in mind when horses that are familiar with human handlers are asked to solve problems in the presence of humans. It is possible that horses have learned that it is best not to offer creative solutions to problems since this can lead to punishment.

Punishment decreases the likelihood that a behavior will be repeated. Positive punishments are those that are instinctively recognized by the horse as detrimental. For example, a horse that bites at a human's arm and in doing so impacts on a spiky object concealed in the sleeve, experiences a positive punishment that is clearly linked to the unacceptable action. Negative punishments involve the removal of desired things in response to particular behaviors. In free-ranging adult horses, resources are rarely withdrawn as a result of an individual's behavior. This may be why negative punishment is not an important feature of equestrianism. The chain of association between events is weaker if the events involve removal of consequences. That said, it is worth noting an interesting example of negative punishment when unbridling a horse after work. Most horses relish a head massage when the bridle is removed. Indeed some learn to rub their head against the nearest human even before the bridle is removed. This is annoying and can be dangerous for personnel. To meet the horse's needs for cutaneous comfort on one's own terms it is possible to negatively punish a horse for head rubbing. This simply involves massaging its head only when it is still. If the horse moves its head, the pleasurable massage stops immediately. Most horses rapidly learn to remain perfectly still under such conditions.

Negative reinforcement involves the conditioning of preceding signals that predict the potentially aversive stimulus. Punishment, on the other hand, is more complex in that it represents a form of backward chaining because any signaling of the aversive stimulus is either absent or follows the undesirable behavior. Trainers who use punishment to eliminate undesirable behavior must ensure that the wrong association is not created. The unthinking rider who thrashes a horse for knocking down a fence runs the risk of associating fence jumping, be it clean or sloppy, with being hit. Rather than correctly associating a painful consequence with the undesirable behavior, many animals learn to fear the trainer or the training area (Fig. 4.13).

Despite some of the problems that are associated with the use of punishers, they remain popular. Free-ranging equids communicate with their companions using mild aggression and reliable threats of aggression. This may

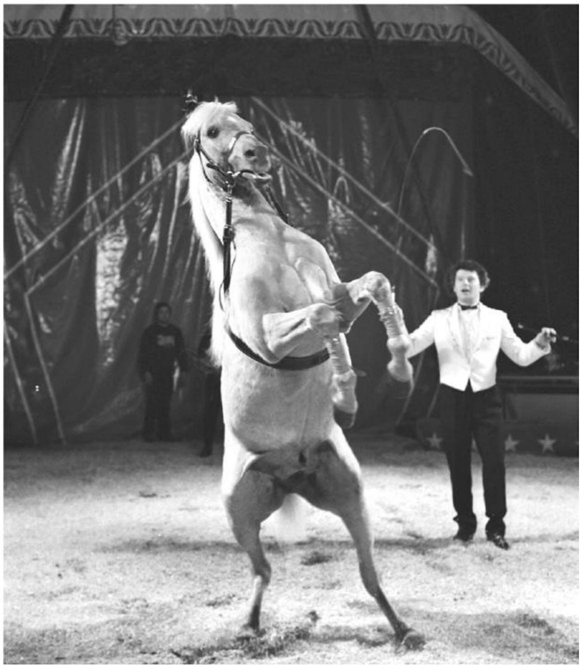

Figure 4.13 Horses can be taught that the only means of escaping aversive stimuli (the whip) is to rear. Discomfort is apparent on the face of this animal as the tight side reins thwart his attempts to balance on his hindlegs. *(Reproduced with permission of the Captive Animals Protection Society.)*

make horses innately tolerant of such negative stimuli but is no excuse for physical abuse by humans.

The punishment procedure makes the onset of an aversive stimulus contingent on a particular response. The punishment procedure may or may not lead to a reduction in the response. The situation is complicated because the punishing stimulus also elicits other responses that may actually increase the performance of the 'punished response'. Whipping a horse for bolting will usually serve to rocket it forth once more. Bit pressure is usually increased prior to such whippings and with discomfort in both the mouth and on the flank, the horse enters a conflict situation (see Ch. 13).

Presentation of aversive stimuli will usually produce an overall suppression of behavior in general. Therefore, a reduction in performing a response may have nothing to do with the specific link between the response and the 'punishing' stimulus. So, in beaten horses, confusion and flight responses are more common than useful learned associations.

The effectiveness of punishments is limited by a number of other factors, including punishment intensity. The more motivated an animal is to perform an action, the greater the intensity of the punishment required to stop it.

Warnings of punishment could be useful, just as clickers are predictors of reinforcement. Therefore it seems likely that both horses and riders could benefit from a device that warns them of imminent rein pressure. There is evidence that horses can learn to take evasive action when they hear noises that warn of aversive stimuli. Early data suggest that reins that stretch and make a noise before reaching the limit of their elasticity and causing discomfort in the mouth are good for horse welfare and indeed rider education.

Contingency

Contingency is the temporal relationship, or correlation, between two repeated events or between repeated responses and reinforcers. It describes the extent to which two events are related, ranging from complete consistency – so that if one event occurs then the other will follow, even if after a considerable time – through completely independent, to a consistent negative relationship where the occurrence of one event indicates the non-occurrence of the other. Contiguity is the closeness of two events in space or time. Contiguity and contingency should not be confused with one another. Most forms of conditioning, except perhaps taste aversion learning (see later), require both contingency (relatedness) and contiguity (closeness in time) between two events (in the case of classical conditioning) or between a response and a reinforcer (in the case of operant conditioning).

As indicated above, it is possible for there to be a very strong contingency between two events that do not occur close together in time. Conversely two events can sometimes occur close together in time but overall there can be a weak or zero contingency between them (independence). In many ways one can think of contingencies as consistent links between events that transcend time. Again, effective training requires that both contiguity and contingency are applied.

The contingency between the response of the horse and its subsequent reinforcement relies on an attentive trainer. To use clicker training as an example: effective linkage of the primary and secondary reinforcers relies on the arrival of a primary reinforcer being contingent on the sound of a click but, as we have seen, contingency varies with the consistency of the training method. Contingency reaches 100% when the 'clicker never lies'. If a food reward arrives without a click or the clicker is sounded without the subsequent arrival of food then the contingency is weakened.

Generalization and discrimination

Pavlov found that almost any stimulus could act as a conditioned stimulus provided it did not produce too strong a response of its own. In very hungry dogs, even painful stimuli such as electric shocks delivered to the paws, which initially caused flinching and distress, quite soon evoked salivation if paired with food.

A colored board in front of Pavlov's dogs could be used to present visual images with an infinite variety of colors and shapes. Pavlov carried out exhaustive tests using this apparatus and a variety of tactile, visual or auditory stimuli. He found that if a dog was conditioned to salivate when a pure tone of perhaps 800 Hz was sounded, it would also salivate but to a lesser extent when other tones were given. This is now known as generalization. The dog generalized its responses to include stimuli similar to the conditioned one, and the more similar they were the more the dog salivated.

Generalization

Stimulus generalization occurs when a response reinforced in the presence of one stimulus is also elicited by similar stimuli. For example, a horse might be trained to nudge an orange panel for a reward. If the color of the panel is changed to yellow the horse will still nudge, though possibly at a lower rate. We capitalize on stimulus generalization when we use mature educated horses (so-called schoolmasters) to educate novice riders. The horse generalizes the rider's cues to others it remembers from previous, preferably better, riders and obligingly executes the required maneuver. Generalization is at play when horses learn to offer the same responses that they have developed in the home schooling *manège* to, say, a dressage arena at a competition. This demonstrates that the trained maneuvers are not context specific to the stimuli that surrounded the animal during its early learning at home. Barrier trials in racing are useful in a similar fashion since they give young racehorses the opportunity to transfer appropriate responses from starting stalls at the training center to starting stalls in general.

Stimulus generalization works against us when we encounter horses that 'hate vets'. Such animals have learned to generalize the stimuli from one human wearing veterinary smells and bearing needles to all humans that meet the same criteria. But by recognizing and mimicking the stimuli horses use to identify vets and making appropriate associations with them, owners can train horses to tolerate and even enjoy vets.

Discrimination

The opposite process to generalization is discrimination. Horses naturally discriminate to some extent, otherwise they would respond equally to all stimuli. Discrimination can be accelerated if, as well as rewarding the right stimuli, the horse is slightly punished when it responds to others. This is called conditioned discrimination and has been of enormous benefit in working out the sensory capabilities of animals (see the case study of Rascal performing a visual discrimination task in Ch. 2).

Commands used to cue a behavior can be the product of discrimination. When a horse learns that certain cues set the stage for a specific response, the cues (i.e. the commands, signals or aids) are labeled discriminative stimuli. The horse is said to be under stimulus control when it always responds to the specific cue and does not offer the response until or unless it has been cued. By rewarding horses for responding appropriately to stimuli that are less and less obvious, we can foster the power to discriminate between the stimuli that are rewarded and all other background information that would otherwise prevail. Discrimination is what allows us to train dogs to detect drugs, pigs to locate truffles and chickens to identify images of familiar feathered friends. A similar process is at play when we train horses to respond to smaller and smaller cues in training. To obey a trainer's leg signal to pirouette, a horse must first be persuaded to rotate on a much larger surface with the use of much less subtle stimuli. All horses can learn to discriminate. Unfortunately, however, only the good trainers learn to deliver cues with sufficient subtlety to capitalize on this ability.

Whether positive or negative, reinforcers are effective only if the recipient is motivated appropriately. Relative to normal or fat horses, those in poor body condition may make horses be less likely to err in discrimination tasks for food rewards.[62] Rather than true learning ability differences, this seems to reflect the lack of motivation in replete horses.

Although the only data available are from experiments using stimuli such as cards and panels that are arguably less salient to horses than, say, grazing-related stimuli, the ability of horses to discriminate is impressive (e.g. see Sappington & Goldman[63]). It appears that, although horses can learn complex discrimination

Table 4.3 Hierarchy of learning abilities

Level	Learning
1. Habituation	Learning not to respond to a repeated stimulus that has no consequences
2. Classical conditioning	Making responses to a new stimulus that has been repeatedly paired with an established effective stimulus
3. Operant conditioning	Learning to repeat a voluntary response for reinforcement or not to repeat a voluntary response to avoid punishment
4. Chaining responses	Learning a sequence of responses to obtain a reinforcement at the end of the sequence
5. Concurrent discriminations	Learning to make an operant response to only one set of stimuli from more than one set of stimuli applied concurrently
6. Concept learning	Discrimination learning based on some common characteristic shared by a number of stimuli
7. Conjunctive, disjunctive and conditional concepts	Learning of concepts that emerge from the relationship between stimuli such as 'A and B' (conjunctive), 'A or B' (disjunctive), and 'If A, then B' (conditional)
8. Biconditional concepts	Logical reasoning, such as 'Option A is likely' if and only if 'Option B is present'

Adapted from Thomas 1986[67] and Murphy & Arkins 2007.[68]

problems based on sameness,[64] we have yet to show that they can generalize this learning to situations involving novel stimulus presentation.[35]

While stimuli that have become generalized may be ignored, those that are enhanced are more likely to elicit a response. Stimulus enhancement describes the process by which an animal's attention can be drawn toward a given stimulus and increase the animal's motivation to approach the stimulus.[65] For example, the sound of a rattling bucket will prompt experienced horses to approach the bucket and eat.

As with all species, learning in the horse reflects core survival requirements. Scientists generally discuss issues of cognition, learning and memory without using the term intelligence.[66] So, leaving intelligence aside, the complexity of learning is captured by a hierarchy of learning abilities from habituation to conceptualisation (Table 4.3).

As mammals, horses have brain characteristics that suggest their learning mechanisms may be similar to those of humans (see Ch. 3). Like humans, horses are proficient at trial-and-error learning (learning to perform a reaction through reward), classical conditioning (learning associations between events) and habituation (learning to ignore aversive stimuli that do not hurt). Beyond these basic learning mechanisms, horses can also generalize stimuli, and can even categorize objects based on similar physical characteristics.[69] That said, cognitive research has yet to produce empirical evidence that horses can develop abstract concepts.[70] Indeed, there is no peer-reviewed published evidence that horses possess significant higher mental abilities beyond generalizing and categorizing (level 5 in Table 4.3). Attributing human cognitive powers to horses is a double-edged sword. It may appear to honor horses' minds, but it inadvertently excuses violence in training since a horse that thinks as we do must surely know what we want it to do and can reason why it is being punished. Without downplaying the unique features of equine intelligence, scientists look for the most parsimonious explanations of phenomena. What horse people may regard as examples of reasoning in their horses usually turn out to be trial-and-error learning. The pony that fiddles with the gate latch and learns to open it is a typical example. It is clever, but it is not an example of reasoning.

Extinction

Extinction occurs if the learned response occurs but is no longer followed by reinforcement or if a conditioned stimulus (such as a clicker) is always presented without the unconditioned stimulus (such as the reward). The effect of these procedures is an eventual reduction in response strength, as measured, for example, in rate of response. If horses do not get their expected rewards, they are less likely to behave in ways that have previously paid off. The behaviors drop out and extinction is said to have taken place. This is what happens when horses that nip and nuzzle humans for food stop doing so because they are never rewarded. Often extinction is accompanied by not simply an absence of the learned responses but a reversion to innate behaviors. Occasionally animals may experiment at this point by adopting sequences of other learned behaviors in an attempt to acquire rewards. Where possible, practitioners should plan ahead to determine which of these should be reinforced.

Because extinction does not occur in a vacuum, context-specific stimuli that were present during learning of the unwelcome response can retard extinction. This explains why behavior-modification programs that advocate removal of perceived rewards work best if imposed at the same time as a fundamental environmental shift such as a change of stable.

Frustration effect

There are some intriguing outcomes associated with extinction. Early in extinction it is usual for a so-called 'frustration effect' to occur. This describes the way responses usually get transiently more frequent before they disappear. For example, rather like a human repeatedly pressing the 'on' switch of a faulty television set, a horse that has superstitiously learned to kick the stable door to get food will kick it harder if the food delivery is delayed. One theory proposes that the subject responds faster because it is 'frustrated'. To avoid misinterpreting an extinction-based behavior-modification program as a failure, it is important for therapists to be aware that the frustration effect occurs.

Spontaneous recovery

Presentation of the conditioned stimulus alone causes extinction. Extinction can apply to any behavior that occurs and is no longer reinforced. Both welcome and unwelcome behavioral responses will weaken in the absence of reinforcement. If, after extinction has been completed, the animal is given a break from training and then presented with the conditioned stimulus again, the previously extinguished response may suddenly reappear.[41] This transient rebound in response strength after a 'rest', following extinction, is called spontaneous recovery. This possibility is sometimes overlooked in behavior therapy designed to eliminate unwelcome behaviors by extinction. If an undesirable behavior makes a return, personnel may forget the strength of the original response when they compare current behavior with previous behavior. So, when the response recurs after a long absence, the owner's conclusion may be slightly damning with remarks like 'the removal of rewards hasn't helped' or 'the animal has regressed'. In fact, this is the typical pattern found in extinction. This is particularly important with originally fearful responses that have been modified by counter-conditioning because these responses can show spontaneous recovery if reinforcement is withheld. To prevent the original fearful response recurring, the trainer must continue to expose the animal to the relevant stimuli from time to time.

Memory

Memory is the retention or storage of information and therefore the basis for all higher forms of learning. The laying down of memory traces is considered to occur in stages, but can be thought of as a continuum. Fraser[71] rather boldly suggests that the length of time an animal can remember a specific signal of training or command can be taken as some measure of intelligence. However, horses that learn a task most readily are not necessarily those that have the best memories.[7]

Sensory memory refers to memory traces formed within the sensory areas of the CNS (see Ch. 3) whenever any sensory receptor is activated. It has been estimated that only about 2% of sensory input is ever committed to permanent memory. For input to pass from sensory memory to short-term memory there must be some kind of response to the experience. The trace is more likely to be stored if the experience was bad (the speed with which horses learn to avoid electric fences is pertinent here). Animals under the influence of sedatives, tranquilizers, etc. have their sensory experiences dulled and therefore have great problems remembering new experiences. Veterinarians do well to remember this before they prescribe psychoactive drugs for behavior modification. This explains the poor results obtained when horses that are fearful of, say, clippers are treated with acepromazine or detomidine: they show no attenuation of the fear response when presented with clippers after the effects of the sedative have worn off. Similarly, studies on the effect of reserpine on unhandled yearlings[72] suggest that the attenuating effect it has on heart rate response to the presence of handlers is transient. This is state-dependent memory. There is also place-dependent memory, which is considerable in horses. When teaching a young horse a new response it is useful to go back to the same spot in the arena to rehearse it. Because confusion often prevails when an animal is in a highly emotional state, an upset and anxious horse does not learn desired responses as well as a calm subject. Hence classical riders advocate the practice of the systematic elimination of resistance. This approach requires that the horse must be calm before being cued to perform. After stress, conflict or confusion during training, the good trainer waits for the calm to return before resuming work. Even though classical riders often apply very subtle pressure-based stimuli, one can see how the return of calm would be less elusive if one were using positive reinforcement.

We know that primary memory involves continuous neural activity because if anything interrupts the activity (for example, a blow to the head, drugs, an unexpected interruption) then the short-term memory trace is lost. Short-term memory appears to have a temporal sequence, so what goes in first will be replaced by later inputs if the memory is not repeated (learned). This repetition is essential for pushing the memory into the long-term stage. The mechanism for the long-term storage of memory traces is thought to be biochemical. Being physical, they do not depend on sustained neural activity. Specifically, long-term memory depends on alteration in gene expression, which influences the formation of either persistent proteins or nerve growth factor.

There are many impressive accounts, anecdotal and scientific, of the resilience of equine memory traces.[3,38,73,74] An established means of testing memory in equids is to offer 20 pairs of patterns (Fig. 4.14). The horse is taught that regardless of its position, one of each pair will always yield a food reward when pressed. Deterioration depends on the extent to which horses are taught new associations and perhaps new apparatus in the interim, but the reported frequency of correct choices when the same apparatus is presented after 6 months is approximately 85%. Horses and ponies compare well with donkeys and elephants using this experimental paradigm.[75]

An interesting phenomenon is the effect of a period without conditioning, because the temporal distribution of training trials influences equine learning abilities.[76] While this is challenged by data showing that horses learn more quickly and make fewer errors if they are trained daily,[77] it accounts for the reported effectiveness

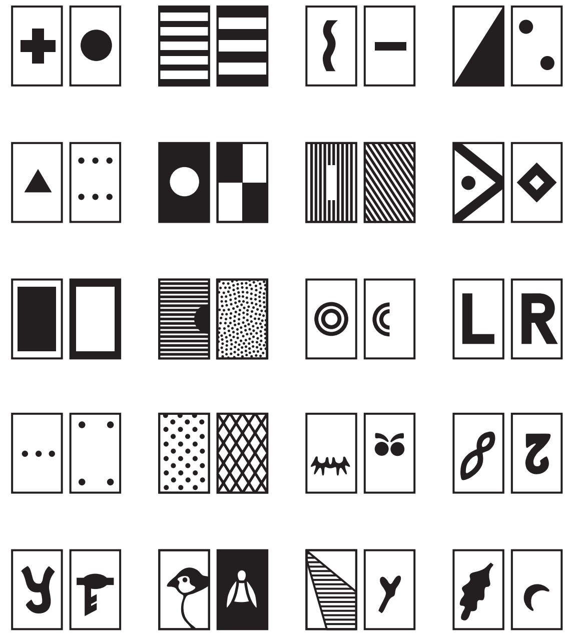

Figure 4.14 Twenty pairs of patterns used for equine memory tests, including those by Dixon[73] and Voith.[74] To obtain food the horse had to select the patterns that appear on the left of each pair in this illustration.

and popularity of turn-out or spelling periods during the early education of horses, even though plausible mechanisms have yet to be investigated.

The robust nature of equine memory helps to explain the poor performance of horses in discrimination reversal tests[5,47] in which, for example, a turn to the left is reinforced for a given number of trials and then the reverse, a turn to the right, is required.

Additional topics in equine learning

As we begin to appreciate the complexities of studying equine learning scientifically, the role of cognition in adaptive behavior is becoming clearer.

Learning sets

Horses learning to use experimental apparatus, such as in the pairs discrimination tests in Figure 4.14, often take time to grasp the challenge of discriminating between operant panels. Once they have established the learning set, their responses become more rapid and accurate. Such horses are described as having learned to learn. When they build on a basic groundwork and then begin training more high school maneuvers, dressage trainers report a similar phenomenon. That is, having reached a certain understanding about what is being asked of them, educated horses learn to pay attention to yet finer stimuli and climb a steep learning curve that takes them to Grand Prix level.

Insight versus simple learning

Using insight, an animal can arrive at a solution without trial and error. The possibility of such complex learning has to be approached with caution since apparently complex patterns of learning can often be explained in terms of simple associative learning. Take, for example, the story of Clever Hans, a horse that lived in Austria in the 1900s.[78] Hailed as an equine arithmetic genius, Hans appeared to be able to count and do basic algebra. When set any puzzle with a number as its answer, Hans would begin to count out the solution with his hoof. He would never tap too many times; always stopping at the right number. This looked like complex learning and was the subject of detailed scientific scrutiny. His owner, Baron von Osten, was justifiably proud of him and their fame spread. They were fêted far and wide until a panel of scientists assembled to determine the status of the horse's IQ. By placing a screen between the horse and any observers, they found his accuracy was entirely dependent on being able to see his audience. A question was posed and the counting commenced. The answer was reached and the counting continued. On and on it went because the horse had received no cue to stop. Hans had learned that he would be rewarded if his foot movements stopped when he detected subtle behavioral changes in human observers. These cues reliably emerged whenever he was set a problem and, of course, they always coincided with the human's anticipation of the arrival of the right answer. It is believed that von Osten leaned forward as Hans approached the correct number and adopted a more upright posture when it had been reached. Furthermore it is thought that his brimmed hat (Fig. 4.15) helped to accentuate this visual cue. In addition, maybe the observers smiled, grimaced, braced themselves or changed their breathing patterns. Whatever they did constituted a sufficient cue for the horse to stop counting.

So, rather than complex learning, simple associative learning could explain the illusion. Hans was responding to tiny physical changes in the behavior of his trainer and observers as they became more tense and anxious that he was about to count too many times and disappoint them. He was declared a fraud even though he was in fact a brilliant judge of minute detail who had trained himself to spot these cues and earn rewards. This should serve as testament to visual acuity in the horse and remind us of the central importance of consistent body language when handling and training horses. The same principle has subsequently been used many times in entertainment to give the illusion of such unlikely academic brilliance.

Maze tests

Maze tests have been used extensively to measure the learning ability of animals. These typically involve a T-maze, in which an animal is presented with a choice to go left or right; the wrong choice runs into a dead end, the correct choice to an exit to food, water or an area with other animals (Fig. 4.16).[79] Mazes have merit because they allow the animal to demonstrate its ability without human presence and thus avoid the Clever Hans effect. The absence of humans helps to eliminate other operator effects in horses, especially those that have been previously handled. It is worth noting, however, that the absence of humans is far from absolute in maze studies since they have to lead the horse to the starting point in the maze and retrieve it at the end point. It is important, therefore, to establish baseline results for each individual in an attempt to control for horses that, for example, may prefer not to be left or those that dislike being caught.

Differences between types of horses in maze-learning ability are intriguing. Foals learned which way to turn in a maze in fewer trials than their dams,[80] and adult horses were particularly slow to learn a reversal, i.e. turning right after learning to turn left. Houpt et al[80] investigated how a foal's early experience with its dam could influence its learning ability. Using a single-choice maze, they compared the learning abilities of foals raised with their dams with those of orphan foals. Although the orphan foals spent more time in the maze during their first exposure to it, the learning abilities of the two groups did not differ.

Previously unhandled and extensively handled horses learned less quickly in a maze than moderately handled horses.[53] This may have been because the previously unhandled horses were still adjusting to being handled, and the extensively handled horses were dependent on human contact to show them the way. In contrast Marinier & Alexander[3] found no correlation between horses' abilities to learn a maze and the extent to which

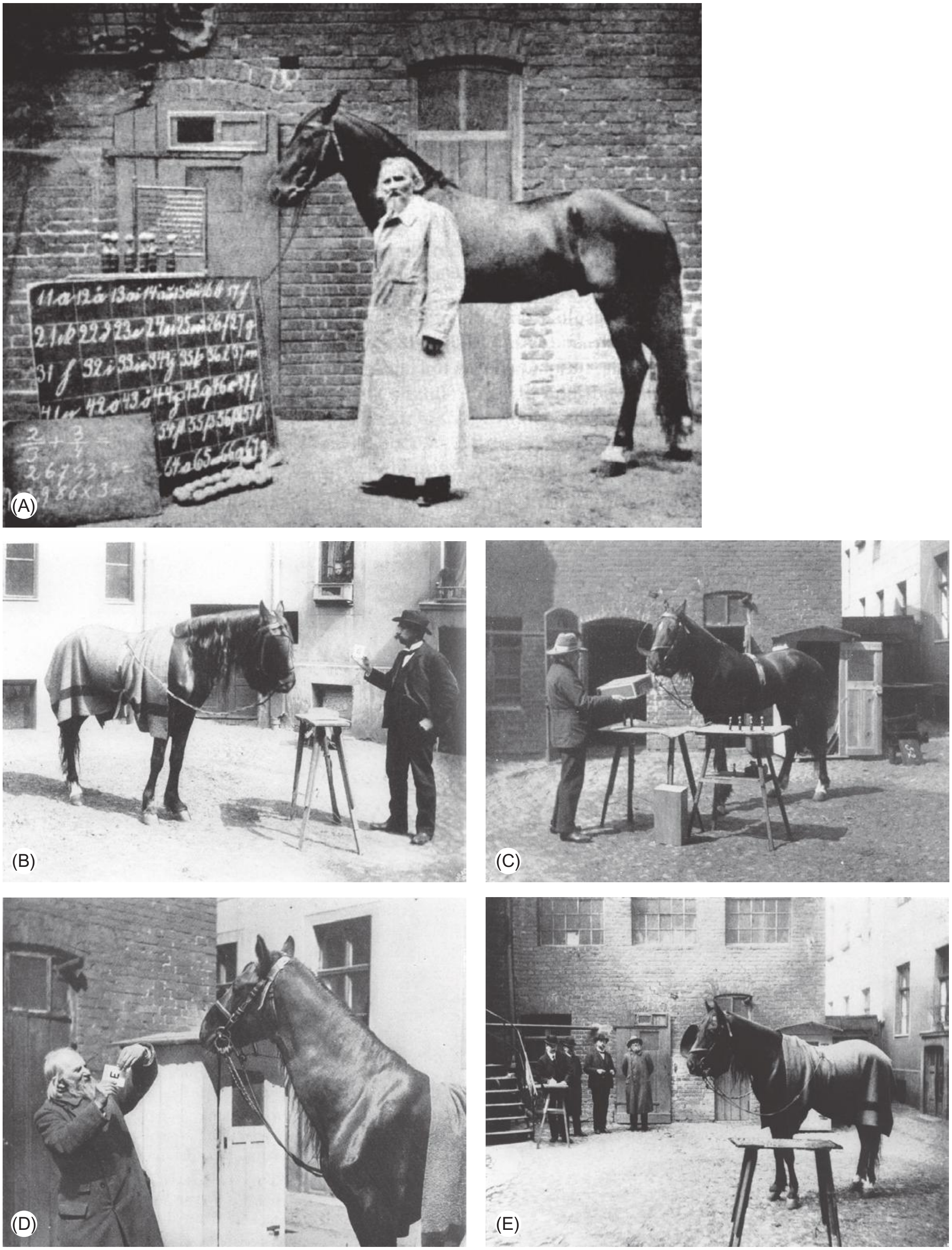

Figure 4.15 (A) Clever Hans and Baron von Osten. (B–E) Clever Hans undertaking a series of tests intended to demonstrate problem solving without trial-and-error. *(Reproduced with permission from Pfungst.*[78]*)*

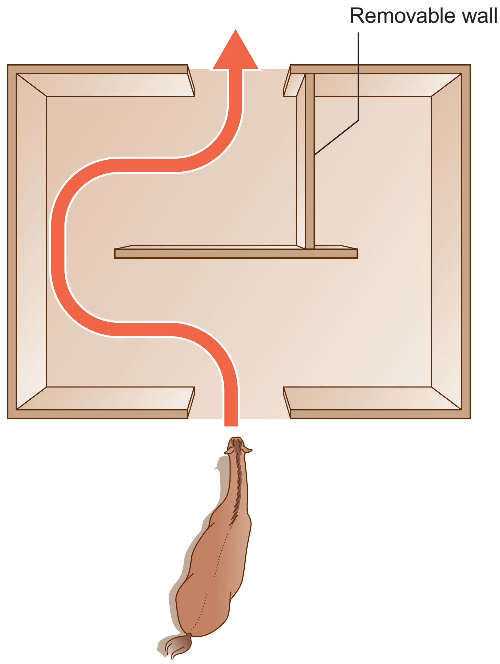

Figure 4.16 A horse about to enter a T-maze. *(© Stephen Budiansky. Redrawn, with permission, from Budiansky.[79])*

they had been handled earlier. Maze studies suggest that a social rank does not predict problem-solving ability. A study of artificially reared and naturally reared foals[81] that showed the latter group to take longer to solve a maze problem, alluded to the role of dependence on a leader. Perhaps we have yet to recognize the role of bonded pairs in problem-solving situations relevant to free-ranging equids. Other explanations for differences in learning ability in a maze also include the motivation for the reward and inhibition resulting from nervousness.

Many horses begin maze trials with a clear preference for one side or the other. An example comes from Kratzer et al[47] who allowed 37 yearling geldings, fed diets with a range of protein contents, to wander through a T-maze on a daily basis. At the beginning of the experiment when the horses were allowed to freely walk through the maze five times with both exits open, 5 of the 37 horses chose the right side every time, and 5 chose the left side every time. For the next 5 days, the right side was open and the left side was blocked. Therefore horses with a left preference had to return to the bifurcation before completing their trip through the maze. Although on the fifth day of the experiment the mean number of wrong turns per trial fell from 0.65 to 0.27, about 20% of the youngsters still turned left as their initial choice on entering the maze.

Figure 4.17 The relevance of a bucket to a naïve horse may be enhanced by observation of feeding.

Social learning

The transmission of new information and behavioral strategies among animals is slowly becoming more clearly understood. When we consider the transfer of information between animals it is important to distinguish between social facilitation, stimulus enhancement and true cultural transmission. In social facilitation, innate behaviors are initiated or increased in rate or frequency by the presence of another animal carrying out those behaviors. Horses, for example, are more likely to drink when they see others drinking. Stimulus enhancement is the ethological term that describes the ability of one animal (the so-called demonstrator) to draw the attention of another animal (the observer) to the location of reinforcement opportunity rather than an activity per se. These hard-wired copying responses commonly found in social animals are distinct from true cultural transmission, which is considered a higher mental ability and describes the observational learning of a novel behavior without trial-and-error experience.

This is taking us into the realms of what is known as observational learning and allelomimetic behavior. In laboratory settings, a variety of species, including chickens, grey parrots, quails, ravens, cats, octopi and chimpanzees, have been shown to pass information about foraging strategies from one individual to another. It makes sense for offspring to learn from their parents and for social animals to learn from one another, for example, about what food is safe to consume (see Ch. 8).

As social animals with excellent vision, one would predict that horses would use observations to improve their biological fitness (Fig. 4.17). It makes sense that animals that conform to a form of social order should

Figure 4.18 Schoolmasters can be hitched with youngsters to assist in the training of draft horses. *(Photograph courtesy of Les Holmes.)*

be able to learn from pre-trained conspecifics; for example, young farm horses were traditionally harnessed alongside a steady mature plough horse to be taught verbal driving commands (Fig. 4.18). But this is associative and not necessarily observational learning. While horses seem good at hard-wired copying, the empirical evidence of true cultural transmission is rather scarce. Controlled studies in the horse have provided some evidence that stimulus enhancement may result from the behavior of demonstrator horses as they approach and interact with experimental apparatus that delivers food (Fig. 4.19).[82] However, they have failed to demonstrate that observational learning enhances an individual's ability to perform an operant task[57] or make a choice between two feeding sites.[82] As such they have generally challenged the notion that stereotypies can be acquired by mimicry.

Studies in other species demonstrate that animals do not observe all conspecifics with the same enthusiasm. It may be that we have failed to ask the right questions of horses that are appropriately related in terms of rank, kinship or affiliation to demonstrators. There are likely to be serious limitations on what can be learned by observation. However, there is some evidence that learning to follow a human can develop through observation and that relative social rank affects the way observer horses may learn this from potential demonstrator horses,[83] higher-ranking horses offering a more compelling model than equally familiar but lower-ranking conspecifics (the challenges of defining and measuring relative social rank are explored in the next chapter).

Figure 4.19 Results of tests of observational learning in horses have proved disappointing when compared with those for other domestic species. *(Reproduced by permission of the University of Bristol, Department of Clinical Veterinary Science.)*

Feeding behaviors are more likely to be transmitted than those such as maintenance behaviors with less obvious proximate advantages to the performer. Glibly, one might add that if horses learned to respond to riders by observing other horses being ridden, dressage arenas would most surely have been constructed with gallery-style stabling all around them.

Future studies on social learning should focus on the role of the dam as tutor to her foal because vertical transmission of information seems the most likely form of observational learning in a social species. Houpt et al[80] reported no evidence of foals learning a spatial task from their dams. However, foals that were exposed in the first 5 days of life to humans as they groomed and fed their mothers during a short period (total of 1.25 h) approached and initiated physical interactions with humans sooner than those subjected to forced handling that included imprinting and haltering.[28] Studies of this sort may help us to explore how we provide cooperative teaching to equine subjects, e.g. by interacting with relevant objects verbally.[84] The importance of pursuing this line of enquiry lies chiefly in the notion that any training program or technique instituted by humans could be improved by incorporating appropriate elements of the horse's highly developed social behavioral and learning repertoire and that, fundamentally, social learning may operate quite differently from mainstream learning theory.[85]

Obedience trainers report that motivation is enhanced in dogs that are allowed to observe others working with their trainer. This reflects dogs' motivation to play (part of the so-called 'will to please') and the increasing use of rewards, especially toys, in their training. Although the opportunity to observe has little effect on the dogs' ability to complete a task, it certainly seems to enhance their desire to get involved. The equivalent in horses will continue to elude us as long as we persist in using only negative reinforcement. The laudable use of educated horses in training novices to jump is sadly flawed as an example of effective use of observational learning in horse-training, because it relies on the youngsters' motivation to follow (other horses) rather than to jump per se.

Error-free learning

In operant-conditioning, the most humane exposure of an animal to correction seems to arise in so-called error-free learning, in which circumstances are modified to reduce the chances of errors being offered. For example, in training horses to jump obstacles, a jumping lane can be used to instill the behavior pattern of negotiating the obstacle without testing the opportunities for evasion and acquiring inappropriate responses. Unfortunately, arranging schooling sessions so that opportunities for errors do not arise is far easier said than done. Given this reality and the likelihood that horses are learning all the time, it pays to bear in mind the following maxim:

Just because you don't intend to teach a horse something doesn't mean that you won't; and just because you are not aware of having taught a horse something doesn't mean that you didn't.[86]

Influences on learning

Breed differences in normal behavior

When the learning ability of different breeds is compared we do well to consider breed differences in perception and normal behavior that may create a bias. While many of the behavioral differences among breeds reflect the uses for which they have been bred[87] (see Table 1.2 on p. 8), the origins of others are rather more obscure. For example, Icelandic horses are said to have a particularly good homing instinct, though it is not clear whether they have advanced skills or a heightened motivation to return to their home range.

Bagshaw et al[88] reported a breed effect of an oral dose of L-tryptophan on horses' reactions to 15 minutes of acute isolation stress. Arabians were more active and vocalized more in isolation compared with Standardbreds. This study also showed that the Arabian had lower resting serotonin concentrations than the Standardbreds and that Arabians on a separate farm had lower serotonin than 10 Swedish Warmbloods fed the same feed and housed under the same conditions.[88]

If we assume that all horses are equally able to deliver signals from within the equine ethogram, some interesting differences seem to emerge in the extent to which they signal. Standardbreds have been noted to be more likely to demonstrate snapping behavior in estrus than Arabians.[89] This intriguing finding merits further exploration. It is possible that this is a form of displacement behavior that masks behavioral conflict. When 224 adult riding horses' responses to humans were observed and scored on the basis of their posture, French Saddlebreds showed friendly behavior more often than Anglo-arabs, whereas Thoroughbreds were more indifferent.[90]

In addition to the intriguing, intrinsic behavioral differences between breeds, breed differences in learning ability have been reported by several authors. Mader & Price[91] found that Quarterhorses learned a visual discrimination task more readily than Thoroughbreds, a finding attributed to the relative distractability of the Thoroughbreds. However, the importance of the experimental apparatus in reducing fearfulness may have been confirmed by Sappington et al,[5] who found no difference in the learning ability of Quarterhorses, Thoroughbreds and Arabians. Hot-blooded and warm-blooded horses learned an operant task less quickly than cold-blooded horses.[82] As with any comparison of problem-solving exercises for a reward, it pays to consider whether all one really ends up testing is the motivation to access the resource. Thoroughbreds are often fussy feeders. Being generally less motivated to eat they may be disinclined to solve problems for food rewards. Thoroughbreds are also more reactive (see the discussion of emotionality in the subsection on temperament, below) and therefore may take longer to approach novel pieces of apparatus calmly. Also, because they tend to be stress susceptible, learning may be reduced as a result of generalized anxiety.

Six personality components reliably reported in horses are *dominance*, *anxiousness*, *excitability*, *protection*, *sociability* and *inquisitiveness*.[92] When eight different breeds were surveyed to explore differences across these six personality components, variability between personality components depended on breed.[93] *Anxiousness* and e*xcitability* showed most variability, and the Thoroughbred, Arab, and Welsh ponies and cobs were ranked as the top three breeds on both of these components. In contrast, *dominance* and *protection* varied the least, with Shetland pony and Irish Draft horse being ranked as the lowest on this component.

Some intriguing individual differences in temperament, in correlation with the height of facial whorls, have been reported. Horses with a single whorl above or between the eyes are said to be of an 'uncomplicated' nature, whereas horses with a single whorl below the eyes are said to be 'unusually imaginative and intelligent'.[94,95] Notwithstanding the problems that arise when one attempts to measure intelligence, these reports merit thorough investigation because similar reports in cattle have been ratified by repeated studies.[96–98]

Temperament

Temperament is a nebulous construct and therefore is difficult to define, so a range of approaches to definitions exist. In humans, temperament has been defined as a person's behavioral tendencies that appear early in life and continue throughout life.[99] The main premise of temperament is that it manifests at an early age, is elicited in specific situations, and remains relatively stable over time.[100] The word 'personality' is used interchangeably with temperament[101] and is generally accepted as describing stable and enduring behavioral tendencies.[102] A number of temperament tests for horses have now been reported,[103–106] and it is possible that in combination they may form a suite of tests that may be useful in identifying the best horses for certain sorts of work.[107]

'Horsonality' has emerged in a bid to capture the individual differences that characterize equine temperaments.[108] This is an interesting advance but one that may suffer considerably from lay interpretations. 'Horsonality' includes features such as laterality, compliance and trainability. Laterality is of growing interest to equitation scientists as the impact of left- and right-hemispheric dominance and consequent motor preferences become more clearly understood.

It is important to note that emotionality (or nervousness) has an influence on behavior. McCann et al[109] scored emotionality in 32 Quarterhorse yearlings based upon their response to a series of procedures, including standing in a chute, being identified and being released from the chute. The nervous yearlings tended to have a higher overall activity index than the normal yearlings. This correlated with heart rates. Escape tendencies, reactivity to people, behavior after release and overall emotionality contributed to the horses' being classified as highly nervous, nervous, normal or quiet. Emotionality of the horses affected their frequency of eating and drinking, defecation, locomotion and contact with the other members of the group.

It seems that the learning ability of an individual horse is profoundly influenced by emotionality. Fortunately it is becoming clear that measurement of emotionality as an outcome of avoidance learning tests is possible and that early detection of this quality in yearlings gives a reliable prediction for life and is more consistent than responses in reward-learning tests.[110] It may be that time spent grading young horses in this way could reap economic benefits for the industry in the long term.[110] Tailoring training schedules and ultimately jobs to meet the individual emotional profiles of horses rather than assuming that all of them can do a single form of work may save time and money. That said, care must be taken to avoid oversimplifying equine temperament tests, because they do not show significant interrelationships.[111] It is suggested that several different qualities of a horse's personality must be assessed before predictions of its working performance can be made with any confidence. So, tests used to predict a horse's performance as, say, a show-jumper must include its response to novel objects, handling, avoidance learning, reward learning and technique in free jumping.[111] The limitations of these assessments reflect the additional role of physical development, long-term training and the skill of the horse's future riders.[111]

Stallions and colts are generally less timid than mares and fillies.[112] This, along with the absence of reproductive cycles, which have the potential to interrupt training schedules[113] and produce variability in competitive performance, accounts for male horses being favored for show-jumping and eventing. Meanwhile, the dynamic presence of stallions predisposes them for work in elite dressage. Behavioral tests comparing saddle mares with draft mares showed the former to be more fearful, and indicated that pregnant mares demonstrated fewer fear responses than non-pregnant mares.[114]

There are anecdotal reports that socially high-ranking horses can be difficult to train because they are more likely than passive, subordinate animals to deploy evasions.[79] However, social rank appears unrelated to learning ability in visual discrimination,[6] simple maze,[61,80] and avoidance learning tests,[61] suggesting that there is a need for more work in this domain. Indeed the whole concept of dominance and the translation of equine social order to horse–human interactions has been questioned.[2] The individual differences in emotionality and trainability demand the collection of data from a battery of temperament tests.[23,112,113,115–117] Given the wastage that results from behavior problems and the advent of databases for logging the careers of sport-horses, it may be that the time is right for the FEI to develop an international model of breeding stock selection and agree upon a suite of tests that help select breeding stock on the basis of their being tolerant and trainable.

Other differences among breeds include a predisposition to stereotypic behaviors. Horses may inherit both sensitivity to stressors and an ability to express a stereotypy.[118] Certain breeds are more prone to stereotypies than others. Usually these are also the breeds that are managed most intensively. Standardbreds are a possible exception here in that they are regularly stabled but show fewer stereotypies than similarly managed Thoroughbreds.[119] Thoroughbreds appear particularly predisposed to cribbing and weaving, while Arabians tend to stall walk more.[120] These trends may be of significance to horse-trainers since some retardation in learning (specifically persistence in tasks that are no longer rewarding) has been shown to accompany stereotypies.[121,122]

SUMMARY OF KEY POINTS

- Learning facilitates adaptation to novel environments.
- Horses learn in the same way as other species.
- Horses are remarkably adaptable and tolerant.
- A good lesson provides a novel environment with stimuli to which the horse must learn appropriate responses.
- Habituation is the pivotal technique for overcoming flight responses.
- Most horse-training involves operant conditioning.
- Shaping relies on reserving reinforcement until an improved response appears.
- Horses are generally trained with negative rather than positive stimuli, but innovations that accentuate the positive are being successfully developed.
- Clicker training offers a simple method for shaping appropriate responses and therefore provides a basic framework for retraining many unwelcome responses, especially in the unridden horse.
- Consistency and timing are the hallmarks of good training.

Case study

Star is a 6-year-old Thoroughbred being trained to work in the mounted police force. Mounted police perform a wide variety of duties, ranging from park and street patrols to parades, escorts, demonstrations and crowd control at special functions. Whenever on duty, police horses work in pairs and are required to remain calm and steady regardless of highly unusual circumstances. This requires the horse to be relaxed and unflappable, and to remain stationary unless instructed otherwise.

It is central to this training that the horse learns to ignore stimuli from crowds and respond only to those from its rider. It must stand firm under physical pressure from a noisy, pushy crowd and push a pedestrian when so directed by its rider. In other words, the strongest of equine instincts, the flight response, must be vanquished. When given signals, the horse must learn to follow them precisely, irrespective of jostling people, noises, lights and other distractions. Owners who have encountered unwelcome flight responses, including shying (see Ch. 15), could learn a great deal from this case study.

Horses newly acquired by the police force spend 6 weeks being evaluated by a general trainer. Selection is based on temperament and responsiveness. After

Figure 4.20 Police horse being trained for crowd control.

6 weeks of assessment, each horse is paired with a single rider for both training and operational work over a number of years, so that a bond develops between mount and rider that, over time, increases the horse's capacity to cope with new situations. The benefits of this appear in later schooling, where the horse is required to perform unfamiliar tasks, facilitated through rider reassurance.

Initially, the horses are given basic education, including responses to leg, seat and rein signals. On command, they will then move sideways, forwards or backwards, and it is essential that they will stand for extended periods. They are handled daily during grooming and saddling so that they become accepting of contact on all areas, especially sensitive regions such as groin or head. The basic training program generally continues for 6 weeks before specific behaviors are trained.

There is considerable attrition in the selection and training of police remounts. Of the horses that commence training, 10% go on to perform all desired behaviors adequately while only 5% do extremely well. Flighty or nervous horses are unsuitable for crowd control. Mares and stallions are also avoided, as they are considered rather less predictable than geldings and are regarded as being easily distracted when working with other horses.

To train the horse to ignore pressure cues from bystanders, it is first cued to stand with a pedestrian in front of it touching its neck and chest. Next, the rider makes the horse stand still while the pedestrian applies pressure. Although horses have a tendency to move away from persistent pressure, the rider ensures that the horse responds only to commands from him. The horse is then prompted with leg and rein signals to advance toward the applied pressure, that is, toward the pedestrian.

The next stage is to simulate contact from multiple directions within a crowd by organizing several people to surround the horse (Fig. 4.20). The horse is again cued to respond only to the rider's signals, and walk forward as directed. Discrimination is required in that the horse must learn to discern between pressure on the flank that comes from the rider and that coming from other humans. The most difficult step is training the horse to continue walking even when pedestrians in front of it do not retreat. This is achieved by continuing to apply leg signals until the horse responds.

Gradually other distractions are added to the horse's repertoire, including pedestrians holding or waving strange objects, or broadcasting loud noises. When multiple novel stimuli are used together, the greatest risk is that they will frighten the horse. In other words, advancing too far too quickly is a real danger. If the horse behaves fearfully, the training reverts to the last step with which the horse was under stimulus control, before the challenging step is attempted again. Verbal and physical reassurance from the rider is considered particularly important during this stage.

Training sessions are given every day, with the length of an average training session being 45 minutes. As horses are worked every day, it becomes an accepted routine, and no specific attempt is made to change motivation prior to a session.

Reinforcement of crowd-control responses is not part of a police horse's routine training. Basic training is reinforced whenever horses are ridden, but specific maneuvers, such as quadrilles, are revised only in an intensive lead-up to a particular event, such as a public display. Training is then tailored specifically to that event, using appropriate lighting, sound effects and props.

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Social behavior

CHAPTER 5

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Social organization

Social interactions between horses have been the focus of several recent studies. This is good news for domestic horses because by understanding the relationships between horses, humans can learn to build a better understanding with their equine companions. That said, there are limitations on the extent to which horses use elements of their social repertoire to communicate with humans.[1] Fundamentally, we do well to remind ourselves of this, especially when riding since, clearly, horses never mount one another to take a ride.

As the nature of social hierarchies in free-ranging horses, the effects of domestication and the significance of behavioral and social needs are better understood, our ability to comment on equine welfare issues is necessarily enhanced. For example, studies of groups of free-ranging horses have provided information on the roles of stallions, mares and juveniles within their natal groups (Fig. 5.1). This may provide the rationale for single-sex grouping of horses in some domestic contexts, especially where social flux is constant and agonistic interactions must be modulated for the sake of horse safety. Thoughtful planning of social groups can help to ensure normal social development, reduce some of the undesirable effects of pair-bonding on ridden work and minimize injuries from conspecifics in the paddock. It is usually better to find the optimal social milieu for horses than take the 'safe' option of isolation in a paddock or, worse still, a stable.[2]

Domestic horses are not the only beneficiaries of studies of free-ranging equids, since the humane control of feral horses is also facilitated with this sort of information. For example, given the importance of a stable social group, the relocation and confinement of feral horses, while sounding reasonably simple, is likely to modify current social structure and range use, ultimately leading to fights and injuries in the short term and the need for more intensive management in the longer term.[3]

Groups of horses

Other than occasional solitary individuals (which are more often than not transiently drifting between groups), two main groupings of horses occur within herds: the natal band (or birth band or family group) and the bachelor group (Fig. 5.2).[4] Traditionally, horse herds are thought of as harems, comprising one stallion, his mares and foals and juveniles. This simplistic view fails to embrace the leadership role of mares and the context-specificity of the stallion's place in the social order.

Figure 5.1 Feral horses and herds that receive minimal management, such as these Konik horses in Oostvaarders Plassen, the Netherlands, provide critical information on normal horse behavior.

In a group of horses, the lead animal shows the way to resources, such as water, saltlicks and rolling sites, as well as initiating activities such as grazing or resting. This individual is often an older experienced mare but, depending on the context, the stallion may also direct its herd by herding and snaking, for example when he detects predators or competitors. Increasingly, the importance of mares as the functional core of the group is being recognized, with 25% of them staying permanently in their original natal band[4] and with matrilineal dynasties spanning generations. Mares and their filly foals often share strong bonds and this affiliation may facilitate vertical transmission of information about optimal use of a home range. Those mares that disperse into a fresh band often remain within it for life. It is important to note that the stallion may not always be the highest ranking member of the natal band.[5–7] Similarly, sex has been demonstrated to be a poor predictor of rank in foals.[8]

Bands with more than one stallion are not uncommon. Subject to the above, stallions within these groups establish a dominance hierarchy that helps to define roles. If there are several stallions associated with the family band, the dominant stallion copulates more than subordinate stallions.[4] Band cohesion is a task shared by stallions in multi-stallion bands but the subordinate males tend to herd and occasionally mate with

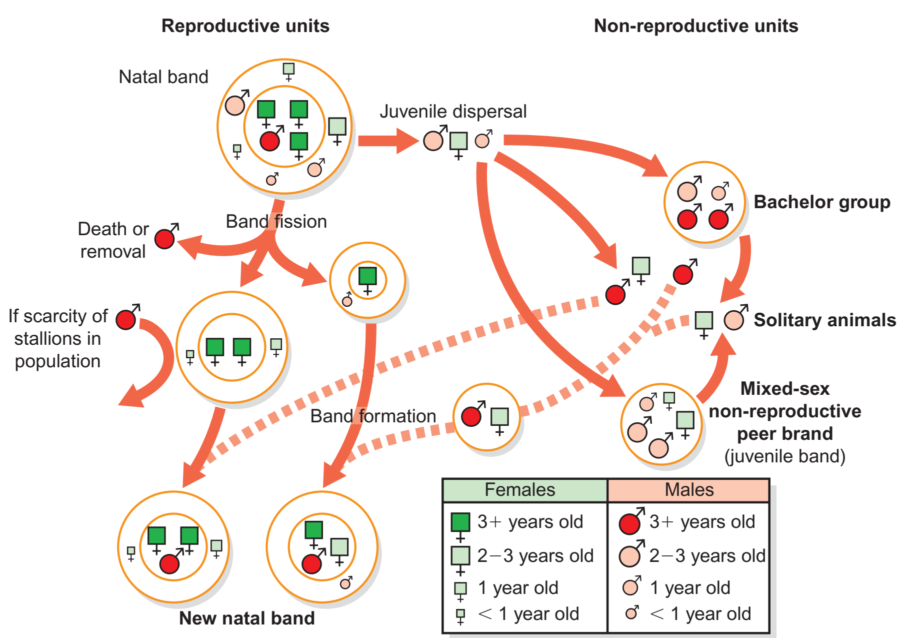


Figure 5.2 Social groupings of free-ranging horses. *(After Waring.[16])*

the lower-ranking females. One study noted that mares are more likely to leave single-stallion harems and that therefore harems with several stallions are generally more stable.[9]

Linklater[10] defines a natal band as a stable association of mares, their pre-dispersal offspring and one or more stallions who defend and maintain the mare group, and their mating opportunities, from other males year round. For example, in New Zealand's Kaimanawa ranges, the horse population has a social structure like that of other feral horse populations, with an even adult sex ratio, year-round breeding groups (bands) with stable adult membership consisting of 1–11 mares, 1–4 stallions, and their predispersal offspring, and bachelor groups with unstable membership.[3] Changes in the adult composition of natal bands are rare (e.g. Miller[11] suggests 0.75 adult changes per year). However, harems may split into smaller groups based on social attachment, when fodder becomes scarce.[12]

Found in all free-ranging horse populations, the bachelor group comprises males that have dispersed from natal bands. Although most colts leave the natal band at around the birth of a sibling, or when there is a shortage of playmates or food, some remain.[13] However, as they mature and begin to represent a threat to a resident stallion's mating rights, pubescent males may occasionally be ostracized from their natal band. More generally, colts gravitate to bachelor groups because that is where they find many potential play partners. Bachelor groups also provide sanctuary to older stallions, including some that have been unsuccessful in defending their bands from other stallions.[14] Bachelors live in their groups adjacent to natal bands, waiting for opportunities to capture dispersing mares, perform sneak matings, herd away mares and to challenge natal band leaders. For this reason, membership of the bachelor band is subject to the greatest flux during the breeding season. Despite the companionship it offers, bachelor groups are literally full of competitors that engage in agonistic encounters that may persist over several months and may end in dispersal.[15] It is therefore perhaps predictable that young stallions usually spend some time alone before forming their own harems.[13] The bachelor group provides valuable physical and social learning opportunities for its transient members. In juveniles there is a relationship between time spent in the bachelor group and latency to form a harem.[13]

Role of stallions in natal band cohesion

The main roles of a resident stallion involve monitoring and maintaining the integrity of his band and protecting it from predators and other stallions that may attempt to steal or perform sneak matings with mares and fillies. The reproductive success of a harem stallion is limited not least by his ability to prevent such matings.[16] Harem stability is not affected by the size of the harem nor by the age of the stallion, but is thought to be enhanced by the presence of subordinate stallions attached to the harem.[9] Depending on the terrain, the stallion will protect his band by patrolling a radius of 10–15 m around the group as they move through the home range.[6] For this reason natal band stallions are less likely than mares, juveniles or bachelors to form pair bonds. The relationships they form tend to be heterosexual (usually with all adult females in the natal band) or paternal.[17]

Being less timid than mares and fillies,[18] stallions and colts usually take the initiative when the band encounters a potential threat. That said, the stallion's response to a challenge depends on whether the cause of the threat is a predator or another stallion. If a predator threatens, the stallion will herd his group together and lead or drive them away from the threat using snaking gestures (Fig. 5.3). Feist[19] noted that in 77% of band movements, the stallion was either driving or leading the group. Stallions sometimes herd wandering foals back to the band and protect them from danger.[20]

By placing himself between the band and a predator the stallion can reduce the fragmenting effects such stimuli can have on the group. The role of the stallion in responding to potential predators is illustrated by the report that Camargue foals born into bands in which two stallions have an alliance are 20% more likely to survive than those in single-stallion bands because of reduced predation.[21]

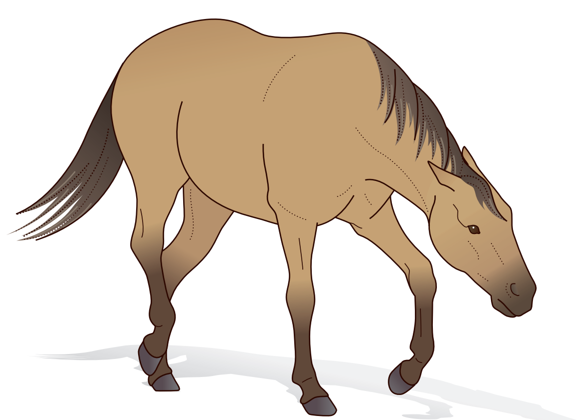


Figure 5.3 Snaking behavior used by a stallion to move other horses, especially members of his natal band.

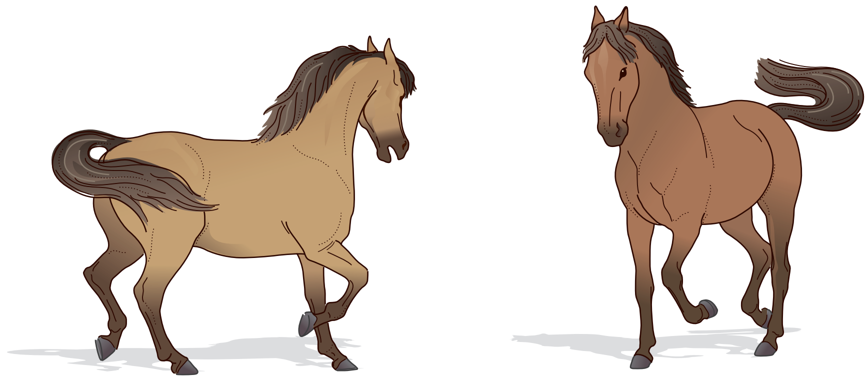


Figure 5.4 Stallions (a) and (b) approaching one another spend time assessing each other's fitness and readiness to fight.

If the threat is from another stallion, the initial response by the band's stallion will be to attempt to chase the challenger away. Agonistic behaviors are discussed later, but the resident stallion's motivation to fight depends on a number of variables summarized in a notional equation that forms the central tenet of game theory (Fig. 5.4).[22] Whenever two horses dispute access to any resource, both must weigh up the value of the resource, the cost of defending it and their ability to retain it (also known as their resource-holding potential). Without performing any calculations as such, the would-be protagonists (a and b) compare

$$\frac{V_a + RHP_a}{C_a} \quad \text{with} \quad \frac{V_b + RHP_b}{C_b}$$

where: V is the value of the resource to that individual; RHP is the resource-holding potential of that individual; C is the cost of a fight to that individual. Factors on which these variables depend are given in Table 5.1.

This theory helps to explain why interactions between the resident stallions of two interfacing bands are less intense than those between a resident stallion and an interloping bachelor. The latter has a lower cost to pay for fighting more intensely since he is already outside a core group. The value of the home range is greater for the resident than the intruder so the resident may be more likely to persist in combat. This helps to explain why the forays of bachelors into the home range of natal bands are only rarely successful.

Snaking and herding are most likely to be seen in domestic contexts when the stallion is introduced to a group or when an existing family group is moved to a new pasture.[23] After either of these interventions the stallion's response generally returns to baseline levels by the third day.[23] The addition of new mares to an established natal band does not induce herding of the original mares. However, primarily because they are chased by the stallion for up to 3 days, the introduced mares are kept at a distance (of approximately 8–12 mare lengths) from the original mares.[23] Band integrity is further enhanced by a harem stallion when he facilitates bonding between mares and their neonatal foals by keeping other conspecifics away from them. Again, snaking and herding may be used for this purpose.

Despite the benefits of having the company of a stallion, band members lose some of their freedom. In the absence of a stallion, mares mutually groom more, form

Table 5.1 Game theory variables predicting conflict between horses, and factors on which the variables depend

Variable	Factors include
Value	Experience of the resource, investment in the resource, short-term and long-term future needs
Resource-holding potential	Size, physical fitness (as evidenced by display used when the challenge is detected), ability to deceive observers, fighting experience and number of individuals involved in the dispute
Cost	Risks of being injured (with consequent risk of infection at the site), killed or displaced from natal band

more stable pair bonds and have a better-developed social order.[24]

Role of mares in natal band cohesion

The chances of inbreeding between stallions and their daughters is reduced by the experience of having lived together before the filly's maturity, a factor thought to prompt migration of fillies from their natal band.[25] While 75% of the fillies disperse to other bands, the females that remain are the most fixed and stable members of most natal bands, often taking leadership roles in governing the band's daily activities. Although regarded as the resident core of the equine family group, mares will disperse from natal bands notably when resources are scarce: e.g. up to 30% of adult females have been observed changing harems during the winter.[9]

Affiliative behavior between females is important because mares of an established band remain together even in the absence of a stallion.[26] We should never underestimate the strength of social bonds among mares. Indeed there are anecdotal reports of mares abandoning their own foals to reach the comfort of their herd mates. These affiliations may have their origins in foal associations since fillies tend to spend more time with other fillies than with colts.[27] Daughters also tend to remain closely associated with their dams.[17,28]

As discussed in detail later in this chapter, the concept of hierarchy is controversial since some commentators fear that it legitimizes human domination of and violence toward horses. However, as we use clearer terminology that provides the most parsimonious explanation of effective and safe human–horse and horse–human interactions and thus advances the welfare of horses, we must not deny the importance of social order, since it is highly adaptive in reducing intraspecific aggression. The rank of a mare has a predictive effect on her role in band cohesion. For example, as a reflection of the investment they have made in the group, dominant mares are more likely to defend the area around the group. Although territorial behavior is an irregular feature of the equine ethogram,[29] in some free-ranging populations, such as those in Shackleford Banks on the eastern coast of the USA, which show defense of a territory rather than simply maintenance of the integrity of the band,[30] higher-ranking mares within the natal band are more often involved in mutual grooming with the resident stallion, while lower-ranking mares are the chief recipients of his snaking and herding attention when he rounds up the band. Most adult mares in a natal band will contribute to band cohesion by responding to the sound of the resident stallion's call.[31]

Role of juveniles in natal band cohesion

In a natal band, the juveniles issue the least amount of aggressive behavior and conduct the most non-agonistic behavior.[7] One of the main behaviors of foals is play: it is very important that they learn how to interact with one another and to establish pair bonds (see Ch. 10). Play in foals is unrelated to rank. So, the play-rank order of foals, as measured by the number of times a foal left a bout of play, is not significantly correlated with social rank order determined by agonistic interactions.[32] Yearlings and two- and three-year-olds continue to be involved in play activity but are also seen nipping and wrestling each other as they consolidate their social order and as they practice herding or fighting for adulthood.

Group size and home ranges

Herds of horses may be as large as 600 (Machteld van Dierendonck, personal communication 2002). Bands within herds form relatively stable nuclei[33–35] that are often at their most discrete when resting but may graze in close proximity to one another and usually unite when fleeing from a predatory threat. Band size tends to vary with population density. For example it can range from 12.3 in Shackleford Banks,[30] with a population density of 11 individuals/km^2 to 3.3 in Wassuk Ridge, in the Nevada Desert, with a population density of 0.1.[36] Because of the terrain and its resources, horse density in a given ecological sector can vary: e.g. while the population density in the Auahitotara of New Zealand averaged 3.6 horses/km^2, it ranged from 0.9–5.2 horses/km^2 within different zones.[3] Group size therefore is dependent on the density and pattern of distribution of resources, and this is why, when external resources are provided, groups can become larger than those observed in the free-ranging state. For example, in working ponies that are seasonally managed on a free-living basis, groups of 30 or more can exist.[37] Island populations, such as those on Sable Islands and Shackleford Banks, have higher population densities than those with fewer limitations on their ability to spread.[30,38] Demographic data on feral horse groups in North America are given in Table 5.2.

Home ranges incorporate grazing sites, waterholes, rolling sites, shade, windbreaks and refuges from insects and can vary in area from 0.9–52 km^2.[39] Exploitation of

Table 5.2 Demographic data for feral horse groups in North America

	Range	Mean	SD
Population size	78–703	266.8	206.9
Population density/km^2	0.2–6.3	3.5	3.9
% Adults	53–77	63.2	7.5
% Juveniles	14–29	22.8	5.2
% Foals	9–19	14.2	3.6
Home range area (km^2)	3–52	17.8	16.6

After Fraser[37] and Waring.[17]

the home range depends on numerous variables including the climate, the season, predation risk and the prevalence of biting insects. For example, Auahitotara horses generally avoid high altitudes, southern aspects, steeper slopes, bare ground and forest remnants.[3] Instead they tend to occupy north-facing slopes (because they have warmer aspects) with short vegetation and zones with well-nourished swards. In spring and summer when subsistence is less of a challenge and there is less need to forage in hostile terrain, they tend to be found on gentler slopes.[3]

Horse populations do not use all parts of their home range equally since the grazing is rarely of uniform value and the emergence of latrine areas is normal (see Chs 8 and 9). Thus bands tend to spend much of their time in relatively small focal areas within the home range.[17] Natal bands often shift with the season such that in spring they gravitate to river basin and stream valley floors for the beginning of foaling and mating and, when there is a chance of frost, to higher altitudes in autumn and winter.[3] The appeal of certain areas changes with the season. For example, whereas during the winter months they may avoid standing in water, during the summer months horses may be driven into surf or shallow bays by biting insects. Equally, the cooling effect of rolling and standing in water should not be underestimated. That said, in some groups of horses no pattern of cyclical use of areas has emerged.[17] Since the use of terrain seems to be initiated by leading members of the group and since a change of leader may bring a change in a band's use of resources, this finding may have arisen because behavioral observations were coincidentally made at a time of flux in the band's composition or social order.

Social behavior in feral horse populations is more common than territorial behavior, in that if one band of horses encounters another, any defensiveness shown usually appears to be an attempt to maintain the integrity of the band rather than to defend a site.[17] Although the home range of one natal band often overlaps entirely with the home ranges of others, natal bands and bachelor groups are loyal to undefended home ranges with central core use areas.[3]

In cases where home ranges overlap, a social order among groups can be observed that allows the predictable displacement of subordinate (usually smaller) bands and individuals from shared resources such as watering-holes. Although linked to the size of the group, its relative rank compared with others is not a function of the number of males it contains.[34] This is illustrated by the deference exhibited by bachelor groups to natal bands and by the way in which the rank of a bachelor is enhanced once he has acquired a mare.[34] Disputes between bands are generally resolved by interaction between one or occasionally two high-ranking representatives from each. The remainder of both bands typically look on and await the outcome before accessing resources in an order determined by their representatives.[34]

Social order

The establishment of defined social status within any group of equids promotes stability within the band. A stable social order within the band decreases the accumulative amount of injury by allowing *threats* of kicks and, perhaps more importantly, bites to replace the aggressive responses themselves.[7]

Each horse's position within the band is held through a blend of aggression and appeasement behavior. Aggressive behavior can be biting, kicking, circling and displacement, but the most common response to a competitor is a threat to kick or bite. Rank is determined not only by threats issued but also deference to threats received. Such submission may involve lowering the head and averting the gaze. Unfortunately, the intraspecific harmony seen in stable horse groups (facilitated largely by deference) is sometimes hijacked by humans seeking to justify the use of force to render horses submissive.[1]

Houpt et al[40] found that although individual rank order is unidirectional it may not be linear throughout the group. Thus A may dominate B who may dominate C, but C may dominate A.[40] This facilitates the formation of so-called social triangles. While rank orders are generally linear in the top and bottom of a band's organization, most triangles occur in the middle.[41]

Figure 5.5 A mare moves forward to defend her group by attacking an approaching dog. *(Photographs courtesy of Michael Jervis-Chaston.)*

Also one must consider the role of protected threats that allow individuals to enhance their rank by associating with a higher ranking band member – for example as seen in foals that attain rank enhancement when with their dams. Thus the possible influence of the dam may help to explain why Icelandic yearlings often have a higher rank than their 2-year-old siblings (Machteld van Dierendonck, personal communication 2002).

If a social order were not developed and maintained, each horse would need to affirm its rank by increasing levels of aggression during every dispute with a conspecific over a resource. Without a hierarchy, injury and distress associated with social flux may have reproductive costs, e.g. the rate of conception might be decreased and there could be an increase in the rate of fetal and foal mortality.[42] In general, a social structure is important for organization, especially during times of emergency such as when a predator approaches (Fig. 5.5). A defined social structure based on affiliative relationships allows the band to mount an appropriate response, be it fight or flight, as the lead animal rises to the defense of the group or herds it together to escape. Social order per se is highly adaptive. However, the concept of hierarchy unsettles some applied ethologists because, being resource-dependent, it is complex and therefore the outcomes of agonistic interactions between two or more individuals are sometimes difficult to predict but also because it has been used to justify fear-eliciting activities within the human–horse dyad.

The empirical determination of rank is complex and not easily predicted. Height or weight or both have been found to correlate with rank in many studies[43–45] but not all.[5,41] Age more usually shows a correlation with rank in studies of feral *E. caballus*[6,43,46] and *E. przewalski*[47] but again this is not always the case.[42] It is appropriate that age should contribute to social status since it is likely to reflect experience in dealing with local challenges and a wealth of knowledge about how best to exploit the resources in the home range.[7] That said, in their dotage the oldest mares may relinquish leadership but occupy a beta position, much more elevated than their body condition would suggest. Perhaps this reflects some sort of respect earned earlier in life (Machteld van Dierendonck, personal communication 2002). In managed herds, the length of residency within a band also contributes to the determination of rank.[41,48] In geldings, rank seems strongly influenced by an individual's position in the social hierarchy at the time of castration (see Ch. 11).

Either sex can out-rank the other because there is little sexual dimorphism in the sizes of hooves and teeth, which are a horse's main weapons.[6] Stallions' ranks are very much context-dependent. They may rarely dominate, as they have less contact with the band than female peers because of their need to patrol around rather than within the band. Furthermore they do not participate in many aggressive encounters if they enter the band chiefly during sexual situations.[6] Therefore when a youthful stallion secures mating rights in a band containing mares older than himself, the oldest yet healthiest mare will tend to prevail in a leadership role. Although over 80% of threats are directed down the dominance hierarchy,[32] the use of the term 'dominance' is somewhat controversial since some authors highlight avoidance behavior on the part of subordinates as being the main activity necessary to maintain the order. In view of this, it has been argued[37] that avoidance order is a better measure of the social system than the 'aggression order'.

In the process of learning to recognize their place in the hierarchy, yearlings receive the largest number of attacks (46% according to Keiper & Receveur[7]).

Significant positive correlations have been found between rank of mares and foals and the rate at which they directed aggression to other herd members.[8]

As suckling foals play away from their dams, they establish a hierarchy based largely on birth order such that there is a linear relationship between age and social position.[7,8] Although weaning tends to have a disruptive effect on the ranks of foals (so that birth order no longer correlates with rank), significant correlations have been found between mare rank and the rank of foals both before and after weaning.[8,32] This would suggest that the influence of the dam is relatively constant over time.[8]

Since the adult offspring of a high-ranking mother does not *necessarily* become high-ranking, it cannot be said that resource-holding potential is purely genetic.[6] Status is a learned relationship between two individuals, and learning plays a role in the development of effective displacing strategies, which can include deceptive responses such as bluffing. Additionally there may be heritable behavioral predispositions in the high-ranking dynasties within a herd. Although offspring may learn aggressive behavior from their mothers this is challenged in part by evidence of inverse correlations between aggression rates and rank in foals.[32] Perhaps they have only to learn *how* to impose their rank rather than doing so frequently. One alternative is that status is bestowed upon the foals of high-ranking mares simply by association with their dams, since mares may assist their foals in agonistic encounters with other foals.[8] It is acknowledged that foals share their mother's rank while she is in close proximity[17] but that they are more likely to show displays thought to be deferential such as snapping (tooth-clapping, yawing, champing, yamming; Fig. 5.6) to adults when beyond her protection.[43] Furthermore the rates of aggression towards foals rise with weaning as the mare's support is withdrawn.[8] The relative contribution of environmental and genetic factors will be better understood when the influence of non-biological mothers can be measured from studies of foals that have been transferred as embryos or cross-fostered after birth.

Although mares may undergo significant changes in social behavior at the time of foaling,[49] no coincident changes in social status have been reported with foaling,[43] so mares with foals at foot do not necessarily rank higher than a mare without a foal.

The effect of rank on behavior

By definition, with higher rank comes priority access to most resources. In every dispute the rank of protagonists correlates with their resource-holding potential and contributes to the prediction of the outcome. However, rank alone is not a simple, absolute predictor, since game theory applies, too. Therefore the outcome must also remain a function of the value of the resource (i.e. the motivation to acquire the resource) and the cost of any fight to possess it. For these reasons rank is also context-dependent, especially in stallions.

Figure 5.6 Youngster showing snapping response to an older horse. *(Photograph courtesy of Francis Burton.)*

Rank has been correlated with the priority bestowed on those horses that gain first access to maintenance resources such as resting sites and watering holes,[34] unless they have been distracted by having to repel another band. Conversely, rank dictates the order in which bachelors eliminate on one another's excrement,[24] and all bands use rolling sites[50] (Fig. 5.7). Rank influences social dynamics within a band, including the selection of nearest neighbors and mutual grooming partners.[46]

The rank of an individual horse does not influence its sociability rate in any group.[8] However, the debate continues about the role of the higher-ranking partner in mutual grooming pairs, with evidence that high status animals may be both more likely[46] and less likely[43] to start a bout when grooming started asynchronously.

Despite the relationship between age and rank, difference in the ages of band members influences social networks. Bonded pairs with less difference in age that demonstrate frequent grooming, usually remain in close proximity to one another, beyond the effects of rank and kinship.[51] Additionally, middle-ranking horses tend to be more frequently in the close vicinity of another horse than high-ranking or low-ranking horses.[41] Again, the mid-ranks are also characterized by social triangles.[41]

There are a number of ways in which social rank affects reproductive behavior. Just as stallions can reject maiden mares, they have been reported to select high-ranking estrous mares for mating when offered a choice.[52] Males outside the natal band and low-ranking (juvenile) males within it are seldom able to mate with mature mares unless by sneak matings, because the resident stallion consorts with these mares when they are in estrus. The peripheral and subordinate stallions can therefore usually mate only with lower-ranking mares with reduced biological fitness. The trade-off for these males is that they have not invested time in protecting these females. For mares, elevated rank means they are less likely to be harassed by these males seeking sneak matings. As they solicit the attentions of the senior stallion they may also be seen chasing away subordinate females that would otherwise divert his attention.[50]

The benefits of high rank in terms of biological fitness are clear. For example, since the foals of high-ranking mares may grow bigger and faster than other foals in the natal band, they may breed earlier and the colts among them may be more likely to gain a harem.[8,53] Other, less favorable associations with high rank are becoming better understood, with studies in wild dogs indicating that rank is positively correlated with cortisol concentrations.[54] In horses, one might predict this to be the case in herd leaders because of the associated burden of having to maintain band integrity and investigate potentially dangerous stimuli. Similarly, recent data demonstrate that the foals of higher-ranking mares are more likely to develop oral stereotypies than foals of middle- or low-ranking dams.[55] It is speculated that this may reflect the influence of mares' behavior towards foals prior to weaning or may relate to the nature of the mare–foal bond and effects of severance at weaning.

Figure 5.7 Horses in a group often take turns rolling. *(Photograph courtesy of Francis Burton.)*

Low-ranking mares and those in poor condition are more likely to have female foals, which are better able to reproduce than colts from dams on marginal nutrition.[56]

Certainly this is an area that merits more study. The role of rank in competitive success of race and sports horses continues to fascinate both ethologists and punters alike. It is possible that high-ranking animals in a race allow others to take the lead and with it the potential risks of what may lie ahead. This, however, may be offset by the reluctance of subordinate animals to overtake them, an abiding argument for the use of blinkers that may reduce the ability of horses to detect threatening behaviors from conspecifics as they overtake them in a race.

Measuring rank

The factors that influence rank are complex, as is determining rank within a group of horses. The absence of an established protocol for measuring social hierarchies in horses accounts for the lack of consensus among studies. Perhaps because there are fewer complexities such as social triangles and because of the complete absence of mare–foal dyads, measuring rank is easier in all-male groups than in natal bands.[24] The importance of deference displays by subordinate horses when withdrawing from disputes over resources is now being recognized, so instead of establishing hierarchy solely on the basis of threats given,[7] the trend is towards including submissive gestures[32,45] and calculating rank only from submission data.[8]

It is generally true that one can best see the dominance relations between individuals at the site of limited resources: water holes, saltlicks, sandy places to roll, shelter, etc. It is natural for horses to attempt to displace each other as they compete for affiliates, mates, food, salt or water. For this reason, some studies of hierarchy tend to record all occurrences of agonistic behavior between pairs of subjects during feeding of supplemental grain.[8] However, the desire to acquire or defend food pellets in competitive situations is not necessarily the same for all individuals involved. Additionally, rank in an isolated dyad is not necessarily a true reflection of what applies in an unmanipulated group that may feature coalitions, social triangles, leadership and defense.

Because simply recording the outcome of a bout is an inelegant measure of rank, submissive and aggressive behaviors should be analyzed in detail. This approach has shown that agonistic responses involving the head are related to offensive behaviors, while the hindquarters are used both offensively and defensively.[41] So, when scoring a dispute between two horses to determine rank, it is advisable to summate bites and bite threats separately from kicks and threats to kick because the latter may be less useful for determining hierarchy.[41]

Affiliations

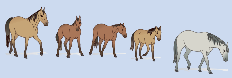
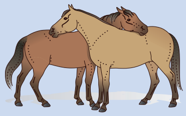
Under free-range conditions, even where the territory is extensive, group bonding is important to the extent that horses maintain continual visual and, to some extent olfactory, contact with each other.[37] A central mechanism of band cohesion is the establishment of affiliations, notably pair bonds and mare–foal bonds.[57] Pair bonds in bachelor groups are generally weaker than those observed in natal bands and become more tenuous as bachelors mature and are driven to establish reproductive relationships.[17]

While domestic horses generally group together according to certain sex or sex–age classes – adult mares, adult geldings, foals, juveniles – mares sometimes socialize according to their reproductive state: pregnant, postpartum and barren (Machteld van Dierendock, personal communication 2002). Most horses have one or more preferred associates with whom they maintain closer proximity than with other herd members.[46] The resilient bonds between such paired affiliates are of particular importance among equids and are demonstrated by reciprocal following, mutual grooming and standing together (Table 5.3).[58] In youngsters, they are demonstrated chiefly by play. The cardinal signs of stability among groups of horses include group activities such as rolling and trekking and mutual maintenance behaviors including insect control and grooming.

Although one recent study showed that a foal's sex had no significant effect on the choice of preferred associate,[8] others have found that foals tend to preferentially associate with other foals of the same sex.[32,59] Both before and after weaning, foals associated preferentially with the foal of their dam's most preferred associate.[8] As further confirmation of the influence of the mare on the social behavior of the foal, it has been reported that the sociability rates of mares and their foals are correlated prior to weaning but not after.[8]

Horses tend to bond with conspecifics of similar age and rank.[45,46] This means that in biological terms they associate with their closest competitors, and this may account for ongoing disputes, however mild, over

Table 5.3 Features of the ethogram (as described for bachelor bands[15]) characteristic of stable groups

Response	Description
Trekking 	Two or more animals moving together, typically following one another
Mutual grooming 	Two horses standing beside one another, usually head-to-shoulder or head-to-tail, grooming each other's neck, mane, rump or tail by gentle nipping, nuzzling or rubbing

resources. Preferred associates receive more total aggression than do other herd members, but proportionately more of the aggression directed against preferred associates is mild, such as laying back of the ears, when compared with more severe aggressions, such as kicking.[45] This is supported by a study that compared 2-year-old colts that had been group-reared and single reared for 9 months.[60] Whereas group-reared colts tended to make more use of subtle agonistic interactions (displacements, submissive behavior), more aggressive behaviors, i.e. bite threats, were recorded in the group of singly reared colts.[60] Increasingly, therefore the concept of a hierarchy based on dominance and subordination has been challenged by one based on tolerance and attachment.[58]

Social groupings have evolved for individual protection against predators, and cohesion is maintained by a variety of mutually beneficial behaviors such as mutual grooming and tail-to-tail fly-swatting. More than half (51%) of allogrooming contacts occur at the preferred site in front of the shoulder blade and include the cranial aspect of the withers.[61] This behavior (Fig. 5.8) has been reported in foals only 1 day old.[43]

Attachment between foals increases after the first 2 or 3 weeks of life, as the initial protectiveness of mares and the intensity of the foal–mare bond subsides.[17] As confidence with an affiliate increases, so does the boldness of play and the strength of the bond with a given peer, as shown by the frequency of mutual grooming bouts. Mutual grooming characterizes the relationship in filly–filly and colt–filly partnerships. This is regularly interspersed with sustained episodes of playfighting if the partners are both colts.[43] Since natal bands are largely female, the bonds formed between fillies at this stage can be lifelong, other partnerships being destined to dissolve at the time of juvenile dispersal (see below).[17] Exceptions to these generalizations include the occasional formation of trios and the dispersal of juveniles in pairs.[17] As testament to the robust memory horses boast, pair-bonds can withstand extended periods of separation (e.g. 6 months in the case of two New Forest pony mares[43] and 5 years in the case of some Icelandic mares (Machteld van Dierendock, personal communication 2002).

Pair-bonded horses sometimes defend their affiliates from other band members (e.g. by intervening in mutual grooming that involves their preferred partner) as though they are possessive of the resource their affiliates represent.[17] Similarly, mares sometimes attack stallions found courting their female affiliates.

Pair-bonded individuals conduct most of their daily activities together. Penetration of the personal space tends to cause avoidance more often than defense on the part of the subordinate horse. This means that while affiliative behaviors are active, affirmatory actions shown by pair-bonded horses, in many cases proximity reflects simple passive acceptance of conspecifics.

The social distance of horses is defined as the spatial limit companions will occupy, and beyond which they will either return to their affiliates or await their arrival.[17] Social distance is shortest in mare–foal dyads but begins to increase after only 1 week of life.[43] Depending on the scarcity of forage the social distance may extend to 50 m.[31] However, it is rapidly reduced as a transient response to alarming stimuli. On the other hand, even affiliated horses can be too close for comfort when they encroach on one another's personal space, usually within a radius of 1.5 m of the forequarters.[24]

Figure 5.8 Pair-bonded foals can often be seen mutually grooming. Of all horses, foals seem to find being scratched in hard-to-reach places most gratifying. *(Photograph courtesy of Francis Burton.)*

Dispersal

The proximate causes of dispersal from the natal band vary with the youngster's sex.[62] The resident stallion plays a cardinal role in the dispersal of colts and only rarely allows a member that has been driven away to rejoin the natal band. If the stallion is not active in causing the departure of a surplus member, he may passively facilitate dispersal by simply allowing a member to drift away (i.e. in contrast to his usual band maintenance activities). Lead mares may also take a role in driving away colts that are beginning to make sexual overtures.

Because they reach puberty earlier, colts tend to leave before fillies. However, the age of departure from the natal band also varies with the experience of the departee and demographics (e.g. colts leave if they have no playmates) and social pressure in the natal band.[17] Most of the juveniles that eventually leave the natal band, most will do so by the age of 4 years.[43]

When she matures sexually a filly will solicit attention from males. Since this is rarely effective with resident stallions in natal bands, the filly will consort with immature males in the natal band or males at the periphery of the group. Such behavior is rarely tolerated by the resident stallion, who precipitates dispersal by driving the couple away. Occasionally a stallion may drive away a female with whom he has failed to form a sociosexual bond.[17] Sometimes the birth of a sibling is a catalyst for the departure of a filly.[25] Once they have emigrated, females are usually quick to find established reproductive groups or form new ones. Most fillies leave the natal band during an estrus period[63] between the ages of 1.5 and 2.5 years and rapidly find companions, usually males.[64] Sometimes they join with colts with whom they have previously affiliated as members of the original natal band.[65] Exiled males, on the other hand, may remain solitary for months or sometimes years.[17]

The home ranges of neighboring bands often overlap, and freshly dispersed youngsters regularly consort with adjacent groups since the value of their home range is enhanced by its familiarity compared with a completely novel area. Some juveniles leave their natal bands with a companion and consort with another group as a bonded pair or provide the nidus of a new group after encountering a small bachelor group or a similar mixed-sex juvenile band.[17] Sometimes aged horses drift between bands.[24] As their rank slips, agonistic encounters escalate until they become untenably frequent and cause dispersal.

Agonistic behavior

This term describes a whole suite of behaviors associated with aggression, protest, threat appeasement, defence and avoidance between conspecifics.[66] From the everyday alerts and flight responses of stable groups to the drama of stallions in combat, these behaviors are of tremendous significance to humans working with horses. They provide the cardinal signs of behavioral conflict that establish thresholds of spatial infringement.[67] Moreover, when ignored they form the basis of potentially lethal responses.

The frequency and character of agonistic displays depend on herd size, since triangular and more complicated relationships, such as reversals, are more likely to occur in large herds.[49] Agonistic encounters within a band are often repeated in a series that eventually diminishes to leave the protagonists grazing alongside one another.[15] As a social order becomes established, the intensity of repeated encounters declines and aggression can become ritualized.[15] Non-agonistic interactions outnumber agonistic ones for all horses except adult males that have yet to secure a natal band, i.e. bachelors.[7] The agonistic ethogram of the bachelor group has been described in detail and includes a total of 49 elemental behaviors, three complex behavioral sequences and five distinct vocalizations.[15]

Responses to potential danger

One advantage of social living is the increased surveillance afforded by the group members' eyes and ears as they scan for potentially dangerous stimuli. In grazing animals it is important for all members of the group to remain alert since, with their heads to the ground, the bodies of other horses can block some of the views around them.

The chief alert response in horses is an elevated head and neck and intense orientation of the eyes (facilitating binocular vision) and ears. This tends to evoke similar responses in other members of the group, and false alarms can amount to a cost of social living. As a means of reducing this risk, natal bands tend to take their cue from the stallion and will soon calm down, despite having been originally alarmed, if the stallion remains calm.[24]

After alert responses come flight and investigation that is usually conducted by a high-ranking member of the group (Table 5.4). The advantage of investigation over constant fleeing is that it may allow the group to continue grazing in an otherwise ideal part of their home range. Species that lack this response pay a heavy price because they are obliged to spend a great deal of time and energy in flight. Horses tend to investigate potential threats by wheeling round and adopting a circuitous approach. Depending on the novelty of the stimulus, the horse may trot as it conducts a visual appraisal of the situation. This may have the advantage of preparing its muscles for a possible flight response and, as a symmetrical gait, does not impose any lateral bias to the horse's locomotion should it need to take flight. The circuitous approach may be deployed in both directions before the horse gets any closer to the stimulus, thus increasing the information gained without a related increase in danger. Dilation of the nares and blowing of air accompany visual examination of the stimulus, and the noise made by this blowing often alerts band members that have not picked up on the visual indications of their peers' concern. Snorting may have the added advantage of causing some approaching animals to flee or simply disperse either because they did not intend to prey or, if they did, because they appreciate that they have been detected.

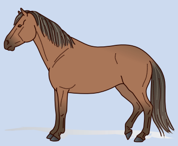
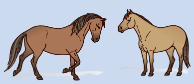
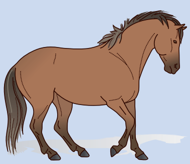
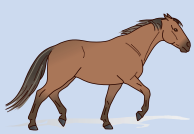
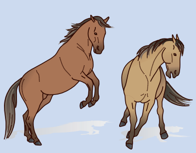
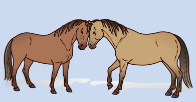
Often a horse has to get quite close to the threatening stimulus to sniff it thoroughly. For this reason it may make a series of false starts before getting close. While increasing the approaching horse's confidence, these false approaches may invite a naïve predator to launch a premature attack. When approaching a conspecific, dominant horses may be accompanied by one or two affiliates to form assemblies.[15] Solitary horses confronted with any potential threat tend to make more cautious approaches than when accompanied.

If the auditory or olfactory investigation confirms the presence of a potential predator the horse takes flight. Intriguingly humans evoke a swifter flight response by naïve, unhandled horses when they assume a quadrupedal stance.[69] Similarly, two familiar humans who combine to form the shape of a quadruped will elicit flight. The putative role of human actions in roundpen work (see Ch. 13) solely as analogues of predatory responses should be considered conjecture in the light of this finding. Fundamentally, this view assumes that horses have a concept of predation,[1] rather than the more parsimonious explanation that some stimuli are simply aversive. Possibly because it is the most economical (see Ch. 7), the trot is the gait adult horses tend to use for withdrawal from a threat, while the gallop is often employed by foals. Postural tonus increases with arousal and brings the horse into a state of readiness for flight and alerts conspecifics to the possible need for escape. This response is regularly accompanied by defecation and occasional pawing at the ground.

Aggression

As we have seen, aggression is generally associated with head threats and bites whereas defense involves responses by the hindquarters. Since horses are

Table 5.4 **Features of the ethogram (as described for bachelor groups[15]) employed in investigation of a potential threat**

Response	Description
Alert 	Rigid stance with neck elevated and head oriented toward the object or animal of focus. The ears are held stiffly upright and forward and the nostrils may be slightly dilated. The whinny may accompany this response
Approach 	Forward movement at any gait or speed toward the potential threat via a straight or curving path. The head may be elevated and ears forward or the head may be lowered and the ears pinned back
Arched neck threat 	Neck tightly flexed with the muzzle drawn toward the chest. Especially characteristic of stallions, arched neck threats are observed during close aggressive encounters and ritualized interactions and may complement or coincide with other responses such as olfactory investigation, parallel prance, posturing, pawing and strike threat
Avoidance/retreat 	Movement that maintains or increases an individual's distance from an approaching threat. The head is usually held low and the ears turned back. The retreat can be at any gait but typically occurs at the trot
Balk 	Abrupt halt or reversal of direction with movement of the head and neck in a rapid sweeping dorsolateral motion away from an apparent threat, while the hindlegs remain stationary. The forelegs may lift off the ground. Typically associated with an approach or lunge of another horse
Olfactory investigation 	As part of interaction between conspecifics, this investigation of the head and/or body is seen after horses have approached one another nose-to-nose. After mutually sniffing face to face, typically one horse works its way along the other's body length, sniffing any or all of the following: neck, withers, flank, genitals, and tail or perineal region. During the investigation, it is common for one or both to squeal, snort, kick threat, strike threat or bite threat

primarily in the company of affiliated band members, more demonstrations of (mild) aggression are exchanged between pair-bonded individuals than between other members of the group. Gestures used differ in their frequency depending on the sex and age of the horse making them, e.g. mares have been shown to make more kick threats than stallions and juveniles.[69]

The most common form of aggression among all horses is the head threat, which involves the extension of the aggressor's head and neck towards another individual while flattening the ears against the head. Head threats are economical and can achieve results without the aggressive animal having to move away from the resource it is seeking to protect. If the mouth is open and biting motions are included but no contact is made with the recipient, the response is labeled a bite threat. Such a threat may or may not be used before an actual bite. Similar gestures are seen when horses respond to other annoyances such as flying insects and abdominal pain.[17] Bites delivered to the hindquarters of conspecifics may be used to drive other horses forward, and bite threats have the same effect. This is most notable in the snaking gestures offered by stallions when herding and driving his band. Here lateral swinging of the lowered head and neck is accompanied by the ubiquitous pinning of the ears to repel band members. Another sort of threat a horse can give using its forequarter is the threat to strike which again is accompanied by ear-pinning but is characterized by movement of one or both forelimbs outward and forward in the direction of the recipient.[8]

If the object of a horse's displeasure is closer to its hindquarters than its forequarters then kick threats and kicks are the more likely response (Fig. 5.9).[17] The hindlegs can be especially effective in aggression, and threats to use them involve simply moving the hindquarters near another animal, or lifting, occasionally hopping and ultimately kicking with the hindlegs. As with other threats, the ears are laid back as a cardinal element of these responses and the more the ears are flattened the more serious is the threat (and with it the more likely will be the emergence of physical contact). Tail-swishing and squealing often accompany kick threats. Horses are remarkably accurate when they choose to strike with their hindlegs,[70] and this is why kicks that do not engage on the protagonist are described as threats rather than misses. If threats given with the fore or hindquarters are ineffective, the aggressor may give chase (Fig. 5.10).

Where there is a lack of deference, for example when two band members are virtually level in the hierarchy or when an interloping bachelor makes a bid to displace a resident stallion, fights typically ensue. Mares tend to engage in kicking fights whereas stallions are more likely to rear. The specific ritualized displays stallions offer in a bid to offset the need for combat are described in Chapters 6, 9 and 11.

Posturing describes a suite of responses that are not ritualized but often seen together before combat.[15] It includes generalized muscular stiffening of the limbs, olfactory investigation, stomping, prancing and head-bowing and arched neck threatening. If displays are ineffective in dispelling aggression between stallions, fights of tremendous intensity and violence may arise. These may include circling or rearing and striking. Biting is very common and serves to impair the balance or nerve of the combatant. If one of the protagonists is knocked to the ground his chances of defeat and serious injury are increased. Broken bones are a not uncommon result of fights between feral and, for that matter, domestic stallions. The repertoire of behaviors that arise in horse–horse interactions, human–horse interactions

Figure 5.9 Two horses exchanging threats. Aggression between horses is accompanied by liberal signaling, i.e. threats that are used primarily to repel protagonists in a bid to avoid physical combat. *(Photograph courtesy of Francis Burton.)*

Figure 5.10 Chasing by band members is costly in terms of energy so it occurs only when threats have not been heeded. *(Photograph courtesy of Francis Burton.)*

and horse–human interactions are summarized in Tables 5.5–5.7 and Box 5.1, along with an estimate of their biological correspondence and their dependence on context.

Submission

Submission, in the form of deference and withdrawal, is the cement of equine social integrity but, perhaps because it involves signaling that is less obvious to human observers than that of aggression, it is often overlooked and its importance underestimated.[15,58] It allows subordinate animals to avoid injury and is similarly helpful to dominant individuals since it can conserve energy and thus reduce the cost of holding a resource. The same principle applies for inter-band aggression, with fewer than 25% of interactions between bands of horses over resources such as water and winter grazing ending in physical contact.[31,44]

When in close proximity with their aggressors, submissive horses often simply have to turn their heads away from their protagonists to switch off the aggression. If this fails, then they must give ground. If the subordinate horse finds that it is unable to get out of the way of an aggressor to the fore, it may throw its head with a rapid swing and roll its eyes thus exposing their sclera. The presence of an ongoing threat from the rear will usually cause the horse to tuck its tail and drop its croup as it tries to shuffle out of the way.

Other signals of deference may be given when horses are at a greater distance from one another. Signs of submission in a colt transiently exiled from the band (as described by Roberts[71]) are said to include lowering his head to the ground, chewing, and licking his lips. That said, head-lowering or licking-and-chewing may be displacement responses. They are reported less in intra-specific encounters in roundpens than has been suggested by roundpen advocates.[72] Their presence in free-ranging horses is the subject of ongoing discussion.[58] These oral responses are slightly reminiscent of the snapping (tooth-clapping, champing, yawing, yamming) gestures illustrated in Figure 5.6 and the jaw movements of estrous mares, especially maidens[43] and Standardbreds.[73] An alternative explanation is that such oral movements are the behavioral manifestation of a physiological response. As part of the plasma response to the distress of being in the pen with inescapable aversive stimuli, circulating adrenaline will rise and lead to a relatively dry mouth. This prompts licking, which may elicit saliva secretion when the balance of sympathetic and parasympathetic discharges returns to normal (Francis Burton, personal communication 2002).

The true snapping display involves extending the head, often while splaying the ears laterally and drawing the corners of the mouth back. It is characteristic of horses 3 years of age and younger. The mouth is opened and closed but without any true biting, i.e. the teeth usually fail to meet. Usually performed while approaching

Table 5.5 **Activities for which naturally occurring analogues exist in both directions: human–horse and horse–human**[1]

Horse–horse interaction[105]	Human–horse interactions	Horse–human interactions	Biological correspon-dence	Stability/ context dependence	Attractiveness of the proximate outcome for the horse	Extent to which the horse may have control over the interaction
Alert	Staring at horse while standing within its visual field	=[a]	+/ ?	+	−	+
Approach	Walking/running directly up to horse	=	++	+	−/ ?	+
Avoidance/ retreat	Withdrawal (e.g. during roundpen training or simply moving away from horse)		+	+	+	−
		Horse avoiding being caught	++	++	++	++
Balk[b]	Stopping suddenly while walking		−	−	−	−
		Horse avoiding being caught	++	++	++	++
Bite threat	Rapid turning of the head towards horse		++	+	−	−
		Horse threatening to bite handler	++	+	+	++
Boxing	Hitting a horse with fists, hands or whips		+/ ?	−	−	−
		Horse rearing and paddling forelegs at handler	+ +	+	+	++
Chase	Running after horse to catch it or harry it away from given spot[c]		+/ ?	+	−	−
		Horse chasing human out of stable, paddock or roundpen	+	−	+	++
Grasp	Neck twitch or so-called 'gaucho' twitch		+/ ?	+	−	−
		Horse grasping handler	++	+	?	++
Head bump	Head- (or possibly hand-) to-head contact with horse's head or neck		−	−/ ?	?	−
		Head-to-head contact with human	+	?	+	+

(*Continued*)

Table 5.5 **(Continued)**

Horse–horse interaction[105]	Human–horse interactions	Horse–human interactions	Biological correspondence	Stability/context dependence	Attractiveness of the proximate outcome for the horse	Extent to which the horse may have control over the interaction
Head on neck, back or rump	Head- (or possibly hand-) to-head contact with horse's neck, back or rump		–	–/?	?	–
		Head-to-neck, back or rump contact with human	+	?	+	+
Head-bowing	=	Horse bowing towards handler	++	+	?	++
Herding and driving	Moving horse(s) from behind with mildly aversive stimuli		++	+	–	+/?
		Horse causing human to move in one direction	+/?	–	+	++
Interference[d]	Human in paddock or stable with more than one horse, attempt to 'split up' fight		+	+/?	–	–
		Mare protecting foal	++	+	++	+
Kick	Some humans do kick horses[e]		+/?	+	– – –	–
		Horse kicking handler	++	+	+	++
Kick threat	Threaten to whip or sound the whip[e]		+/?	+	–	–
		Horse threatening to kick handler	++	+	+	++
Lunge	Moving rapidly towards horse		+/?	+	–	–
		Lunging towards handler	+	+	+	+
Mutual grooming	Grooming/scratching a horse's lower neck/withers	=	+	+	+	+
		Nuzzling	+	?	+	+
Mounting	Mounting-to-ride		–	–	+/–	–
		Attempting to mount human	?	–	–	–

(Continued)

Table 5.5 (Continued)

Horse–horse interaction[105]	Human–horse interactions	Horse–human interactions	Biological correspondence	Stability/ context dependence	Attractiveness of the proximate outcome for the horse	Extent to which the horse may have control over the interaction
Nip	Brief pinching of skin (often lip) as punisher		–	–	–	–
		Horse nipping handler	++	+	+	++
Olfactory investigation	Nose-to-nose exchanges as advocated by some trainers		+/ ?	+	?	+
		Responses to novel human-borne odors	+	+	?	++
Parallel prance	Leading in-hand at the trot (as in in-hand showing)		+/ ?	+	?	+
		Prancing alongside handler	+/ ?	+	?	+
Push	Moving horse with pressure on shoulders or flanks		++	+	–	+
		Barging	++	+	+	+
Stomp	Stamping foot near horse		+/ ?	+/ ?	?	–
		Stomping at handler	+/?	+	+	+
Trekking[f]	Leading a horse without rein pressure		+/ ?	+	–	+
		Following a horse (e.g. in long-reining)	?	+	–	–

[a]=sign denotes the existence of a corresponding activity in the opposite direction to the usual.
[b]Abrupt halt or reversal of direction with movement of the head and neck in a rapid sweeping dorsolateral motion away from an apparent threat while the hindlegs remain stationary. The forelegs lift off the ground.
[c]Loose jumping sometimes involves this interaction.
[d]One or more horses may simultaneously interfere with an ongoing agonistic encounter between conspecifics. Disruption of combat occurs by moving between the fighting individuals, pushing, attacking or simply approaching the combatants.
[e]Hitting, using a whip, is a closer analogue of a kick than a bite, since it causes sharp pain and is the result of a movement that extends toward the target but does not involve teeth.
[f]Two or more animals moving together, typically following one another.

Table 5.6 **Activities for which a naturally occurring analogue exists in only one direction: horse–human[1]**

Horse–horse interaction	Horse–human interactions	Biological correspondence	Stability/ context dependence	Attractiveness of the proximate outcome for the horse	Extent to which the horse may have control over the interaction
Arched neck threat	Flexed necks are favoured in dressage competitions	−/ ?	−	−	−/ ?
Bite[a]	Horse biting handler	++	+	+	++
Circling	Horse being lunged or worked in a roundpen	+/ ?	+	−/+	−
Dancing[b]	Horse attacks human Circus/pignonesque tricks	−/ ?	−	−	−
Ears laid back/ pinned	Ear threat towards human	+	+	++	++
Erection	Erection while being groomed, shod or otherwise handled	+/ ?	+	?	++
Flehmen	Responses to novel human-borne odors	+	+	?	++
Head threat[c]	Horse threatening handler	+	+	++	++
Neck wrestling[d]	Same as dancing (above)	+/ ?	+	+	+
Pawing	Pawing in presence of handler	+/ ?	+	?	+
Posturing[e]	Posturing towards handler	+/ ?	+	?	+
Rearing	Rearing towards handler	+	+	+	++
Rump presentation	Presenting rump towards handler	+/ ?	+	?	+
Snapping[f]	Foal or young horse snapping towards human	+/ ?	+	+	+
Receptive and non-receptive female responses	Mare displaying to human	+/ ?	+	?	+

[a]*Arguably, bite has analogues in pinching and whip use.*
[b]*Two stallions rear, interlock the forelegs and shuffle the hindlegs while biting or threatening to bite one another's head and neck.*
[c]*Head lowered with the ears pinned, neck stretched or extended toward the target and lips often pursed.*
[d]*Sparring with the head and neck that may involve one or both protagonists dropping to one or both knees or raising the forelegs.*
[e]*Posturing describes a suite of pre-fight behaviors that includes head-bowing, olfactory investigation, stomping, prancing, rubbing and pushing, all with neck arching and some stiffening of the entire body.*
[f]*Moving the lower jaw up and down in a chewing or sucking motion, with the mouth open and lips drawn back.*

Table 5.7 Activities for which no naturally occurring analogues exist (things horses never do to each other) (i.e. no biological correspondence)[1]

Human–horse interaction	Attractiveness of outcome for horse	Extent of horse's control
Picking feet up, hoof trimming and shoeing	+	+
Leading into trailer or box	+/−	+/−
Trailer loading without leading	+/−	+
Feeding by hand or from bucket	++	+
Invasive veterinary work (e.g. injecting and suturing)	−	−
Grooming inguinal, ventral and perineal regions	+/−	+/−
Pulling hairs from the mane and tail	−	+/−
Spraying against flies	+/−	−
Clipping	+/−	−
Branding	−−	−
Driving in close proximity to other horses (e.g. driving horses side-by-side demands tolerance of breached individual space)	+/−	+/−
Mounting-to-ride	+/−	+/−−−

Other things we make or train horses to do: bow, hyperextension, capriole, jump over another horse, walk on hindlegs, tolerate predator on back, vaulting, towing, jumping, racing, driving, showing/parading, treadmill training, semen collection.

Box 5.1 Elements of the ethogram that do not appear in horse–human dyads (horse–horse activities, but not horse–human or human–horse)[1]

- Maternal licking (although sponging may equate)
- Suckling (although equivalent may appear as hand-stripping prior to bottle feeding)
- Blocking (defined in ethogram as foal stopping in front of and perpendicular to mare)
- Mutual insect control (although a human may swat flies away from horse, and may also be target of tail swishing from horses, these two activities rarely occur simultaneously, so it seems inappropriate to call it 'mutual').

the head of another horse at an angle, the snapping display exposes the incisors. A sucking sound may be made as the tongue is drawn against the roof of the mouth. Typically the head and neck are extended, with the ears relaxed and oriented back or laterally.

There is some debate surrounding the communication intended by animals performing these gestures, the frequency of which declines with age. For example, it has been suggested that this response has its origins in allogrooming[74] and that the performer is trying to placate the recipient by demonstrating an intention to consolidate a putative pair-bond.[24] Foals that have become displaced from their dams snap as they approach adults in the band and continue to do so until they have recognized their dams.[43] It is interesting to note that stallions evoke more of this response than do other adults, and that male foals offer it more often than females.[69] However, studies have shown that snapping fails to inhibit aggression and in some cases may even seem to precipitate it.[8,27] This breadth of circumstance and consequence has led some to suggest that the interpretation of snapping may be context-dependent or alternatively a displacement response derived from a suckling behavior.[27,58]

Homing

Being less opportunistic than other species, the horse has evolved to be able to find its way back to its home range – for instance, after being pursued by a predator.[75] In addition to the promise of finding its companions there, the value of the home range to its occupant reflects the comfort of knowing tracks and escape routes within the area as well as the topographical location of resources such as food, water and shelter. The role of olfaction (and the detection of familiar fecal material) in homing is likely to be significant.[76] Horses have been recorded homing over distances of more than 15 km, and Icelandic horses are thought to be especially good at finding their way home.[68]

The tendency to increase speed when turned for home, shared by most horses, speaks of the motivation to remain in the home range. Bolting is far more often in the direction of home than in any other direction, and riders of horses not intended for high-speed performance do well to avoid reinforcing this tendency, e.g. by never racing in the direction of home. Horses are generally more wary of novel stimuli away from their home range, and this is one of the reasons why schooling at home is often easier than at a competition.

Social organization in donkeys

The social structure adopted by donkeys in any particular area is dependent on the availability of resources such as food and water. In bountiful environments, donkeys use a natal band system, similar to those of horses and ponies, with complex social order within the groups, in which rank is not a simple function of age, sex, aggression or weight (Jane French, personal communication). In arid and semi-arid regions, a loose social structure (also typical of African asses and Grevy's zebras) exists with temporary groups of males, or females, or males and females predominating while some jacks become solitary. Small aggregations in this system rarely last more than a few days – membership is very fluid with mixing and splitting of groups occurring when animals congregate, e.g. at watering sources. There is no aggression between groups. Dominant jacks do not maintain a harem but dominate breeding activity within a large area, called a lek. The only permanent association is between a female and her foal, who travel together unassociated with others. This behavioral characteristic has a profound effect on the frequency of interactive behaviors, e.g. social play is rare in donkeys when compared with harem equids.[77]

The characteristic flexibility of hemionine social structure has practical implications for the management of grazing and the housing of donkeys with horses. Since donkeys are good mixers they are used as companion animals for performance horses. Being familiar and calm, they are valued as travel companions when particularly reactive sports horses leave their home yard for competitions and shows.

Although separation-related distress expressed with the drama of bolting back to the herd is less common in donkeys than in horses, some donkeys show some signs of extreme separation-related distress, such as braying, pacing and general pining, most notably when the individual is one of a bonded pair. These coping strategies do not become stereotypic. If one of a bonded pair dies, allowing the companion contact with the body for about 30 minutes seems sufficient to prevent the onset of overt separation-related distress.

Aggression toward people is very rare among donkeys (Jane French, personal communication 2001). In contrast, aggression toward other species, such as dogs and sheep, is more common in donkeys than aggression toward other equids. Indeed, along with llamas, donkeys are recognized as an effective guardian species.[78]

Applying the data from free-ranging horses to domestic contexts

When considering the effect of domestication on the social behavior of the horse, it is appropriate to compare the social structure of domestic groups with Przewalski horses and those that have had an opportunity to revert to type. The organization of social structure in wild, feral and domestic horses is similar enough to suggest that domestication has not had an effect on this facet of horse behavior. Perhaps because of artificial selection of passivity in *E. caballus* over the past 6000 years, *E. przewalskii* in captive environments were said to have a higher level of aggression than domesticated and feral horses.[7] That said, it is worth noting that reintroduced *E. przewalskii* stallions do not show the high aggression recorded in confined populations. Furthermore, we should be cautious about making inferences about behavior of male *E. przewalskii,* because the extant population has only one Y chromosome since a single-stallion cohort was originally salvaged from the wild. So, presumed aggressiveness may not be a case of a characteristic of the species, but an individual variation on that chromosome (Machteld van Dierendock, personal communication 2002).

Horses naturally defend a space around them, and this accounts for the reluctance of many horses to stand close to one another when being ridden. Notwithstanding the need to maintain such a distance between horses, there are excellent reasons for riding naïve horses in the company of calmer, more experienced animals. Just as free-ranging horses after being alarmed soon calm down if the stallion remains calm,[24] so do domestic horses take their cues from companions. It is advisable to capitalize on this tendency as often as possible when introducing naïve horses to novel stimuli. It is likely that, in the process of domestication, while we have found innate reactivity desirable in racing breeds, we have selected some breeds to be less reactive than their wild forebears. This is especially so for draft work that requires animals to be docile. Cold-blooded types are therefore generally preferred as exemplars and propagators of desirable behavior in potentially fearful situations such as heavy traffic.[70]

Since it is natural for horses to develop bonds and social order based on affiliations and hierarchies, managers and owners must understand that, once relationships have formed, the introduction of new horses increases the risk of injury and stress in the group. Youngsters receive the largest number of attacks in any group of horses as they are naïve and may be less responsive to threats. Just as horses in free-ranging groups tend to bond with conspecifics of similar age, so when establishing long-term groups it is appropriate to provide companions of similar ages and sufficient space for bonded pairs in a paddock to avoid one another. It has been suggested that the restrictions associated with human management may precipitate higher rates of aggression than would be seen in the free-ranging state.[5,8] This should be borne in mind when horse-holding facilities are designed, e.g. paddocks should have rounded corners to prevent subordinate animals becoming trapped and kicked by dominant 'bullies'.[70] Structures in paddocks that provide a visual screening or baffling effect may be used for sanctuary by subordinate field-mates.

Since most aggression occurs near resources it is best to place water, feeding stations and even gates away from corners. The extent to which an individual can monopolize a resource can be limited by providing one more portion of that resource than there are horses in the enclosure. To avoid low-ranking individuals failing completely to access concentrates, it is worth providing them with feeding havens or removing them from the group for supplementary feeding. Even pair-bonded affiliates may maintain a personal space of 1.5 m when feeding, and so this should be used as the approximate minimum distance between individual feeding bays. Wire partitions along a feeding trough have been shown to reduce aggression by allowing subordinate horses to eat alongside more assertive individuals.[79]

Horses adapt poorly to the constant introduction of newcomers to a social group. Indeed, equine physiologists have used social instability to induce chronic stress as indicated by elevated free plasma cortisol concentrations (i.e. a reduction in corticosteroid-binding globulin).[80] It can take 3 weeks for a new social order to be established.[81]

Fighting can lead to severe injuries especially when animals are crowded or continuously grouped or regrouped.[15] Where there is a continuous flux in the complexion of a domestic group such as on a livery yard, placing mares and geldings in separate groups is thought to help reduce agonistic encounters that are reproductive in origin. The adoption of single-sex groups provides an analogue of the social dynamics that prevail in natal bands without a stallion (in which mare–mare bonds are successful) and bachelor groups that offer a model for male-only groupings. Providing an even number of horses in all groups may facilitate pair-bonding and, if the space is available, large groups seem to be associated with less aggression than small groups, perhaps because the increased choice of preferred partners reduces the need to defend key field-mates.

In some domestic contexts mixed groups can work well, but they are more often avoided because of overbonding between individuals of the opposite sex. Most commonly, this manifests when geldings become difficult to ride away from mares with which they have bonded. Such animals often demonstrate signs of considerable anxiety, and in their hurried return to the group they show little consideration for their own safety, let alone that of their riders. Sometimes a gelding may entirely monopolize one mare in a group to the extent that she is prevented from socializing with any other horses. Equally, one gelding may harass another for the monopoly of a given mare.

Before placing new horses in a group, it is preferable to introduce horses to one another individually so that they have the opportunity to form pair bonds. The first meeting of two strangers can be facilitated if both are sufficiently hungry to be distracted by food sources placed a safe distance apart. To facilitate the establishment of social hierarchies in very small groups, horses of disparate predicted rank (e.g. old and young horses) can be mixed. Conversely, placing horses of similar ages in the same paddock has the potential to extend the period of flux (Fig. 5.11) during which peers challenge each other repeatedly until a hierarchy emerges. It is therefore not the preferred blend for transient groupings.

Allowing horses to meet for the first time with a fence between them has its merits but only if the barrier is safe and solid. Injuries, especially to the legs, should be expected if the fence is of wire or barbed wire. If there is no choice but to mix a new horse directly with an established group, it is best to first turn out the newcomer alone so that it can explore the paddock before it has to cope with the intensity of the whole group at once with their 'home ground advantage'. With particularly reactive animals that are likely to run rather than graze when turned out, it is advisable to walk them around the fenceline before release since this may reduce the chances of them running into the fence. This is most likely to work if other horses that may distract new arrivals are out of sight.

The overall effect of isolation of mares from an established group with or without a companion for short periods has been described as minimal.[82] Its behavioral effects include increased whinnying, urination and rolling.[82] In contrast, the effects of long-term isolation on youngsters are profound. The complete isolation of foals and juveniles is particularly inadvisable since it can lead to

Figure 5.11 Horses that have very recently been introduced to one another posture and jostle to form a hierarchy. *(Reproduced by permission of the University of Bristol, Department of Clinical Veterinary Science.)*

mal-imprinting in foals[83] and compromise social skills in juveniles.[70] Animals that have undergone such isolation as youngsters regularly offer undesirable social behaviors upon being introduced to other horses.[14] The same animals can learn to be assertive with humans, and this seems to have the capacity to foster aggression. By way of an example, young horses that have been inadvertently reinforced for pushing humans bearing supplementary feed, can ultimately defend the resource with frank aggression.[70] Providing foals with conspecific peers is the best way to channel play-fighting in an appropriate direction and reduce the extent to which dangerous coltish responses such as rearing are directed towards humans. As the colts mature, fights become less playful when estrous mares are detected, and separation of males is advisable. This management decision should not mean that colts have to be isolated completely, as this can result in undesirable and maladaptive responses such as self-mutilation. Two-year-old colts have been shown to be sensitive to social deprivation in that stabling in isolation has long-term effects, lasting 6 weeks at least, on their social behavior.[50] Stallions can be successfully pastured together if the paddock is spacious and several watering holes are available.[15]

The companionship of an older horse can help to teach youngsters social decorum (so-called 'manners'). Meanwhile providing colts intended for breeding with a mature female companion may even help them learn mounting techniques.

Wherever possible, horses should be kept in social groups with a variety of age and sex classes. The horse responds poorly to isolation (Fig. 5.12) and is likely to

Figure 5.12 Even at pasture, isolated horses may have compromised welfare.

Figure 5.13 When given mirrors, isolated horses often stand beside their own image. Mirrors used in this way should have rubber backing that prevents dispersal of shards should any damage occur. *(Reproduced by permission of the University of Bristol, Department of Clinical Veterinary Science.)*

show physiological and behavioral distress responses including stereotypies if deprived of contact with conspecifics.[84] Horses without conspecific company have been shown to spend 10% less time eating and are three times more active than those that could make auditory, visual and tactile contact with other horses.[85] There is also evidence of physiological stress reactions with increasing time spent confined in stalls and in isolation.[86] Affiliations cannot be imposed on horses by simply housing them beside one another. This is borne out by comparisons of 2-year-old colts that had been group-reared and single reared for 9 months.[60] Once released together, group-reared colts frequently had a former group mate as their nearest neighbor, whereas singly reared colts did not associate more with their former neighbors with whom they had limited physical contact via bars between stalls.[60] Instead of guessing which horses will enjoy being neighbors, stable managers should take care to stable beside one another horses that have demonstrated some affiliation in the paddock. This may serve to reduce the distressing effects of confinement. There is evidence that mirrors can provide some of the stimuli that isolated horses need (Fig. 5.13).[70] Horses do not appear to recognize the mirror images as their own, since they will sometimes show transient aggression towards them.[70] For this reason, feed should be provided at a safe distance from the mirror, especially when the mirror has only recently been introduced.

Housing horses together in the long term allows stress reduction activities (such as mutual grooming) to take place.[67] Furthermore it is even possible for managed herds to be more stable and therefore involve less risk of injury than free-ranging groups, since most changes in the social hierarchy are due to changes in the younger age classes.[69,87]

Although housing horses together is better than isolating them, care must be taken to avoid unwelcome analogues of herd responses. Social facilitation can cause hysteria to spread through a group of horses, and this is why stabling should be designed to facilitate visual and auditory contact between close neighbors but not between large numbers of horses.

Homing tendencies can be put to good use as in the case of most racecourses that have the stabling beyond the finishing line (being the site of some food and company, the stables are likely to represent the horses' temporary home range). Similarly desirable responses can be reinforced when providing horses with access to their band or affiliates, e.g. when jumping novice horses it is best to ride them over obstacles towards rather than away from other horses. Social bonds can sometimes be used to riders' advantage. For example, one horse can help to lead another through water (Fig. 5.14).

Figure 5.14 One horse following another's lead into water.
(Reproduced with permission of Australian Equine Behaviour Centre)

Social behavior problems

Mal-imprinting and over-bonding

Hand-reared foals often show evidence of mal-imprinting, such as when they prefer human company to that of other horses.[83,88] The first suspicion that a foal is adopting an individual human caregiver as a surrogate mother may be when it offers the snapping response to humans.[88] This rule of thumb should be used with caution since naturally reared foals occasionally offer the same greeting to humans. Mal-imprinting is less likely if the foal is housed in visual contact with its own kind (any non-aggressive conspecific will serve the purpose) during the sensitive period that has been estimated to end at approximately 48 hours of age.[17] While this so-called window period remains ill-defined, it is worth noting that the vocalization rate of foals experimentally separated from their dams peaks just before 4 weeks of age. This implies that their needs are maximal during this time, and therefore the possibility of bonding to a surrogate caregiver can also be considerable at this time. So there is a strong argument for fostering such orphans or, failing that, rearing them within a group of conspecifics.

Over-bonding is recognized in horses that fail to behave normally in the absence of an attachment figure – usually an affiliated horse, rather than a member of another species. Prevention involves habituating the pair to separation during the early stages of bond formation.

Vocalization and locomotion that is often frenzied are the most common features of the affected horse's response to separation. Anorexia and failure to drink are also seen in horses distressed by separation, thus contributing to transit stress (see Ch. 14). Signs of separation-related distress can persist for several months.[17] Affected horses often attempt to escape from their enclosure, thus compromising their safety. Similarly, concerns are raised for the welfare of horses that work a trough into the ground in front of the critical piece of fence-line that separates them from the companion or where it was last seen or heard (Fig. 5.15).

Treatment should be based on providing an appropriate new companion or, if this is impractical, a mirror may have desirable effects. Not least because anxiolytics take longer to work than most horses take to form a bond with conspecifics, they are often less desirable than providing a companion. It should be noted that horses do not always crave company for its own sake, e.g. once a stallion's behavioral needs for female companions are met, he will not generally continue to seek others.

Aggression to humans

Aggression towards humans is a common problem behavior seen in fearful horses but also in those that have learned to defend the resources within their enclosures from humans. These horses may charge or simply stand their ground to prevent humans getting past. It is thought that others may become 'socially dominant' to humans, but this is highly contentious since it may prompt some humans to perceive a need to prevail over their horses and this can lead to breakdown in the human–horse relationship. The complexity of horse–horse interactions and the unlikelihood of there being numerous analogues in the horse–human dyad has been discussed elsewhere.[1] The learned aspects of aggression to humans should not be underestimated. The unwelcome behavior is reinforced by the departure of the human. Therefore, notwithstanding safety considerations, personnel should be warned that capitulating to horses that show aggressive responses in the paddock is an effective means of rewarding the behavior and so exacerbating the problem.

Houpt[89] describes a gelding aggressively guarding a mare to which he had bonded. Other horses may have learned to defend food, water or even their liberty (especially in the case of horses that have grown to associate ridden work with pain). Resolving this problem requires the handler to identify which resource the horse is defending. If the horse resents the human approaching

Figure 5.15 Composite image from three stills of a stallion showing barrier frustration. Over time this horse had eroded a 1-m deep track beside the fenceline.

affiliates, the key members of the group or the whole group should be brought in using supplementary feed as necessary. By controlling the group, handlers can retain control while extinguishing the defensive response.

If the horse is defending resources within the paddock, moving the group into a new paddock usually disorients the animal long enough for a fresh regimen to be instituted. Providing multiple feeding and watering spots helps to dispel defensive aggression. The diagnosis of dominance has been controversial not least because it ignores evidence that the relationship between humans and horses is profoundly different from relationships between horses.[1,26]

While operant conditioning techniques are often successful in shaping safe, neutral or deferential responses in aggressive horses[26] (Fig. 5.16), the use of muscle relaxants such as succinylcholine, followed by comprehensive handling, has been advocated to induce learned helplessness in extremely aggressive horses.[90] However, the ethical problems with such an approach are manifold.

Trainers who hit horses for displaying aggression demonstrate poor consideration of the effects of contiguity (see Ch. 4). It is rare indeed to find someone hitting a horse in a field, because most humans can work out that this will simply drive the horse away. Instead,

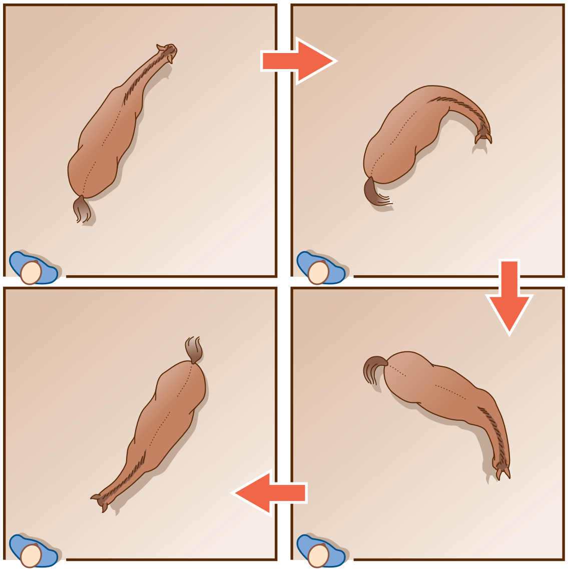


Figure 5.16 For horses that habitually turn their hindquarters towards people as they enter the stable, shaping techniques can be very helpful in teaching the horse to turn to face humans. Food should not be used as a lure. As with all shaping, the reward is withheld until the horse has shown some improvement on previous responses. In this case the shaped response is turning the forequarters towards the human.

one tends to find whips being used punitively in stables from which there is no escape for the horse. This must increase the horse's fear and the likelihood of it using agonistic responses towards humans when trapped. If the desired response is a calm, passive approach to humans, trainers who are aware of the effects of contingency and contiguity would not expect this to be offered readily if humans have freshly been associated with aversive stimuli. When threatened by horses, personnel should remove themselves from danger and then plan a strategic program of learning opportunities that allows the horse to develop safe alternative responses to the eliciting stimuli. Examples of such programs are offered in the case studies of Chapters 11 and 15. For horses that habitually turn their hindquarters towards people as they enter the stable, shaping techniques can be very helpful in teaching the horse to turn and face humans (Fig. 5.16). If there is no time for behavior modification, the tactful use of chemical restraint for dangerous horses is vastly preferable to physical restraint or punishment (see Ch. 14).

The use of mirrors seems to reduce aggression in stabled horses (Daniel Mills, personal communication 2002). This indicates that at least some instances of aggression towards humans (e.g. as they pass the stable door) are related to social frustration.

Voluntary isolation

Horses are so very social that one can regard individuals (other than peri-parturient mares) that habitually avoid other horses as abnormal. Locoweed poisoning[91] is associated with a tendency to seek isolation, and any deficit in perception may affect the individual's ability to locate and remain with its affiliates or the group. Just as old free-ranging horses begin to wander between bands, so do domestic horses in their dotage tend to withdraw from group activities and ultimately the group itself.

Weaving and box-walking

Two locomotory behaviors are described as stereotypic: weaving and box-walking. They are very similar in causation and their strong association with social needs indicates that this chapter is an appropriate home for them in the current text. Weaving is the lateral swaying of the head, usually over the stable door or in the face of some other barrier.[92] The activity may include swaying of the rest of the body, notably the shoulders, and picking up the front, and sometimes the hind, legs. Box-walking is the pacing of a fixed route around the stable.[28] Typically, a circular route is traced but, in larger stables or in the field, horses may trace a 'figure of eight' shaped route. Concern exists for the ongoing soundness of the weaving horse, as it is likely to cause excessive wear and tear on the hooves and the musculoskeletal system. Similarly box-walking in a single direction is likely to cause lateralized atrophy and hypertrophy of the lumbar musculature.

Timing

Locomotory stereotypies and similar repetitive activities such as pawing the ground are commonly seen in stabled horses prior to feeding or other arousing daily events such as when other horses arrive at or leave the stable-yard.[28,92,93] Therefore it seems unlikely that they are caused by under-stimulation (or what might be labeled 'boredom') but rather they may arise when horses' motivation to move (e.g. to be with other members of the group or to reach to food) is thwarted.

Risk factors

In a prospective study of a population of foals, locomotory stereotypies tended to arise at a median age of 60 weeks for weaving (i.e. after the foals have been sold from the stud to new homes) and 64 weeks for box-walking, compared with 20 weeks for crib-biting and 30 weeks for wood-chewing.[56] Therefore weaving does not appear to be related to weaning practice. Instead it seems to be related to environmental social disturbances. So research efforts should focus on reducing the impact of management interventions during this high-risk period, e.g. by examining the effects of anxiolytics and antidepressants.

Although weaving has been reported as both more[94] and less prevalent[95] in standing stalls than in loose boxes, it is seen at pasture only when horses have encountered a barrier. If being in a stable is frustrating for a horse, it is possible that the lack of free exercise plays a role in the motivation to stereotype. However, the evidence for a relationship between exercise routine and stereotypy is equivocal. For example, exercise routine was not identified as a risk factor in epidemiological studies[84] and there was little evidence that exercise routine has a consistent effect on incidence of stereotypy in the stable.[95] There is evidence to suggest that turning out acts as a focus for the expression of locomotory stereotypies.[93] Many owners report that preparatory cues prior to the event of turning out seem to initiate weaving and nodding.[93] So locomotory activity may either be the expression of an unusual form of species-typical anticipatory behaviors, such as attempts to socially interact with other horses being led away, or a learned response to a desirable outcome, such as leaving confinement.[93,96] It is interesting to speculate how some horses evolved to have these responses in the absence of domestication.

Allowing close tactile and visual contact with the neighboring horse, directly through a grille or open space between stables rather than over the stable door, significantly reduces weaving and nodding when compared with the traditional solid-walled box.[93] Indeed, in short-term studies, the incidence of weaving dropped to zero when the horses had opportunities for social interaction with their neighbors on all four sides of their enclosure.[93] Therefore weaving and, by inference, box-walking can be regarded as frustrated escape responses.[28]

Physical prevention

Anti-weaving bars that provide a V-shaped aperture through which horses can put their heads and necks but which limits lateral movement are the most common response to, or prophylactic for, weaving (Fig. 5.17).[97] Their use is reported in approximately 70% of establishments.[97] Other attempts to prevent weaving include suspending a heavy object or fixing an upright bar to occupy the space above the door, both of which aim to interrupt the weaving motion, or to prevent the horse from putting its head over the stable door.[98] In response to all of these physical barriers, most weavers simply move to a different area of the box and weave without having their head and neck over the door.[69,98] In stables with weaving grilles a stereotypic activity labeled treading[28] may be observed. This involves swaying the body or alternative lifting of the forelegs, without the swaying of the head and neck.[28] Box-walking may be less easily accomplished if obstacles such as straw bales are arranged on the stable floor or if the horse is tied up, but these crude approaches are largely impractical.[99]

The use of physical impediments to locomotory stereotypies has to be questioned since they reduce the utility of the spaces occupied by affected horses and their overall effect may be to increase total frustration with the environment.[100]

Figure 5.17 Anti-weaving bars thwart the performance of weaving, but they are unlikely to be effective in reducing the emergence of weaving in young horses. *(Reproduced by permission of the University of Bristol, Department. of Clinical Veterinary Science.)*

Managing locomotor stereotypies

Changing the cues that precede feeding or changing the time of feeding reduces pre-feeding stereotypy but not post-feeding stereotypy (Jonathan Cooper, personal communication 2002). This and the involvement of certain stimuli that reliably elicit locomotory stereotypies suggest that the role of learning in the emergence of stereotypies is significant.[100] Therefore changing the husbandry routine may be an effective treatment of such stereotypies but it is unlikely to be permanent, because the horses will most likely learn new associations that predict feeding in novel routines. Therefore, unless the husbandry routine is continually changed to maintain the novelty effect, the stereotypy would return to its original level. Additionally, flux in routine is generally considered to be harmful to horses, not least in terms of gastrointestinal motility and health.

Empirical studies indicate that if stereotypic or normal horses must be stabled it is advisable to provide them with visual and tactile contact with conspecifics. Providing close contact with conspecifics may help to explain the low incidence of stereotypies reported in some stall-tied horses,[92] but even close contact between neighboring horses does not stop weaving completely.[101] Giving stabled horses a wall to look at rather than a view of other horses and activity in the service passage may reduce arousal and therefore the perceived prevalence of stereotypies but it provides little of the environmental enrichment we know to be of tremendous value. Although husbandry systems are being developed to facilitate social housing,[58] they may remain unattractive to some owners because of undesirable social interactions, risk of infection, or financial outlay required to maintain additional horses. Exercise may help reduce time spent stereotyping by inducing fatigue and therefore rest, which is an appropriate activity for stabled horses. Additionally a practical band-aid measure may be to provide stabled horses with mirrors.[70] In both short-[102] and long-term[103] studies, mirrors appear to have a similar effect to social contact. With long-term use of mirrors, fewer repetitive head threats are reported.[103] Although the effects are impressive, it is not clear whether horses are simply distracted by reflected visual stimuli or whether they 'see' another horse. The latter seems more likely since unpublished data show similar effects with posters of horses but not when these images were pixelated (i.e. when they had the same content but the equine form was scrambled) (Daniel Mills, personal communication 2002).

As interest grows in weaving as a model of human behavioral disorders,[104] we may well see the development of pharmaceutical approaches to horses that show barrier frustration. However, we should avoid becoming reliant on such approaches, especially if they are used in the absence of appropriate environmental enrichment.

SUMMARY OF KEY POINTS

- Free-ranging horses form social hierarchies that are complex and rarely linear.
- Under natural conditions, equids seldom have the equivalent of an alpha individual, because the social roles of leadership and defense are more critical than domination.
- Domesticated horses have similar social organization to groups of free-ranging horses but often show more aggression as a product of various artificial impositions, including social flux.
- Social hierarchies increase stability in the band and decrease aggression, injury and distress.
- Individual attachment, most notably in the form of pair bonds, is the fabric of social groups.
- Housed horses benefit from social contact with conspecifics.
- Social status determines the order in which members of a group access resources.
- Horses are not usually territorial but work to maintain the integrity of their group.
- Matrilineal dynasties can be observed in many bands of horses.
- Social rank is not determined by weight, height or sex, but by age and length of residency.
- Stallions are not always the leaders of their natal bands. Their rank is context-dependent.
- Stallions tend to form weaker pair bonds than mares, juveniles or bachelors, but this does not justify isolating them from conspecifics.

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Communication

CHAPTER 6

Chapter contents

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Body language

Monitoring of Przewalski horses has shown that a band's behavior can be synchronized between 50% and 98% of the time.[1] Communication between members of a social group of horses facilitates this synchrony. Horses most often communicate without using their voices. This is because they are social prey animals that must organize themselves as a group but without attracting predators. Used to scan for responses after vocalization, the ears are the most important body part in equine non-vocal communication. When flattened, they generally qualify all concurrent interactions as agonistic, and the extent to which they are pinned back correlates with the gravity of a threat.[2] An important feature of bite threats, ear pinning may have evolved simply as a means of avoiding ear injury during fighting, but it has taken on an additional signaling function. Rather than being pinned back, ears are simply turned to point backwards during avoidance responses as horses retreat as a display of submission.[3]

Ears are not central to expressions of threatened aggression alone. Indeed they are focal to a series of expressions elegantly described by Waring & Dark.[4] Neck posture changes significantly during agonistic encounters between horses, being flexed during approach responses and often arched in response to threats, especially by stallions.[3] It is important to note that such arching is extremely transient and therefore cannot plausibly be cited as a natural analogue of the prolonged hyperflexion seen in Rollkur or so-called long-deep-and-round training.[5] Head bowing that involves rhythmic exaggerated flexing of the neck to the extent that the muzzle may touch the pectoral region is seen as a synchronous display by two stallions as they approach one another head to head.[3]

The series of illustrations in this chapter demonstrates the importance in communication of various features of the equine head, including the nostrils or nares. The nares dilate and constrict with changes in mood. For example, during forward attention, as a horse sniffs the ground, they are moderately dilated whereas during aggression they become drawn back to form wrinkles on their aboral edge. In combination with head position, the ears and nares contribute to expressions of forward attention (Fig. 6.1), lateral attention (Fig. 6.2), backward attention, alarm, aggression, submission and pleasure.

When ears are pointing forward the horse is, as one might expect, attending to a stimulus in front of it. Horses are sometimes seen pointing their ears in two directions (see, for example, Fig. 2.14 on p. 48). Swiveling of the ears is associated with pain; e.g. a horse with colic may swivel its ears back in the direction of its abdomen before it gets to the stage of kicking at its belly.

The positions of horses' ears in a moving band seems to be predicated on the spatial positions of those horses in the group. Horses at the front of a moving group tend to have their ears forward while those to the rear orient their ears backwards. This suggests that, in this instance, ears are used chiefly for surveillance rather than for

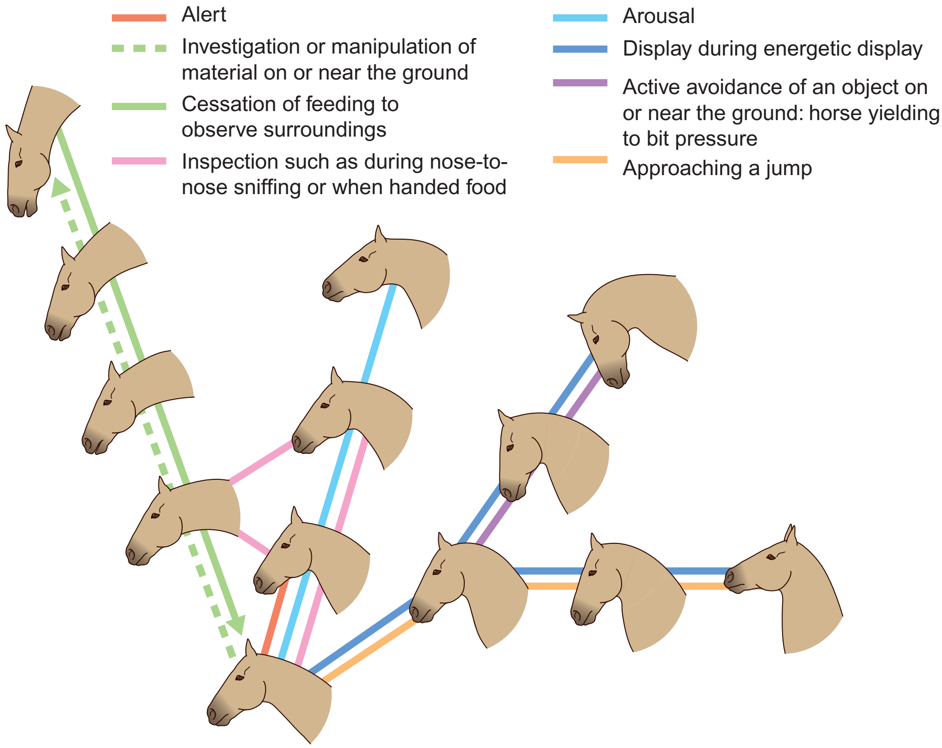


Figure 6.1 Expressions of forward attention. *(Redrawn from Waring[2], after Waring & Dark[4], with permission.)*

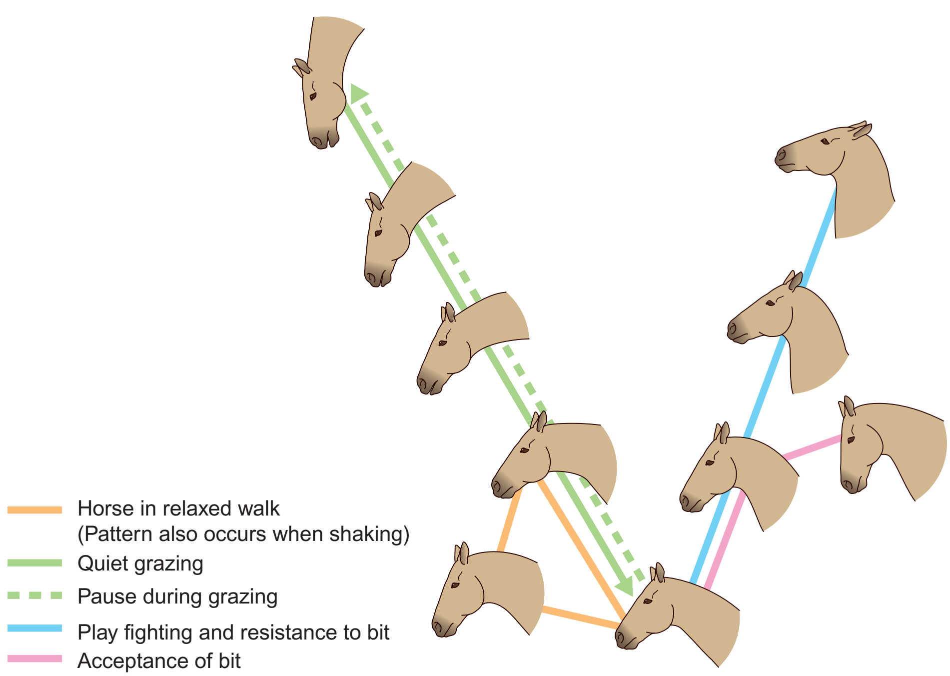


Figure 6.2 Expressions of lateral attention. *(Redrawn from Waring[2], after Waring & Dark[4], with permission.)*

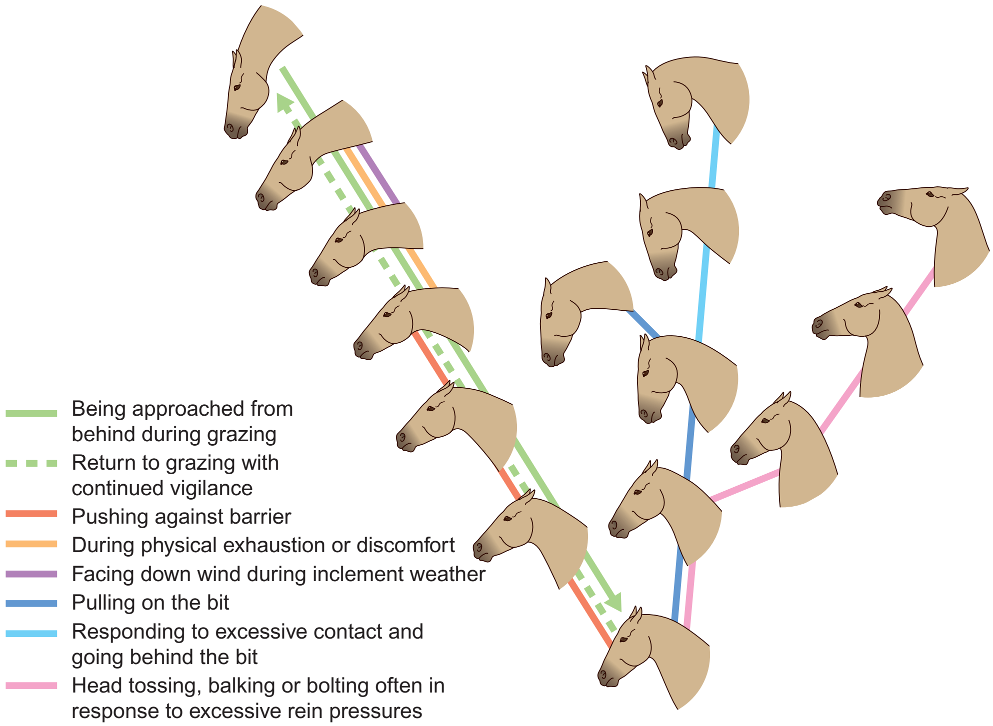


Figure 6.3 Expressions of backward attention. *(Redrawn from Waring[2], after Waring & Dark[4], with permission.)*

signaling. To that extent, horses that are not leading may have the rear under surveillance (Fig. 6.3). This strategy makes sense for the safety of the group since it allows the leaders to concentrate on hazards ahead of the group. Some racehorse trainers use blinkers to reduce the influence of other horses (Fig. 6.4).

When horses are frightened by or simply suspicious of a stimulus, their alarm is often indicated by switching the direction of the ears and by a tense mouth and dilated nostrils. Alarmed horses tend to withdraw from such stimuli with rather jerky movements that alert conspecifics and contribute as a survival strategy because they confound a predator's ability to predict the horse's intended route of escape. The same unpredictable responses can make frightened horses dangerous to lead and ride and thus alarm conspecific companions (see Ch. 15).

Aggressive horses look similar to alarmed horses (Fig. 6.5). Indeed, one expression can give rise to the other, except that aggressive horses tend to pin their ears back and wrinkle the aboral edge of their nares, sometimes to the extent that their teeth are exposed. When driving his mares (see Ch. 11), a stallion feigns snapping[2] and drops his head below the horizontal with additional nodding and swinging movements. These embellishments to the posturing of regular aggression represent expressive movements that qualify the signal as a driving cue rather than direct aggression.

Figure 6.4 A racehorse wearing blinkers to modify its flight response and reduce distraction from other horses. *(Photo courtesy of Sandra Jorgensen.)*

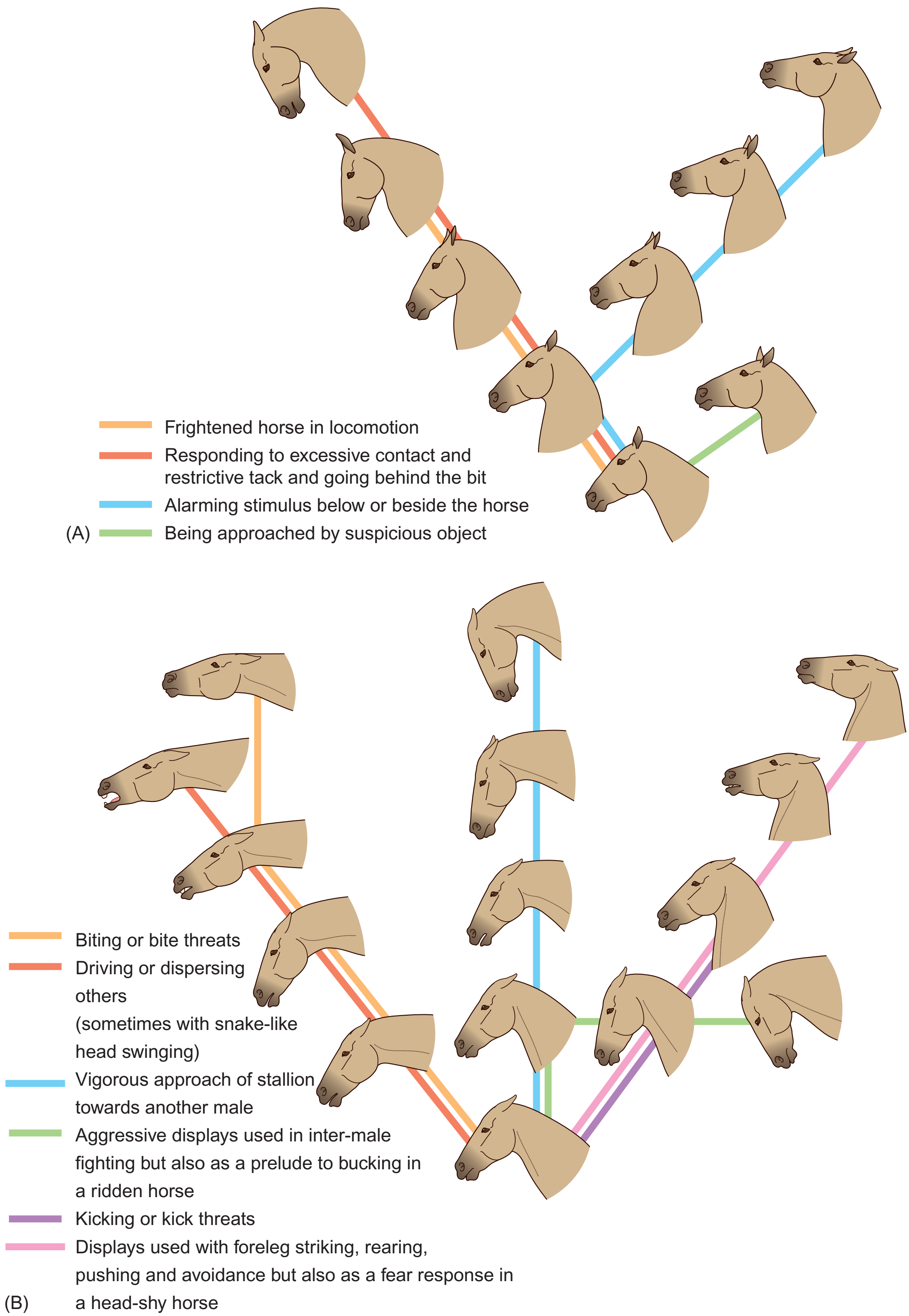


Figure 6.5 Expressions of (A) alarm and (B) aggression. *(Redrawn from Waring[2], after Waring & Dark[4], with permission.)*

The reasons for horses to signal submission have been dealt with in the previous chapter but it is worth emphasizing that, in the midst of a conflict between horses, it is often the appeasement signals that determine the outcome. These may be very subtle. Mindful of the example offered by Clever Hans (see Ch. 4), we would do well to remember that, with their excellent vision, horses are able to detect minute cues in animals around them. When submitting, a horse will look away from the threat and try to shuffle away, often with its croup and tail lowered. If trapped in a melée, submissive horses raise their heads and often show the whites of their eyes.

Head nodding forms part of the greeting a stallion makes when he approaches a new mare or a mare that may be in estrus. Head lowering and lip-licking have been identified as signs of submission in roundpen exercises and indeed they tend to precede movement of the horse towards the trainer. Because these responses have not been recorded in scientific literature on studies of free-ranging horses, it remains difficult to interpret them. Therefore there is a need for studies of physiological responses that coincide with such behaviors. It is possible that these behaviors are not so much signals as signs of conflict. Regardless of their true meaning, the trainer can capitalize on these responses by withdrawing to reinforce appropriate behaviors. For example, when the horse slows down or looks towards the trainer after showing these responses, the trainer can reward the horse by retreating and reducing the threats offered by his posture.

Although still the source of some controversy, the snapping action of youngsters is regarded as an attempt to communicate (Fig. 6.6). The extent to which it is successful remains unclear. Since prevalence is inversely correlated with the age of the performer, it may be that its relevance wanes as its refinement peaks. It is not offered exclusively to horses, having been observed being offered to cows, humans and horse-rider pairs. Although sometimes accompanied by sucking and tongue clicking sounds, it is chiefly a visual signal that is marked by the assumption of a characteristically extended neck, head lowering and exposure of the teeth.[2] The performer often lolls its ears laterally but maintains visual focus on its target.

While the lips are usually drawn back to expose the incisors during snapping displays, they are often pursed as part of a head threat display.[3] The teeth and masseter muscles may be clenched during pain even though the lips may appear loose. The same loose-lipped appearance has been noted in some sexually receptive mares and many older animals.

During mutual grooming, horses often extend the upper lip (Fig. 6.7) and move it from side to side and

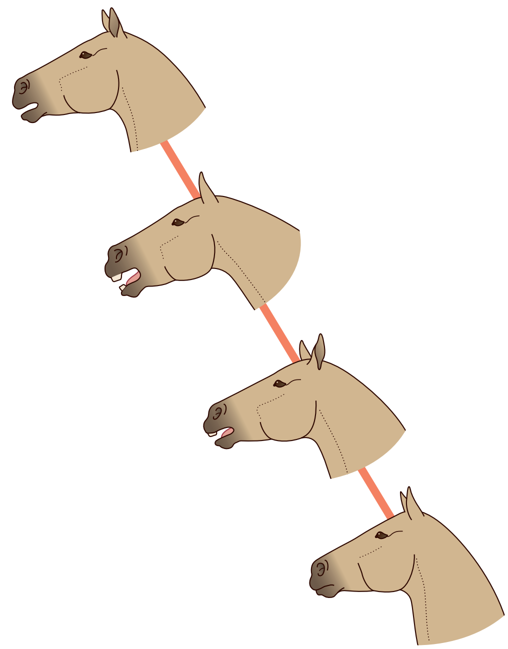


Figure 6.6 Juvenile greeting used on adults. *(Redrawn from Waring[2], after Waring & Dark[4], with permission.)*

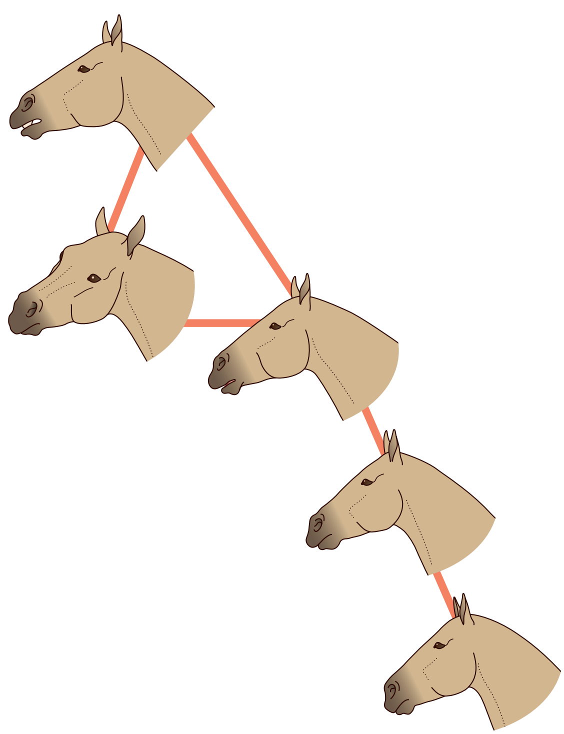


Figure 6.7 During pleasurable stimulation the upper lip may extend and twitch and on some occasions the head may turn. *(Redrawn from Waring[2], after Waring & Dark[4], with permission.)*

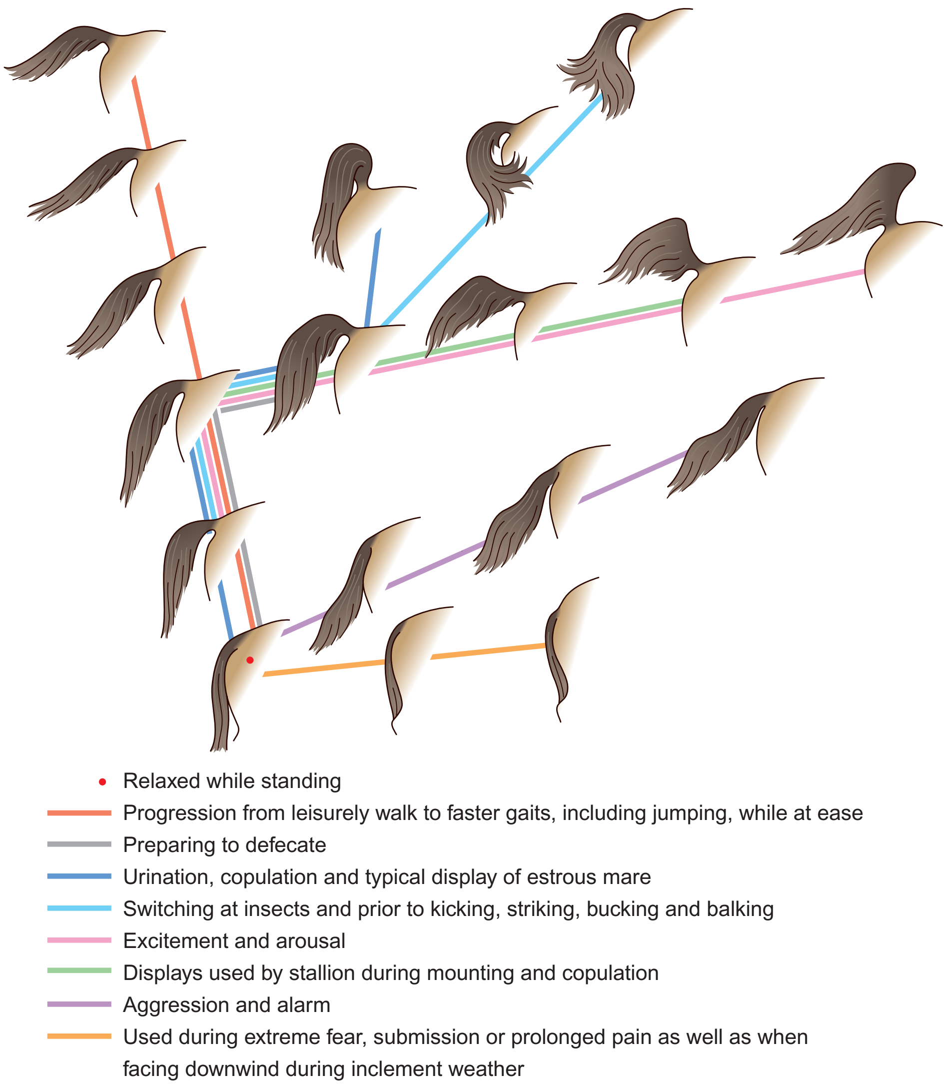


Figure 6.8 Tail positions during various displays. *(After Kiley-Worthington.[7])*

sometimes tilt their head and swivel their eyes laterally. With the panoramic quality of equine vision, it is possible that a grooming partner is able to detect this response as a signal that it has located a seat of irritation. This response, also seen when a solitary horse uses a scratching post, is sometimes accompanied by deep respiratory excursions and some luxuriant groaning.

Although rarely used in isolation from other forms of body language, the tail, or more especially its position, is an important indicator of mood or intention (Fig. 6.8). Horses are likely to be able to see the tail of another herd member if they cannot see its ears. So the tail plays a key role when horses are sorting out social spacing while at rest or while grazing in close formation. Tail movements form a characteristic element in kick threats and as such are most commonly seen in play and courtship rather than in disputes over resources such as food or shelter.

As a characteristic of anti-insect responses, swishing movements of the tail are a sign of irritation. Riders often report this response when a horse resists or enters behavioral conflict (see Ch. 13). The significance of tail-swishing in dressage competitions is recognized by the rules, which stipulate that such signs of resistance should attract penalties. However, dressage judges struggle to agree on signs of resistance in horses competing at the elite level.[6] Tail-raising is generally associated with the high postural tonus of arousal and an intention to move forward, while tail-lowering signals to observing horses that the bearer is intending to decelerate.[7] The tail is also lowered in horses as they withdraw from threatening stimuli. It is unfortunate that, in recognizing the importance of tail carriage in articulating demeanor, humans have chosen to interfere with it for the sake of supposed competitive success in the show ring. For example, in a bid to mask excitement, horses shown as Western pleasure horses, which are judged partly on an absence of reactivity to stimuli, may have their tails deadened by local anesthetic or even neurectomy.[8] Similarly, weights are regularly integrated into the tail hairs of show horses to lower the tail carriage (Cameron Wood, personal communication). Conversely, Arabian show horses are expected to have an elevated tail carriage as a measure of their reactivity and therefore, to raise the tail of some unfortunate individuals, irritants such as ginger are inserted per rectum.[8] Unfortunately, in contrast to tail deadening, which can be detected by an electromyogram, 'gingering' is difficult to confirm.[8]

These abuses, along with 'soring' (the application of caustic material to the pasterns) to accentuate the extension of the forelimbs of Tennessee Walkers[8] are more likely to be controlled if veterinarians remain aware of them and prioritize the welfare of the animals in their care. Legislation may have outlawed many such interventions, but policing the emergent rules relies on the cooperation of the profession and greater empowerment of stewards.

Other movements of the tail accompany urination and defecation. Clitoral winking and the increased frequency of urination of mares during estrus serve as visual signals that attract stallions to investigate the performer. Meanwhile, the characteristic flagging of the stallion's tail during coitus is used by stud managers as evidence of ejaculation.

Lifting of the fore- or hindlegs is used as part of striking or kicking threats, respectively. Pawing is recorded in free-ranging horses as they attempt to unearth hidden water soaks or remove snow from forage. A similar foot-stamping response is seen as a sign of frustration in domestic contexts, e.g. after administration of unpleasant-tasting oral anthelmintics. Pawing is often seen in combination with restraint, especially when a ridden horse is held back from joining the rest of the group, when a horse is denied access to food, or when a stallion is required to wait before approaching a mare in a service area.[9] The response can be inadvertently reinforced by feeding[10] and can readily be trained as a trick.[2]

Ritualized displays between stallions

There are generally thought to be five possible steps in the display sequence exchanged by stallions before they get as far as actually fighting.[2] Partially driven by the need to prevent mixing of natal bands, these displays are performed at a distance and allow demonstrations of resource-holding potential without combat as a reflection of the possible cost of fighting between stallions. While it should be noted that any element may be omitted, the five steps in the characteristic interactions between stallions are described in Table 6.1.

After any stage in the sequence of responses a pair of stallions may separate. After the fecal pile display, the sequence either as a whole or in parts may be revisited. With each sequence, one element may be accentuated and the threats tend to escalate.[2]

Sounds

Noises produced by the larynx are considered more important in communication between horses than the non-laryngeal noises such as groaning, which are, to an extent, byproducts of the expiratory effort as it passes through the upper airways. For example, groaning is often made by swimming horses, chiefly because the respiratory excursions are made very difficult when the thorax is immersed (David Evans, personal communication 2002). Coughing and sneezing are other sounds linked to upper-airway maintenance. Kiley-Worthington[7] notes that waves of sneezing may occur in groups of horses in stables and at exercise. This may be a result of an irritant common to all affected members of the group or may even represent social facilitation. Under-saddle, horses make deep but gentle nasal exhalations when they appear to relax during a training session (Andrew McLean, personal communication).

When they use their voices, horses capitalize on their voluminous sinuses to produce sounds that travel well. Indeed in the case of a stallion, snorts and nickers can be heard from 30 m and 50 m, respectively, while his neigh can be heard by humans 1 km away.[2] Depending on the sound that is being produced, the mouth may be opened or closed during vocal communication. For example, squeals are usually emitted through a closed mouth whereas whinnies are generally produced with the mouth slightly open.[3] Laryngeal and non-laryngeal vocalizations are considered in Table 6.2.

Table 6.1 Five stages that occur in recurring sequences when stallions meet

Core response	Additional movements	Vocalization
Standing and staring at one another while separated	Tail switching Pawing Scanning for other bands Ears forward	Whinnying
Posturing and mobile displays with elevated trotting action	Arching of neck Flexing of the poll Nodding Tail elevated Ears forward Pawing of fecal piles Sniffing of fecal piles	Snorting
Advance towards one another and conduct olfactory investigation during close encounter	Start by sniffing the nostrils and muzzle then often moving over neck, withers, flank, groin, rump and perineum	Snorting followed by sudden squealing
Threats and pushing	Bite threats Strike threats Biting Striking Circling and occasional hindleg kicking	Squealing
Defecating on a fecal pile either one after the other or simultaneously (see Fig. 9.2)	Smelling the pile usually before and after defecation	

After Waring.[2]

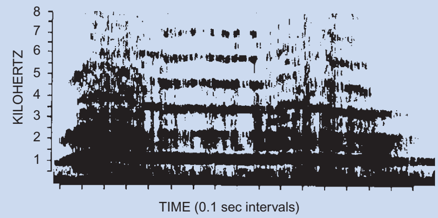
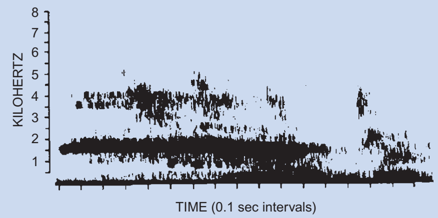
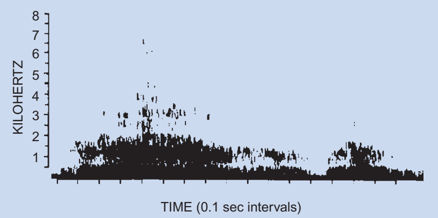
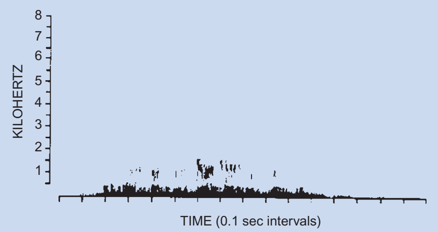
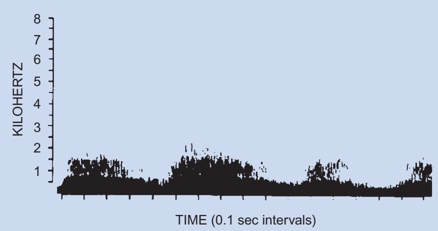
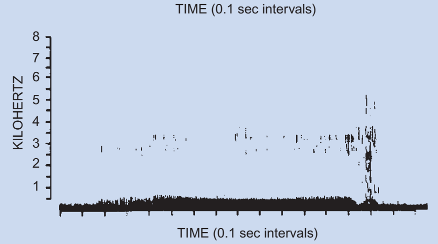
Other noises made by horses without involvement of the larynx include the rhythmic sloshing sound made by the sheath of some, but not all, males during trotting and the footfalls that other horses use to help locate conspecifics. The sound of footfalls, especially the characteristic pattern emitted when a horse investigates a novel stimulus,[2] can communicate the possible need for flight.

Recognition of sounds

Field studies suggest that, by 3 weeks of age, foals can recognize their dam's neighs.[11] Other interesting observations imply that band members may respond only to the calls of affiliates that have been absent from the group for some time.[11] The importance of the neigh as a means of connecting affiliates is demonstrated by its increased frequency when one places a horse in unfamiliar company. The sight of another horse often prompts neighing, presumably in a bid to ascertain whether the conspecific is familiar. Like humans, horses seem capable of cross-matching unique auditory and visual/olfactory information from known individuals. In one study, horses watched a herd member being led towards and then behind a screen, before a recorded vocalization from that herd member or from a different affiliate was played from a loudspeaker near the screen.[12] Observer horses looked more quickly and for longer when presented with incongruent combinations that violated their expectations, i.e. when they were shown one affiliate before hearing the call of a different affiliate.

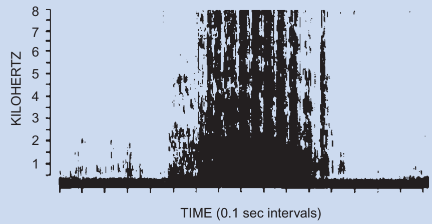
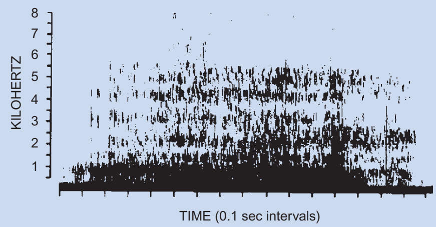
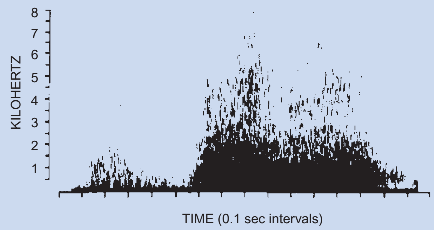
By playing back recordings of equine vocalizations, we can begin to measure the extent to which individual calls can be recognized by their intended recipients. Compared with recorded squeals and nickers, neighs elicit more attention.[13] There is evidence that mares are better at recognizing recordings of their foal's calls than vice versa.[14]

Table 6.2 Laryngeal and non-laryngeal vocalizations

Name	Context	Mean duration (ms) ± SD	Sonographic form[a]
Laryngeal vocalizations			
Squeal	Associated with both defense and aggression in agonistic interactions and with frustration on the part of mares when touched in sexual encounters and when resentful of having their udder palpated. Particularly loud and long squeals are sometimes referred to as screams[3]	870 ± 340	
Neigh (whinny)	Used to maintain or regain contact with affiliates or offspring. A confident greeting,[8] usually followed by playful or friendly interaction[3]	1500 ± 530	
General greeting nicker	Generally associated with the arrival of food or the return of an affiliate	870 ± 370	
Mare nicker	Used by dam when she affirms the maternal–infant bond as her foal returns to her side. Can be successfully mimicked by humans when working with foals	870 ± 370	
Stallion nicker	Part of early courtship	870 ± 370	
Groans and grunts	Associated with pain, the strain of rising and swimming but also with relaxation when standing. Grunting is associated with combat (including boxing, rearing, circling and kneeling) and olfactory investigation	450 ± 380	

(*Continued*)

Table 6.2 (Continued)

Name	Context	Mean duration (ms) ± SD	Sonographic form[a]
Non-laryngeal vocalizations			
Snort	Used defensively and aggressively,[8] especially by stallions as part of a display to alien conspecifics and in equestrian contexts in association with exercise and conflict during restraint. Also associated with startle, pain and fear responses,[3] olfactory investigation (e.g. after rolling) and upper airway maintenance	900 ± 410	
Snore	Associated with recumbent sleep	1380 ± 270	
Blow	Associated with arousal as part of an exploratory sniffing response	390 ± 50	

Reproduced, with permission, from Waring.[2]
[a] *Spectrographs (kHz) analyzed at a filter bandwidth of 300 Hz. The x-axis is graduated in intervals of 0.1 s.*

Tactile communication

As social creatures, horses have a behavioral need for tactile communication. Foals are first licked (immediately post-partum), and nuzzled (during suckling) by their dams. In return, mares are regularly nibbled by their offspring in attempts to initiate mutual grooming and play. This sets the pattern for interactions between the pair and with other horses in general. Tactile contact with the conspecific's shoulder, flank and groin forms a pivotal stage when two horses greet.[2] Unfortunately, stable managers often find that meeting the need for tactile contact is made unattractive by the risk of neighbors fighting and causing injuries as they become familiar with one another. The traditional design of standing stalls in coach houses prevented contact by the inclusion of high sides at the head end of the partitions between horses. Abnormal behaviors are commonly associated with stable designs that deny tactile communication between neighbors.[15]

Communication by odors

Although they very often squeal and strike afterwards, horses sniff each other and each other's breath as part of greeting and recognition (Fig. 6.9). This had led some authors[7] to advocate blowing up the noses of horses as a means of saying 'hello'. Until we more fully understand

Figure 6.9 Horses sniffing one another's breath. *(Photograph courtesy of Francis Burton.)*

the function of the squeal-and-strike epilogue to sniffing, this practice remains appropriate only for experienced personnel, since novices may misread the signals that the horse sends back to this overture and injuries may result.

As demonstrated by the accuracy with which mares can recognize the odor of their own foals, horses use odor to identify group members. Similarly they are sensitive to the odors of alien conspecifics, and this is why they investigate excrement carefully when given the opportunity. When presented with samples of their own feces and those of familiar and unfamiliar conspecifics, horses distinguished their own from conspecifics' but did not differentiate between familiarity and sex.[16] They focused most on the feces of familiar horses from which they had had the greatest amount of aggressive interaction. There is evidence that horses can use urine odor to discriminate between conspecifics, but that the detail that can be garnered from urine may be limited to broad differences, such as sex or reproductive status.[17] However, when offered samples of urine, feces and body odor samples (acquired by rubbing fabric on the bodies of conspecifics), mares sniffed the body-odor samples for longer.[17]

By leaving a sample of urine, mares are able to communicate their proximity to estrus. Stallions investigate mares' urine using the characteristic flehmen response that is thought to facilitate sampling of pheromones (see Ch. 2).[18] Typically, the flehmen response includes rolling back the upper lip, rotating the ears to the side and extending the neck while the head is elevated.[3]

Estrous urine does not elicit more of a flehmen response than non-estrous urine, so it seems that visual displays including an increased rate of urination in estrous mares and their clitoral winking help to excite the stallion's interest in their deposits.[19,20] Approximately 50% of female urinations may be inspected by the natal band stallion.[21] His usual response after sampling the volatile odors from the urine is to walk forward slightly, urinate on top of the mare's urine and then turn to sample the composite odor that remains. The composition of stallion urine varies in its fatty acid, phenol, alcohol, aldehyde, amine and alkane content according to maturity, sex and stage in the breeding season.[22] Because of the high concentration of cresols in the urine of stallion urine during the breeding season it has been suggested that one role of urinating on top of a mare's feces is to mask their odor and presumably thus thwart other stallions' attempts to locate potential breeding partners.[22]

Olfactory communication between stabled stallions and mares that are expected to breed can be enhanced by personnel delivering samples of both urine and feces from the stallion to the mare and vice versa. There are anecdotal reports that this practice reduces injuries when partners are brought together for mating.

Marking strategies

Marking, especially with feces, enables horses to communicate their presence and status and to be able to know the whereabouts of other groups of horses. Because rank may dictate the order in which bachelors eliminate onto one another's excrement, the highest-ranking member of the group may try to ensure that his scent, be it from rolling (see Ch.10), urine or feces, prevails. Regular marking by the natal band stallion is an effective means of avoiding fighting and confrontation between neighboring stallions. The significance of stallion piles lies in their utility as sources of both visual and olfactory signals. They do not occur only at the periphery of a stallion's range but rather are throughout the area he patrols. This makes sense given their role in inter-stallion displays, which are by no means limited to home-range boundaries.

Donkey communication

Donkeys have a more limited repertoire of vocalizations than horses. Five types of vocalizations have been described: grunts, growls, snorts, whuffles and brays.[23] While many calls are similar to those of horses, the most obviously different is the bray. Brays can carry over several kilometers and as a result they allow donkeys to stay in touch across sparsely populated areas. Braying choruses are a feature of social communication, but donkeys other than harem leaders usually reserve braying for attracting other donkeys when isolated, anticipating food or searching for a mate (Jane French, personal communication 2001).

In the free-ranging state, breeding donkey stallions bray most often. Unless part of a braying chorus, subordinate males rarely bray in the presence of higher-ranking males. The bray is used to affirm the stallion's status and advertise the group's presence in and possession of the area. Free-ranging jennies and foals usually bray only in response to the braying of a stray group male or when separated from the group. In domestic conditions, they often bray in response to other brays, when expecting food, or when they or their companions are in estrus (see Chs 11 and 12). When braying, the donkey's message is qualified by the position of its ears. During greeting rituals, usually prior to tactile contact, the ears are held back slightly. While they are flattened further back during agonistic challenges, the ears point forwards during courtship.

SUMMARY OF KEY POINTS

- Because horses have excellent vision, the nuances of equine body language can be very subtle.
- Ear position and head posture are the most important variables in non-vocal communication.
- Tail positions can help to coordinate the movements of a group of horses.
- The olfactory cues in urine and the visual stimuli offered by characteristic estrous urination are used by mares to communicate their readiness to mate.
- Dung-piles and the rituals attached to them are effective means of avoiding aggressive interactions between stallions.

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Locomotory behavior

CHAPTER 7

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Fetal movements

The movements of the equine fetus have been studied with ultrasonography in a bid to explore the extent of normal locomotion in utero and its roles in optimizing presentation before labor and preparing the musculoskeletal system for work immediately post-partum. In addition, ultrasonography has demonstrated that sucking and swallowing is common in fetal foals, a finding that explains the development and strength of the sucking reflex at birth.[1]

Simple movements, such as the extension or flexion of a limb or the vertebral column, can be detected from the third month of gestation.[1] As the fetus matures, these combine and become repeated to form complex movements that eventually appear coordinated.[1] The hooves are tipped with collagenous eponychia, which prevents damage to the amnion and beyond. Most of the coordinated kinetic activity of the foal, including extension of the forelimbs and head toward the maternal pelvis, occurs well in advance of uterine contractions, sometimes as much as 12 days earlier.[1] These final adjustments are considered critical in the avoidance of dystocia.[2]

While simple movements may occur 55 times per hour from the fifth to the ninth month of gestation,[1] complex movements as frequent as 84 times per hour have been recorded in the 3 days pre-partum.[1] The frequency of the final complex movements that ultimately change the fetal position from supine to prone and occasionally from posterior to anterior[1] is illustrated in Figure 7.1.

Infant growth and movements

An appreciation of the normal development of foals is useful for practitioners, since deviations from the typical developmental pattern can indicate abnormal progression in a neonatal foal.[3] Fraser[1] suggests that five steps can be identified in the development of the primary mobility required of a foal before it takes its first mouthful of milk and the self-reinforcement of feeding can take place (Table 7.1).

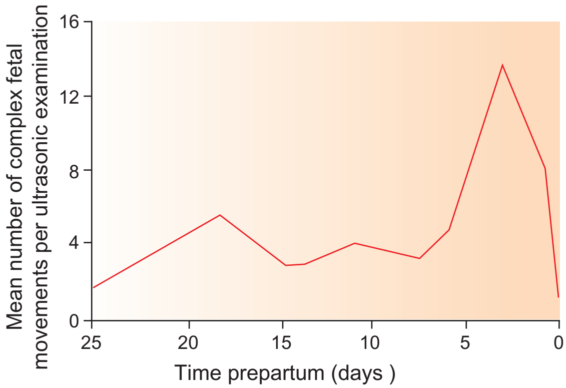


Figure 7.1 Frequency of the final complex movements in the terminal stages of gestation. Complex movements of the equine fetus become more frequent until a position suitable for engagement in the maternal pelvis is achieved. *(After Fraser.[1])*

The order in which features of the ethogram emerge is described in Figure 7.2. Foals that accomplish one phase quicker than the mean often show similar precociousness in other domains.[1] Perhaps because they have shorter long bones and therefore require less leverage to stand, pony foals are usually stable on their feet within half an hour,[1] much earlier than neonatal Thoroughbreds. The time taken to stand depends on the sex of the foal (average for Thoroughbred fillies being 56.3 minutes and for colts 70.6 minutes, n = 127)[4] – a difference attributed to the lighter bodyweight of fillies, who therefore require relatively less strength to rise. Unsurprisingly, fillies are the first to feed, generally having their first drink 1.5 hours after birth while colts take an average of 2 hours before feeding.[1]

After the first drink, a melange of rest and sleep occupy most of the foal's first week but, along with locomotory play, this is punctuated by feeding every 15–30 minutes.[1]

Table 7.1 The steps involved in achieving primary mobility in the equine neonate

Step	Foal's responses	Dam's responses
Recumbent coordination	• Elevation of the head and neck • Headshaking • Movement of the ears • Flexion of the forelimbs • Defecation of meconium • Arranging limbs before first attempt to rise • Body-shaking between attempts	• Completing third-stage labor • Licking dorsum of foal
Rising and quadrupedal stability	• Maintenance of a half-up posture as a prelude to successful standing • Extension of the neck and forelimbs • Standing in stable position on all four feet • Gradual adduction of limbs	• Demonstrable concern for unstable offspring
Ambulation	• Four-step walking	• Demonstrable concern for unstable offspring
Maternal orientation	• Attraction to the underside of large solid objects • Attraction to junctions between the legs and trunk of the mare • Tactile exploration with muzzle • Nibbling and mouthing of objects • Location of the mammary glands • Development of dam as focus of all activity	• Minor positional changes • Sniffing and licking the foal • Nickering vocalization that helps bring the foal back to the dam and teaches avoidance
Teat-seeking and sucking	• Tactile identification of the teat • Tilting of the head • Drinking	• Pelvic tilting – often shown before milk-letdown

After Fraser.[1]

A daily tally of motor activities in the equine neonate is given in Table 7.2. The prevalence of vigorous stretching (or pandiculation) from the first day of life suggests that it is not only pleasurable as a comfort behavior, but also that it occurs as a result of uterine confinement.[1] Stretching may occur when the foal is recumbent or upright (Fig. 7.3). The importance of stretching is dealt with elegantly elsewhere[1] but can be summarized in terms of its role in athletic development, growth and joint correctness. By the third day of life, estimates of 80 or so stretches per day have been recorded.[1] Some support for the putative orthopedic benefits of stretching comes from the coincidental peak in the frequency of stretching on day 3 of life, the age by which marginally contracted tendons have self-corrected. It would be interesting to investigate the effect of post-foaling thoracic trauma[5] on the frequency of holistic stretching.

Table 7.2 Frequency of motor patterns in the equine neonate

Activity	Daily frequency
Defecation	2–4
Urination	4–10
Walking	8–14
Sleeping	20–25
Sucking	18–24
Stretching (recumbent and upright)	40–60

After Fraser.[1]

In the first 6 weeks of a foal's life, most vigorous exercise takes the form of play,[6] but the motivation to rest, play and feed changes with age. Crowell-Davis[7] identifies three periods of behavioral development in foals, all of which involve different proportions of locomotory activity:

1. dependence (first month)
   – maximal dependence on dam
   – minimal contact with other conspecifics
2. socialization (second and third month)
   – rapidly increasing contact with non-dam conspecifics, especially peers
   – peak frequencies for mutual grooming and snapping are reached

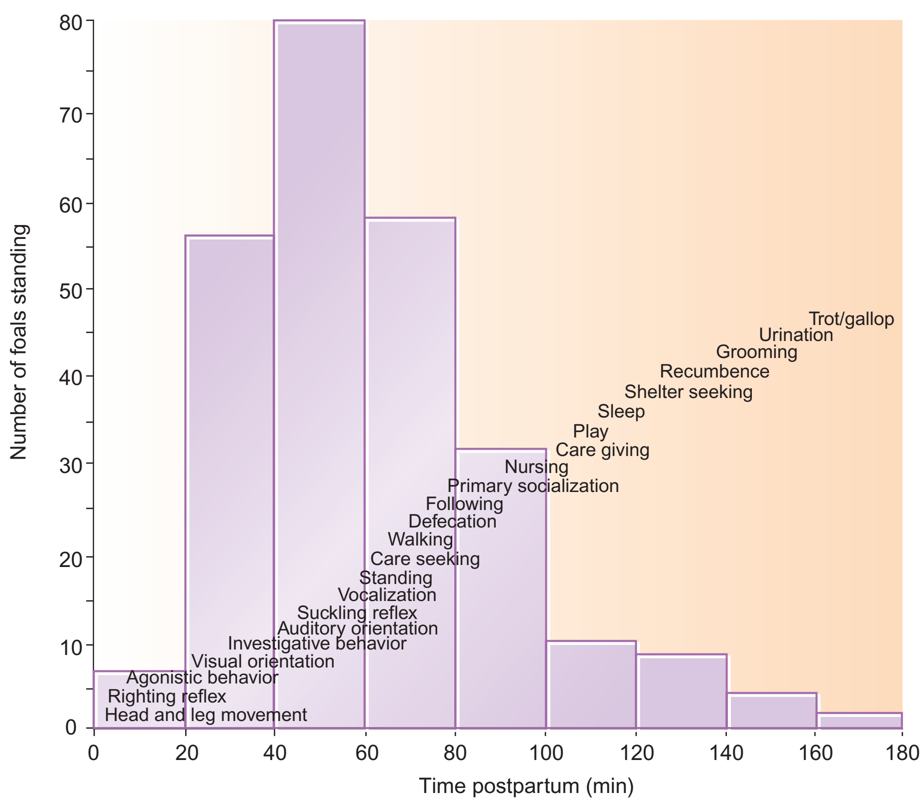


Figure 7.2 The distribution of time taken to stand, and the progressive appearance of novel responses, in the equine neonate. *(After Waring[3] and Fraser.[1])*

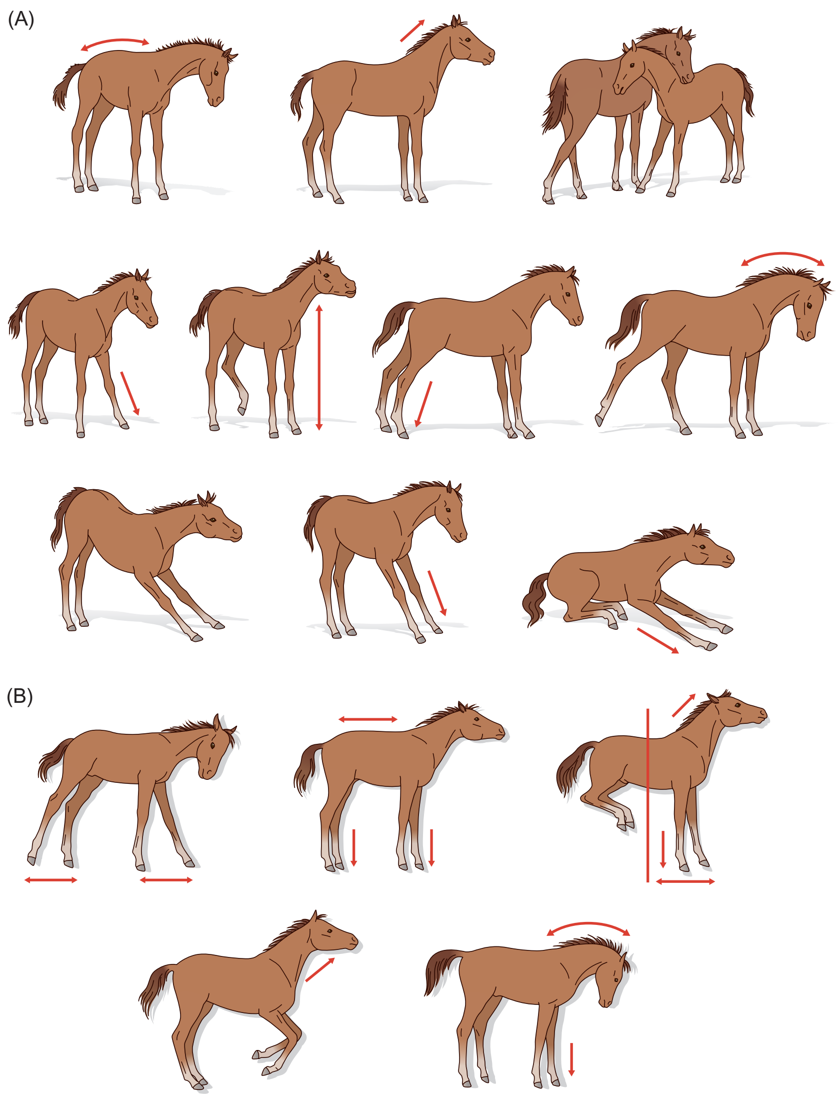


Figure 7.3 Stretching can be observed before and after locomotory activity and may occur when the foal is (A) upright or (B) recumbent. *(Redrawn, with permission, from Fraser.[1])*

3. stabilization and developing independence (fourth month and beyond)
   – gradually increasing independence from all conspecifics.

Adult kinetics

Horses have been shown to travel on open ranges (for example, to water) up to 65–80km daily. For pastured horses, movement during grazing is the main initiator of locomotion, and an estimated daily figure for kinetic behavior in this context is 20km.[1] The distance that grazing horses travel depends on the location of water, the availability of food and the time that has to be spent foraging.

As a means of returning horses to their home range and indeed their social group, homing can occur over distances of more than 15km.[3] The stimuli used to guide this locomotion probably involve olfaction that relies on ground-based stimuli, but they remain the subject of some debate,[8,9] especially since homing may even traverse water.[3]

While incessant walking has been reported as a presenting sign in serum hepatitis,[3] route-tracing in the form of box-walking (stall-walking in the USA) is far more common and emerges as a stereotypic behavior in animals that fail to cope with social isolation (see Ch. 5). Conversely, stereotypies are reported less frequently as exercise is increased.[10] Locomotion is useful as an indicator of distress, especially when conducted at the expense of feeding; for example, solitary horses walk and trot three times more often than those that can make auditory, visual and physical contacts with other horses.[11] Furthermore, locomotion's role in recreation is considerable, with 75% of the kinetic activity of foals, for example, being in the form of play.[12] The need for spontaneous exercise is emphasized by reports of post-inhibitory rebound in locomotion among horses after periods of confinement.[13]

While locomotion is an integral part of equine antipredator strategy and ingestive behavior, it is also used in communication and courtship. Exercise tends to affect other behaviors. For example, exercised horses spend more time drinking and lying but urinate less than unexercised controls.[14] Tantalizing insights into the effect of training on behavior have been offered by studies showing that horses that lose races tend to be more aroused and require greater control in the parade ring/mounting yard than winners.[15] Some of the more important dependent variables from these studies are summarized in Table 7.3. For a more comprehensive list and detailed consideration of likely reasons for these variables being significant to performance, readers are directed to an informative and entertaining book, *Watching Racehorses*.[15]

Table 7.3 Some of the features of a racehorse's behavior and presentation that can be used to predict poor performance (not winning)

Location	Variable	Extent to which this variable predicts poor performance
Birdcage[a]	Weaving and repetitive head movements	********
	Kicking	*****
	Pawing	**
Parade ring	Crossover (figure-of eight or grackle) noseband	********
	Gaping mouth	****
	Twisting neck	***
	Nose roll (sheepskin noseband)	***
	3rd metacarpal bandages	***
	Other bandages	**************
	Pacifiers (meshed eye protection)	**
Mounting yard	Slow gait	********
	Fast gait or circling	*****
	Bucking	*****
	Balking	****
	Courtship behaviors	***
	Ears pointing laterally or aborally	**
	Defecating	**
	Flicking ears	*
Track	Late	********
	Conflict behaviors	****

Adapted from Watching Racehorses[15] with kind permission of Geoffrey Hutson.
[a]In Australia, racehorses can be observed in a gallery of open-front standing stalls called the birdcage, prior to being paraded (Fig. 7.4).

Sidedness and symmetry

Although the forelegs alternate in leading during grazing, the time horses spend with the left leg advanced is generally longer than for the right (Fig. 7.5). This manifests as a significant directional bias to graze with the left foreleg in advance of the right.[16] This tendency seems breed-dependent with Thoroughbreds showing it more than Standardbreds who in turn show it more than Quarterhorses.[17] If advancing a forelimb when grazing reflects greater mobility on that side of midline, then it is possible that the brains of left-preferent animals are right-hemisphere dominant. However, a counter argument is that the non-advanced limb is the more critical for survival because it supports more weight, reflects greater agility on the weight-bearing side of the animal and is arguably better positioned to launch the animal into a flight response and a more dominant left turn (owing to the abduction of the right foreleg in the stance phase). We are yet to study how this affects ridden work, such as canter leads and preferred side for poll-flexion and lateral bend.

Even in symmetrical gaits, such as the trot and the pace, asymmetries often become evident at high speeds. In pacers, temporal gait variables, including suspension times, may differ between the left and right couplets, while in trotters high speeds have been used to expose left-right asymmetries that are particularly apparent in the hindlimbs.[18] This is not necessarily an effect of training to work in one direction. Slight individual tendencies toward

Figure 7.4 Horse in cross ties pawing in the standing stalls of a birdcage gallery at a racecourse. *(Reproduced, with permission, from Hutson.[15])*

Figure 7.5 Even in the absence of lameness, some foals lock in a strong preference for an unbalanced grazing stance before weaning. There is a general population bias to advance the left foreleg. (Figure from www.avma.org)

either left or right laterality in general responses, such as in lying down,[1] and in foraging, have been reported by others.[19,20] Kinematic differences between the left and right limbs have also been reported in 8-month-old Standardbreds that have yet to be trained.[21]

It is reported that, when jumping, most horses seem to lead with and land with the right leg.[1] However, other workers have shown this preference only when horses are jumping on a right-handed turn.[22]

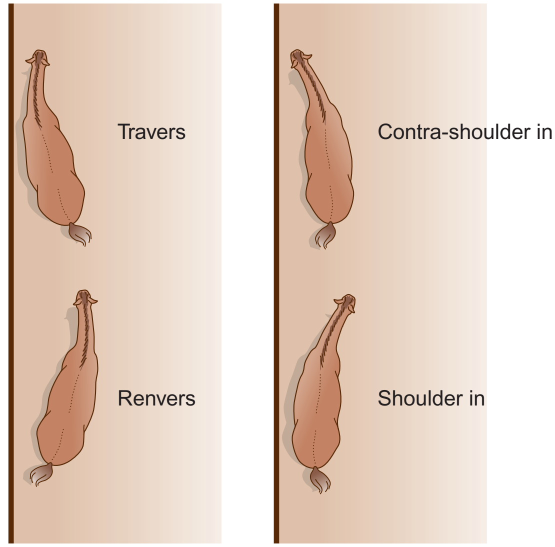


Figure 7.6 The labels for lateral movements depend on the lateral flexion of the horse's vertebral column and the direction of movement relative to the side of the school.

Lateral flexion

If by design or by default a horse fails to use its hindlimbs in the same path as its forelimbs, it is said to be traveling in two tracks (or two-tracking). Horses can perform a number of lateral movements, most but not all of which require some flexion of the vertebral column.

In the leg yield, the neck and vertebral column are straight except for a slight flexion at the atlanto-occipital joint that flexes the head away from the direction of motion. For the movements in which the vertebral column is flexed, it is easiest to consider the horse moving relative to an imaginary straight line. In some of the movements the neck and forequarters align with the line and the hindquarters deviate to the side (travers, renvers). In other movements the hindlegs follow the line while the forequarters deviate from it (shoulder-in, contra shoulder-in) (Fig. 7.6).

Naming lateral movements depends on the direction in which the horse's body is bent relative to the direction of movement around the arena – clockwise (on the right rein) or counter-clockwise (on the left rein). When the convex curve of the body forms the leading edge of the horse as it travels forward, the maneuver is called shoulder-in. For the reverse maneuver, in which the direction of flexion is the direction of locomotion, the terms travers or renvers are used. Half pass (Fig. 7.7) is the

Figure 7.7 Half-pass. *(Photography by Neil McLeod.)*

Figure 7.8 Canter pirouette to the left. *(Photography by Neil McLeod.)*

same as travers except that it is performed on a diagonal line across the arena.

The extent to which lateral movement (i.e. steering) in racehorses is affected by lateralized use of the whip has been questioned by photographic evidence from New South Wales and Victoria, Australian states in which horses race in opposite directions. Of 200 jockeys racing counter-clockwise, 183 (91.5%) were holding the whip in the right hand and of the 200 jockeys racing clockwise, 107 (53.5%) were holding the whip in the right hand. The primary conclusion is that the data indicate that placement of the whip appears to be primarily determined by handedness of the jockey, not by the direction of the track. Given that over half of NSW jockeys hold the whip in the inside hand, this study challenges the view that the whip is used for steering in NSW.

Simple turns and pirouettes

Turns on the forehand and turns on the quarters are achieved by the rider signaling for more movement by the quarters and forehand respectively. In their elementary forms they are conducted at the rhythm of a collected walk, but when the same principles are applied in advanced horses, elaborate balancing maneuvers, such as canter pirouettes (Fig. 7.8), result. However, despite the theoretical requirement that a good canter pirouette be conducted with the same tempo and rhythm as the collected canter, this is rarely the case. Analysis of individual medal finalists at the Barcelona Olympics showed that pirouettes were performed at about two-thirds of the tempo of a collected canter, had no suspension phase, and were dissociated to the extent that they could be considered to have a four-beat rhythm.[23]

This chapter will consider the gaits and maneuvers of ridden horses and those at liberty (Fig. 7.9).

Gaits

By measuring oxygen consumption in trained ponies that change gait on command, Hoyt & Taylor[24] demonstrated that walking is the gait that needs least energy at low speeds, trotting at intermediate speeds, and galloping at high speeds. This accounts for the evolution of gaits as adaptations for economical locomotion within a range of speeds.

It is argued that, in many ways, the physics of equine locomotion have evolved to their limits in that, for example,

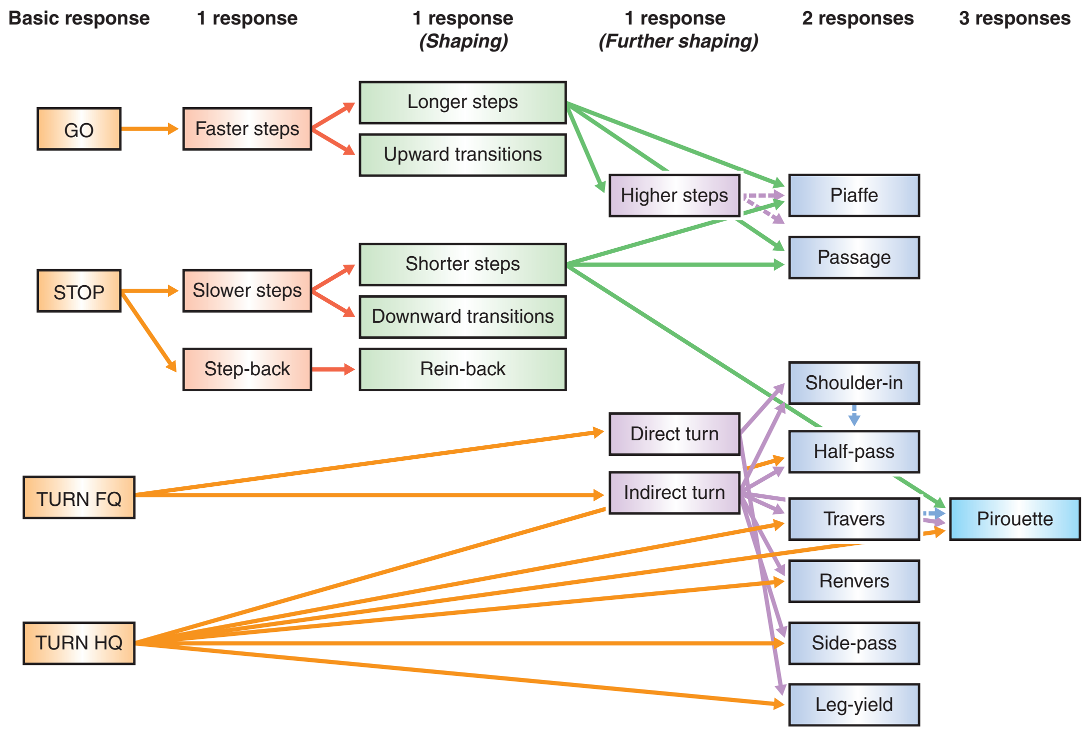


Figure 7.9 All movements required of trained horses are derived from the basic responses of acceleration, deceleration, turning the forequarters (FQ) and turning the hindquarters (HQ). Dotted arrows refer to shaped preparatory movements that usually precede elicitation of the targeted movements. *(Reproduced with permission of Australian Equine Behaviour Centre.)*

if the horse's legs were any longer, its hindlegs would be repeatedly interfering with its forelegs, as happens when the hurried (so-called butcher's boy) trot leads to forging. Budiansky[25] points out that this is the reason species such as the giraffe, with its relatively longer legs, cannot trot.

The care with which horses place their feet at speed is remarkable. With only one toe upon which to land there is little margin for error. Balance is matched by the tremendous care horses take over their hooves. This book would not be a book for hippophiles without the oft-quoted adage 'no foot – no horse'. This appears here to remind us that horses seem to live by the very same dictum. Their motivation to avoid getting their feet trapped accounts for the reluctance of some horses to accept hoof-care. Considerable neural circuitry is required for any animal to plot a safe course for four limbs, especially as the feet disappear from sight so rapidly. To perform this at the speeds horses reach and through the terrain they can traverse helps to explain why so much of the brain has to be devoted to coordinating limbs and controlling locomotion (see Ch. 3).

Much has been said about the need for good gaits, since they give horses a head-start in training for jumping and dressage. The term kinematics describes scientific measuring of gait. Gifted horse breeders using a visual impression, and indeed scientists using kinematic data, can predict future gait performance of foals by the age of about 4 months.[26,27] This is because the kinematic indicators of gait quality (swing duration, the maximal protraction-retraction angle and the maximal flexion of the hock joint)[28,29] show a good correlation between foals of this age and adults. A horse's conformation affects the way it moves, the extent to which its rider is displaced and the work it can successfully perform. For example, although their relative stance durations are similar, ponies make shorter strides than horses, evidenced by a shorter stance and swing duration.[29] As a further example, although there are occasional exceptions, Arabian horses are not generally suited to dressage because of their conformation: they frequently have disunited canters, and the hips are rotated, which has the effect of raising the tuber ishii so that their hindlegs 'trail' out behind and abduct during lengthened strides. For this reason Arabians often have trouble collecting their hindquarters (Andrew McLean, personal communication 2002).

Gaits are either asymmetrical or symmetrical. If some legs appear to work together and others do not, the horse is doing an asymmetrical gait – either a canter or gallop. As shown in Table 7.4, all of the lateral, diagonal and square gaits are symmetrical, in that the legs on one side of the horse mirror the actions of those on the other. When the legs appear to move independently of one another, not moving forward as ipsilateral or diagonal pairs, the horse is doing a square gait, which may be either a walk, flat walk, running walk or tölt. If the legs on one side appear to move in opposite directions, the horse is doing a diagonal gait which will be either a trot, fox walk or fox trot. If the legs on one side move forward at the same time, the horse is doing a lateral gait which may be a pace, stepping pace, or rack.

Table 7.4 The footfalls and beats that characterize symmetrical equine gaits

Gait	Footfalls	Beat	Other names
Walk	Square	1–2–3–4	–
Flat walk	Square	1–2–3–4	–
Running walk	Square	1–2–3–4	*Paso llano* (Peruvians) *Tölt* (Icelandic)
Trot	Diagonal	1–2	–
Fox-walk	Diagonal	1–2– –3–4	–
Fox-trot	Diagonal	1–2– –3–4	*Trocha* (Paso Finos) *Pasitrote* (Peruvians)
Pace	Lateral	1–2	–
Stepping pace	Lateral	1–2– –3–4	Broken pace *Slow gait* *Amble* *Sobreandando* (Peruvians)
Rack	Lateral	1–2–3–4	*Hreina tölt* (Icelandic) *Trippel* (Boerperds) *Largo* (Paso Finos)

Walk

The normal equine walk is a four-beat gait in which the feet move individually and sequentially in diagonals as follows: right fore, left hind, left fore, right hind (Fig. 7.10). At any one time the horse is supported by two feet (about 60% of the time in elite dressage horses[30]) or three (about 40% of the time in elite dressage horses[30]).

Four types of walk are recognized by the FEI: collected, medium, extended and free. In the free, performed only in the lower levels of competitive dressage, the horse is allowed to stretch the neck. As can be seen from Table 7.5, differences in the kinematics of the medium and extended walks of dressage horses are not significant. This helps to explain why accelerometers may one day be used to increase objectivity in scoring some aspects of dressage performances (such as the purity of gaits).

As with all transitions in dressage, great importance is given to maintaining a given rhythm and tempo, so different gaits and variations within gaits are achieved by changes in stride length independent of stride

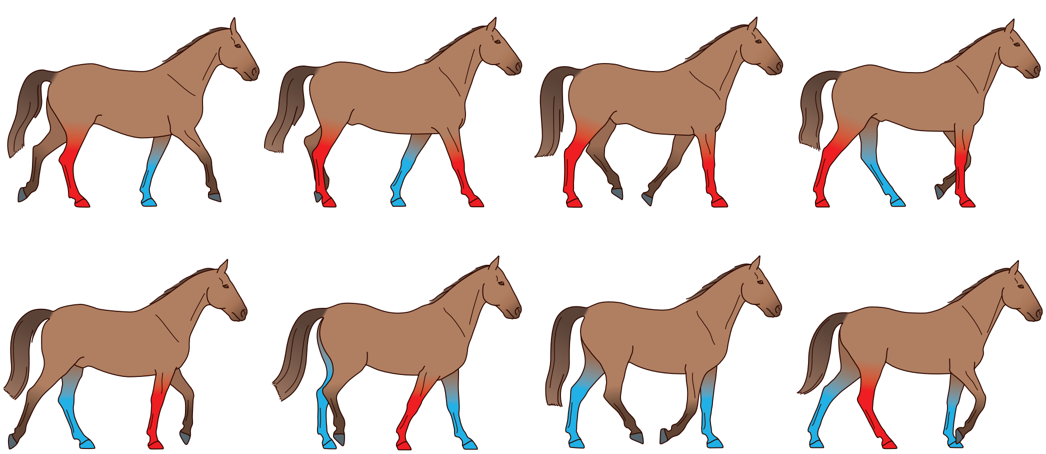
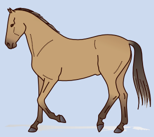
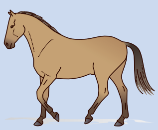
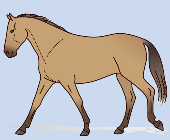


Figure 7.10 The cycle of movements at the walk. The weight-bearing limbs at each stride are indicated.

Table 7.5 Mean values for stride kinematics of the collected, medium and extended walk in dressage horses

	Speed (m/s)	Stride length (m)	Stride frequency (strides/min)	Lateral distance (cm)	Tracking distance (cm)
Collected walk 	1.4[a]	1.57[a]	52[a]	158[a]	27[a]
Medium walk 	17[b]	1.87[b]	55[b]	167[a]	19[b]
Extended walk 	1.8[b]	1.93[b]	56[b]	166[a]	27[b]

Different superscripts indicate values that differ significantly, p = 0.05.Data from Clayton.[31]

frequency. Despite its being a rule of the FEI that the same stride frequency be maintained at all types of walk, this has proved difficult to demonstrate even in advanced horses.[31] Irregularities in rhythm arise because lateral couplets are included.[31]

Stride-length is of interest to equestrians because the hindfoot should at least reach the impression made by the ipsilateral hoof (this is also known as tracking-up). If this is not the case in walks other than the collected walk, the horse is either being badly ridden or is in poor condition. In horses that have been educated for self-carriage (see Ch. 13), there is a longer stance duration (the time during which weight is borne) in the hindlimbs than the forelimbs at both the collected and extended walk.[31,32]

In the show ring, the ability of American gaited horses to demonstrate an exaggerated reach with the forelimbs and a substantial over-stride with the hindlimbs (the so-called ‘big lick’) is highly prized.[33] While it can be shaped behaviorally, this attribute can also be enhanced by abusive interventions. The practice of ‘soring’ to make horses’ soles, heels or pasterns hypersensitive in a bid to emphasize their ability to lift their feet extravagantly has been subject to considerable scrutiny by the welfare lobby. Indeed it is the focus of legislation and industry self-regulation, but sadly, as fast as the industry agrees on a protocol to identify cases of soring, certain trainers develop new means of avoiding detection.[33]

Flat and running walks

The flat walk is the same as an ordinary walk, speeded up a little. A good running walk (Fig. 7.11) is the same as a flat walk, with more speed again. In Icelandics it is called a tölt and attracts different additional labels according to the speed with which it is performed (see hreina tölt, below). The fastest of the four-beat show gaits, the running walk, is characteristic of the Tennessee Walking Horse. Maximal stride frequencies are accompanied by tremendous stride lengths rather than the high foreleg action of the rack.[3]

Diagonal and lateral walks

Horses can perform a diagonal walk in which the footfalls occur as diagonal couplets. The lateral walk (or fox-walk)

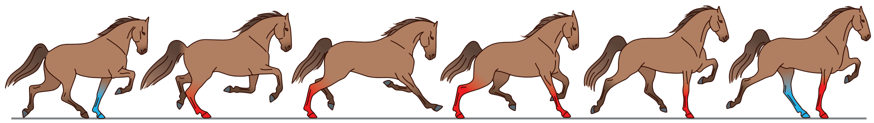


Figure 7.11 The running walk. *(Redrawn, with permission, from Waring.[3])*

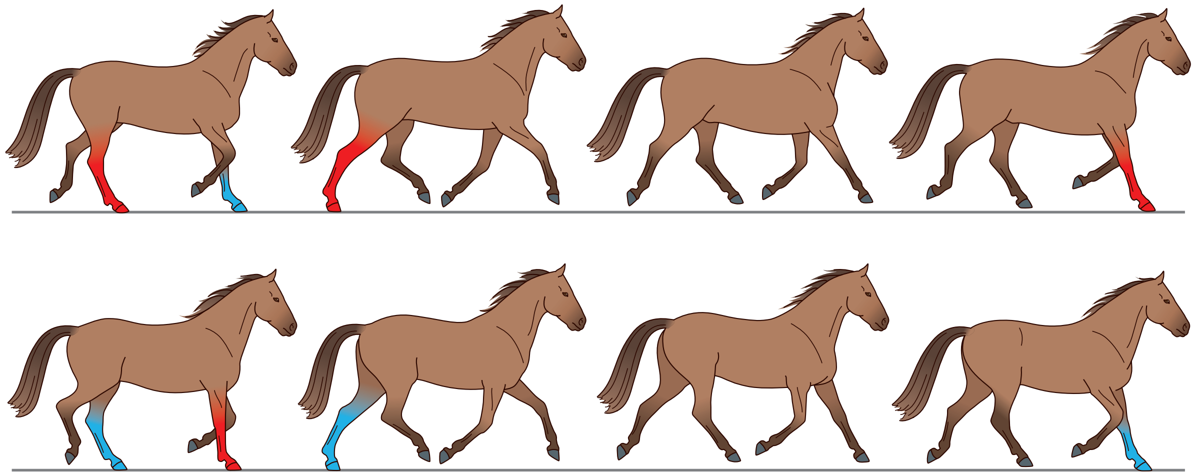


Figure 7.12 The cycle of movements at the trot. The weight-bearing limbs at each stride are indicated.

is characterized by movement of the first foreleg being followed by movement of the ipsilateral hindleg, contralateral foreleg and contralateral hindleg. This gives rise to a lateral rocking action. An extreme example of this is the gait called the fox-trot, in which diagonal pairs of hooves lift off and move forward together, with the front landing noticeably before the hind of the pair.

Trot

The trot is a two-beat gait in which the diagonal pairs of limbs move in apparent synchrony and the footfalls of the diagonal limb pairs are evenly spaced in time (Fig. 7.12).[34] The four recognized types of trot (collected, working, medium and extended) are distinguished by their speed, stride length, stride frequency, lateral distance and tracking distance (Table 7.6).

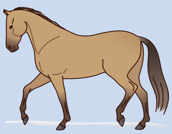
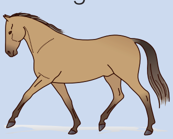
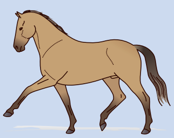
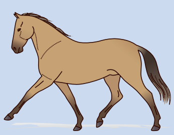
The interval between the contacts of the fore- and hindlimb with the ground is termed the diagonal advanced displacement. This value is positive if the hindlimb contacts the ground before the forelimb and is negative if vice versa (and zero if both contact simultaneously) (Fig. 7.13). Although it is no longer, strictly speaking a trot (since, according to FEI Rules of Dressage,[35] a trot must be a two-beat gait), a trot with a positive diagonal advanced displacement is considered desirable for dressage. The extended trot variable that correlates closest with high scores in elite dressage competitions is stride length (Fig. 7.14).[30]

At the trot, stride length depends on the distance between both diagonal pairs of hoofprints (diagonal distance) and lateral pairs (tracking distance). To increase stride length, the horse must increase the suspension phase of the trot by pushing off the ground with a greater vertical velocity (Fig. 7.15).[36] Ponies have a larger range of protraction and retraction than horses, with a more protracted forelimb and a more retracted hindlimb, therefore they demonstrate a more extended trot.[29] However, they move with a stiffer trot than the supple trot of horses, which show a larger maximal fetlock extension during the stance phase.[29]

Pace

The most lateral gait, the pace, is innate for some horses (e.g. Icelandics) but can be acquired by others. The progeny of pacers almost always pace, whereas only some 20% of the offspring of trotters are innate pacers.[37] As with the trot, there are two periods of suspension in each

Table 7.6 **Mean values for stride kinematics of the collected, working, medium and extended trot in FEI-level dressage horses**

	Speed (m/s)	Stride length (m)	Stride frequency (strides/min)	Diagonal distance (cm)	Tracking distance (cm)	Suspension (ms)
Collected trot 	3.20[a]	2.50[a]	77[a]	132[a]	7[a]	16[a]
Working trot 	3.61[b]	2.73[b]	79[a,b]	132[a,b]	4[b]	17[a]
Medium trot 	4.47[c]	3.26[c]	82[a,b]	136[a,b]	27[c]	32[b]
Extended trot 	4.93[d]	3.55[d]	83[b]	137[b]	39[d]	37[b]

Data from Clayton.[36] Different superscripts indicate values that differ significantly, $p = 0.05$.

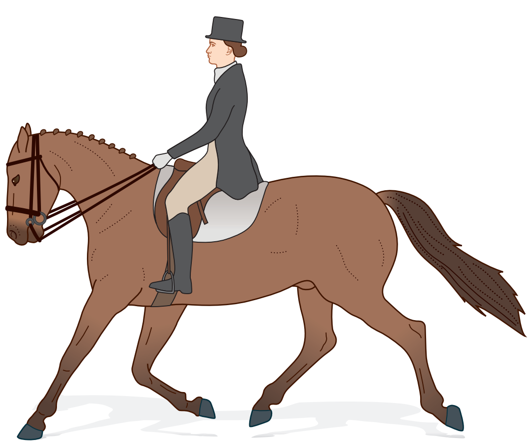


Figure 7.13 Negative diagonal advanced placement (DAP) occurs when the foreleg begins its stance phase before its diagonal hindlimb. Positive DAP is when the opposite situation occurs: the hindlimb begins its stance phase before the forelimb.

pace stride. Ipsilateral couplets are used almost synchronously so that the left fore is swung with the left hind, and the right fore with the right hind. The hindfoot makes contact with the ground before the ipsilateral foreleg (Fig. 7.16).[38] Although the pace is often described as a two-beat gait, there is sufficient dissociation between the footfalls at racing speed for it to be considered a four-beat gait.[35] A pacing horse tends to swing or 'wag' its hindquarters from side to side, while its whole body may appear to rise and fall in a motion similar to the trot.

Stepping pace

In five-gaited show horses, the stepping (or broken) pace is one of the acquired gaits characterized by lateral rather than diagonal couplets, and the return of the hindleg to the ground before the ipsilateral foreleg,

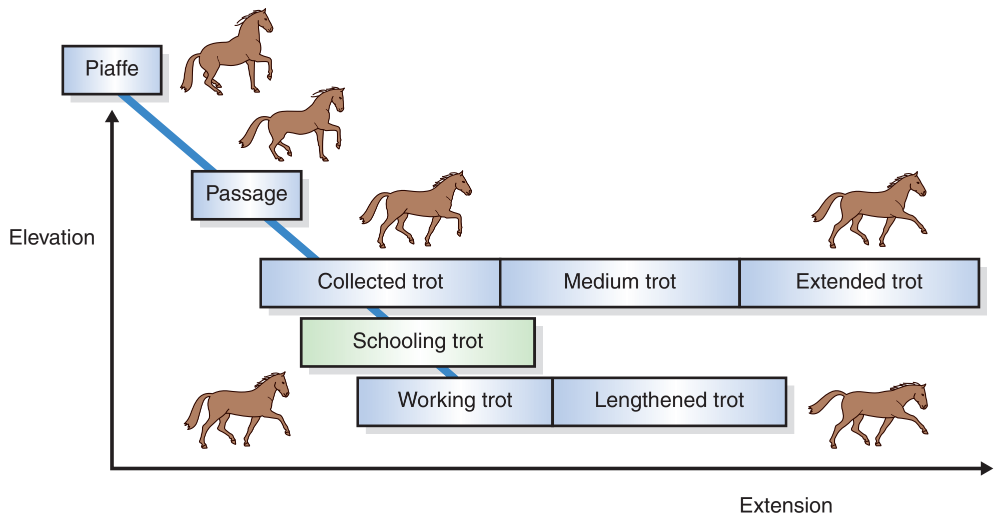


Figure 7.14 This graph shows the increased collection and simultaneous shortening of the stride as the horse becomes more educated toward piaffe. *(Reproduced with permission of Australian Equine Behaviour Centre.)*

Figure 7.15 A good quality trot is characterized by a long duration of both swing phases and suspension phases as a result of emphatic retraction and protraction of the forelimb and hindlimb respectively. *(Reproduced with permission of Australian Equine Behaviour Centre.)*

which undergoes pronounced elevation (Fig. 7.17). The horse is supported by one, two or three legs at a time.

Rack

In five-gaited show horses, such as occur within the American Saddlebred to name but one of the numerous so-called gaited breeds, the footfall sequences of the lateral walk are applied in a variation called the rack. The beat is an even 1–2–3–4 (Fig. 7.18). With striking animation achieved largely through heightened foreleg action, the rack can be performed with considerable speed, stride frequencies reaching 120 per minute.[39] The horse is supported first by two, then by one hoof at a time, jumping forward between transverse pairs of legs (both front, both hind). There is a moment when the horse's weight is supported by first one hindhoof, then by one front hoof.

When Icelandics travel at the hreina (meaning clear) tölt, there is no 'jump' in the movement. The hreina tölt has the footfall sequences of the lateral walk, with an even 1–2–3–4 beat. Only one or two feet support the horse's weight, with never a moment of suspension or a moment of three-legged weight bearing. In the higher speeds the two-feet-weight-bearing phase becomes shorter while the one-foot-weight-bearing phase becomes longer. Since the horse never takes its weight from the ground, this gait is very comfortable for the rider, and allows the horse to be sure-footed in uneven terrain. Icelandic horses are the only breed in which individuals can innately show both pace and tölt from slow to gallop speed.

Passage and piaffe

With diagonal pairs of fore- and hindlimbs moving more or less in synchrony, the passage and its almost stationary analogue, the piaffe, are similar in footfall sequencing to the trot but differ from even a collected trot in terms of speed and stride length (Table 7.7). With two suspensions per stride and a characteristically long positive diagonal advanced displacement, the passage

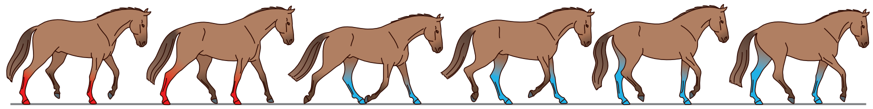


Figure 7.16 The pace. *(Redrawn, with permission, from Waring.[3])*

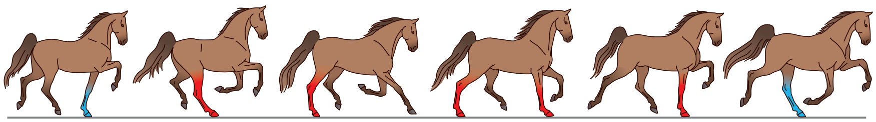


Figure 7.17 The stepping pace. *(Redrawn, with permission, from Waring.[3])*

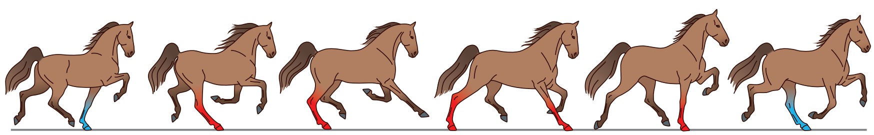
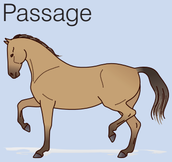
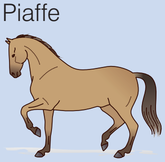


Figure 7.18 The rack. *(Redrawn, with permission, from Waring.[3])*

Table 7.7 Mean values for stride kinematics of the collected trot, passage and piaffe in dressage horses in the individual medal finals of the Barcelona Olympics

	Speed (m/s)	Stride length (m)	Stride frequency (strides/min)
Collected trot 	3.3^{a}	2.50^{a}	71^{a}
Passage 	1.6^{b}	1.75^{b}	55^{b}
Piaffe 	0.2^{c}	0.20^{c}	55^{b}

*Different superscripts indicate values that differ significantly, **p** = 0.05.Data from Clayton.[68]*

involves marked elevation of the limbs, which visibly pause for a moment before descending. It is seen in free-ranging horses as the prancing display characteristic of stallions (see Ch. 6).[3] Classically, the toe of the forehoof should be elevated to the middle of the contralateral cannon, while the hindhoof should rise slightly above the contralateral fetlock. Notably, none of the individual medal finalists in the Barcelona Olympics demonstrated this degree of forelimb elevation.[40]

Studies of the ground reaction forces during passage demonstrate its similarity to the collected trot, in that the hindlimbs provide forward and upward propulsion while the forelimbs have the higher peak vertical force and elevate the forehand while providing longitudinal

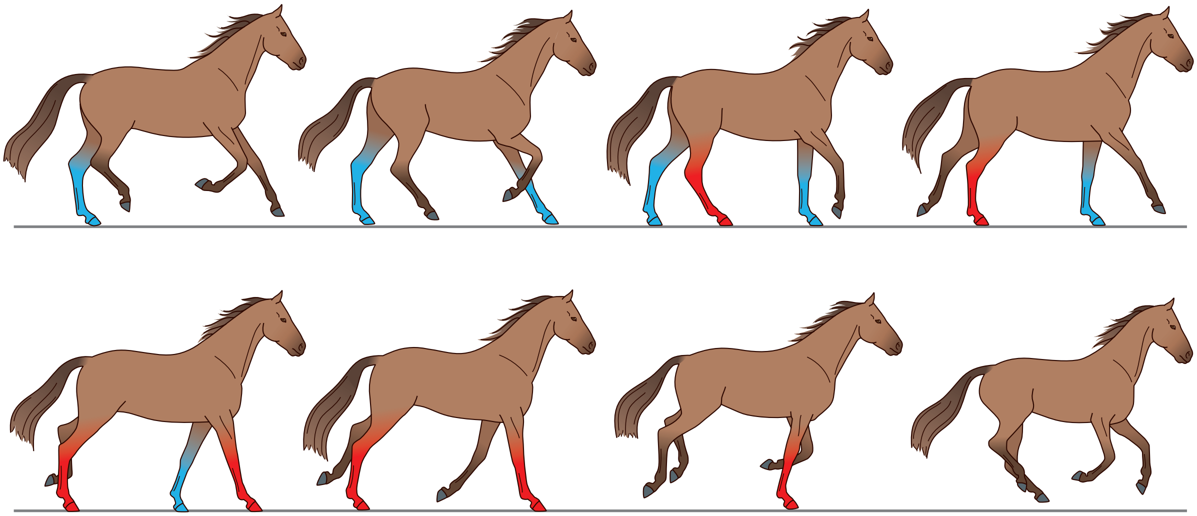


Figure 7.19 The cycle of movements at the canter (right-lead). The weight-bearing limbs at each stride are indicated.

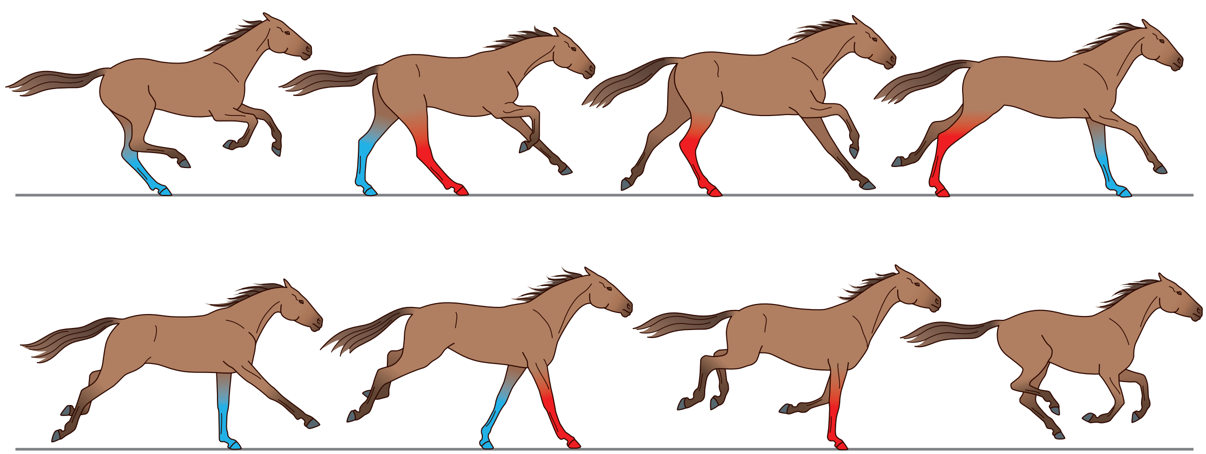


Figure 7.20 The cycle of movements at the gallop (right-lead). The weight-bearing limbs at each stride are indicated.

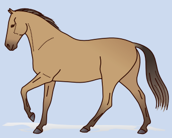
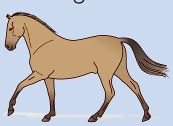
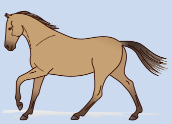
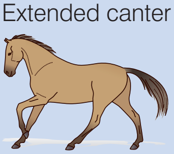
retardation.[35] Conversely, the ground reaction forces from the piaffe show that the forelimb provides all there is of longitudinal propulsion, while the hindlimb has a retarding influence.[35] The piaffe shares a momentary pause at the peak of elevation in the swing phase, but can be readily distinguished from all other variants of the trot by having little, if any, forward movement and no suspension phase – there is always at least one hoof in contact with the ground.

Canter and gallop

The canter, with three beats to the stride (Fig. 7.19), and the gallop (Fig. 7.20), with four, are asymmetrical gaits and are labeled left or right in reference to the leading foreleg and ipsilateral hindleg. The body pivots over the leading leg, which is the last leg to lift off the ground. As the horse leans toward or makes a turn to the right, it usually leads with its right leg, and vice versa. So, a right-lead canter footfall sequence is as follows: left hind, right hind/left fore, right fore. Conversely, a left-lead canter footfall sequence is: right hind, left hind/right fore, left fore.

Speed can be used to distinguish the four types of canter recognized by the FEI (Table 7.8), with stride length being the cardinal marker of elite horses performing the extended canter.[30] In its slowest form, the canter may adopt a four-beat pattern as the second and third feet meet the ground separately. Paradoxically, as the speed increases, the four beats return with a diagonal or transverse sequencing that distinguishes the

Table 7.8 Mean values for stride kinematics in the collected, working, medium and extended canters in FEI-level dressage horses

	Speed (m/s)	Stride length (m)	Stride frequency (strides/min)	Suspension (ms)
Collected canter 	3.27^{a}	$2.00^{a,b,c}$	99^{a}	$0^{a,b}$
Working canter 	3.91^{b}	$2.35^{a,d,e}$	99^{a}	$5^{c,d}$
Medium canter 	4.90^{c}	$2.94^{b,d,f}$	101^{a}	$54^{a,c}$
Extended canter 	5.97^{d}	$3.47^{c,e,f}$	105^{a}	$87^{b,d}$

Data from Clayton.[69] Different superscripts indicate values that differ significantly, $p = 0.05$.

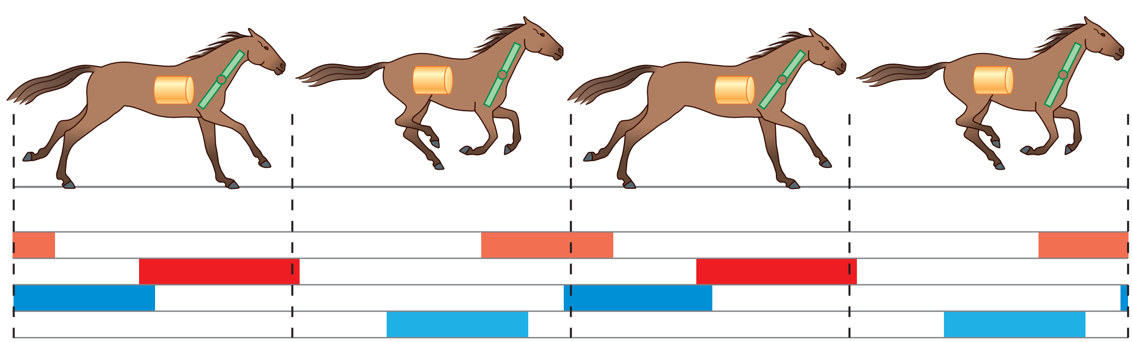


Figure 7.21 The pendular action of the head and neck are coordinated with the footfalls of the gallop stride, so that propulsion from each limb is optimized sequentially. (The barrel represents the centre of gravity.) *(Copyright Stephen Budiansky. Redrawn, with permission, from Budiansky.[25])*

equine gallop from the lateral or rotary gallop of the cheetah.

Although minimal dorsolateral flexion of the vertebral column is noted during galloping, systematic angular displacement of the neck occurs, presumably to assist balance. The angulation correlates with support periods of the individual legs so, effectively, the head is raised maximally shortly after the lead foreleg leaves the ground.[41] The rolling action of the neck gives the impression of the horse's cervical musculature lifting the body forward as it descends[3] (Fig. 7.21). This notion is further supported by evidence that the semispinalis capitis and splenius muscles differ in terms of their fiber type and histochemistry.[42]

Neck movement is not a feature of natural equine locomotion that is encouraged in dressage and the show ring, where maintaining head carriage is considered desirable. This is problematic for horses since there may be a modern obsession with imposing neck flexion on ridden horses. The longitudinal neck flexion of the degree desirable by popular opinion in ridden horses is not a common feature of unridden horses moving naturally.[43] Regardless of head restraint, the vertebral column, rather like the frame of a bellows, contributes to the forces of ventilation as it undergoes flexion and extension. For this reason each gallop stride is accompanied by a respiratory cycle with the horse exhaling as it lands on its leading foreleg.[44]

It is fascinating to note that, without prompting by riders, horses need considerable space to canter readily. It has been demonstrated that the tendency for horses to canter is restricted in fields of 1.5 ha or less.[45] Therefore, the dimensions of available paddocks should be borne in mind when turnout is advocated as an effective means of normalizing a stabled horse's behavior.

Airs above the ground

A number of in-place leaps can be achieved with meticulous training (Fig. 7.22). Evocative as they are of the military origins of dressage, they are not performed in FEI competitions but instead form part of demonstrations of haute école training. All of these maneuvers involve the horse beginning by elevating its forehand. With the forelegs tightly flexed and the vertebral column inclined between 30° and 45° above the horizontal, this is called the *levade*. Maintaining this posture requires balance, strength and the ability to flex the hindquarters profoundly. A series of levades joined together by the horse rocking smoothly forward and punctuated briefly by the forelegs contacting the ground is called *mezair*.

If the horse leaps off the ground from a levade and lands in virtually the same place, it is said to have performed a *croupade*. This is distinct from a *courbette*, which integrates deliberate forward movement within the leap. The *cabriole* is a smooth sequence of movements in which the horse emerges from levade to take off and then kick backwards with the hindlimbs while at the peak of the airborne phase. In the *ballotade* the horse leaves the ground in much the same fashion, but tucks its hindlegs underneath it.

Other locomotory maneuvers

Jumping

Unless trained to jump, horses generally avoid ditches and horizontal obstacles. Being able to see where to place their feet is critical for their safety. To gallop full-tilt into the unknown is inherently aversive and so must be trained. This explains why foals are not seen spontaneously leaping out of paddocks for the sheer joy of jumping. Of course, some horses are sufficiently trained to tackle fences without their jockeys, but this reflects their conditioning and the herd effect rather than any thrill they may feel from soaring over a man-made obstacle. Horses that bolt toward jumps in show-jumping and cross-country are recognized as a danger to themselves and their riders. Running at hazards should not be confused with choosing to jump.[46] Experienced horses approach fences in an active canter.[47] This makes sense because, in its simplest form, jumping can be viewed as an animated canter stride, except that at the moment of take-off a half-bound is inserted that aligns the hindlimbs so that both can be used to push off the ground together.[34] In 92 of 96 jumps analyzed (over oxers; see Glossary), the leading forelimb was the appendage closest to the fence at take-off.[48] In the remaining four jumps in this series, the leading hindleg was the appendage closest to the fence at take-off. The non-leading hindlimb is usually placed between the hoofprints of the two forelimbs at take-off.[48]

Although limb placements do not differ between a vertical fence and an oxer, more faults occur when horses jump the former,[34] suggesting that horses regularly get too close to fences. Forelimb errors, often forced by riders, are involved in the vast majority of jumping faults (e.g. 87% in one study of trunk accelerations[49]).

A study of 72 horses jumping in 609 rounds of competition produced some fascinating results that demonstrated that the number of faults at a particular obstacle depended on several major variables: the obstacle-type, height, color and arrangement.[50] Attempts to jump the third and fourth obstacles in the courses were faulty most often. Furthermore, while walls were the most often avoided by lateral run-outs, uprights and oxers were the most frequently knocked down. The least number of faults was accrued at the second obstacle in a combination compared with the first and third.[50]

A trajectory of 45° is implied by riding manuals that advocate the ideal take-off point for a simple vertical fence as a distance equal to its height. However, this dictum has been questioned in the light of data that

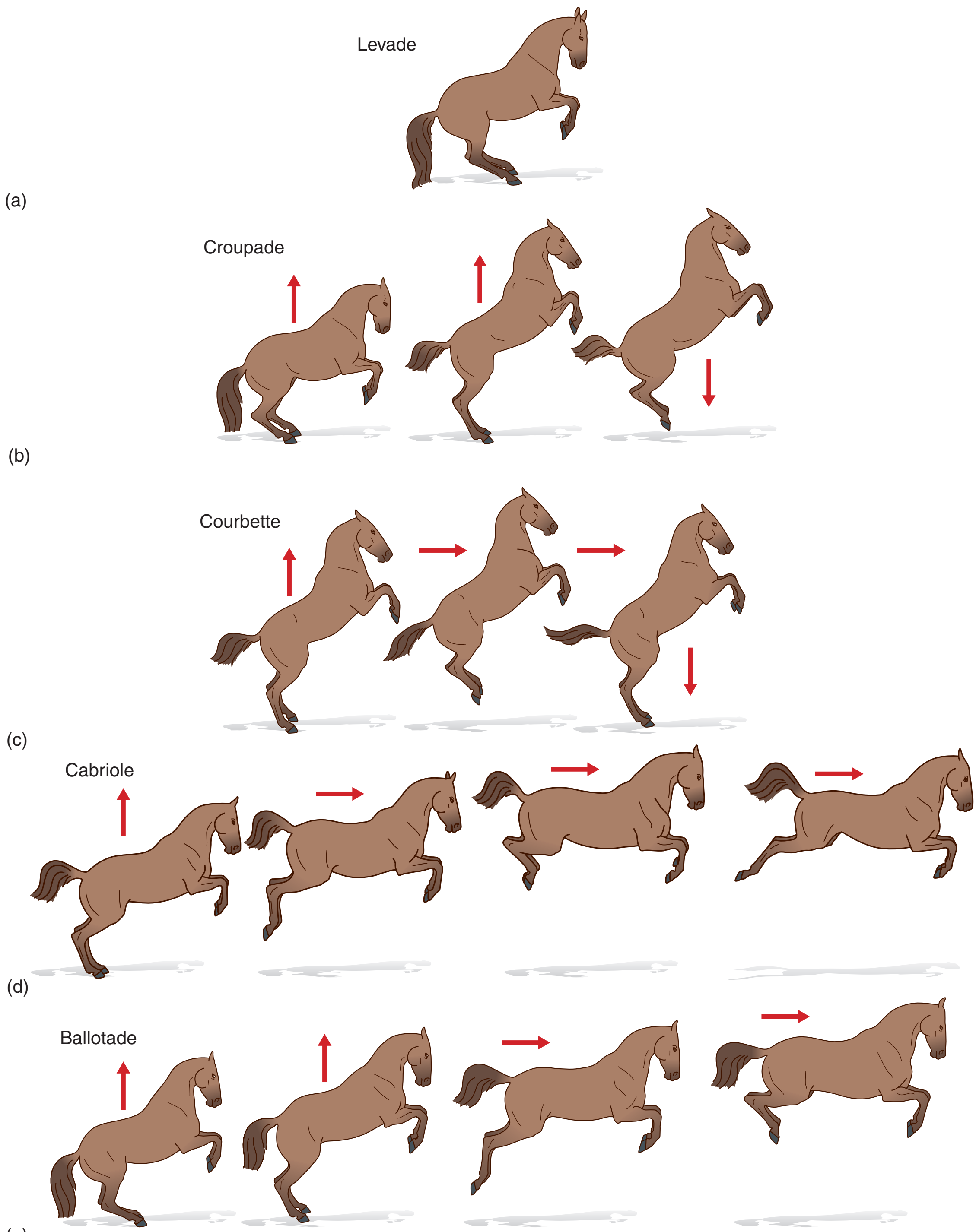


Figure 7.22 The airs above the ground: (A) levade; (B) croupade; (C) courbette; (D) cabriole; (E) ballotade. *(Redrawn, with permission, from Waring.[3])*

demonstrate Grand Prix show-jumpers using reasonably consistent take-off distances over a variety of upright and spread fences.[25] In contrast to a standard show-jumping technique, steeplechasing is associated with placing both hindlimbs closer to the fence than the leading forelimb.[47]

When a horse lands after a jump, the non-leading forelimb is the first to meet the ground. It provides forward propulsion that carries the horse along, in contrast to the next limb to make contact, the leading forelimb, which has an effective braking action. The return of the trailing hindlimb, which provides more forward thrust, means that the horse has resumed a normal canter stride by the time the fourth foot falls. Good jumpers naturally tuck their forelegs more than average jumpers, and therefore, in untrained horses, this feature and the absence of excessive speed while approaching fences are considered the best predictors of later competitive success.[51]

Bucking

Arching and humping the vertebral column in combination with retrograde propulsion of the forehand ('pig-rooting') occur in play and as a resistance to forward movement in horses under-saddle or on the lunge. Classically, the horse is said to be bucking when the hindlegs leave the ground. If the horse vaults into the air completely, it is described as buck-jumping. Although bucking is often interpreted as a demonstration of joie de vivre, it is worth remembering that in evolutionary terms it may have been a maneuver to dislodge a predator or, possibly, to signal to predators 'don't bother with me, I'm in the very best of health'. It is important to eliminate pain, either from the saddle or in the horse's vertebral column, before assuming that a horse that starts to buck is simply being disobedient (see Ch. 15).

Rearing

Generally an unwelcome response in ridden horses, rearing is a defensive maneuver used to evade aversive stimuli suddenly appearing to the fore, and an intrinsic part of the horse's agonistic repertoire. It is difficult to resolve because as an evasion it is often the result of conflicting rein pressure and leg pressure. For that reason, there is little left for the rider to do in the case of a rearing horse but to hang on. It is easy to see how a rear can be unintentionally reinforced as the rider removes pressure from the legs in a bid to stay on-board. Since it can be difficult for horses to balance on their hindlegs, the greatest danger is that the horse may fall to one side and crush the rider. For this reason many texts advise the rider to dismount from a rearing horse as soon as possible. However, to eliminate any reinforcing outcomes if the behavior has emerged as an evasion, it is important to drive the horse forward towards the stimulus that evokes the resistance. Therefore, many experienced riders choose to stay on-board to pursue the lesson. They often turn the horse as it descends to the ground so that they have an increased chance of triggering forward movement by avoiding the stimuli that prompted the horse to rear.

Interestingly, in horses, such as circus animals, taught to rear, this maneuver is one of the first responses that proves difficult to achieve as the horse approaches old age. The strength a horse needs to support itself on its hindlegs and balance there is considerable and can prove limiting for these performers, as it does for geriatric stallions when required to mount mares.

Swimming

When swimming, the horse uses its hooves as paddles with a trotting action, but is required to keep the neck extended and the head relatively still. Despite the buoyancy afforded by displacing such a large volume of water, the effort required to move in the water with such small paddles, while inflating the lungs against the pressure of the surrounding water, makes swimming very hard work (Fig. 7.23). This accounts for much of the grunting one hears from horses as they swim. The benefits of swimming in the conditioning of racehorses and as a therapy for orthopedic injuries are well recognized but may be offset by the respiratory effort required from the horse, the coaxing required by personnel and the risk of injury associated with the activity.

Influences on locomotion

The effect of conditioning

Naïve riding animals may trip when ridden, simply because they are unused to supporting the weight of a rider. At the other end of the equine educational spectrum, correctly trained dressage horses move in self-carriage, which implies lightness of the forehand and a greater reliance on the hindquarters for propulsion.[34] At the walk and the trot, trained horses have an increased ratio of swing to stride duration. This is achieved by a short stance duration and

Figure 7.23 The collapse of the nostrils in a swimming horse helps to illustrate the inspiratory effort that this form of locomotion demands. *(Photograph courtesy of David Evans.)*

reduced flexion in the hindlimb, which combine so that maximal protraction occurs earlier in the stride. The action is characterized by increased fetlock extension, which is said to illustrate that more weight is being carried by the hindlimbs. This is what equestrians refer to as 'engagement of the hindquarters'. Most notable at the trot, the hindlimbs generate what is termed 'impulsion' by operating faster and with less limb flexion. Although these variables may seem of importance chiefly to dressage competitors, similar changes as a result of fitness-training are reported in young Standardbreds trained for 5 months. They show increased carpal and fetlock extension in the forelimb and increased tarsal and fetlock extension in the hindlimb.[52] The gait of pastured horses is characteristically more relaxed, with the forelimb acting as a passive strut and therefore giving the impression of movement on the forehand.[34]

The effect of the rider

Kinematics change when a horse carries a rider,[53] and the effects tend to be amplified as a function of the rider's weight. When first ridden under-saddle as part of foundation training, horses show movement that is described as being short in front.[34] This reflects the need to increase muscular strength and a new balance in order to support the rider. With training, most young horses find their balance and are therefore able to carry themselves 'on the bit' while being ridden (see Ch. 13).[34] The extent to which a rider can help a horse balance is the stuff of riding manuals rather than a horse behavior text. However, it is worth noting that, with experience, and as their balance improves, riders adopt a more upright position in the saddle and other characteristics of a good seat as illustrated in Figure 7.24. Although this posture may make humans more effective as riders, because it makes them more stable in the saddle and increases the flexibility of the legs for delivering signals, it is not clear whether it makes the horse's task easier. With the rider in a more upright position, the centre of gravity shifts to the hindquarters, which, in an educated animal, are required to do proportionally more work than when at pasture.

During the rise phase of a rising trot, riders may set up a left–right asymmetry in ground reaction forces, but competent riders are able to compensate for this by shifting part of the weight to the hindlimbs.[54]

A great deal of effort on the part of riders goes into pursuit of a desirable outline in their horses, which involves the nasal planum being within 6° of the vertical. To the novice observer, this gives the illusion of the horse being in self carriage and therefore well-trained. Unfortunately, regardless of whether the horse has learned to carry itself that way or whether it has simply lost the battle with its rider to keep its head in a more natural position, the effect of head and neck flexion is variable upper airway obstruction (Fig. 7.25).[55]

It has been shown that in 87% of cases, faults attracted during jumping can be blamed on forelimb

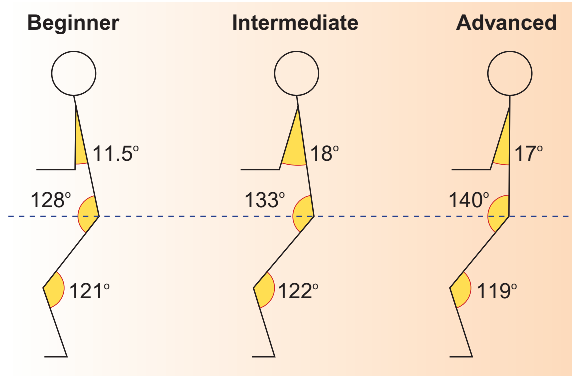


Figure 7.24 At a sitting trot, the angles of the arm, hip joint and knee joint of the beginner, intermediate and advanced riders show significant differences that can have an effect on the way in which the horse can carry itself. *(Redrawn from Schills.)*

Figure 7.25 Flexion of the neck can compromise pulmonary ventilation. *(Photography by Neil McLeod.)*

error,[49] and they are usually the result of inappropriate stimuli from the rider.[56] Interestingly, over-jumping occurs when horses are ridden by less competent riders. The effect of dead weight on a horse's ability to jump is seen chiefly in the clearance achieved by the leading forelimb and the extension of the fetlock and carpal joints on landing.[57] Because these indices are respectively precursors of falls over solid fences and strains of the suspensory ligament and the superficial digital flexor tendon,[34] these data led to the abolition of the minimum weight rule for eventers.

Responses to the whip

In a study of Quarterhorses at the gallop, the use of a whip on the shoulder of the leading forelimb, in rhythm with the stride, did not increase speed but reduced stride length and increased stride frequency.[58] Analysis of racetrack patrol videos has shown that 38% of breakdown injuries occur after use of the whip.[59] (This may reflect the rider's response to the horse beginning to pull up with an acute lameness.)

When measurements of whip strikes and sectional times during each of the final three 200-m sections of 5 races were analyzed, jockeys in more advanced placings at the final 400-m and 200-m positions in the races were seen to whip their horses more frequently.[60] However, horses, on average, achieved highest speeds in the 600-m to 400-m section when there was no whip use, and the increased whip use was most frequent in the final two 200-m sections when horses were fatigued. This increased whip use was not associated with significant variation in velocity as a predictor of superior placing at the finish. Under an ethical framework that considers costs paid by horses against benefits accrued by humans,[61] these data make whipping tired horses in the name of sport very difficult to justify.

Responses to confinement and refusal to load

Many horses seem to find pleasure in exercise.[9] When mares were confined in standing stalls for 6 months, they showed no significant differences in baseline plasma cortisol concentrations or in cortisol responses to ACTH compared with exercised controls.[62] However, in the same way that crib-biters show more of the behavior after a period of deprivation, confined horses show a post-inhibitory rebound in locomotion, indicating a compensatory response to exercise deprivation.[13] When, after 6 months of confinement, exercise was permitted, a group of confined mares showed an increase in plasma cortisol concentration, whereas mares given 30 minutes of exercise per day showed a decrease.[62]

Unfortunately, because the motivation for movement and indeed general activity is greater in horses kept in confined and isolated environments,[63] turning-out can be associated with injury. Airs above the ground are not uncommon when confined horses are turned-out (Fig. 7.26). This can have harmful effects on the musculoskeletal system, which is generally in poor condition as a result of confinement.[64]

Confinement does not just bring reduced opportunities for exercise, but is often also associated with the absence of companions, a reduced ability to observe surroundings, and relative darkness. The enriching effects of being at pasture may help to account for data showing that training takes less time in pastured horses than stabled horses.[65]

Figure 7.26 A 27-year-old horse frolicking enthusiastically after 3 months of box rest. *(Reproduced by permission of the University of Bristol, Department of Clinical Veterinary Science.)*

Horses in a dark stabled environment have demonstrated a preference for a lighted environment by learning to turn on lights by means of an operant device (trial-and-error conditioning).[11] Similarly, since stress responses are associated with confinement in stalls,[63] one would predict that horses would prefer to remain outside a trailer (a float in the USA and Australia) (see Fig. 2.7). There is generally very little reinforcement to be found in a confined space and, therefore, using the principles of learning theory, one would predict that the likelihood of the horse entering the trailer would naturally decline. This is often what happens when horses that naïvely load once or twice learn that it is a response that yields few rewards. If, when they balk and refuse to load, they are summarily punished, some learn to associate the presentation of the trailer with pain and back away from it.[66] The subsequent introduction of ropes to drag the horse in, and various aversive stimuli to send the horse forward, do nothing to dissuade the horse of these associations. The learned fear abates only when the horse is allowed time to enter the confined space at its own pace and find reinforcement therein. Because of the horse's resistance to behavioral extinction,[9] this training should be conducted at home under relaxed conditions.

Owners of horses that load without being reinforced are fortunate to have obliging, tolerant and adaptable animals. Owners of horses that associate no benefits with being loaded do well to approach this problem by reinstalling the leading signals (see Ch. 13) and by instituting a remedial reward system. Given the time such an approach takes to bring results, there is a strong argument for putting rewards in place for all novice horses until loading becomes a habit. The rewards used include premium food items and the opportunity to join a favored affiliate. Offering youngsters daily feeds in a stable (then in a horse-box and then a trailer) is a simple means of creating positive associations with confinement.

The effect of warming up

Routine exercises before competitive work help to warm up the muscles, establish rhythm and reacquaint the horse with the tasks currently required. The effects of such warm-up exercises on stride length are considerable. In endurance horses, stride length at the walk and at the trot, respectively, can increase to 115% and 151% of their pre-race values after 41 km.[67]

Hyperflexion or rollkur (or long-deep-and-round or low-deep-and-round) are terms used to describe a technique where the horse's neck is dorsoventrally hyperflexed as a result of bit pressure to the point where the horse's chin may touch its pectoral region. It is used in training and warming-up horses prior to competition but would attract penalties if seen in dressage competitions themselves, since the horse would be judged to be overbent (the nasal plane being carried behind the vertical). Proponents of this method claim that they shape this response gradually and that the horse is ridden in this 'frame' (posture) for only short periods. However, many observers have described longer durations,[70,71] and the mechanisms by which this technique might achieve greater flexion of the hock joints (as is claimed) are not yet known. It is plausible that any advantages conferred by this technique in achieving higher steps occur as a result of post-inhibitory rebound where the extension of the nuchal ligament and concomitant alterations in the back muscles may, when released, permit higher steps.

Hyperflexion is believed to decrease stride length and increase elevation of the hindlimbs, while also increasing the dorsoventral oscillation of the lumbar vertebrae.[72] Certainly, its current prevalence among elite dressage competitors strongly suggests that it lends some competitive advantage in that its use must help to produce a performance the judges wish to see, even though it is a warm-up practice that is at odds with what is required in the competition itself.

SUMMARY OF KEY POINTS

- Movements in utero are of tremendous importance in priming a foal for precocial existence.
- Horses have a behavioral need to stretch and locomote.
- Gaits have evolved for economical energy use at any given speed.
- Kinematic studies are useful for understanding the within-gait differences required in dressage.
- Riders, whips, conditioning and warming-up can influence locomotion in ridden horses.

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CHAPTER 8

Ingestive behavior

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The transition from milk to solids

Foals will nibble at blades of grass from their first day of life,[1–3] often targeting grass on raised ground, such as on banks, because this overcomes the need (in horse foals rather than pony foals) to spread their forelegs.[4] As foals grow, they gradually increase their exploration (Fig. 8.1A) and intake of solids[5] and learn to flex their knees to access vegetation on the ground (Fig. 8.1B). The phase of playing with grass and, for that matter, drinking-water is very transient, often lasting less than a day.[6] However, a rapid increase in time spent grazing does not occur until approximately 4 months of age[5,7] (Fig. 8.2).

Consuming a variety of non-grass substrates, including clay, bark, twigs, leaves and humus has been noted in many adult equids, with the suggestion that in moderation this response may be adaptive and provide necessary trace elements[8] or material that may facilitate gut motility. Learning about food substrates can have a profound effect on biological fitness. Indeed the availability of appropriate nutrients can have an impact not only on individual success but also on herd composition. For example in a study of a herd of horses that underwent a period of nutritional stress, male offspring had higher neonatal mortality rates in nutritionally poor years than in good years.[9]

Avoiding poisonous plants and selecting grass rather than other items occur concurrently between the ages of 4 and 6 weeks.[10] Foals generally feed when their mothers are feeding.[2] In a domestic setting some may acquire some of their dam's concentrate feed by stealth, while others are offered their own concentrate feed from birth or are given concentrate diets just prior to weaning to encourage good growth.

Although foals need a balanced diet to support adequate bone formation, regular concentrated feed should be restricted, since it may contribute to problems of gastric acidity.[11] Furthermore, because the rate of developing stereotypic and redirected behavior is greatest during the first 9 months of life and is related to feeding concentrates,[11] great care should be taken in selecting diets for nursing mares and weanlings. Diets that most frequently cause stereotypic responses in adult crib-biters should be avoided. These include acidic diets and those that can be ingested without much chewing.

Nicol et al[12] compared the behavior of foals fed from one month of age on a starch-and-sugar-based diet with

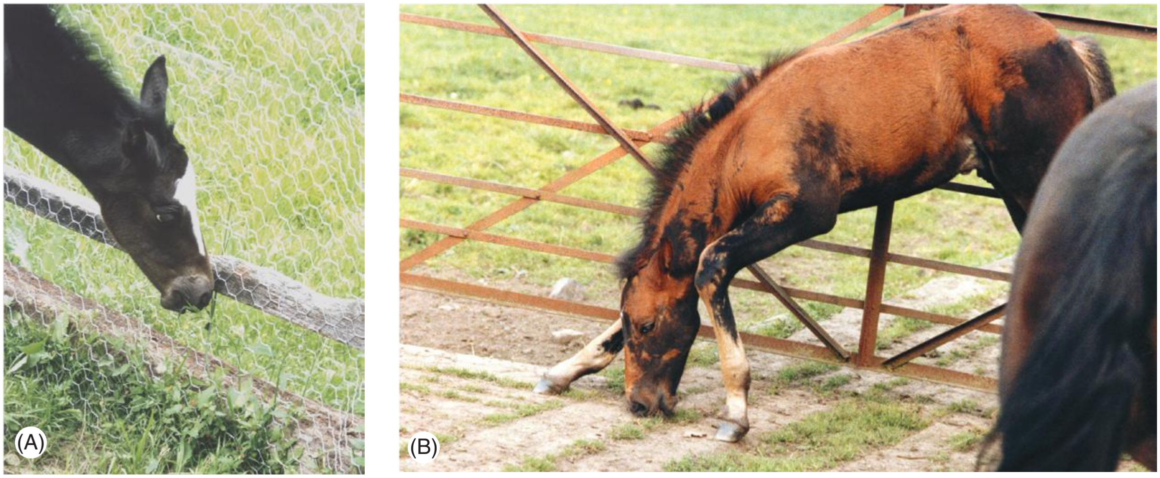

Figure 8.1 Foals (A) explore a variety of foods and (B) then develop ways of prehending them. *((A) Courtesy of Kate Ireland; (B) courtesy of Francis Burton.)*

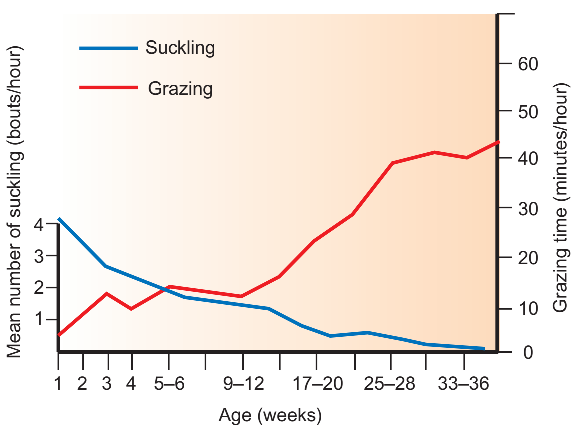

Figure 8.2 Mean time foals spend grazing and the number of bouts of nursing prior to weaning. *(After Tyler.[5])*

foals fed an isoenergetic fat-and-fiber-based diet. During weaning, the foals fed fat and fiber appeared more settled and less distressed than their counterparts fed the starch-and-sugar-based diet, cantering less frequently and for shorter periods. During temperament tests, they also seemed calmer and more inquisitive than the foals fed the starch-and-sugar-based diet. For example, they were more willing to approach and investigate a novel object, less likely to walk away from unfamiliar personnel and significantly quicker to cross a novel groundsheet.

Grazing becomes more efficient as juveniles mature.[13] Juveniles also learn to avoid areas used by adults for elimination purposes.[14] Using the upper lip to isolate the selected plants, horses pass them as a bundle into the teeth and break them away using a backwards jerk of the head. Several bundles may be taken into the mouth before a bout of chewing begins.[4]

Animals seem to learn about food selection more quickly when in groups than when alone,[15] possibly reflecting an ability to learn which foods to select through social facilitation. Although several studies have failed to demonstrate observational learning related to the acquisition of food,[16–18] at least one[19] showed that horses that observed a demonstration of an approach to feeding learned the general location of the food and therefore had a shorter latency to approach the food than control horses.Thus, stimulus enhancement may improve learning efficiency, through the transfer of information from experienced to inexperienced grazers.[20]

Observational learning studies in horses have tended to use mature subjects that are unaffiliated to one another. This represents an important possible flaw in experimental design since these may be among the least likely of all horses to be receptive to socially transmitted information. In contrast, one would predict that young foals at pasture would be more likely to use social models to learn correct food selection if their dams were effective demonstrators, because they are inexperienced foragers in a social group. Hypotheses that support this view generally assume that the greatest transfer of information occurs between a mare and her offspring. Moreover, lessons do not have to be learned by direct observation. Although yet to be demonstrated in horses, work in other species has indicated that ‘taints’ in a mother’s milk as a result of her diet may provide a mechanism for such exchange.[20]

Foals between 1 and 6 weeks of age display exploratory grazing which, unlike typical adult grazing, involves mouthing plants rather than ingesting them. Although it is likely that a combination of mechanisms is involved in learning food selection, one of the most likely involves coprophagy (ingesting feces). Often seen after pawing at fecal material, coprophagy by foals peaks during the exploratory period. The dam's feces are the preferred or only fecal substrate that is explored in this way.[10,21] Old feces are rarely consumed.[8] As a feeding-exploratory behavior, coprophagy may be a method of learning about the gustatory and olfactory features of plants consumed by the dam. The significance of this activity in learning is supported by the coinciding decline in the foal's interactions with toxic plant species during this time.[10] In this way it appears that horses may circumvent the sort of observation learning typical of predatory species such as felids, by modifying their behavior in response to information from the gastrointestinal tract being transmitted to the brain.[22] Coprophagy may have additional purposes,[23] such as the acquisition of intestinal microbes and possibly deoxycholic acid, which has been found in the feces of lactating rats and is thought to play a role in the deposition of myelin.[24] For these putative reasons, hand-reared foals should be given the opportunity to perform coprophagy. It is unlikely to expose the foal to viable forms of endoparasite. By contrast, coprophagy is rarely seen in adults, except in those on fiber-restricted diets (see p. 198).[25]

Once valuable food sources have been located, they will be revisited after a lull that allows regrowth. Spatial memory of food patches has been demonstrated in horses,[26] and it has been suggested that this is an adaptive feature for grazers that allows them to take short-cuts through their environment.[27] Seasonal variation in the use of home ranges (see Ch. 5) supports the view that such memory may be retained from one year to the next.

Food selection and rejection

Preferences and aversions allow horses to obtain the correct nutrition for their current needs, while preventing the intake of numerous toxic plants. Post-ingestive consequences seem to influence short-term diet selection based chiefly on a substrate's apparent energy content.[28] Because nutrients are used at different rates, they are required in different amounts in the diet. Feedback from the liver and gastrointestinal tract informs the brain of the body's current balance between nutrient supply and demand.[29] Wood-Gush[30] suggests that a 'specific hunger' for a given nutrient ensues, and the horse will then select foods that alleviate this. However, a counter argument proposes that horses eat for pleasure, and correction of specific deficiencies is improbable due to a lack of specific regulatory systems.[31] This may help to explain why horses and, possibly even more so, ponies show a lack of nutritional wisdom when foraging on substrates that elicit metabolic catastrophes, e.g. laminitis.

Figure 8.3 Pony being offered diets of different dilutions. Visits made to each bucket broke infrared beams and were subsequently logged to demonstrate that, to an extent, horses eat for kilojoules not volume. *(Photograph courtesy of Katherine Houpt.)*

In a study of ponies' voluntary feeding responses to different diets, meal size increased and meal frequency decreased as diets were increasingly diluted with undigestible fiber[32] (Fig. 8.3). Although ponies responded to energy dilution by increasing voluntary food intake to maintain energy intake when the diet had 25% sawdust added, increases were at a rate inadequate to maintain energy intake when the diet had 50% sawdust added.[33]

To select different foods, equids must be able to differentiate, and this is achieved through sensory analysis. Using innate taste preferences or aversions alone would be undesirable since it could result in ingesting inappropriate material.[15,33] Therefore, prior to being prehended by horses, plants are distinguished on features of their visual appearance, including leaf shape and color, as well as their odor.[33] The importance of familiar odors in selecting food is hinted at when respiratory disorders are sufficiently profound to interfere with the horse's ability to recognize its food. Olfaction plays a particularly significant role in the way horses avoid areas contaminated with equine feces.[14,21] Although the rate of grazing is often sustained,[32,34] selectivity is hampered when the horse is grazing at night, as visual assessment of plants is impaired. This is believed to contribute to a reduction in soluble carbohydrate intake at night.[35] Once taken into the mouth, the taste and texture of plant matter provide further sensory information. More detailed differentiation between food items is facilitated by cognitive feedback that allows the visual and olfactory features of a food item to be integrated with its taste.[20]

To differentiate beneficial from detrimental feeds, horses must relate the post-ingestive consequences of ingesting a food item to the sensory stimuli that food provided before deglutition. A learned aversion can result from ingesting a food that contains a toxin, or an excess of a nutrient, such as protein, that then acts as a toxin.[33] If toxins are present, neurons in the brainstem are stimulated, causing the animal to feel discomfort.[29] Affective feedback can then integrate information about the taste of a food to the post-ingestive consequences of that food. When this is combined with the cognitive processes that integrate taste and smell, an aversion to that food is formed and committed to memory so that the food will be rejected in future.[29]

Strong aversions to novel foods can be formed when illness *immediately* follows ingestion of a novel food. Houpt et al[36] also showed that an aversion could be formed to a novel food that caused illness, even when the novel food was given simultaneously with a familiar food. In sheep, aversions to novel foods can occur even if the post-ingestive consequences are not experienced until 12 hours after the food was tasted and ingested.[37] This is also seen in carnivores. However, in the horse, if the discomfort is delayed by as little as 30 minutes, the ability to link the discomfort to the causative food is significantly reduced.[36] A possible reason for the difference between horses and carnivores is that the latter tend to eat large sporadic meals, usually from a single source, and can therefore relate post-ingestive consequences to the last food consumed, even after a long delay.[36] In a natural situation, horses spend most of each day grazing, and consume a variety of plants. It is therefore difficult to identify the cause of discomfort after only a short delay, as more food has since been ingested.

Grazing

Grazing is the preferred means of ingestion in adult horses, but browsing is also adopted when grass becomes particularly scarce.[38–40] Although, like horses, donkeys graze, they tend to select coarser grasses and demonstrate greater agility as they exercise their preference for browsing. Because of their motivation to select a variety of forage, donkeys are in greater danger of ingesting poisonous plants than horses are. Horses generally prefer legumes and grasses to shrubs and herbs[41,42] but there is apparently no correlation between gross energy of a given species of forage and the amount voluntarily consumed. Within legumes, horses are reported to prefer alfalfa pasture.[43] When grazing, horses prefer young growth and select leaf material rather than stems,[15,44] presumably because it is higher in carbohydrates. Studies on the preferences shown by horses for different grass species are rarely consistent and perhaps reflect variation in fiber and sugar content as the plants mature. However, timothy and white clover are often cited as preferred species.[41,45,46]

Horses spend much more time than cattle feeding on short grass.[47] Compared with cattle and sheep, horses maintain their levels of food intake even at low sward heights.[13] That said, dense leafy herbage is generally preferred because it provides the maximum intake per bite.[48] Apart from grasses, herbs and browse, horses will also eat bark,[49] roots,[50] soil,[51] acorns and aquatic plants.[5]

Typical domestic horse pastures have a patchy appearance not seen in free-ranging contexts.[52] Selective grazing of feeding areas and the preferential deposition of potassium-rich manure in latrine areas (see Ch. 9) combine to form well-defined lawns and roughs that are typical of horse-sick pastures.[53] Adult horses tend to avoid the long growth that characterizes latrine areas.[54,4] Once this pattern has emerged, it persists and can lead to as little as 10% of the pasture being grazed.[44] The avoidance response is attributed to the fecal content of latrine areas, urine being less repugnant.[44,55] This may be an anti-endoparasite strategy that relies on the presence of alternative grazing opportunities. Therefore, because horses kept at exceptionally high stocking rates will graze near feces in the roughs and will also defecate in the lawns, the risk of parasite infection is increased under such circumstances.[56] Indeed ponies can develop serious helminth infections within 20 days of being released onto a small pasture.[57]

Equids coexist with bovids of similar body size in many ecosystems. Although the grasses usually selected by horses have a higher fiber content than those selected by cattle, they have variable fiber content.[44] Ponies have been shown to have lower digestible organic matter intake than cattle and deer.[58] They compensate for this with a greater total dry matter intake.[59] Time spent by cattle ruminating is occupied with grazing in horses.

While grasses preferred by horses have a variable soluble carbohydrate content, they have significantly higher water contents and lower sodium concentrations than non-preferred forages.[45] Notwithstanding their tendency to develop mosaics of lawns and roughs (prized by some ecologists as a form of structural diversity), horses are recognized as economical grazers of marginal land and can be combined with goats and sheep to make the best use of pastures in poor condition.[60,61] Horses are helpful in integrated pasture management because, compared with cattle, they graze closer to the ground and use the most productive plant communities and plant species (especially graminoids) to a greater extent.

Taste tests

Studies on immature horses have provided useful data on innate preferences. When given a choice between tap water and sucrose solution (at concentrations from 1.25–10 g/100 mL), foals preferred the sweet solution.[62,63] With salty (NaCl) and sour (acetic acid) flavorants, the foals rejected solutions of higher concentrations (of 0.63 g/100 mL and 0.16 mL/100 mL respectively).[62] Water made bitter by the addition of quinone hydrochloride at concentrations greater than 0.16 mL/100 mL was also rejected. Although bitterness is commonly linked to toxins,[29] some adult horses have been shown to be extremely tolerant of it, and this accounts for its variable effectiveness as a taste deterrent – for example, to prevent wood-chewing.[64] Even in foals, taste preferences can vary among individuals. For example, both Randall et al[62] and Hawkes et al[63] found that individual subjects rejected sucrose.

Through sampling and operant (trial-and-error) conditioning, horses can learn which foods should be ingested to meet given needs. In combination with nutritional wisdom,[65] this may account for selection and ingestion of soils that contained more iron and copper than surrounding samples.[51]

Flexibility in dietary intake is desirable since it allows horses to adapt to fluctuations in the availability of vegetation. When the availability of preferred food items is limited, horses are quick to reach a compromise between plant quality and quantity to meet their dry matter requirements.[35,61] Therefore, horses may ingest poisonous plants when they are more prevalent than safe forage or when they are dried and less detectable.[66,67] Because horses differ individually in their ability to graze selectively,[64] observing individuals as they graze a mixed sward may be worthwhile since it can help to predict their ability to avoid eating toxic plants.[68]

Natural influences on food intake

Social factors

Among the strongest influences on a free-ranging horse's feeding behavior are the size of the group and the horse's rank within the group.[52] Leaders play a critical role in the timing of grazing,[23] and social facilitation is an important stimulant of grazing.[69] When grazing as a group, horses tend to distance themselves from conspecifics other than their preferred associates.[70] It is likely that although they are often dispersed,[4] herd members use subtle visual signals to communicate while grazing. The subtlety of such signals may account for the ability of horses to detect discrete cues in handlers.

The caution exercised by all horses when sampling novel potential foods is appropriate since horses do not regurgitate readily.[20] In some circumstances, horses can be very reluctant to eat new foods. Such neophobia is most common in horses that are currently consuming a well-balanced diet.[33] Neophobia can be overcome through social facilitation. If they are less neophobic than mature conspecifics, foals may be more able to learn preferences from experienced foragers.[10]

Lactation and seasons

Time spent grazing by mares increases with lactation, most notably in the first 3 weeks after parturition.[71] Notwithstanding the energy demands of milk production, mares have been found to have a slight tendency to forage more than stallions in all seasons.[72]

Because the duration of the photoperiod and equine appetite, as measured by voluntary food intake, are similar, a causal relationship has been suggested. Physiological responses to photoperiodic change are not immediate, sometimes occurring after a delay of up to 8 weeks.[73] Free-ranging horses take advantage of seasonal increases in food availability by increasing their intake and accumulating body fat.[61] In a study of Przewalski horses under semi-natural conditions (12 mares in a 44 ha enclosure), feeding activity accounted for 40% of total activity in summer and 62% in spring.[74] The fresh weight of single stools defecated by grazing ponies peaks in mid-summer.[75] As the quality and availability of forage declines, a peak in food-searching activity occurs in autumn.[76] In winter the continued decline in availability is accompanied by a trough in the level of general activity.[74,77]

Biting flies have a strong influence on the feeding behavior of horses at pasture.[78] During hot summers many activities, including feeding, are shifted to night-time.[74,79] Heavy rain also tends to inhibit grazing activity.[71]

Time-budgeting

Although the only true wild horses (*E. przewalskii*) are in or from captive populations, we can use their behavior and that of feral *E. caballus* as guidelines for what could be regarded as normal equine behavioral organization. Of the major groups of behaviors, those that occupy most of a free-ranging horse's day are searching for choice grazing spots and ingesting forage. Equine feeding control mechanisms appear to have evolved to maintain a high gut-fill.[78]

Horses spend an average of 16–17 hours a day grazing,[80] but when forage is scarce the grazing period may exceed 19 hours[81] and horses increase their bite-frequency.[82] Horses devote much less time to chewing than ruminants, such as sheep,[83] but compensate for this by ingesting more food per unit of bodyweight per day. Peaks in foraging occur in the early morning and late afternoon[1] with bouts lasting from 30 minutes to 4 hours.[84] Both the morning and afternoon grazing bouts may be extended when forage is scarce.[85] Nocturnal ingestion naturally punctuates periods of drowsing and sleep,[86] and for this reason stable managers seeking to reduce the behavioral changes inherent to stabling should leave horses with sufficient forage for the whole night.

Time-budgets for feral horses[7] (see Fig. 1.11) are similar to those of domestic horses at grass,[87] with a similar diurnal rhythm of foraging.[88] Night feeding accounted for 23% of total feeding time in pastured fillies.[89] The suggestion is that foals may learn normal feeding time-budgets from their dams,[2] and this has led to some debate about the extent to which orphan foals develop normal feeding behavior.[90,91]

While prehension may amount to 30 000 bites per day,[78] chewing rates range from 1.0 to 1.7 per second[92] with faster rates being achieved by reduced displacement of the lower jaw.[93] The type of food consumed affects the number of chews and therefore the time taken before deglutition. For example, per unit of weight, hay requires four times as many chews as oats and therefore takes approximately four times as long to consume.[94] It has been estimated that a horse foraging exclusively on high-fiber substrates may chew 57 000 times per day, but that this can be almost halved under moderately intensive stable conditions (e.g. a 500 kg horse on 5 kg of forage and 7.8 kg of concentrate).[95] This has a profound impact on salivation which, in horses, occurs chiefly in association with mastication rather than in anticipation of a meal (Table 8.1). Up to 100 L per day has been estimated as the saliva production of a 500 kg horse on a very dry hay diet.[94] Conversely, the consequence of feeding less fiber is that there is less chewing and that the horse generates less saliva.[96] Since the buffering effects of bicarbonate are diminished under these circumstances, gastric acidity rises and the risk of gastric ulceration increases.[97]

Table 8.1 Saliva production associated with different foods

Food	Dry matter (L/kg)	Wet food (L/kg)	Swallowed bolus (%)
Grass	4.0	0.7	11.5
Hay	4.8	4.3	17.3
Mixed feed	2.1	1.8	32

Reproduced from Harris[94], with permission.

In stabled ponies fed ad libitum, the number and frequency of feeding bouts are lowest between 1700 and 0800 hours.[87] Experimentally, satiety has been mimicked in ponies by intragastric infusions.[98] Infusions of glucose, vegetable oil and socka floc (cellulose) stimulated satiety, but in a time-dependent fashion: glucose caused immediate reduction in intake, vegetable oil took a few hours to work and the cellulose caused a reduction only in 24-hour intake.[98] The interpretation of this was that gastrointestinal cues play very little part in the immediate control of intake, but that metabolic cues related to caloric availability controlled intake by regulating the size and/or frequency of meals. Interestingly a sodium chloride infusion reduced intake, not by stimulating satiety but by causing malaise. The ponies developed a learned aversion to the nasogastric tube after receiving the sodium chloride, whereas after the other infusions they actually seemed to welcome the tubing process (Sarah Ralston, personal communication 2002).

Human influences on food intake

Timing and content

In the domestic situation, food is concentrated to give performance horses readily digested energy resources that can therefore be consumed more rapidly than less energy-dense (more natural) forages. In a bid to reduce the chances of colic, it is usual to restrict access to concentrated food immediately before and after strenuous exercise. It is not clear whether this traditional practice is effective. The effect of exercise itself is interesting since, compared with non-exercised animals, exercised horses modify their grazing behavior by taking fewer, but larger, bites.[99]

Providing long fiber such as hay in nets and raised feeders to prevent wastage by soiling in the bedding confounds the horse's natural grazing posture. It has been suggested that some horses demonstrate their motivation to graze when they displace forage from these devices onto the stable floor.[100] That said, the most profound imposed impediment to natural behaviors is the increase in concentrated parts of the diet relative to feral menus and the accompanying reduction in fibrous components.

Bulky foods that make a considerable contribution to gut-fill and thermal load are avoided in racehorses because they are thought to compromise lung-volume and racing performance. Furthermore, fiber and the saliva that must be swallowed with it add to the non-functional weight that the horse must carry. Hay has also fallen out of favor with some horse-keepers because of its role in the etiology of chronic obstructive pulmonary disease[95] and the suggestion that attempts to reduce its allergen content by soaking may decrease its nutritive value.[101,102] All of these factors mean that horses are often denied the opportunity to fulfill their behavioral needs to forage to maintain gut-fill, even though their nutritional needs may be met. Because horses evolved to be trickle feeders, the stomach of an adult horse is relatively small (9–15 L) and inelastic.[94] It empties within about 20 minutes, and its rate of emptying is a function of the physical qualities of the current meal. Restrictions on feeding behavior, and especially the provision of discrete meals, lead to digestive anomalies and behavioral frustration.

The physical form of food is known to influence the rate of chewing[103] and the energy[104] required for ingestion. The addition of chaff, a traditional means of increasing the time taken to consume concentrated feeds, works simply by increasing the total forage content of the ration. High-energy hay replacers, such as haylage, have been associated with the development of wood-chewing in foals.[11] Haylage is often fed in restricted quantities and as such may result in the redirection of oral behavior due to increased motivation to forage because of decreased gut-fill[105] or other feedback mechanisms.[106]

Food presented as highly compounded pellets may be less attractive to horses than softer substrates.[107] Palatability can increase motivaiton to defend food and can play a signfiicant role in some cases of food-related aggression (Fig. 8.4). While foodstuffs are dried to make them easier to store and handle, this may also make their flavors less accessible and reduce their palatability. In the case of hay, some horses learn to remedy this dryness by dunking mouthfuls in water, either because moisture makes it more pleasing to the palate, or makes it easier to swallow,[4,25] or less painful to swallow if there is concurrent dental pain (Caroline Hahn, personal communication 2002).

Figure 8.4 Horse showing signs of aggression toward a human at feeding time.

In the free-ranging state, the primary function of movement within a home range is to select habitat that allows horses to maximize their intake of high-quality food.[108,109] Similarly, the tremendous variability in the shape and quality of pastures offered to horses in domestic contexts influences the amount of locomotion required to forage on them optimally (although it has been estimated that horses take 10 000 steps per day) when grazing (Katherine Houpt, personal communication 2002). Pasture shapes of equal length and breadth evoke more even grazing than do rectangular paddocks.[110] When exposed to a new pasture, horses rapidly detect patches of their preferred grasses and concentrate foraging activities within them.[92] Fertilizers that encourage leaf rather than stem growth increase the intake per bite.[111]

Free-ranging horses regularly consume soil,[77] but it is not clear what elements they are seeking when they do so. It has been suggested that sodium, iron and copper supplementation are among the benefits of this activity.[51,112] Voluntary salt intake is noted to increase in stabled horses when they are not exercised.[113] This is surprising because generally exercise increases the voluntary food intake of horses offered food ad libitum[114] and salt consumption could be expected to rise to reflect salt losses through sweating. However, the oral occupation that salt-licking offers to stabled horses with unmet oral needs should not be overlooked here. Ponies fed an all-concentrate diet spend more time licking salt than those on a hay diet.[115] Occasionally, the use of salt-licks may become excessive and result in polydipsia (see subsection on drinking, p. 204).[116]

Variety

Although strong seasonal variation may occur in diet quality, the grass content of diets rarely falls below 80% in open-range situations.[77] When offered a choice of edible plants, horses tend to select grasses to meet their immediate energy needs and then seem to select more forbs in a form of supplementation.[117] Schafer[118] suggests that Icelandic horses have been observed selecting medicinal plants among the surrounding grasses. He proposes that this is helpful in a bid to 'avoid worm infections' and he offers the consumption of chestnut leaves as another example of pharmacognosy, suggesting that this causes a demonstrable improvement in vigor.[118]

Most stabled horses are provided with a single forage,[119] so they have no opportunity to blend substrates to suit their individual needs. The effects of such monotony are as yet unclear, but it seems plausible that providing multiple forages may improve the welfare of stabled horses by enriching their environments and allowing them to perform highly motivated foraging behavior patterns.[120] Further, it is proposed that this approach may reduce the chances of intestinal obstruction by decreasing the amount of straw that stabled horses consume (Fig. 8.5).[120] That said, in the absence of any better forage source, horses in developing countries are commonly fed large quantities of straw with no apparent ill-effects on gut motility (Caroline Hahn, personal communication 2002). This is presumably because the gut flora of horses fed straw have had an opportunity to adapt to the robust nature of such a substrate.

Figure 8.5 Horse eating straw bedding.

Behavior associated with ingestion

Locomotion is an integral part of grazing behavior, and horses cover large areas because they seldom take more than two mouthfuls in one spot before moving on to the next.[21,31,41,46] Because stabled horses are generally offered forage in one site, they are not driven to move between food sources. Although the extent to which they can move in a stable is limited, it would be useful to increase locomotion if we are seeking to mimic free-ranging feeding strategies. As horses travel between food items in a pasture, they accelerate to a maximum foraging velocity by increasing both the length and frequency of strides.[121] On sloping pasture the dedicated use of certain routes becomes apparent with the formation of tracks that facilitate grazing. The spacing of the tracks depends on the incline.[122] Increasingly, pasture management protocols are considering the locomotion of horses at grass, since it is believed that requiring movements between feeding and watering stations in a paddock mimics free-ranging behavior and has health benefits. For example, the spaced provision of food, water and mineral licks is being used to force unshod horses to traverse gravel in a bid to toughen their hooves.

Submersion of the muzzle may be required when horses feed on aquatic vegetation.[4] Meanwhile, pawing may occur as horses forage for roots under soil[50] or grass under snow that is too deep to be pushed aside with their muzzles.[77] Pawing is also reported in horses as a means of breaking ice over watering holes.[118]

While vocalization and walking occur more often before than after feeding,[34] presumably as a result of anticipation, a significant elevation in heart rate occurs in ponies both before and during feeding.[123] Meanwhile, in horses fed large meals episodically, there is a transient post-prandial hypovolemia[124] and an increase in blood flow to the feet.[125] Although their function is obscure, these changes are thought to be of clinical significance in the etiology of laminitis and may relate to the persistent increase in hoof wall temperature for 16–40 hours after vasodilation.[126] As an aside, it may be that lack of locomotion between mouthfuls of food is a contributory factor in the emergence of laminitis.

Although increased surveillance is a benefit of social living for prey animals, such as the horse, vigilance by individuals within a group always persists. The rate of looking-up during grazing and drinking[23] and social spacing are important anti-predator strategies that are mathematically related to herd size. For example, when the number of Thoroughbred yearlings in experimental groups at pasture was increased from 2 to 12, the mean distance between them increased from 5 m to as much as 50 m.[127]

Social facilitation strongly influences behaviors associated with grazing in the horse.[69] This is illustrated by the finding that locomotion as an adjunct to grazing is significantly greater for a lone horse than for those in a group.[127] Meanwhile, the duration of grazing bouts increases linearly as the group size increases up to four.[127] This could reflect competition among grazing horses or possibly decreased anxiety as a result of increased predator vigilance.

A study of stabled Shetland ponies, showed that social facilitation was crucial for the stability of time budgets and that visual, more than olfactory or auditory, contact with conspecifics facilitated feeding behavior.[128] However, the presence of conspecifics is not equally helpful for all members of a group, since when feeding from a shared trough, in the presence of high-ranking pen-mates, subordinate horses are less likely to be disturbed if solid partitions between feeding bays are used. Stable designs that give horses the choice of visual contact or privacy (Fig. 8.6) are an appropriate response to these findings. The use of computer-controlled feeding stations may help to reduce disturbance of lower-ranked members of a group, although attention must be paid to the design of feeding bays so that entering and leaving are facilitated.[129,130] Some horses learn to guard the entrance to automated feeding bays even when it is not their turn to enter and thus they can deprive herdmates of access to food.

Strangely, fluctuations in the R–R intervals that are common features of equine heart function and possibly represent respiratory sinus arrhythmia are absent during feeding periods.[131] Perhaps there is an increase in vagal tone associated with gastrointestinal activity that means that feeding has an effect on autonomic activity in the same way that crib-biting bouts are associated with reductions in heart rate.[132]

Figure 8.6 Partial barriers between stalls allow horses to choose between visual contact with neighbors or privacy. This simple form of environmental enrichment can help to reduce distress in stabled animals. *(Photograph courtesy of Centennial Parklands Equestrian Complex, Sydney, NSW, Australia.)*

The relationship between nutrition and behavior

This relationship is fascinating. For example, there is a report that a group of horses in New Zealand with deteriorating 'behavior and manners' responded to parenteral administration of vitamin E-selenium.[133] Horses on pasture, however, have higher plasma serotonin and tryptophan concentrations than those in stalls fed grain (unpublished data from Sarah Ralston, personal communication 2002). Many equestrians report that horses and especially ponies become 'hot', 'fizzy' or 'corned-up' – in other words, more reactive and less tractable – when fed more oats and less hay. This may reflect a shift in the glycemic peak that merits further scientific study. As mentioned above, there is evidence that replacing starch and sugars with fat and fiber may diminish spontaneous locomotion and reactivity to a variety of novel stimuli.[12,134,135] Those who report 'not resting properly' (restlessness) as one of the more common undesirable behavior patterns in sport horses[136] should consider the role of over-nutrition in the emergence of the problem.

Paradoxically, changing the diet of ponies from hay to oats has been reported to cause a transient augmentation of total sleep time with increases in both slow-wave and REM sleep.[137] However, after 4 days sleep patterns in these animals had returned to normal. It may be that the post-prandial physiological changes in the lower limbs of these animals as a result of the dietary imposition, resulted in spending more time in recumbency, and that sleep was the consequence of the physiological stimulation that also resulted from the novel carbohydrate load. Fasting is associated with similar transient increases in both slow-wave and REM sleep.[86]

It is possible that some diets may better equip horses to cope with stressors associated with competition and fatigue.[135] A crossover study demonstrated that foals coped better during weaning if they were allowed access to a supplement in which starch and sugar were replaced by fat and fiber, before separation from the dams. Similar amelioration of stress-related behaviors, such as vocalization, has been noted in foals supplemented with zinc.[135]

Dysphagia

Reasons for dysphagia can include trigeminal nerve injuries that may cause the mouth to gape.[4] Difficulty in swallowing is also noted in white muscle disease, botulism and some cases of poisoning. Dental problems may cause refusal of hard dry foods, irregular chewing and tilting the head while chewing. Food dropping may also be associated with dysfunction of the facial nerve. Horses with esophagitis may lower the neck and extend the head, while those with stomatitis may loll out their tongues and those with choke often show repeated arching of the neck. While involuntary chewing and tongue flicking have been described as symptoms of Yellow-star thistle poisoning,[4] bruxism (tooth grinding) is generally regarded as a sign of generalized low-grade discomfort, e.g. as a result of gastric ulcers.[138]

Anorexia and hypophagia

In normal horses the reasons for failing to meet nutritional requirements are often related to social consequences or distracting arousal. Subordinate members of a group may be bullied away from a limited supply of food, especially if it is not dispersed appropriately. In addition, horses that eat slowly may miss out if peers can consume more than their share of the ration. Horses may also fail to feed when distressed by a move to a new environment, or the departure of a favored affiliate, or by the arousal resulting from activities on the yard, such as the arrival of conspecifics.[84]

When horses are given an equal opportunity to feed, disease is the primary cause of a reduced food intake. For example, febrile states are a common finding by practitioners called to acutely inappetant horses. Pain may not only reduce appetite but also affect behaviors associated with eating. For example, an individual may be less likely to approach food and defend its rations. In donkeys such changes in behavior can mark the onset of estrus but nevertheless should be taken very seriously because they may be the only indication of illness that may be grave but masked by the species' apparent tolerance of discomfort.[139] Feeding responses to disease in the donkey are important, since anorexia, a frequent consequence of pain, can lead to hyperlipemia and death.[140]

While dental erosion can lead to inadequate mastication, dysphagia and food being lost from the mouth during mastication (so-called 'quidding'[141]), buccal pain can even cause reluctance to approach food. With horses that present with weight-loss, time spent observing them as they interact with a variety of foods can be extremely helpful in diagnosing the problem. For example, this may help to determine the extent of quidding versus inappetance or the preference a horse may have developed for soft or moistened food. Intriguingly, patterns of feeding behavior are altered markedly as a legacy of dysautonomia.[142]

Among the best approaches to improving food consumption in a sick horse, one should consider:

- warming the food to release volatile flavorants – this works best if the horse has encountered that sort of warmed food when healthy
- dampening the food to reduce the effort involved in chewing (this is especially helpful if the horse is experiencing oral pain), or adding dissolved attractive components to lubricate the passage of food and facilitate deglutition
- feeding small amounts at a time in a bid to mimic the trickle effect, and avoid the horse being overwhelmed with food to sustain a healthy interest in the food
- feeding within sight (but not physical contact) of an affiliate that is eating.

Hyperphagia

The prodigious appetite of horses is well recognized, and it is suggested that the ability of oropharyngeal stimuli to override metabolic or gastrointestinal feedback within a single feeding session contributes to the horse's susceptibility to colic and metabolic disorders.[143] The rate of eating and size of meal in ponies is negatively correlated with pre-prandial plasma glucose concentrations.[87] Gorging and bolting of food may therefore occur after a period of food restriction and can lead to esophageal obstruction.[138] Because they precipitate excess acidity, periods without food can rapidly lead to severe gastric ulceration.[144] Clearly, therefore, management regimens that facilitate trickle rather than episodic feeding are desirable.

A rapacious appetite is sometimes accompanied by inadequate mastication that may compromise the horse's ability to buffer gastric acidity and digest its food. Veterinarians are rarely consulted about horses that are eating too rapidly, since it is rarely a sign of ill-health. However, there are clear behavioral reasons for this to occur, and owners should consider the role of current or even previous competition from other horses as among the most likely. Feeding more fiber to increase the sense of gut-fill prior to the presentation of discrete concentrated meals is the best approach to these cases. Furthermore, increasing the fiber content of concentrated meals themselves by introducing chaff is more effective than attempts to thwart ingestion by the use of physical obstacles such as bricks within the feeding device.

Practitioners should be aware that over-feeding of laminitic ponies (that through no fault of their own are depreciating rapidly in market value with age) may sometimes continue contrary to veterinary advice to ensure that euthanasia ensues and the insured value can be realized.

Wood-chewing and bed-eating

Food restriction is a common feature of stable management because of the appeal of concentrated foods that can be consumed rapidly, often in less than 3 hours. Although when offered food constantly, ponies consumed 80% of their daily intake in an average of 10 separate meals,[87] most owners provide feed at frequencies and times that suit them rather than their horses' gastrointestinal function. This often leads to the imposition of fasting at night.[145] Food and fiber restriction may prompt horses to consume straw provided as bedding, and this has been linked to impaction colic.[146]

Bark chewing is a common feature of horses on irrigated pastures that have less fiber content than natural pastures (Fig. 8.7).[49] That said, it is also seen in horses grazing on pastures that appear entirely adequate, leading some veterinarians to blame trace element deficiencies. Once fiber, vitamin and mineral deficiencies have been ruled out, bark chewing can be considered normal. Sometimes referred to as a normal vestige of browsing behavior, wood-chewing is important because, although it is not sufficiently invariant to be classed as a stereotypy, it may be associated with or precede the development of crib-biting.[147] The tendency to chew wood can be reduced by increasing the fiber content of the ration. While helping to normalize gut function, this intervention can also save stables from rapidly being destroyed by their occupants. Horses can ingest approximately 1.5 kg of timber per day.[148] This may help to explain why it is one of the most troubling behaviors for stable managers and may be more likely than less destructive responses to be spotted and reported when stakeholders are asked to comment on unwelcome behaviors in stabled horses.

Figure 8.7 Although wood-chewing is regarded by some as unwelcome, many ethologists consider it a normal analogue of bark-chewing, a normal feature of the repertoire of free-ranging horses. *(Photograph courtesy of Francis Burton.)*

It is accepted that horses fed low-forage diets spend significantly more time chewing wood than horses fed hay.[106,149] Further, Krzak et al[113] reported that wood-chewing increased when the stomachs of horses were at their emptiest. Lignophagia is particularly unwelcome because it can cause intestinal obstruction.[150] It is suggested that fiber restriction reduces hindgut pH and that this leaves horses fundamentally unsated, but it also has the effect of eliciting abnormal oral behaviors.[106] While my own studies have shown an increase in intraspecific aggression in horses on so-called 'complete' diets, others have noted an increased nervousness as well as wood-chewing in ponies deprived of hay.[151] When forage is in short supply, many owners report increased aggression among horses at pasture. Along with biting the stable, wood-chewing was the main oral behavior that was reduced by giving stabled horses non-therapeutic oral doses of virginiamycin.[106] A suggested mechanism for this phenomenon involves the reduction of fermentative acidosis in the hindgut by changing the population of hindgut flora. The remedial elevation of a horse's hindgut pH with antimicrobials may be an expensive alternative to increasing its fiber intake. Studies of crib-biters (and weavers) have failed to show an effect of virginiamycin on the frequency of stereotypy[152]. It is possible that early reports of its effect on oral behaviors were simply reflecting its significant effect on the palatability of rations that had been supplemented with virginiamycin. Less palatable feeds are generally associated with reduced crib-biting.

Fiber restriction has been associated with the ingestion of a variety of unusual substrates (so-called pica), including shavings and sawdust (in bedding), hair[153] (from the manes and tails of other horses) and feces.[84] That said, foals mouth and chew many of these items as a normal part of object play.[6]

Coprophagy

In all foals coprophagia is a normal behavior with a variety of suggested functions (see above). In free-ranging horses, there are rare reports of foals and their dams consuming old fecal material as a consequence of food shortage.[51] Fiber-restricted rations,[8,154] frustration (which probably results from the same deficit) and underfeeding in general[84] can lead to an adult horse consuming its own feces or those of a conspecific. The digestible energy content of equine fecal material is sufficient to suggest that this substrate may help to nourish a horse.[84]

There are anecdotal reports of horses consuming the blood and even the flesh of freshly dead rabbits, some of which are said to have been killed by the horses themselves.[155] It is interesting to contemplate the sort of nutritional deficit that could generate the motivation to perform this behavior. Generally speaking, practitioners should investigate the possibility of a dietary deficiency and screen blood biochemistry before labeling an unusual craving 'depraved'.

Geophagia

Occasionally, horses lick and chew at soil but it is not yet clear whether they do so to resolve nutritional deficiencies or because they simply enjoy the activity.[51] Involuntary soil ingestion occurs mainly during grazing, because soil adheres to vegetation.[156] Incisor erosion may sometimes result and may even mimic damage caused by crib-biting. Sand colic is associated with the ingestion of some soil types either during eating or drinking.[83] In many cases, horses reject, from their mouths, roots that contain appreciable amounts of soil and grit. This serves as evidence that their teeth and buccal lining are sensitive and should caution us against assuming that, until habituation has occurred, bits do not cause at least some discomfort.

Oral stereotypies

Licking and crib-whetting

Although rarely reported as problems by owners, licking and crib-whetting are sometimes seen as appetitive behaviors before crib-biting or may become stereotypic in their own right. The approach to their management follows that of other redirected and stereotypic oral activities.

Crib-biting and wind-sucking

A crib-biting horse repeatedly seizes fixed objects with its incisor teeth and pulls back while making a characteristic grunting noise that signifies the passage of air into the esophagus. A wind-sucker achieves the same characteristic neck posture and grunt without holding onto any fixed object. It is believed that crib-biters may become wind-suckers – for example, if no substrate is available or if this component of the behavior is punished.[157] Horses that merely hold onto a fixed object without grunting are said to show grasping.[158] These behavior patterns have been linked to various forms of ill-health, including tooth wear, colic and a failure to maintain bodyweight. Radiography of horses as they were crib-biting challenged the traditional view that crib-biters actively ingest air, because there was no movement of the tongue as one would expect in true swallowing.[159] Instead, each horse showed an explosive distension of the proximal esophagus (Fig. 8.8) that prompted no peristalsis. Much of the air exited the proximal esophagus between crib-bites by returning through the cranial esophageal sphincter into the pharynx. This may explain why tympanitic colic (abdominal pain associated with wind or flatulence) is not seen in all crib-biting horses.

Risk factors

Epidemiological studies have identified husbandry factors that are associated with peaks in the prevalence of abnormal behavior in racehorses.[119,149] These management factors include small amounts of daily forage (less than 6.8 kg) and stable designs that limit the amount of communication possible between neighboring horses. This association is somewhat predictable because one would expect horses to behave normally if they have plenty of food and company. However, when interpreting the results of surveys, it is important not to arrive at

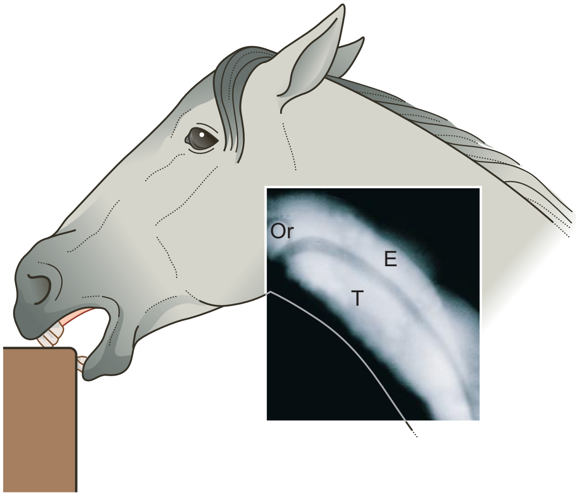

Figure 8.8 Composite image from three stills captured during fluoroscopy of the cranial half of a horse's neck during a bout of crib-biting. Air is visible in the esophagus (E), trachea (T) and oropharynx (Or). *(Reproduced by permission of the University of Bristol, Department of Clinical Veterinary Science.)*

Figure 8.9 Crib-biting foal. *(Photograph courtesy of Caroline Bower.)*

cause-and-effect conclusions. Although cross-sectional studies have revealed and quantified the association between certain management practices and stereotypic behavior, it must be remembered that all such studies are essentially retrospective.

Further light has been shed on the causal factors influencing the development of stereotypic behaviors by a 4-year prospective study of a population of 225 young Thoroughbred and part-Thoroughbred horses.[11] Dynamic cohorts were followed for between 1 and 4 years, with each foal being observed directly during the pre-weaning period, at weaning and at regular intervals post-weaning. The study found that crib-biting was initiated by 10.5% of this population at a median age of just 20 weeks (Fig. 8.9).

After weaning, youngsters given concentrate feed have a significantly greater risk of developing crib-biting than those not given concentrate, while those fed on hay replacers (such as silage or haylage) rather than hay have a significantly greater risk of developing wood-chewing.[11]

The strong effect of weaning is of considerable importance. Weaning is a stressful time for the juvenile, and abrupt weaning has been implicated as a source of emotional anxiety, because of numerous management changes at weaning time.[160–162] These often include:

- withdrawal of opportunities to suckle
- breaking of the mare–foal bond
- altered feeding practices
- introduction to drinking water (in one study of 15 foals, only 7 were observed to drink water before weaning[2])
- novel housing
- new social groupings
- the amount of human contact often being increased.

Although the use of creep feeds may benefit the foal nutritionally, they may compromise the health of the gastric mucosa[163] and do little to meet the behavioral needs of non-nutritive suckling. After traditional total and abrupt weaning, which involves permanent, sudden separation from the mare, foals frequently attempt to redirect suckling behavior toward the genital regions of conspecifics. It is believed that the thwarted motivation to suckle at this time may contribute to the emergence of crib-biting and wood-chewing in some individuals.

Crib-biting may also originate from specific dietary problems in young horses. For example, foals that received concentrates after weaning were four times more likely to develop crib-biting than those that did not.[11] It has been suggested that normal gut motility and transit times in crib-biting horses may depend on physical flushing by saliva associated with their crib-biting behavior.[164,165] Furthermore, crib-biting may increase the flow of alkaline saliva and reduce gastric acidity[146] associated with feeding concentrates.[166] There is some evidence that the volumes of saliva produced by crib-biting are sufficient only to have a soothing, rather than a flushing or buffering effect on the gastrointestinal tract.[167] Compared with the company of other distressed freshly weaned peers, the presence of calm, grazing horses may help to reduce the distress of weaning for paddock-weaned foals, even if they have been abruptly separated from their dams.[11] Because links between distress and gastric ulcers have been proposed in foals[168,169] and established in other species,[170,171] strategies that help to reduce the emotional impact of weaning are likely to be of benefit at a somatic level.

The relationship between oral stereotypies and gastrointestinal health

The significance of gastric ulceration in intensively managed (food-restricted) horses is now widely recognized, with 82% of racehorses[172] and 51% of Thoroughbred foals under the age of 3 months[173] showing lesions.

Epidemiological risk factors for oral stereotypies that relate to diet (such as small amounts of daily forage) could have the effect of increasing gastric acidity.[116,153] Saliva is the natural buffer to excess gastric acidity; however, in horses, its production depends on pressure being exerted on the parotid salivary gland, primarily as an adjunct to chewing. If insufficient time is spent grazing or eating forage, horses may produce saliva of insufficient volume and quality to buffer their stomach contents. It has therefore been proposed that crib-biting may originate in an *attempt* by the horse to produce additional saliva.[144] This is supported by there being a trend towards increased water consumption by crib-biters compared with normal horses.[174] The fact that the attempt may not always be successful may be one reason why the biting behavior develops stereotypic characteristics.

The putative links between weaning and crib-biting have been explored because of the causative role of concentrate feeding in the emergence of gastric ulcers.[164] Furthermore, because the original eliciting causes of the stereotypy are more apparent in youngsters, which have been exposed to fewer variables than older animals, a cohort of young horses was recruited to explore this hypothesis.[164] After an initial assessment of behavior, and endoscopic examination of the gastric lining, horses were randomly allocated to antacid or control diets. Initially, the stomachs of crib-biting foals were significantly more ulcerated, eroded and inflamed than the stomachs of normal foals. However, the use of antacid diets resulted in a significant improvement in the condition of their stomachs. Crib-biting behavior declined in all foals (a finding that challenges the concept of emancipation) but the decline was especially marked in those maintained on the antacid diet.[164] These results are of great interest, because they indicate humane approaches to preventing and treating oral stereotypies in young horses. That said, we should be careful not to oversimplify the etiology of crib-biting.

Figure 8.10 Erosion on the tables of the mandibular incisors of a crib-biter. *(Reproduced by permission of the University of Bristol, Department of Clinical Veterinary Science.)*

Physiological associations with crib-biting

Plasma cortisol concentrations in crib-biters are higher than in normal horses under a variety of treatments,[175] which suggests that they are particularly susceptible to stress. Crib-biters are often regarded as being less able than normal horses to maintain bodyweight. Although this is sometimes blamed on incisor erosion (Fig. 8.10), it more commonly arises because they are occupied with performing their stereotypy and therefore they rest less than normal horses.[176] The catabolic effects of sustained elevations in circulating concentrations of cortisol may also contribute to this failure to thrive. This may be an important cost for crib-biting horses as they expend energy that would otherwise have been conserved at rest. The tendency for crib-biters to spend less time eating is also likely to contribute to a relative energy deficit and consequent unthriftiness when on a critical plane of nutrition.

A significant reduction in oro-cecal motility has been reported in crib-biters prevented from eating and crib-biting.[166] This suggests that normal gut function in these animals is affected by oral activity. However, horses on ‘nutritionally complete’ diets, with no forage component, showed an association between crib-biting and increased total gut-transit time.[176] These data suggest that eating and crib-biting may be partial substitutes for each other and that there is a triangular relationship between diet, gut activity and crib-biting. Certainly, in terms of their diurnal distribution, eating and crib-biting tend to occur together (Fig. 8.11). Studies of gut mobility are important because increased total gut transit times may predispose horses to simple colonic obstruction and distension colic.[177]

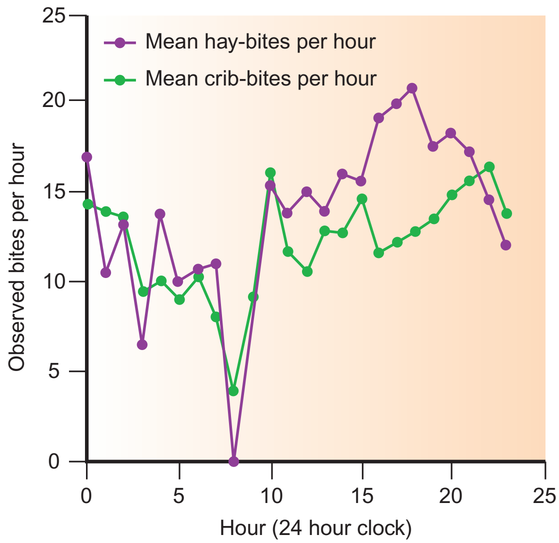

Figure 8.11 Diurnal rhythm in the bite rates for crib-biting and eating hay (from 64 days of observation). Horses were stabled with ad libitum hay. Between 0830 hours and 0930 hours they were turned out in paddocks.

The consequences of preventing crib-biting are interesting because they help to clarify the possible function of oral stereotypies. Studies using purpose-built projection-free looseboxes have compared short-term deprivation of crib-biting with the temporary withdrawal of forage. Intriguingly, neither deprivation of food nor of opportunities for crib-biting alone was associated with a plasma stress response.[165,178] However, when the horses were deprived of both food and the opportunity to crib-bite, they showed a significant rise in the plasma stress response. This exposes the link between foraging and crib-biting and explains why restricted feeding is a management factor associated with an increase in abnormal behavior. There was also a significant reduction in orocecal motility recorded in crib-biters deprived of food and opportunities for crib-biting, which implies that normal gut function in these animals depends on their being given ad libitum access to food and to suitable crib-biting substrates. Crib-biters deprived of the opportunity to stereotype ate more than normal horses, suggesting that they had greater oral needs.

The suggestion that crib-biters underwent relative gut stasis when deprived of food and the opportunity to crib-bite, should be borne in mind when owners elect to stable their horses overnight with a haynet that will be emptied by morning. Methods of making horses work harder to gather their forage ration, e.g. by using haynets with especially small holes (so-called restrictor nets), can protract feeding times and may therefore have a beneficial effect on gut function as well as time-budgeting in general. However, this may not be beneficial for all individuals since it is possible that, for some, the frustration associated with working for forage may represent an additional stressor.

Beyond proximate gastrointestinal effects, crib-biting may bring more subtle rewards that could account for its persistence in the absence of gastric insults. Dopamine may activate basal ganglia motor systems to reinforce crib-biting via a reward mechanism. It has been suggested that stress stimulates the release of endorphins, triggering excessive dopaminergic activity within the striatum.[179] In rats, the release of dopamine by endorphins has been shown to depend on activation of NMDA receptors.[180] When 9 crib-biting horses were treated with the NMDA receptor antagonist dextromethorphan (1 mg/kg i.v.) – the active ingredient in most cough mixtures – eight showed a reduced cribbing rate compared with baseline.[181] This pathway certainly merits further investigation so that we can better understand the way in which crib-biting may be self-reinforcing and therefore prone to emancipation. There is evidence that emancipation may reflect increased activity within the mesoaccumbens dopamine pathway[182] that may manifest as a change in motivation.

Treatment of oral stereotypies

Many owners resort to physical restriction in an attempt to prevent the performance of abnormal oral behaviors.[165] One of the most common methods involves the use of a tight collar (Fig. 8.12) designed to make crib-biting so uncomfortable or painful to perform that the horse stops. The effect of these collars was studied in a group of 12 horses fitted with the collars for 24 hours.[178] After removal of the collars, the horses performed crib-biting at a higher rate than before the collars were fitted. This post-inhibitory rebound demonstrates that the motivation to crib-bite increases during periods of physical prevention.

Despite welfare concerns, surgical responses to crib-biting continue to be developed. For example, laser-assisted removal of 10 cm of the ventral branch of the spinal accessory nerve and 34-cm sections of the paired omohyoideus and sternothyrohyoideus muscles is reported to result in elimination of the behavior in 10 horses that were followed up for a minimum of 7 months.[183] This intervention presumably makes the distension of the proximal esophagus difficult and therefore makes the behavior less gratifying.

From rebound studies, it is argued that the reason collars, electric shock ‘treatments’ and surgical removal

Figure 8.12 Collar used to make crib-biting uncomfortable or less gratifying. *(Reproduced by permission of the University of Bristol, Department of Clinical Veterinary Science.)*

Figure 8.13 Horses drink by immersing their lips. *(Photograph courtesy of Francis Burton.)*

of neck muscles or nerves, often prove unsuccessful is because the motivation to crib-bite in horses is sustained.

The relationship between gut acidity and the incidence of oral activities such as crib-biting, grasping and wind-sucking[105,164,184] is becoming clearer and has prompted the development of novel feeding practices, especially regimens that are likely to be particularly useful at weaning. Similarly, the addition of dietary antacids reduces the intensity and frequency of the response in emancipated crib-biters, especially post-feeding.[184] Unfortunately we have no direct evidence to date that shows that resolution of gastric ulceration reduces the frequency of crib-biting, but nevertheless it is prudent to check crib-biters for gastric ulcers. The extent to which an individual horse should be allowed to crib-bite (e.g. on tailor-made surfaces that are cushioned to reduce incisor wear) depends on its colic history. High-risk animals should be managed in ways that minimize the primary need to crib-bite. Moreover, owners of all crib-biters should maximize periods at pasture and, where it is necessary to supplement feed, the fiber component of the total diet. By maintaining a high meal frequency they can give their horses the chance to emulate trickle feeding and thus reduce gastric acidity.

Drinking

Nursing foals rarely drink water, relying on milk for their supply of fluids.[2,52] The youngest age at which foals have been confirmed to drink water is 3 weeks.[2] Drinking in weaned animals is related to ambient temperature, water availability and lactational status.[2]

Movement to water is usually, although not exclusively, made by the entire herd.[2] In pastured horses, trips to water most commonly occur in the afternoon.[2] Horses submerge their lips below the surface of the water to drink (Fig. 8.13) and generate a pressure gradient by movement of the tongue in combination with swallowing at the approximate rate of once per second.[4] The importance of the pressure gradient was hinted at by reports of the post-operative behavior of horses that underwent the outdated buccostomy approach to crib-biting and wind-sucking. Such horses were often said to take 2 or 3 days to learn to drink with fistulae in their cheeks. Although it was assumed that these horses were struggling to create a pressure gradient within their altered mouths, we should not discount the contemporaneous buccal pain as a likely post-operative side-effect that would have made drinking uncomfortable.

Hydration levels depend on voluntary fluid intake and are affected by exertion, ambient temperature, humidity, gut-fill, the speed of water conservation responses, such as antidiuretic hormone release, and the accessibility of transcellular reserves, such as those in the gastrointestinal tract.

Although horses in the exceptionally hostile heat of the Namib Desert have been noted to consume an average of 30 L per day,[185] those in a cool environments may drink much less.[186] The water intake of stabled horses is in the range 2–4 L/kg of dry-matter food consumed,[187] the variation being a reflection of the variable amount of chewing, and therefore salivation, required for dry hay versus, for example, cereals.[94] While water intake for working horses is also related to exercise and can send daily requirements up to 90 L,[188] for free-ranging horses, trips to water may vary in their frequency according to the location of forage sources and the environmental temperature.[2] Horses usually visit their water source at least once per day, whereas those foraging farther from their water source may schedule visits up to 72 hours apart.[189] Some Namib horses can survive for 100 hours without water.[185]

Drinking is a social activity undertaken by the group as a whole and it is usually completed within 30 minutes.[50] Competition for fresher, unmuddied water means that the higher-ranking members of a band tend to drink first, as do the more dominant bands.[4] Most commonly undertaken in daylight, especially toward dusk, visits to water involve increased exposure to predation and the chance of encountering other bands. Swift departures from watering holes, which reduce the opportunity for unwelcome interactions, have been remarked upon.[190]

For the owners of performance horses, voluntary fluid intake can prove pivotal to success. Although intake is known to vary with the supply of water, the individual characteristics of a water source (such as its flavor) and the behavior of conspecifics, the pattern of drinking is generally tailored to meet homeostatic demands. In winter, very cold water can be aversive and decrease voluntary water intake to the extent of dehydration and even colic, whereas offering horses a choice of chilled water and ambient warm water in hot weather produces no preferences or qualitative differences in drinking behavior.[191]

Despite fears articulated in lay texts of inappropriate flushing of undigested food particles into the small intestine, most equine scientists seem to agree that, as long as water has not been withheld for an extended period, a horse can safely drink before, during and after feeding.[188] Thirst tends to increase after feeding,[188] and large meals tend to cause a rapid and short-lived decrease in plasma volume.[192] So, rather than hampering digestion, drinking may actually facilitate it. When food and water are freely available 89% of drinking occurs within a period from 10 minutes before to 30 minutes after feeding of concentrates.[193] The flushing effect is of negligible consequence because, when the stomach is full, water tends to pass along the lesser curvature, leaving the food largely undisturbed[194,195] and, in any case, almost all digestion in the horse is post-gastric.[94] By the same token we should accept that the provision of dry foods is unnatural, and for this reason the habit of some horses to dunk their hay should be regarded as a behavioral need and certainly not something to be prevented or discouraged.

As long as it has no harmful effects on gut motility,[196] intermittent water delivery is not thought to have a negative impact on psychological well-being of stabled horses.[197] The method by which water is supplied can affect both drinking behavior and fluid balance in the horse. For example, a preference for buckets over pressure valve bowls and a failure to maintain fluid balance in some horses using the latter system have been demonstrated.[198] This may have harmful effects on horses that have an increased requirement for water. Therefore if a horse is normally watered using an automatic system, supplementation with water from a bucket may help to ensure rehydration after exertion.

Hygiene is of concern, since automatic water bowls and buckets may become contaminated with food or fecal material.[199] Regardless of the receptacle from which horses drink, stable managers sometimes report reduced water intake after the use of potent agents to clean water containers. This is because, even after thorough rinsing, some of the stronger detergents, disinfectants and soaps can leave traces of unpleasant smells and tastes.

Changes in routine, such as those that prevail in international travel and many competitive contexts, can disturb the natural tendency of horses to drink at around feeding time. Until compensation is effected, which can take up to 7 days, the welfare and performance of horses disturbed in this way can be compromised.[200]

Reluctance to drink can be a neophobic response in that many horses and most donkeys[139] are suspicious of novel odors and flavors in their drinking water. Having evolved to occupy a home range, horses are unlikely to have to encounter new water sources in nature and are innately wary of contaminants. Many equestrian competitors counter this neophobia by using flavorants, such as molasses or peppermint cordial, in the drinking water at home so that the same ingredient can be added to water offered at competitions.[201] Equine hospitals should consider the same approach in anticipation of elective surgery. It seems that simply offering a variety of familiar flavors may enhance overall consumption, perhaps as a product of exploratory behavior.[201] Meanwhile, horses that consistently prefer drinking muddy to clean water may be attempting to remedy a mineral deficiency.[25]

Inadequate water intake has been identified as a cause of impaction colic[202] and should certainly be avoided when horses are required to make the transition between pasture and stabling.[95] Horses affected by tetanus are sometimes seen to immerse their muzzle into water without being able to consummate the behavior by drinking. Meanwhile some normal donkeys are said to refuse to drink from troughs if the water level is so low that they have to put their head so far into the trough that they can no longer see around them.[139] Notwithstanding the normal reluctance on the part of horses to drink water from novel sources or via novel receptacles, any suspicion of adipsia should prompt immediate action, including monitoring of water intake and drinking behavior as well as inspection of the water source to eliminate possible contaminants.[84]

Because horses drink in response to falls in plasma volume and increases in plasma osmolality (experimental increases in plasma osmolality over a threshold of 3% prompt drinking[193]), any factor that alters these parameters can cause thirst.[187] Where furosemide (frusemide) has been administered – for example, to prevent exercise-induced pulmonary hemorrhage – horses can be expected to show increased thirst and to crave salt.[203]

Pathologies that lead to polydipsia and polyuria are dealt with thoroughly in other texts. Before a behavioral cause is proposed, polydipsic horses should be assessed for evidence of various pathologies that increase demand for water, including diarrhea, diabetes and Cushing's disease. Stereotypic interaction with water may not necessarily involve increased water consumption, because water may be splashed and dribbled rather than simply drunk. It has been associated with frustrating environments but, paradoxically, in tie-stalled mares it has been reported only in those given continuous access to water.[197,199] Excessive water intake in the absence of medication or disease has been noted as a consequence of stereotypic salt-licking[115] but primary psychogenic polydipsia is more common.[187] When seen in association with feeding in stabled horses, polydipsia should not be confused with a salivation deficit or a product of thwarted oral motivation, as reported in horses fed scheduled feeds from automated devices.[187]

SUMMARY OF KEY POINTS

- Food selection allows horses to adjust their intake of nutrients to suit their current situation, while avoiding poisonous alternatives.
- A horse is born with innate dietary preferences which generally include:
  - sweet-tasting foods
  - grasses high in fiber and carbohydrate
  - short, young growth.
- There is individual variation in preferences and aversions.
- Horses may learn from conspecifics and personal experience which foods to select.
- Concentrated feeds are associated with reduced saliva production and increased gastric acidity.
- Periods without food are associated with increased gastric acidity and risk of gastric ulceration.
- Lack of forage is the most important management factor linked with the development of stereotypic behaviors in cross-sectional epidemiological studies.
- Lack of forage and the provision of concentrate feed are important causal factors that precede the development of oral stereotypies in young horses in prospective epidemiological studies.
- It does not appear easy for horses to copy novel behavior patterns, which suggests that imitation of stereotypies is unlikely.
- Crib-biting is associated with disorders of the digestive system. There is a significant association between stomach ulceration and crib-biting in foals.
- Dietary treatments that reduce the incidence and severity of oral stereotypies offer humane avenues of treatment and prevention.
- The way in which water is supplied to horses can affect both drinking behavior and fluid balance.

Case study

A 4-month-old Warmblood colt was spotted repeatedly grasping at the top of a gatepost and occasionally licking it while the rest of the group, including its dam, idled in the same corner of the paddock. On closer scrutiny the owners found no evidence of wood-chewing and did not detect a grunting sound coincident with the behavior. The foal was not receiving creep feed but the mare, the highest-ranking adult in the group, was receiving concentrated feed every evening. None of the four adult horses in the paddock showed similar behaviors.

Video surveillance was used for this case. Because of its repetitive nature, the invariantly arched neck posture and the appetitive licking associated with it, the behavior was diagnosed as an early form of stereotypic crib-biting.

The grasping behavior was regarded with concern because of the likelihood of its becoming stylized into crib-biting and the probability of its becoming emancipated after weaning, so measures were taken to reduce management factors associated with its appearance. All gateposts in the paddock were coated very generously with a proprietary taste deterrent. The fence-line was protected with a single line of electrified wire. The sward in the paddock was low, so hay was fed to the group on a daily basis. It was delivered to the centre of the enclosure rather than being placed near the gateway where concentrates had previously been offered. This was intended to break down any association between eating and reaching for the gatepost. The hay was placed on the ground in the short term to avoid there being any uprights in close proximity to the feeding horses and to normalize their posture.

Hay from three farms was sourced, and samples of each were offered in seven separate piles, which allowed the five horses a pile each and two forage sources to choose from if displaced. Alternating the source of the hay in adjacent piles meant that the mare and foal had a choice of forages. When the pair were brought in for supervised supplementary feeding of the dam, it became clear that she was dropping a considerable amount of grain while chewing. Great care was taken to ensure that no dropped grain was left lying around for the foal to consume. Meanwhile, the mare received dental treatment that resolved the quidding.

Before weaning was attempted, a mare-and-filly-foal dyad was located by means of an advertisement in a local newspaper and brought to the paddock. The foals bonded extremely well and one month later the visiting mare was removed. Two weeks later the resident mare was removed and the colt was observed carefully for signs of the grasping response. None was seen. The pair of weanlings were kept at pasture throughout the winter. Ad libitum hay feeding was maintained and small amounts of concentrated food with a dietary antacid supplement were introduced very gradually. Although the amount fed to the youngsters was small it was nonetheless divided into three feeds to reduce its effect on gastric pH. Four years later the colt's behavior remains normal. The owners have not challenged him with traditional feeding regimens and intend to keep the time he spends in the stable to a minimum. None of the dam's subsequent foals have shown signs of similar behaviors.

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Eliminative behavior

CHAPTER 9

Chapter contents

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Development of eliminative responses

As a reflection of the changing nature of water balance from neonate to juvenile and the concurrent shift in diet, the frequency of urination decreases as that of defecation increases with maturity (Fig. 9.1). By 5 months of age, defecation has plateaued from approximately twice per day in the first week of life so that it occurs every 3–4 hours.[1] Urination, on the other hand, declines from an hourly event to one that occurs about six times per day.[1] Perhaps because they can tolerate greater distensions of their bladders, filly foals are generally twice as old as colts when they first urinate (10.77 hours post-partum versus 5.97).[2]

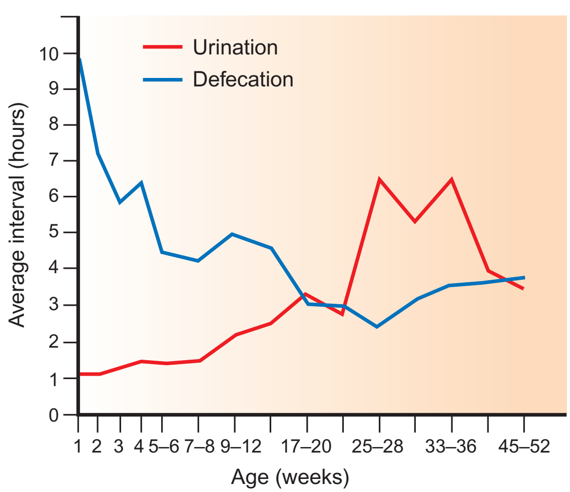

Figure 9.1 Frequency of urination and defecation in foals, expressed as the interval between eliminative behaviors. *(Data from Tyler.[1] Redrawn, with permission, from Waring.[23])*

Defecation

Horses can be prompted to defecate by the sight of feces or the action of another horse defecating. Drinking is also thought to provide a stimulation to dung,[3] possibly via a gastro-colic reflex.[4] Arousal in the form of both fear and excitement can also stimulate horses to defecate,[5] sometimes to the extent of intestinal hurry, as manifested by the presence of undigested grain. It is currently unclear whether feces and urine from fearful horses provide olfactory warning cues to conspecifics, as has been shown in cattle and pigs.[6,7]

Horses tend to show considerable care in selecting defecation sites since they return repeatedly to areas that are not used for grazing. Fecal material makes the grass in latrine areas less appealing, even though the grass itself is readily consumed if presented to horses without the fecal material.[8] This response, which develops in foals as they mature and become less attached to their dams,[9] prompts the development of so-called latrine and lawn areas.[1] The tendency to defecate in soiled areas means the main body of pasture carries fewer parasites. This strategy is appropriate for free-ranging horses that have a virtually unlimited range but in smaller fenced grazing areas it behoves management to institute rotational grazing to break the lifecycle of endoparasites.

The vestiges of dunging strategy are sometimes evident in stabled horses that show an attempt to select sites. As noted by Mills et al,[10] when given the choice between two bedding substrates in looseboxes joined by a passageway, horses defecated in the passageway more than in either box. This could reflect the association between movement (between boxes when exercising choice) and hindgut motility, but should prompt further investigation into the aversiveness felt by horses to fecal material and the extent to which welfare may be compromised by making horses stand in close proximity to their own excrement for extended periods, as is the case in standard husbandry. Certainly, pastured horses tend to move forward after defecation.[9] Porcine studies have provided a possible model by demonstrating the olfactory threshold of the pigs for concentrations of ammonia in the air.[11] Since urine and fecal material may be offensive, not least because of their ammonia content but also because they attract flies, compounds such as sodium bisulfate that have been shown to decrease ammonia concentrations and behavior typical of horses being bothered by flies should be integrated in the stable hygiene routine.[12]

Some owners who note that their horses (often geldings rather than mares) repeatedly defecate in feed buckets, sometimes interpret this behavior as a form of protest. A more likely explanation is the establishment of a habitual dunging pattern that coincides with relatively little space and therefore few alternatives other than that in which the receptacle is routinely placed. Hanging the haynet over the favored site (and ensuring that plenty of hay is contained within it) is usually effective in keeping the horse oriented appropriately and capitalizing on the innate equine tendency to move away from a foraging site prior to defecation. Despite such efforts, some horses do seem to target their food and water receptacles and repeatedly compromise their own ingestive activities as a result. Intriguingly, it appears that Thoroughbreds are more likely to perform this behavior than other breeds.[13] Ethologists note that the response is seen mainly in buckets that are placed on the wall next to the stable door and suggest that barrier frustration may contribute to the etiology.[13]

Despite the rarity of territories, stallions indicate their presence by piling their feces. About 25% of interactions between stallions occur in the vicinity of fecal piles (see Ch. 6).[14] Regular marking by stallions and dung-pile rituals are effective means of avoiding fighting and confrontation between stallions. As a cardinal feature of such interactions, a behavioral sequence that includes defecation is performed by them, either in succession or in unison.[15] It has been suggested that the dominant stallion is usually the last to defecate on the pile.[16] The culmination of these rituals is mutual passive withdrawal, the subordinate being pushed away, or a full-scale fight. The sequence of behaviors targeted on the pile runs as follows:

1. approach
2. olfactory investigation
3. flehmen
4. pawing
5. pivot around or step over
6. defecate
7. pivot around or step over.

The entire sequence, or elements within it, are repeated.

In the free-ranging state, dung piles may serve as orientation marks for stallions. Domestic stallions often accumulate fecal piles beside fencelines because this is the nearest they can get to conspecifics.[17] Occasionally, geldings create fecal piles,[9] but greeting rituals involving them have not been reported. Whereas stallions usually move over fecal material and defecate or urinate on top of it (Fig. 9.2), mares and, to a lesser extent, geldings tend to sniff feces within latrine areas and defecate without much movement. This has the effect of spreading the area of rank grass[6,18,19] and the resultant repugnance and lack of close cropping facilitates the growth of weed species, including thistle (*Cirsium* spp.) and ragwort (*Senecio jacobaea*).[6,20]

Urination

As with defecation, horses prefer to visit latrine areas to urinate. However, movement toward latrine areas occurs less reliably prior to urination than it does prior to defecation.[9] The number of urinations per day is related to water intake but, because of water loss through sweating, it is also negatively correlated with temperature and exercise.[3]

Generally mares and stallions adopt a similar posture before urinating. The croup is lowered and the tail is raised, with the hindlegs abducted and extended posteriorly. Both colts and fillies are sometimes seen urinating on top of fecal material.[1] While this trait disappears in females as they approach puberty, it becomes more obvious in males. When a stallion encounters a mare's dung, he urinates on it, apparently in a bid to mask its odor.[21] After being turned-out, some stallions mark with their urine as a priority ahead of greeting conspecifics.[8]

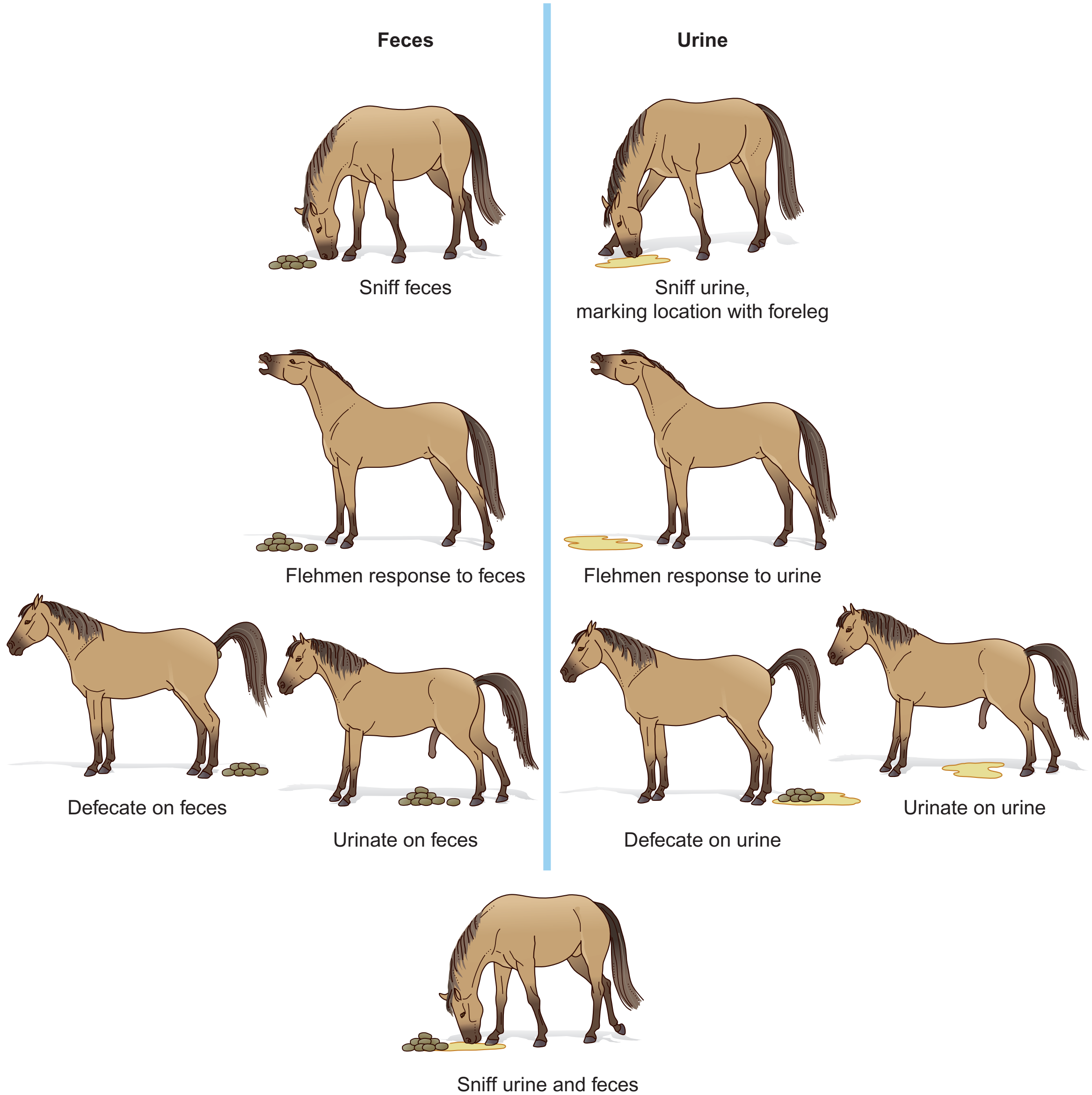

Figure 9.2 The elimination/marking sequence of harem stallions involves voiding feces and urine after the olfactory investigation of urine and feces recently voided by harem members. *(After McDonnell SM.* A Practical Field Guide to Horse Behavior – The Equid Ethogram*. Lexington, KT: The Blood Horse Inc; 2003.)*

Mares are sometimes seen spurting urine, for example, in combination with kick threats when herded by stallions. Urination in mares becomes elaborate when they are in estrus, since they maintain a straddled stance for longer periods than when in anestrus and often tilt their hindtoes until one no longer bears weight (Fig. 9.3). This stance may act as an inviting visual signal for stallions since they have been observed rushing excitedly toward urinating mares.[1] In pony mares the tail is generally not held to one side as it is by horse mares.[22] The clitoral winking that occurs in all mares after urination is far more frequent when they are in estrus. In estrus,

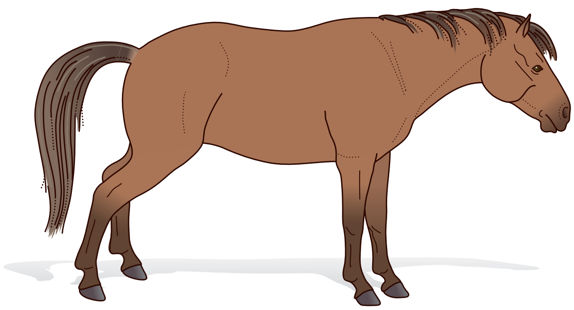

Figure 9.3 Estrous mare urinating with characteristic posture.

mares also pass less urine at each urination.[22] Urination often occurs as a spontaneous solicitation and in response to teasing.[23]

In an apparent bid to avoid having their legs splashed by their own urine, horses select soft substrates on which to urinate. This is thought to be the origin of straw being a classically conditioned stimulus for urination in stabled horses. The association is routinely used to aid urine collection in performance horses (Fig. 9.4). Bedding is often removed from stables during the day for hygiene or economy reasons. While laudable if used only as a means of drying the stable floor while the horse is at pasture, this intervention can have unwelcome consequences if the horse remains in the stable without bedding since it deters both recumbency and urination. The growing trend towards the use of rubber matting in place of traditional bedding substrates may have similar effects on the inclination to urinate and merits investigation. A similar impediment to comfortable urination is thought to apply to urban horses, such as draft animals used in cities for tourism.

Increased frequency of urination has been noted as an indicator of social distress in isolated horses.[24] Although it may reflect urinary calculi and cystitis,[25] polyuria is usually a consequence of polydipsia that can be organic or psychogenic in origin (see Ch. 8). The usual presenting sign is an excessively wet bed. Determining water intake is an important step in defining the extent of the problem, and direct observation of the horse's drinking and eating behavior can help to identify contributing behavioral anomalies such as excessive use of salt licks.

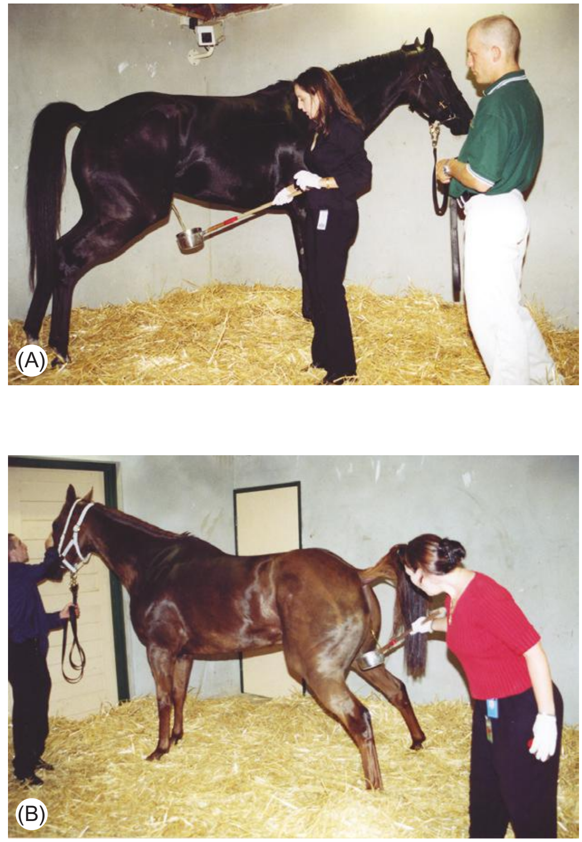

Figure 9.4 (A) Gelding and (B) mare providing post-race urine samples. Familiar bedding materials and whistling are used as classically conditioned stimuli for urination in racehorses. Anecdotal evidence suggests that females are less easy to train to urinate on cue than males.

SUMMARY OF KEY POINTS

- Urination and defecation are influenced by age and sociosexual factors.
- The distribution of feces and urine can affect grazing behavior at pasture.
- Urine may be used to mask olfactory stimuli left by other horses.

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Body care

CHAPTER 10

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Grooming

In addition to maintaining integument health, grooming behaviors can contribute to affirming social bonds not least by reinforcing affiliations and sharing odors. Evidence that body odors prompt horses to undertake longer investigative sniffing than either urine or feces[1] should remind us that horses rely chiefly on scent to recognize familiar conspecifics once they are close.

Mutual grooming

Mutual grooming not only allows horses to reach areas that defy self-grooming strategies, but also facilitates exchange of odors[2] and has been shown to reduce heart rate when conducted in certain parts of the mane and withers.[3] Grooming of withers by humans has a similar calming effect.[4] The effects on cardiac function are particularly striking in foals, with a mean reduction of 14% in heart rate being reported when preferred areas were scratched by humans.[3] This phenomenon is regularly harnessed by personnel who want to reward horses of any age without using food.

Mutual grooming can begin in the first week of life[5,6] but peaks in the second and third months of life,[7] a period during which foals seem to find physical contact intensely gratifying. In the first instance the foal's mutual grooming partner is its dam, who may dismiss other grooming partners if her foal solicits her attention by attempting to allogroom.[5] Although some mature horses never allogroom, most regularly indulge in reciprocated activity of this sort with favored affiliates for periods of about three minutes at a time.[8] Broadly speaking, regardless of their age, females spend more time mutually grooming than males. Mutual grooming partners are usually preferred associates that are close in social rank.[9] In a natal band, mares and their offspring mutually groom kin rather than unrelated conspecifics.[10] The absence of a stallion seems to bring with it some liberation in that grooming partners are preferentially from same sex-age groups.[11] The stallions in multi-stallion harems will mutually groom one another.[12]

Mutual grooming often starts at the cranial neck and proceeds to the withers (Fig. 10.1), the shoulders and then to the tail-head, sometimes changing sides (see Fig. 2.15).[13] While youngsters often attempt to begin allogrooming, such overtures are rarely reciprocated by unrelated adults.[5] As discussed in Chapter 5, there is equivocal evidence for the role of rank when a bout of mutual grooming begins.[5,11] Reports indicate that low-ranking individuals groom more and initiate more

Figure 10.1 Mutual grooming helps equids to develop and maintain pair bonds. *(Photograph courtesy of Sandra Hannan.)*

groomings and that allogrooming may have a role in appeasement.[12] However, most bouts are ended by the departure of the higher-ranking member of the dyad.[5] Mutual grooming between foals is often observed before or after a bout of play.[14]

The frequency of mutual grooming is subject to daily and seasonal variation, with predictable troughs that coincide with recumbency.[15] Shedding the winter coat and the seasonal peak in idling behavior account for annual peaks in mutual grooming (i.e. April and July in northern hemisphere studies[5]). When allowed to interact freely with other horses after 9 months of social deprivation, colts stabled singly showed significantly more social grooming than colts stabled in groups, which may reflect a build-up of motivation (a post-inhibitory rebound effect).[16]

Self-grooming

Self-grooming brings out a great deal of resourcefulness in horses as they use their hooves, their mouths and objects in their environment to relieve irritation (Fig. 10.2). The frequency of self-grooming peaks at 12.3 times per hour in weeks 5–8 of a foal's life.[17] The relative proportion of body parts and the innate flexibility of foals both help to explain their relatively enhanced ability to self-groom and may account for the decline in frequency of self-grooming to 1.2–2.2 times per hour in adults.[18] While their dams focus self-grooming on rolling and rubbing against the forelimbs, conspecifics or inanimate objects, foals are more frequently found scratching anteriorly with their hindlimbs or nibbling posteriorly.[17]

Along with appetite and growth, pelage cycles are related to the duration of the photoperiod.[18] Therefore the amount of self-grooming peaks with the shedding of the winter coat.

Scratching by humans can act as a highly valuable primary reinforcer, so an appreciation of the pleasure that grooming may bring can help to consolidate the horse–human bond. However, grooming by humans must take account of the variable sensitivity of different individuals and breeds.[2] The need to have a clean horse has been overstated by some horse-care manuals. Further, the perceived need to pull manes and tails undoubtedly irritates many horses and possibly compromises the horse–handler bond.

Rolling

Because preferred substrates are sand, fine dry soil and occasionally mud, horses at pasture tend to select bare patches on which to roll, often beside gates or water troughs.[19] Some feral horses have been observed to roll preferentially in water.[8] With more than 80% of rolling occurring where another horse has rolled,[2] its function is believed to include the opportunity to deposit scent over the body. The fact that horses, especially males,[20] smell chosen sites before and after rolling appears to support this view.

The head and neck help to propel the horse laterally while rolling (Fig. 10.3).[13] Similarly, lateral flexion of the vertebral column and thrashing of hindlegs seems to help the horse to balance itself on the dorsal midline.[13] Rolling horses usually return to the same side they started lying on but often repeat the roll before rising.[13]

The physical environment can affect horses' inclination to get down onto the ground. For example, there is evidence that small boxes inhibit sternal recumbency.[21] Apart from some foaling boxes, the space on the floor of most stables and many custom-built sand rolls is less than the width of most natural rolling sites. This helps to explain why we should be pleased that more horses do not get cast (stuck against the walls of stables or upside down in their stables). The use of anti-casting rails is a measure believed to help inverted horses to right themselves when stuck against the side of a stable. These rails are set about one meter from the floor, although their height should, strictly speaking, depend on that of the occupant. They work by providing some purchase against which the horse can push in a bid to move itself away from the wall.

Bedding materials such as straw that lend themselves to being banked up against the side of the stable wall

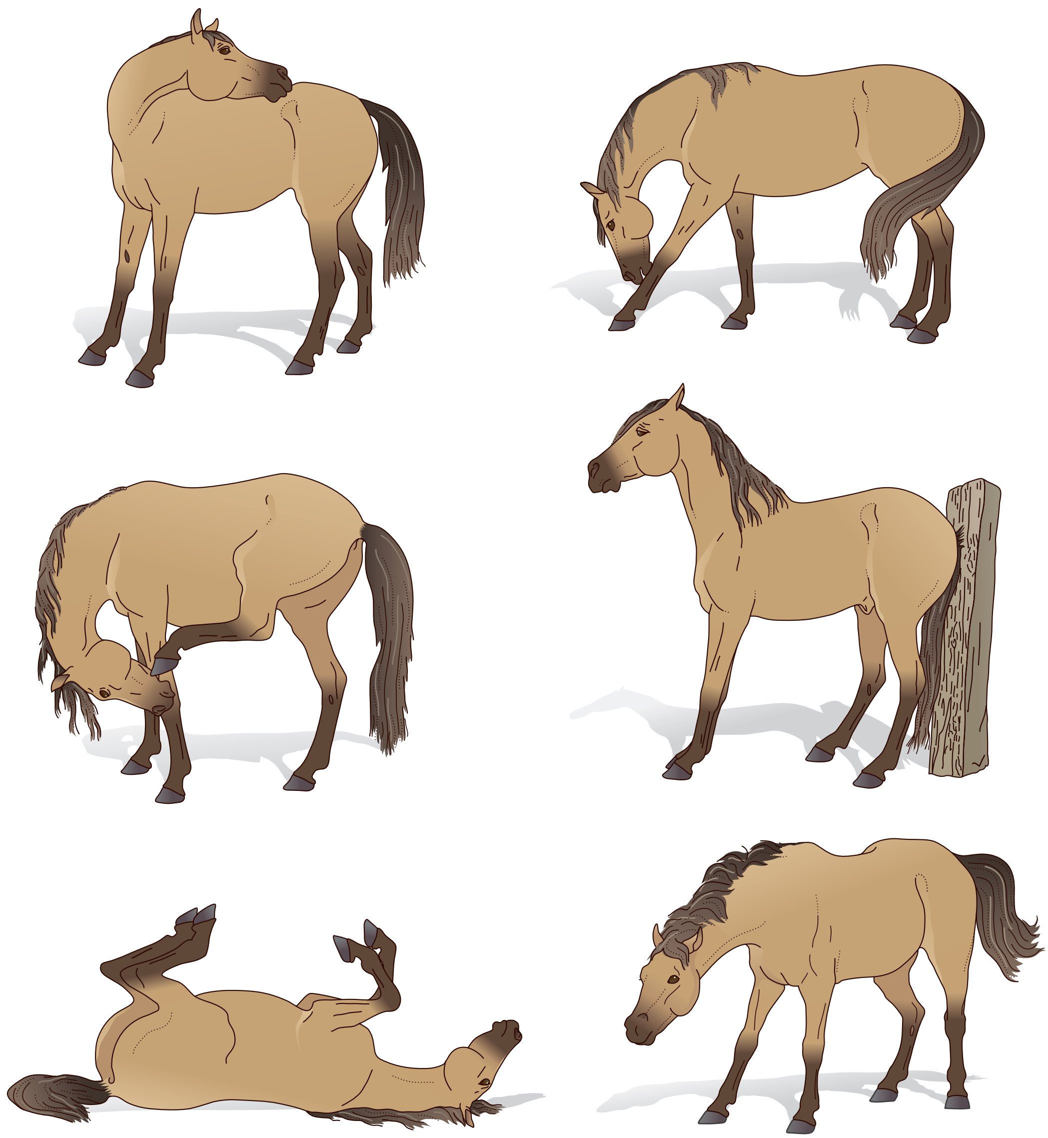

Figure 10.2 Grooming styles used by horses include rolling, shaking, rubbing, scratching and nibbling (of both the back and forelegs). *(Redrawn, with permission, from Waring.[13])*

are likely to reduce the risk of casting. Whatever bedding is selected must be managed carefully to maintain air hygiene. Beds that drain readily are less likely to be accompanied by high ammonia concentrations or allow humidity to rise to concentrations that increase the viability of fungal spores implicated in lower-airway disease.[22] Bedding preference studies suggest that the appeal of straw depends on its being deep and is linked to its alternative use as a source of dietary fiber.[23,24]

Shaking

Shaking is frequently seen after untacking, rolling and recumbency. It involves coordinated contraction of the superficial musculature that travels caudally from the head leading to vibration and rotation of the skin on the body. The neck is lowered prior to shaking,[13] and a wide placement of the forelegs is assumed. Males and non-estrous females often shake after urinating.[13]

(A)

(B)

Figure 10.3 (A) Sequence showing horse rolling. (B) After a bath horses seem more itchy than normal and enjoy rolling, especially in dusty substrates. *((A) Redrawn, with permission, from Waring.[13])*

Head and neck involvement is variable. Nodding and shaking the head can send the mane in different directions in a bid to dislodge insects. Before rectal palpation became established as a means of pregnancy diagnosis, folklore maintained that if water was squirted into their ears, mares would not shake their heads if pregnant.

Rubbing

Rubbing can involve fixed objects or the muzzle.[13] The latter is used to reach places, such as the barrel and forelegs, that are hard to rub against fixed objects. Foals may rub target areas, such as the head, neck, croup and buttocks, on objects for as long as 15 minutes at a time.[13] Less frequently horses are observed using low branches to rub their backs and may sometimes straddle vegetation on which they rub their ventral surface by walking forwards and backwards.[13] Rubbing the vulva, tail and buttocks has been recorded in mares,[13] with accompanying signs of pleasure, such as lip quivering, suggestive of masturbation.[5]

Scratching

After turning its head and neck to the rear, a horse can use its hindlimbs to scratch parts of the cranial and anterior cervical region. More common in foals than in adults,[17] this response is thought to be retained by more ponies than horses.[13] Indeed, some lice-ridden ponies may go on to insert a pastern into the mouth and proceed to mumble on the limb.[25]

Nibbling and licking

The use of teeth in body care varies from a rhythmic scratching action by the upper incisors, to small bites. While the areas that can be reached by the teeth include the sides and loins (see self-mutilation in Ch. 11) and even the hindlegs (Fig. 10.4), the forelegs seem to receive especially detailed attention that incorporates considerable licking. This is a means of removing bot eggs from the hairs that effectively facilitates their ingestion. Although licking seldom occurs as part of mutual grooming,[13] the licking of a neonate by its dam is probably the most important instance of a horse using its tongue during grooming a conspecific. This can last for 30 minutes and, as well as consolidating the mother–infant bond, it provides tactile stimuli that may have a role in stimulating responses such as standing. Licking by a stallion as part of courtship is a means of tasting rather than grooming.

Figure 10.4 Horses sometimes use their mouths to groom the hindlegs. *(Photograph courtesy of Francis Burton.)*

Pest avoidance

Flies bite and spread diseases, such as conjunctival infections, and proteins in the saliva of *Culicoides* spp. are the stimuli responsible for the often grotesque self-mutilation of sweet itch (Queensland itch, summer itch, summer eczema). Apart from ill-advised excoriation, horses have developed adaptive behavioral responses to combat pests. For example, in foals, the percutaneous invasion of the third-stage larvae of *Strongyloides westeri* is reported to cause repeated episodes of frenzied behavior lasting about 30 minutes.[26] The energy expended in motor responses such as tail-swishing to reduce irritation of insect origin may be considerable, and movement to areas (such as cooler parts of the home range) that provide respite may therefore be seen as forms of energy conservation.[27] Tabanid flies drive free-ranging Camargue horses to change their time-budgets and use of their home ranges, apparently in a bid to capitalize on the prevailing winds in key areas.[28] Similarly, Assateague ponies have been noted to use inshore water and snow patches as refuges from tabanids.[27] For horses, insects are not the only airborne pest. Avoidance measures have also been demonstrated in response to the vocalization of vampire bats.[29]

With pliable, mobile skin and extensive subcutaneous muscles, horses are among the best skin-twitching animals. The sensitivity of horse skin, for example, to alighting flies as they stimulate the panniculus response, should serve to remind riders how little pressure is needed for signaling and how heavy whip use can compromise welfare (Fig. 10.5). Riding instructors who find themselves telling their pupils to kick their mounts should consider the lesson they are providing for both rider and horse. While stamping, kicking and shaking

Figure 10.5 Heavy whip use can compromise welfare, especially in sensitive parts of the body such as the abdominal wall. Here you can see the whip has disappeared into an indentation it has made in the skin of the flank. Such indentations and flank strikes occur with troubling frequency. *(Reproduced with permission of Liss Ralston.)*

of the whole body or head are all employed to dislodge insects, the forelock and the tail can act both as screens and swats in combating fly problems. The effectiveness of mutual tail-swishing as a means of reducing the harm caused by flies is reflected by there being demonstrably fewer bites per horse in animals that live in large groups.[30] Horses frequently swing their heads in the direction of flies on their flanks in a motor pattern similar to an agonistic head threat that occasionally includes a consummative nip at their own skin.[13] Along with pawing, tail-swishing increases with ambient temperature in horses while being prepared for work.[31] Since this effect is not a function of fly numbers, it has been suggested that such comfort behaviors may be useful indicators of irritation in horses, especially where ambient temperatures are high.[31]

The use of other horses' tails in helping to reduce the frustration of flies on the face is established in foalhood as foals frequently rest within the shelter of their dams' swatting tails.[7] The solitary housing of horses denies them this facility and should oblige owners to provide such animals with some form of screen. The importance of the tail in body care is implied by reports of horses with docked tails occasionally using sticks to scratch their sides.[32] Veterinarians who prioritize the welfare of animals in their care recognize the function of the tail as a source of comfort and therefore do not dock horses for cosmetic reasons.

Behavioral thermoregulation

Horses often surprise owners with their reluctance to use field shelters. This rejection of enclosed space relates to their dislike of confinement and reduced surveillance and visual contact with conspecifics. That said, horses are often seen using shaded areas, natural windbreaks, sun-baking and occasionally wading in water to regulate their body temperature. Evaporative heat losses are thought to be increased by the sprinkling effect of tail-swishing while standing in water[33] and by the occasional instances of nose-dunking in water (Fig. 10.6). Thermoregulation is often made difficult by rugs, especially in warm weather when rugs are sometimes used to prevent sun-bleaching. Discomfort caused by overheating, skin disorders and generally badly fitted rugs may prompt some horses to become rug chewers. Other horses, especially youngsters, may adopt this response as a form of object play.

Rest and sleep

Fraser[34] identifies four resting states: idling, resting, drowsing and sleeping. He also gives a detailed account of pandiculation (stretching) elsewhere.[34]

Idling is adopted as a passive waiting style between more animated activities and involves stationary standing with some limb-shifting and positional changes. It can occur as a group activity, in contrast to recumbent sleep, which is rarely undertaken by all the members of a group at one time.[35] Seasonal peaks in resting behaviors occur in the summer[5] when forage is relatively plentiful and there is pressure to seek shade and avoid insects. Common sites are usually selected for lying, a behavioral mechanism thought to help produce a group odor.[2] Elevated sites are often selected since they

(A) (B)

Figure 10.6 In an apparent attempt to refresh themselves, horses will occasionally dunk their noses in water. *(Photographs courtesy of Francis Burton.)*

provide refuge from heat and flies.[36] Resting occurs in the standing or recumbent position and in the wakeful periods between sleep and drowsing. Generally, light horses spend less time standing to rest than draft types.[37]

Drowsing

A drowsing horse stands with its eyelids partly opened and its head hanging at a medium height (Fig. 10.7). The flexion of a single hindlimb is facilitated by the reciprocal apparatus in the hindlimb, which means that movements of the stifle joint drive those of the hock.[38] Thus, once the stifle is fixed in position, the hock is obliged to follow suit. In combination with the stay apparatus found in the forelimb as a means of supporting the fetlock, this allows the horse to remain upright with a minimum of muscular effort. The advantages of remaining standing include being able to achieve a quick escape if threatened, but also to avoid cardiorespiratory compromise that comes with recumbency. Interestingly, adopting certain postures for rest has been shown to have familial tendencies.[39]

Sleep

The distinction between drowsing and sleep necessitates understanding the different physiological characteristics of various states of wakefulness. In adult horses, sleep occupies 3–5 hours per day, while drowsing consumes a further 2 hours.[40] Postural changes tend to accompany certain states – for example, although the eyes remain partly open, the head gradually descends as

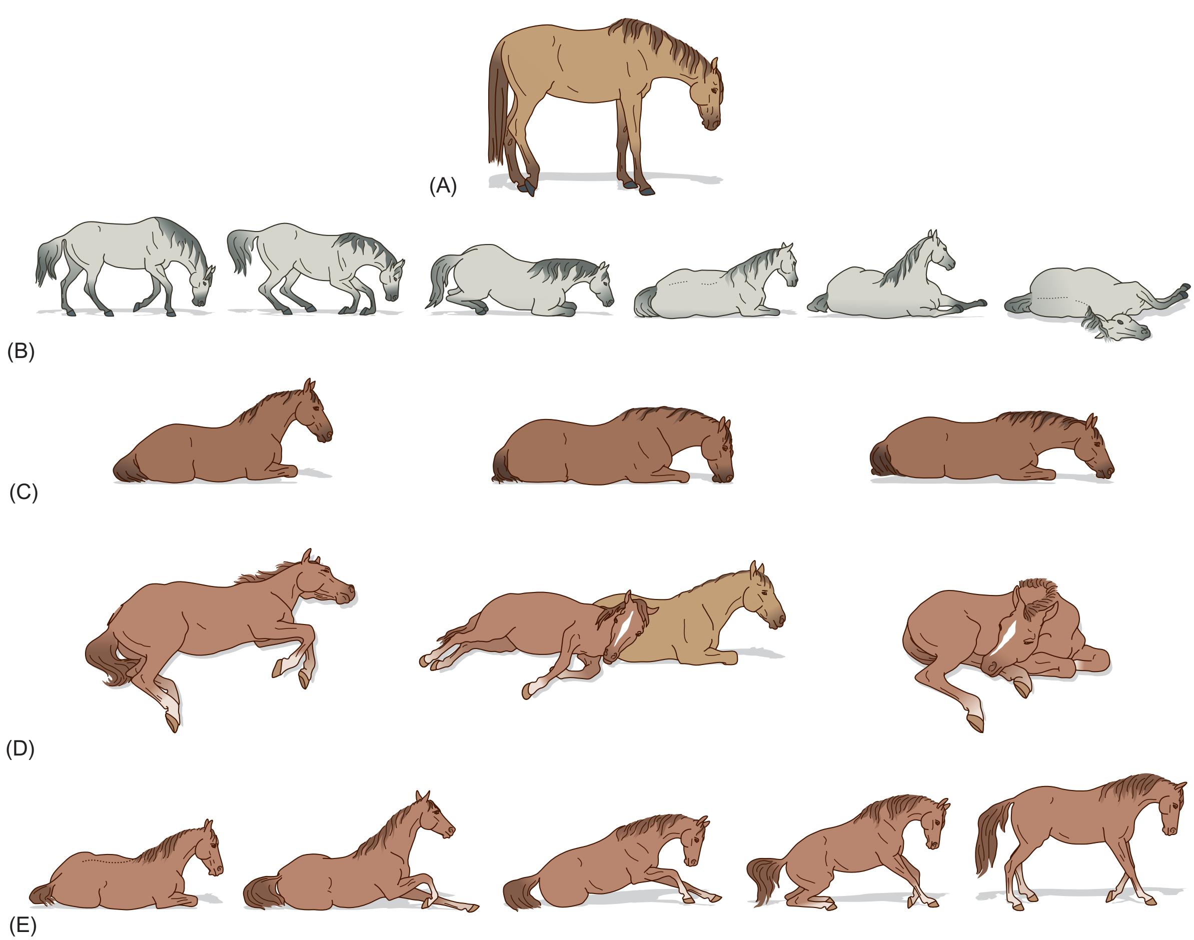

Figure 10.7 A horse's posture changes in various states of activation: (A) resting with weight distributed among only three legs; (B) lying down; (C and D) recumbent resting attitudes; (E) arising. *(Redrawn, with permission, from Waring.[13])*

the horse goes from drowsing to sleep.[36] Animals may rest without sleeping and while the distinction between drowsiness and sleep is reasonably subtle, since they may appear very similar externally, electrophysiological studies of animals in various stages of sensitivity to their environment have helped to unpick the differences. Although such measurements require subjects to be restrained, we can assume that the same differences apply in unrestrained horses. Using data extrapolated from restrained subjects, inferences can be made from the posture of horses indulging in various rest behaviors.

The two types of sleep clearly defined in horses are slow-wave sleep (SWS) and rapid-eye-movement (REM) sleep (also known as deep or paradoxical sleep).[40] The electroencephalogram (EEG) waves of SWS, as the name suggests, are characterized by a low frequency, a feature that disappears as the horse drifts into REM sleep. Some muscular tone is retained in SWS, even when the head is resting on the ground during sternal recumbency. It is the only form of sleep that occurs in standing horses. Although it may increase in horses that are unable or reluctant to lie down, SWS cannot compensate for lost REM. This is illustrated by post-inhibitory rebound in REM sleep after periods without recumbency.[40] Along with the suggestion that horses do not lie down unless they are confident about their surroundings,[35,40] this accounts for some of the concerns for the welfare of horses that do not or cannot lie down.[41]

REM sleep was dubbed paradoxical because, while its EEG is similar to that of wakefulness (Fig. 10.8A), it has the highest arousal threshold. Cardiac and respiratory rates decrease in all forms of sleep.[42] REM sleep is peculiar in that it involves the absence of postural tone (and therefore the eyes are shut). It occurs entirely during recumbency and is marked by the greatest degree of variability in cardiac and respiratory frequencies of any state, including wakefulness. As its name implies, REM sleep is also often accompanied by rapid eye movements. In REM sleep during lateral recumbency, limb movements, especially of the upper limbs, may occur.[13]

In studies of adult horses, REM sleep has not been observed to occur without a preceding period of SWS, and this gives rise to the term 'sleep cycle'. Horses, like most non-primates, are polyphasic sleepers in that they sleep in more than one phase throughout the 24-hour period, with one or more sleep cycles occurring in each phase. During the night, horses have about six sleep phases within which the mean duration of sleep cycles is 15 minutes and the mean duration of SWS and REM sleep they contain are 6.4 and 4.2 minutes, respectively.[40] The balance comprises drowsing within a sleep cycle and a third type of sleep labeled the intermediary phase.[40] Although it has an EEG pattern similar to that of drowsiness, intermediary sleep is characterized by an arousal threshold closer to that of wakefulness than that of drowsing (Fig. 10.8B).[40] Found in almost 30% of sleep cycles, the intermediary phase may provide a protective punctuation of sleep that helps to prompt extra surveillance before deep sleep.[40]

Time spent lying increases in horses when they are exercised,[43] and good deep bedding may therefore help to keep performance horses in peak condition by facilitating adequate rest. While the mean time spent in continuous sternal recumbency is 23 minutes,[35] twice as much time is generally spent in lateral recumbency. In sternal recumbency horses lie asymmetrically with their hindquarters rotated so that the lateral aspect of the lower limb is on the ground. Rising from this position, once the upper foreleg has been extended, is achieved chiefly by a thrust from the hindquarters (Fig. 10.9).[35] In lateral recumbency the importance of the upper limb in rising quickly is demonstrable in that it is almost always anterior to the lower limb, which is usually flexed to some extent.[35] As with rolling, it seems probable that horses demonstrate laterality in their preferred side for recumbency.

The timing of sleep is important, since management schedules sometimes interfere with innate rhythms that facilitate sleep. Although most sleep occurs between 2000 and 0500 hours, horses also often sleep in the first 2 hours after midday.[40] It is therefore good practice to keep activity in a stable yard to a minimum during the early afternoon.[35]

The restorative functions of sleep have been compartmentalized by Dallaire,[40] who proposes that during SWS sleep the brain is resting, whereas during REM sleep the absence of muscle tone suggests that the muscles are resting. Fraser[35] proposes that during REM sleep the brain consolidates long-term memory traces and the forebrain is functionally disconnected so that the brainstem must be responsible for any accompanying limb movements.

The effect of environment

While domestic horses tend to rest in sheltered areas, Przewalski horses when released into extensive enclosures have been noted to rest in the highest parts of the available terrain.[44]

The floor area of a stable can influence the maintenance behavior of horses within it. The duration of

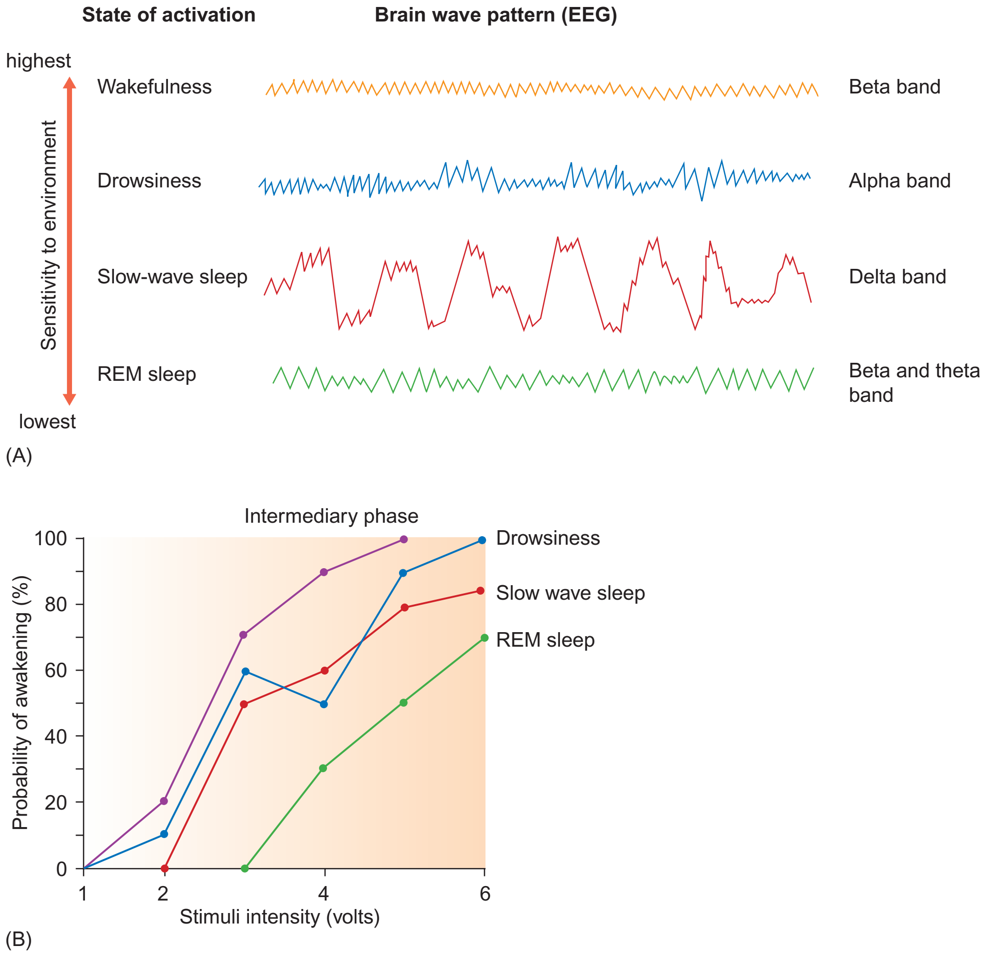

Figure 10.8 (A) In various states of activation in mammals. (B) Variations in arousal threshold from drowsiness to REM sleep. *(After Dallaire.[40])*

Figure 10.9 The main muscular effort used in standing after a period of recumbency comes from the hindquarters. *(Photograph courtesy of Francis Burton.)*

sternal recumbency was significantly longer in large boxes (2.5 × height of the horse squared) than in the small boxes (1.5 × height of the horse squared). Interestingly, horses at pasture show slightly less total sleep and more drowsiness than those kept in separate stalls (Fig. 10.10).[40] Drowsing at pasture studied in a small number of ponies occurred only while they were standing. These data may suggest that the external environment may require the deployment of more surveillance than the stable. However, a similar trend toward an increase in the proportion of SWS is reported in sensory-deprivation studies on ponies, which implies that a barren environment may be sufficient to modify sleep patterns, regardless of any concurrent perception of security.[45]

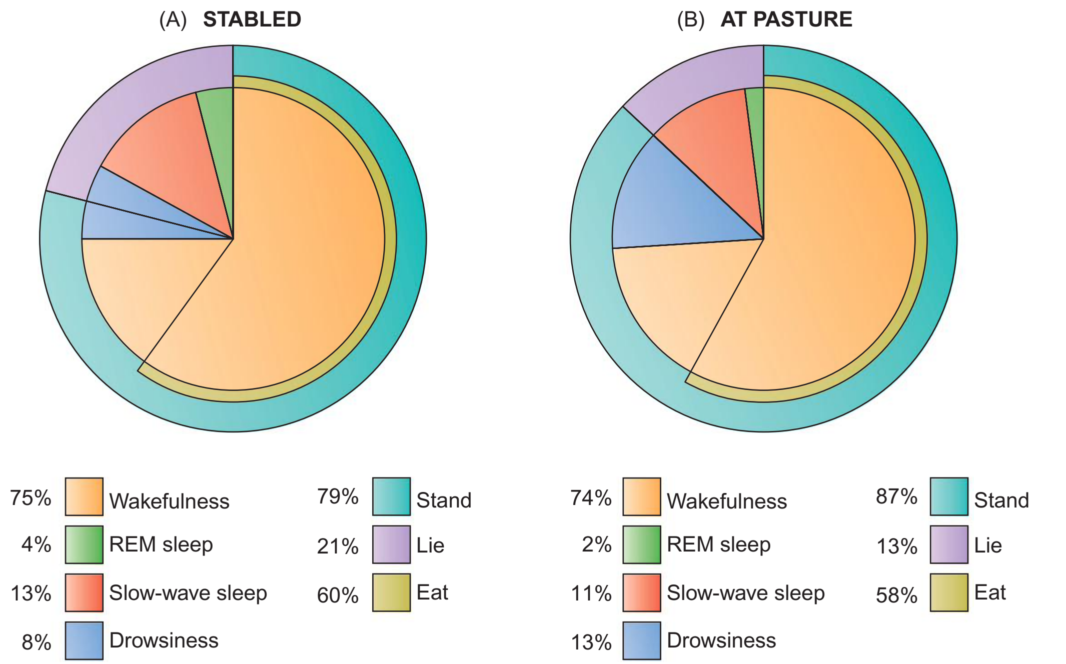

Figure 10.10 The distribution of the four states of activation change according to whether the horse is stabled individually (n = 5) or kept at pasture (n = 2).

The weather may also influence rest behavior. For example, in especially hot weather, perhaps because of the prevalence of flies and the resultant need for mutual tail-swishing, horses may rest only in the standing position.[46] The standing position is also favored for rest during the colder months of the year,[47] perhaps because it involves less heat loss through convection. Daylength, via the action of serotonin and thus melatonin, can influence sleep patterns, and it is reported that tryptophan, a precursor of serotonin, may be used clinically to help sleep.[35]

The effect of rank and group size

Resting postures are subject to individual preferences.[40] However, the standing position is adopted for rest preferentially by adult mares more than males or youngsters.[47] Among adults, the highest-ranking member of a band is often the first to lie down.[48] Furthermore, it is believed that the effects of a novel environment in making horses that are unfamiliar with an enclosure reluctant to lie down may be diluted if a resident horse is present to offer an example.[40] There are data suggesting that as group size rises within a population, time spent resting in the standing position increases at the expense of time spent in recumbency (Fig. 10.11).[47]

The effect of age

Compared with adults, foals have a greater need for sleep and are less capricious about recumbency, so they often rest in groups.[35] Both SWS and REM sleep occur in foals, but their proportions differ.[7] With their mothers nearby, newborn foals spend about a third of their time recumbent. When they lie in lateral recumbency, they enter REM sleep and their limbs may move as if running.[7] It may be that learning is consolidated during these periods.[49] It has been suggested that because it is associated with a reluctance to lie down and therefore may jeopardize sleep patterns and possibly even learning, extended episodes of road transit could be highly undesirable for foals.[7]

Interesting differences between colts and fillies in the amount and characteristics of recumbent rest in the first week of life are emerging. Fillies have been noted spending 42% of their time in recumbent rest while for colts this is only 20%. Furthermore colts rested upright more and stood more (20% and 28%) than fillies (4% and 23%, respectively) (Machteld van Dierendonck, personal communication 2002). After a peak of the daily time budget spent in recumbency that occurs in the first week of life,[50] the need for rest declines as a

Figure 10.11 A horse lying in lateral recumbency close to standing companions. Horses may have a heightened sense of security in a group, but recumbency is unlikely to occur as a group activity. *(Photograph courtesy of Francis Burton.)*

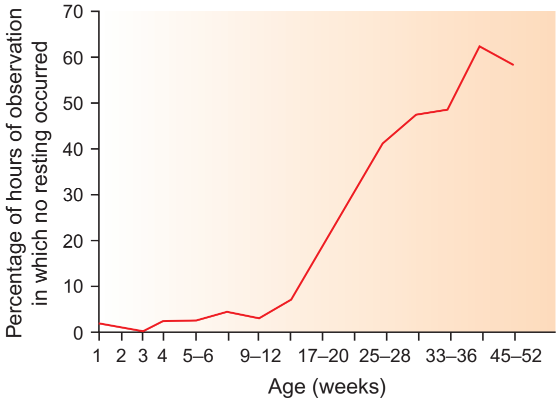

Figure 10.12 The changing percentage of daylight hours that New Forest foals ***do not*** spend resting. *(After Tyler.[5] Redrawn, with permission, from Waring.[13])*

foal matures, with a striking shift occurring at about 3 months of age (Fig. 10.12).

At this time, foals generally become more social with their conspecifics and especially their peers, if any are present.[5] Because of their attachment to their dams, who must graze for extended periods to meet the nutritional demands of lactation, foals do most of their resting in lawn areas.[19] They are more likely to rest either upright or recumbent if the dam is resting upright.[50] Foals spend only 3.5% of their time resting upright in the first week of life but, as time spent recumbent falls, this steadily increases to a peak of 23% in week 13.[50] Meanwhile, nursing mares reach a peak of 32.5% of their time resting upright in week 13 post-partum.[50]

Play

Activities involving a sense of pleasure and elements of surprise but apparently no immediate function are broadly characterized as play.[51] The benefits of play (apparent or otherwise) must outweigh the costs in terms of energy and associated risks.[52] One of the immediate rewards of play may well be pleasure, but this is difficult to study. Often initiated by grooming bouts and oral snapping actions, play may establish or strengthen social bonds within a pair or group.[53] The value of play is illustrated by the way in which bachelor groups can draw colt foals towards them, with the opportunity to play appearing to be the chief attractant.

Most of the galloping and fast twists and turns used in anti-predator behavior are incorporated into play activities by foals. Sexually dimorphic play-fighting preferences reflect adult agonistic responses, with fillies tending to fight by kicking with their hindlegs as a mare does, while colts prefer to rear, bite and chase each other.[12] By practicing these actions before they are required in a serious situation, the foal develops its neuromuscular pathways, the activity becomes learned and so may be executed when needed with ease or flair. Play promotes and regulates developmental rates and therefore contributes to the development of physical strength, endurance and skill.[53]

Fraser[35] argues that the urge to play is derived from a basic need to have optimal blood flow to the muscles. This may provide a mechanism to explain post-inhibitory rebound in locomotory responses after confinement[16,40] and why rain can prompt locomotory activity, especially in youngsters. Other than its physiological functions, play may be a form of training that offers problem-solving opportunities and experience that can yield specific information. This is likely to give young animals tactical and behavioral flexibility to fight, find mates and escape predators as adults.[52] Play in adult horses, which usually takes the form of object or locomotory play,[7] may be a luxury afforded by domestic circumstances and occur as evidence of post-inhibitory rebound or a response to lack of appropriate stimulation from conspecifics at other times.

Play is greatly reduced during periods of extreme ambient temperatures, food scarcity, and other occasions of physiological or psychological stress.[13] While animals that have not had their basic food and water requirements met do not play, a low play drive can also indicate ill health or poor nutrition. The range of play behaviors may also be limited by a dearth of playmates.

Prospective studies may demonstrate links between features of play and neuromuscular development, social rank and competitive performance. Rees[54] suggests that a horse's personality as manifested by its mannerisms during play, may be an indication of what to expect when the same horse is under-saddle, especially when presented with an unfamiliar or unsettling situation. Indeed, Fraser[35] pursues this idea by advocating that we examine horses' personalities before assigning their work, or that we even attempt to create play responses in work situations because, he proposes, this will maximize the horse's willingness to complete the task. For example, a horse that often displays flamboyant paces when playing may experience a play response to the challenges of dressage.[35] This is supported by studies of play responses of 698 horses (representing 16 breeds and 13 types) that showed type, rather than breed or sex, was the major influence on free operant responses.[55]

Playfulness may affect the human–horse bond. For example, Fraser[35] endeavored to explain most equestrian pursuits in terms of game theory,[56] suggesting that horses learned rules of games when they were being schooled. However, the validity of this approach has been questioned by those who propose that equestrian activities such as jumping easily avoided obstacles or moving repeatedly in circles must appear rather pointless to the equids involved.[54,57]

Play can be considered under three broad divisions: locomotory play, interactive play and manipulative play.

Locomotory play

Locomotory play begins within a few hours after birth and takes the form of exaggerated or vigorous physical activity, with the foal moving in circles close to the dam, and exhibiting actions such as spinning, and kicking.[34] Other labels used to categorize locomotory play include frolic, run, chase, buck, jump, leap and prance.[14] Solitary running and bucking are noted more frequently in fillies than in colts.[58] The lengths of locomotory play bouts can be related to the increasing confidence of the foal as it gradually moves farther away from the dam. Williams[59] notes that locomotory play often seems unfinished, since it is often ended by some form of distraction, such as spotting a shadow. Rather than being unconsummated, bouts of locomotory play may end this way for sound reasons that currently elude us. All age groups of domestic horses may indulge in this form of play without conspecific company.[7]

Interactive play

If opportunities are available, interactive play occurs among horses of various ages (Fig. 10.13) and its nature seems to depend on the age and sex of the participants. Characterized by repeated physical contact between participants, it often mimics combat between harem stallions but lacks the characteristic vocalizations, persistent

Figure 10.13 Play fighting is recognized among adult companions as they become familiar with one another, especially in bachelor groups. *(Photograph courtesy of Francis Burton.)*

ear-pinning and heightened risk of injury.[7] It is possible to subdivide interactive play as play fighting and play sexual behavior,[14] but in the current text interactive play is considered in the light of the partners involved. Play partners can be adult horses or other foals.

Play between foals and adult horses

During the month of dependence[7] the focal point of the foal's life is its dam. In the first week of life the foal will spend most of its time with its mother.[5] She allows it to play on or around her, showing considerable tolerance (Fig. 10.14). Types of play behaviors include nibbling and chewing the mane and tail of the mare, biting and bumping her legs and sides, and attempting to climb over or jump the mare when she is lying down.[7] At first this play is rough and there is little the mare can do other than tolerate it. But after 2 weeks or so, as the foal becomes more gentle, his dam will have the opportunity to teach him the benefits of mutual grooming.[54] Play between the mare and her foal decreases as the foal spends an increasing amount of time with its peers. Although time spent playing does not differ between fillies and colts, the types of games and, therefore, the energy consumption do.[58] For example, interactive play bouts of colts are longer than those of fillies.[58]

Play between foals and an adult other than their mother is rare. Mares will often threaten foals that are not their own, while young and barren mares may show more tolerance. Colts engage in this form of interaction more often than fillies.[58] Snapping is usually exhibited before and during these interactions, especially when the adult is a stallion.[34] Free-ranging stallions allow foals (again, more commonly colts than fillies[5]) to investigate or play with them and are generally careful in their treatment of youngsters, often withdrawing from play fights rather than responding agonistically.[5] This gentle attitude may continue to be displayed until the foals reach puberty, at which point they often begin to be treated as competition, if male, or with relative indifference, if female. Kiley-Worthington[2] notes that the stallion may ultimately eject both colts and fillies from the natal band, but more common causes of natal dispersal are considered in Chapter 5.

Play among foals

A neonatal foal's social interactions with other foals gradually increase in frequency so that at 3–4 weeks of age the average number of solitary play bouts matches the average number of bouts of social play (Fig. 10.15).[5] Invitations to play often begin with staring, tentative sniffing and head-tossing approaches that initially amount to no more than touching muzzles followed by galloping retreats and flamboyant bucking (Fig. 10.16).[34] Colts are more proactive than fillies in using these invitations to initiate play with their peers.[37]

Possibly because they often get variable responses from adults other than their dams, foals tend to associate more often with other foals.[60] Foals tend to affiliate and play with one other foal regularly (Fig. 10.17). The nature of the play within these dyads differs according to the sex of the combination, most notably after the first month of life. Tyler[5] indicates that 50% of play involves a colt and a filly, 34% involves two colts and 16% involves two fillies. In the first 8 weeks of life, colts are generally more active and graze less than fillies.[61] Colts attempt to mount their peers or, for that matter, their dam about seven times

Figure 10.14 Pony foal playing with its dam. *(Photograph courtesy of Francis Burton.)*

more often than do fillies,[5] who are seldom seen mounting after the first month.[13] The peak of mounting by all foals coincides with the foal heat. Mounting by foals is tolerated by mares and stallions alike.[58]

The pair-bonds that form between fillies may be lifelong.[2] While pairs of fillies engage in locomotory play and mutual grooming,[54] mock fights are more prevalent and indeed rougher among pairs of colts. Mock fighting includes inhibited biting on the head and neck of the opponent and attempting to unbalance the opponent by pushing against him. Interactive play of this sort may be regularly interrupted by bouts of mutual grooming,[13] occasional mounting[6] and regular flehmen-like responses.[62] It has been suggested that mock fights end with the subordinate player offering a final rear that prompts the higher-ranking player to give chase.[10] Mock fighting also occurs in mixed-sex pairs but it is readily curtailed by outright aggression on the part of the filly if it becomes too rough.[7] It is likely that play between sexes is the natural forum in which colts learn about tactful courtship.[7] Colts that have bonded with colts rather than fillies will nevertheless approach fillies, apparently for mutual grooming.[13] Occasionally, the colt will begin to nibble a filly's hindquarters and sometimes then attempt to mount her. This usually elicits aggression from the filly.

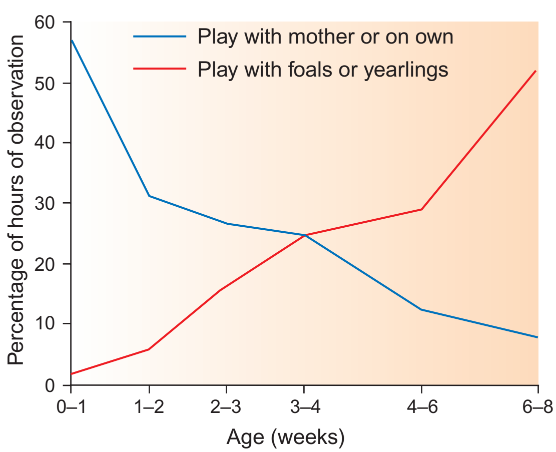

Figure 10.15 The changing complexion of play with age over the first 8 weeks of the foal's life. *(After Tyler.[5] Redrawn, with permission, from Waring.[13])*

Figure 10.17 As they mature, foals increasingly associate with other foals. *(Photograph courtesy of Michael Jervis-Chaston.)*

Figure 10.16 Locomotory play is commonly seen among foals.

Manipulative play

Manipulative play involves nosing, sniffing, licking, nibbling or biting at objects, from stones and sticks to the manes and tails of other horses, and may progress to pulling, lifting, carrying or apparent attempts at throwing.[7] The feet may also be used in manipulation, e.g. when pawing at water or kicking at an object on the ground. Object play seen in foals[58] often follows a repetitive pattern of advancing upon and retreating from the object, with the integration of some locomotory activity. So objects, including other horses, may be the focus of locomotory play as foals circle them and run to and from them.[14]

It has been suggested that, in the absence of conspecifics, providing objects to foals isolated at the time of weaning may improve their welfare.[63] Paddocks give weanlings the opportunity to play, and this may help to explain why they are associated with more normal time-budgeting than stables.[64] In their relative isolation, stabled horses often learn to occupy themselves by manipulating objects in their restricted environment. Water, haynets, chains and bedding provide serviceable playthings.[54] Nipping and nibbling are classic play actions, and horses often chew at wooden rails when confined and on lead ropes when tied-up. Through manipulative play, some horses learn self-reinforcing responses, such as opening stable doors (see Fig. 1.12) and untying themselves.

The social environment of foals influences object play in that foals without peers tend to manipulate objects for longer than socially kept foals.[65] Kiley-Worthington[1] proposes that horses deprived of visual contact with conspecifics may interact with items in their stable to make noise in a bid to keep in touch with others. When owners provide horses with stable toys, they should bear in mind that there is little or no research to confirm their effectiveness in enriching the environment, that the novelty value of such devices can rapidly dwindle and that horses require several toys that can be alternated.[57]

Behavioral anomalies in maintenance behavior

Unmanageable play

Owners sometimes complain about behaviors that, while emerging from a motivation to play and perform vigorous exercise, are nonetheless dangerous. While examples in ridden horses include bucking and pulling at the gallop, similar problems on the ground include pulling away at the time of turn-out, and rearing in hand. These are manifestations of the horse being other than under stimulus control. Horses that are fed too much grain are prime candidates for exuberant locomotory displays. This trend is compounded by their being the horses that generally spend most of the day confined. Fortunately, the managers of stable yards in which play gets out of hand are beginning to appreciate the need for relatively more forage in diets and the provision of a recreation area for affiliated inmates.

It is important to remember the role of learning in these responses. Very often they appear in experimental situations and are allowed to be reinforced. For this reason, thoughtful riders never allow horses to begin to find rewards in pulling but instead respond to playful bucking by reducing the pace and returning to the spot where the buck occurred in a bid to show the horse that it is not effective as a means of progress. Horses that are allowed to pull under-saddle rapidly habituate to bit pressure and soon become horses that can bolt. This is one of the reasons some racehorses are difficult to re-educate as safe riding animals for leisure. Therefore, the racing industry should recognize that heavy hands make horses lean on the bit, and are responsible for considerable wastage. Grading-up to a more severe bit is a very short-term solution to the problem, which lies not so much in the horse's mouth as at the other end of the rein. With consistency at its core, retraining as discussed in Chapter 13 is the best means of preventing battles between horse and rider from escalating.

Interactive play under-saddle can cause horses to use agonistic responses when jostling for position as they begin vigorous exercise – for example, at a place in a familiar route that has become associated with faster gaits. The danger here is that because communication between such horses is compromised by human intervention, both horses and riders may be injured. The safest approach to this contingency is to keep ridden horses at least one body length apart and to keep higher-ranking horses that may be more likely to kick if they are inadvertently challenged, at the back of the group.

Because they are impressionable and can quickly find reinforcement in locomotory play, youngsters should always be handled by experienced personnel. Preventing inappropriate responses not only involves eliminating inappropriate learning opportunities, but also instituting a routine in husbandry techniques. For example, prior to turn-out, it is excellent practice to turn all horses round to face the gateway through which they have just passed. With this routine in place, youngsters learn that they must change direction before being released and this has a tempering effect on the speed with which they pass through the gateway. Older horses, which may kick out simply as a form of post-inhibitory rebound after confinement, are always released facing a direction that is safe for personnel.

Refusal to lie down

While a horse that shows increased resting should be examined for other evidence of illness,[35] less recumbency than normal is also a cause for concern. Refusal to lie down has been listed among 'vices and bad habits'.[66] It was unwelcome because it was often associated with a lack of musculoskeletal rest, and a resultant abbreviation of the horse's working life. The popularity of standing stalls may have contributed to this complaint's prevalence. When 16 mares were confined in standing stalls for 6 months, 9 were not observed in recumbency (on videotapes that recorded each horse for 24 hours every week), suggesting that horses with no previous experience of such confinement may be reluctant to lie down.[41] Thirteen of the mares dropped to their knees at least once during the 6-month observation period, a response attributed to their being in REM sleep while standing.[41] (Readers are directed to Chapter 3 for a consideration of narcolepsy.)

Although horses spend 90% of their time standing and when they lie for longer than is typical there may be a health or welfare problem,[64] it is important that provision be made for them to lie down whenever they wish.[67] While reluctance to rise is associated with musculoskeletal disorders and most commonly lower limb pain (most notably laminitis),[13] reluctance to lie down may occur through:

- neophobia, e.g. in a new stable
- confinement and perhaps fear of becoming trapped in a particularly small stable
- inappropriate substrate, e.g. lack of bedding for a stabled horse or lack of dry surfaces for a horse at pasture
- pain, e.g. an arthritic horse may be disinclined to lie down because lying down and, more especially, standing up may be associated with pain.[33] Pain is also the reason horses show reluctance to lie down as a feature of peritonitis and purpura haemorrhagica.[13]

Inappropriate responses to being groomed

While some horses enjoy being groomed to the extent that they attempt to return the favor and in so doing inadvertently hurt, or more frequently alarm, their grooms, others find the intervention ticklish, distressing or even painful.

Hand-reared foals and single foals that attract the status of pets are more likely to regard humans as suitable mutual grooming partners. Key trigger spots are the part of the neck and withers in which foals find grooming most gratifying (for physiological reasons discussed in Ch. 2). The unwelcome consequences of early learning of this sort should be considered before misguided personnel are permitted to indulge a foal's attempts to reciprocate. Occasionally, owners actively encourage this form of bonding in juvenile and mature horses, despite horses having powerful jaws that can cause inadvertent damage to human skin[54] (Fig. 10.18) but the majority find it inappropriate and seek to eliminate the response. Direct punishment by hitting the muzzle is inadvisable, since it frequently makes the recipient head-shy. To shape the behavior more appropriately handlers should apply negative punishment by stopping

Figure 10.18 Mutual grooming between horse and human. When they have their withers scratched, many horses will attempt to reciprocate as a form of mutual grooming. In most cases this is discouraged because people are fearful of being bitten. *(Photograph courtesy of Sandro Nocentini.)*

the reinforcing stimulation of these premium areas when the horse turns its head toward them. The horse quickly learns that to receive more of the preferred attention it must face away from the groomer.

Breed and individual differences in skin sensitivity through different parts of the body should be accommodated by selecting brushes and modifying brushing technique so that minimal reaction is evoked.[2] The alternative to this considerate, adaptive approach is to simply persist in tickling and annoying the horse, which is likely to signal its frustration with tail-swishing. If this signal is ignored, the behavior may mature to kick threats and eventually kicks. This effectively lowers the horse's threshold to kick and makes it generally more dangerous to be around. Since sensitivity, especially in the groin, is innate, it requires extensive innocuous stimulation before any habituation occurs and, moreover, it is a feature likely to return after a period without stimulation.

Sensitivity in the girth region has been considered part of the so-called cold-back syndrome, an abiding equine enigma that seems related more to somatic pain than wilful disobedience or a desire to avoid work. While it is certainly possible to modify aspects of the evasive strategies learned by horses that seem to suffer such pain, therapy should focus on controlling or eliminating the pain.

Many horses find some husbandry techniques, such as tail and mane pulling, distressing. The repeated use of the twitch to accomplish routine procedures in such horses does nothing to reduce their anticipation of the distress caused by the intervention and, indeed, handling is often made yet more difficult when the horse learns to evade the twitch. Instead of struggling intermittently with a distressed animal and teaching it to struggle more the next time, or waiting for learned helplessness to occur, stable managers aiming for long-term success gradually combine small tolerable exposure to stimuli associated with the procedure before the arrival of meals as the first step in a counter-conditioning program.[68]

Another management technique that can present problems is trimming ear hair. Some humans find ear hair unacceptable, but its function seems related to preventing entry of foreign bodies so its removal is difficult to justify for purely esthetic reasons. Occasionally a build-up of wax on the aural hair can be removed with judicious use of scissors, but pulling such hair is inhumane and the proximate pain involved has the potential to teach the subject to be head-shy after remarkably few lessons.

SUMMARY OF KEY POINTS

- Grooming plays a major role in maintaining health.
- Stabling can compromise a horse's ability to perform many normal maintenance responses.
- Mutual grooming facilitates social bonds.
- The quantity and quality of sleep can be influenced by age, rank, group size, diet and environmental stimuli.
- Prior to 1 month of age, play is more likely to be solitary or with the mother.
- After 1 month of age, play is more likely to be with peers.
- Play is important in physical and social development.

Case study

A 12-year-old Thoroughbred mare had learned to nip her owner when having her girth tightened and to do so very deftly and with little warning. She had learned to get her head out of the way very quickly to avoid punishment but at the same time she was becoming tense and rather head-shy during this part of the tacking-up process.

Before the mare's behavior could be modified the eliciting causes were investigated. The mare was highly reactive to palpation in the girth region. The unusual sensitivity and muscular guarding was ameliorated only slightly by a short course of non-steroidal anti-inflammatory drugs, and the hyper-reactivity of the girth region was considered to be a chronic condition that could be managed (in conjunction with the use of long-term analgesics) rather than cured. Managing the condition involved purchasing some new saddlery and instituting a novel girthing routine:

- the saddle was re-fitted so that it gave a great deal of clearance over the withers
- the existing girth was replaced with a sheepskin-covered cushioned girth with 10–15 cm of elastic at either end.

To overcome the context-specific elements in the mare's response, she was moved to a new part of the yard at the start of the new routine. Palpation of the pectoral region and the thoracic region medial to the elbows was conducted in conjunction with counter-conditioning. If the mare kept looking forward and did not swing her head when touched in these areas she was rewarded with scratching of the lower neck and withers or premium food items.

It was important to implement control of the head movements with consistent commands from the handler. Using the pressure-release system detailed in Chapter 13, the head was turned by pressure on the headcollar to teach the mare that it was appropriate to turn on command. She was rewarded for these turns with rubbing on the forehead and then the head was manually turned back, followed by more rewarding. This palpation program was applied twice daily for 1 week before any girthing.

In a bid to break down learning from previous episodes, the girth was fastened from the off-side. The horse was led around the yard three or four times before the forelegs were stretched to smooth the skin under the girth and were held in the stretched position for 30 seconds before being returned to the ground. In addition to mounting from each side, mounting from a block or some other support became obligatory regardless of the weight of the rider. Once mounted, the rider gradually tightened the girth with one hand while scratching the lower neck and withers with the other.

Two months after presentation, the biting had stopped completely. The mare could best be described as tolerant of the girth. The search for a more substantial cure for her primary girth pain continues.

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Behavior of the stallion

CHAPTER 11

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Free-ranging harem-maintenance behavior

Observations of free-ranging horses have provided numerous examples of the ways in which we restrict the behavior of managed stallions, restrictions that can lead to aggression and reduced fertility, libido and behavioral compliance.

Herding is usually employed by stallions to move the family group away from a threat such as a single stallion or another group. Free-running stallions typically herd together a harem of mares as a relatively stable social unit. They tend to recruit and retain mares most effectively when 6–9 years of age.[1] The upper limit on the size of harems relates to the fact that if a stallion monopolizes too many mares he loses the ability to dissuade other males from performing sneak matings.[1] Sometimes juvenile males, old stallions and, more occasionally, mares cooperate with the harem stallion in his herding activities. This herding behavior can be used to tighten a band or to move interlopers out of or, occasionally, non-member females into the group. Herding, characterized by the neck snaking from side to side, is also seen during courtship, its aim being to transiently distance the mare from the harem for copulation.[2] Cohesion of the group contributes directly to biological fitness because, for example, invasion by non-member stallions can induce abortion and bring mares into season for subsequent mating by invading males.[3] Vigilant herding is most evident after a harem mare has foaled. At this time the stallion works to maintain a greater than usual distance from other bands, perhaps because this helps him to capitalize on the fact that free-ranging mares peak in fertility during the foal heat.[4]

Sometimes low-ranking males, notably the sons of low-ranking mares, form lifetime alliances in which both stallions have mating rights and cooperate to defend their mares from intruding males.[5] The balance of the pair is rarely equal, with the subordinate stallion siring approximately one quarter of the harem's brood. This compares favorably with the success of sneak matings that represent the only alternative for non-alpha males.[5] However, reciprocal altruism and mutualism do not occur in multi-stallion groups. Linklater & Cameron[6] reported a positive relationship between aggression by the dominant stallion toward subordinate stallions and the subordinates' effort in harem defense, which was negatively correlated with the extent to which these stallions were seen to consort with harem mares. Perhaps because they undergo more social flux than single-stallion groups, multi-stallion groups are associated with more aggressive interactions and reduced foaling rates – hence, the suggestion that there is selection pressure for single-stallion groups.[7] The various agonistic responses that arise between stallions appear in Table 11.1.

The harem stallion exhibits characteristic, even ritualistic, responses to urine and feces of harem members. It is believed that olfactory characteristics of these materials inform the stallion of the reproductive status of the mares while his responses to them serve to maintain the harem. Stallions are more responsive to olfactory stimuli from conspecifics than are mares and geldings.[8] Contact with urine, feces or vaginal fluids during courtship and copulation occurs and forms an important part of the mating behavior, resulting in a flehmen response by the stallion.[2] Pawing, sniffing and flehmen are followed by his depositing small amounts of feces or urine on top of previously voided material.[9,10] The stimuli offered by fecal material are discussed in detail in Chapters 6 and 9.

Development and maintenance of sexual behavior in free-ranging stallions

From the first weeks of life colts demonstrate mounting attempts, mainly on their dams. These attempts are rarely accompanied by pelvic thrusting. Erections have been observed in colts as young as 3 months of age but these are of minimal import to a herd since the mature stallions monopolize estrous females and, in any case, spermatozoa are not found in testes before 12 months of age. Spermatogenesis lags behind hormonal maturity. Fertility does not increase significantly until the colt is approximately 2 years old with the histological transition from the pre-pubertal to the post-pubertal stage occurring at a mean age of 27.8 months ($n = 28$).[12]

Most colts leave the natal band and join bachelor groups around the time of the birth of their siblings.[13] For example, in one study of Misaki feral horses in Japan, 17 of 22 colts left their natal bands at this time.[13] Scarcity of resources is also regarded as a common cause of voluntary separation.[14] So, as colts become steadily bolder with age and playmates disperse, they may gravitate toward bachelor groups in search of recreation.[15] Beyond the age of 3 years, remaining young males may be forced to leave the harem group during the breeding season as a result of increased aggression by the harem stallion.[2,14]

The behavior of young stallions can then be considered in two stages. The first is a developmental stage in which the colts that have just dispersed from the natal band (between 0.7 and 3.9 years of age in Misaki horses) engage more in social play than agonistic behavior, while the second is a pre-harem formation stage, which involves departure from the bachelor group.[16] The separation of the highest-ranking stallion from the subordinate males has significant behavioral and physiological consequences.

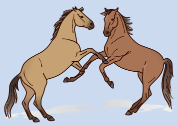
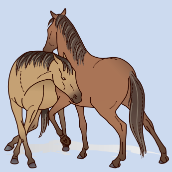
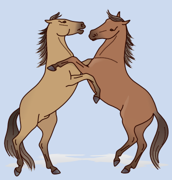
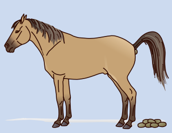
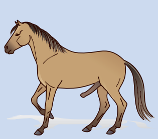
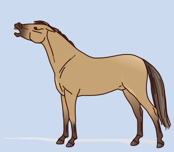
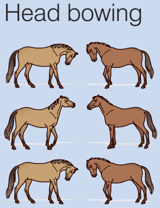
The status of the stallion is broadly correlated with androgen activity. Testosterone concentrations increase with the age of stallions until they form their own harems.[15] Furthermore, for individual stallions, testosterone concentrations are correlated with harem size.[15] So, in a harem stallion, sexual and aggressive behavior, accessory sex-gland activity, testicular size and semen quality are enhanced by the dispersal of potential challengers. Meanwhile, stallions becoming bachelors undergo changes in the opposite direction[3,11] and may show signs of concurrent depression (Sue McDonnell, personal communication 2002). Paradoxically, some domestic stallions may redevelop their libido when another stallion is brought to the breeding area, and some slow-breeding novice stallions seem to increase their arousal when given the opportunity to watch other stallions copulate.[9]

It is worth noting that despite low androgen concentrations, agonistic behavior, including mock and serious fighting, is a conspicuous characteristic of bachelor groups.[11] Continued studies of bachelor groups could serve to further challenge the traditionally held view that stallions are innately aggressive and somehow deserving of isolation.[17]

Free-ranging matings

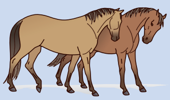
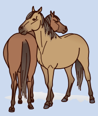
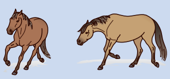
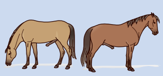
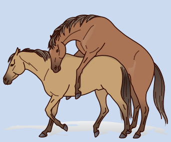
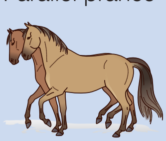
Prolonged pre-mating interactions are the norm for all free-ranging equids. Harem stallions discriminate among mares, according to their maturity and length of residency in the harem. As evidenced by the increased frequency of flehmen responses, olfactory stimuli help to identify estrous mares, but they are supported by visual and auditory cues from the mare.[18,19] Always favoring mature harem mares, the harem stallion will often ignore young estrous mares (from both his and other harems) and actively chase away mature mares from

Table 11.1 Features of the agonistic ethogram (as described for bachelors[11]) that are particularly common among and between stallions

Response	Description
Boxing 	Two stallions in close proximity simultaneously rearing and striking out with alternate forelegs toward one another
Circling 	Two stallions closely beside one another head-to-tail, pivot in circles, usually biting at each other's flanks, groin, rump and/or hindlegs. With prolonged circling, the stallions may progress lower to the ground until they reach a kneeling position or sternal recumbency, where they typically continue to bite or nip one another
Dancing 	Two stallions rear, interlock the forelegs and shuffle the hindlegs while biting or threatening to bite one another's head and neck
Defecate over 	Defecation on top of fecal piles in a characteristic sequence: sniff feces, step forward, defecate, pivot or back up, and sniff feces again
Erection 	Fully extended and tumescent penis. Observed during mildly and moderately aggressive encounters. Bachelors will mount one another with an erection and anal insertion has been observed
Flehmen 	Head elevated and neck extended with the eyes rolled back, the ears rotated to the side and the upper lip everted exposing the maxillary gums and incisors. The head may roll to one side or from side to side. Typically occurs in association with olfactory investigation of feces
Head bowing 	A repeated rhythmic flexing of the neck such that the muzzle is brought toward the point of the breast. Head bowing usually occurs synchronously between two stallions when they first approach each other head-to-head

(*Continued*)

Table 11.1 (Continued)

Response	Description
Head bump 	A rapid toss of the head that forcefully contacts the head and neck of another stallion. Usually the eyes remain closed and the ears point forward
Head on neck, back or rump 	The chin or entire head rests on the dorsal surface of the neck, body or rump of another horse. This often precedes mounting
Herding 	Combination of head threat and ears laid back with forward locomotion, apparently directing the movement of another horse. When lateral movements of the neck occur, the horse is said to be snaking
Kneeling 	Drop to one or both knees, by one or both stallions engaged in face-to-face combat or circling with mutual biting or nipping repeatedly at the head and shoulders and knees
Masturbation 	Erection with rhythmic drawing of the penis against the abdomen with or without pelvic thrusting. This is a solitary or group activity
Mount 	Stallion raises his chest and forelegs onto the back of another horse (be it a mare in a breeding context or another male in a bachelor group) with the forelegs on either side. Also seen primarily in bachelor groups are prolonged partial mounts, typically with lateral rather than rear orientation and often with just one foreleg across the body of the mounted animal. In a behavior similar to the initial mount orientation movements (termed head on neck, back or rump) the forelegs will not actually rise off the ground. Mounts and partial mounts may occur sequentially or independently of one another
Neck wrestling 	Sparring with the head and neck that may involve one or both protagonists dropping to one or both knees or raising the forelegs
Parallel prance 	Often seen immediately prior to aggressive encounters, two stallions move forward beside one another, shoulder-to-shoulder with arched necks and heads held high and ears forward, typically in a high-stepping low cadenced trot (passage, in dressage terminology). Rhythmic snorts may accompany each stride. Solitary prancing also occurs
Posturing 	Posturing describes a suite of pre-fight behaviors that includes head bowing, olfactory investigation, stomping, prancing, rubbing and pushing, all with neck arching and some stiffening of the entire body
Sniff feces 	Approach and sniff a pile of feces or a fecal pile, usually as a part of a fecal pile display. Often associated with some pawing, this is almost always followed by defecating over the feces and again sniffing the pile

other harems.[20] Free-running stallions usually interact with sexually active mares or their excrement for many days before copulation. Often these encounters can be counted in hundreds per day.[20] Because stallions can differentiate the sex of a horse on the basis of its feces (not its urine), it has been suggested that sampling of feces is extremely informative for a stallion when monitoring the cyclicity of females in his harem.[10]

When he has located an estrous mare, or she has located him, the harem stallion will often attract her attention by whinnying from a distance and then pawing the ground, prancing and nickering as he approaches. Once these preliminaries have taken place, the mare actively contributes to precopulatory behavior.[21] To illustrate, it has been demonstrated that 88% of sexual interactions that lead to successful copulation begin with the mare approaching the stallion.[20] An important trigger of the stallion's physical sexual arousal seems to be the head-to-head approach by the mare toward him, followed by her moving forward or swinging her hips toward his head.[20]

A stallion's method of determining a mare's receptivity is to nuzzle and push her hindquarters. Pre-copulatory behavior demonstrated by the stallion includes sniffing, nuzzling, licking and nibbling or nipping the head, shoulder, belly, flank, inguinal and perineal regions of the mare (Fig. 11.1).[2,20,22] These prompts may elicit a mildly aggressive display by the mare, despite her being in full estrus. However, as this aggression subsides, the mare tolerates closer approaches by the stallion. Further arousal results when positive feedback is received from the mare.[23]

Pre-copulatory behavior continues until the mare's stationary 'sawhorse' posture cues the stallion to mount. Mounting may occur without erection. Studies have shown that mounting without an erection is common and has been demonstrated among highly fertile pasture-breeding horses.[2] The number of mounts without an erection is typically 1.5–2 times the number of mounts with erection.[2] In free-ranging equids, mounting with an erection almost always leads to insertion and ejaculation. While young inexperienced stallions typically mount laterally and then adjust their position, mounting by mature males is usually achieved by an approach from the rear. Although they may ejaculate sooner than their more experienced peers, colts take significantly longer to achieve an erection (after first seeing an estrous mare) and to mount.[24] Once he has mounted correctly, the stallion grasps the mare's iliac crests with his forelegs while his head leans against her neck, and he often nips or grasps her mane with his teeth.[2]

Free-ranging pony stallions achieve intromission during the first mount in 55% of copulations.[25] Successful intromission (Fig. 11.1) during subsequent attempts is facilitated if the mare remains stationary. Intromission is generally accomplished after one or more seeking thrusts and is often marked by the stallion closely coupling up to the mare and paddling his feet as if attempting to ensure that they are on a firm surface.[2] An average of seven pelvic thrusts[26] occur before ejaculation, which is characteristically indicated by:

- flagging of the tail (associated with transient shrinkage of the urethral lumen and six to nine spurts of ejaculate)[27]
- rhythmic contractions of the muscles of the hindlegs
- an increase in respiratory rate
- drooping of the stallion's head against the mare's mane.

The period from intromission to ejaculation is usually 10–15 seconds, with young males tending to take less time.[23] After ejaculation, the stallion often appears dazed as he relaxes on the mare's back and his penis becomes flaccid. Once the stallion has regained his alertness, the mare steps forward, easing the stallion's chest over her hindquarters, so that he lands gently on his front feet.[27] The mean interval between the end of ejaculation and the start of dismount is eight seconds (Table 11.2).[23]

The stallion's post-copulatory behavior often includes sniffing the mare's vulva, as well as the spilled ejaculate or urovaginal secretions of the mare, and this typically prompts the flehmen response.[28] After ejaculation, the stallion and mare generally uncouple within 3–15 seconds, with the mare being first to move away in 60% of cases and the stallion in 26%, although occasionally the mare follows.[25]

Mares and stallions will often separate from the harem group during courtship and mating. Although the pre-copulatory interactions with mares may last several days, the copulatory interactions themselves frequently last for less than a minute. While breeding rates as high as 18 per day have been recorded,[2] the daily mean for adult stallions is 11.[23] The refractory period after ejaculation appears to be shorter in free-running stallions than in their intensively managed counterparts.[20]

Seasonality

Stallions possess an endogenous circannual reproductive cycle that is responsive to photoperiod.[29] Timed to synchronize with the emergence of mares from winter anestrus,

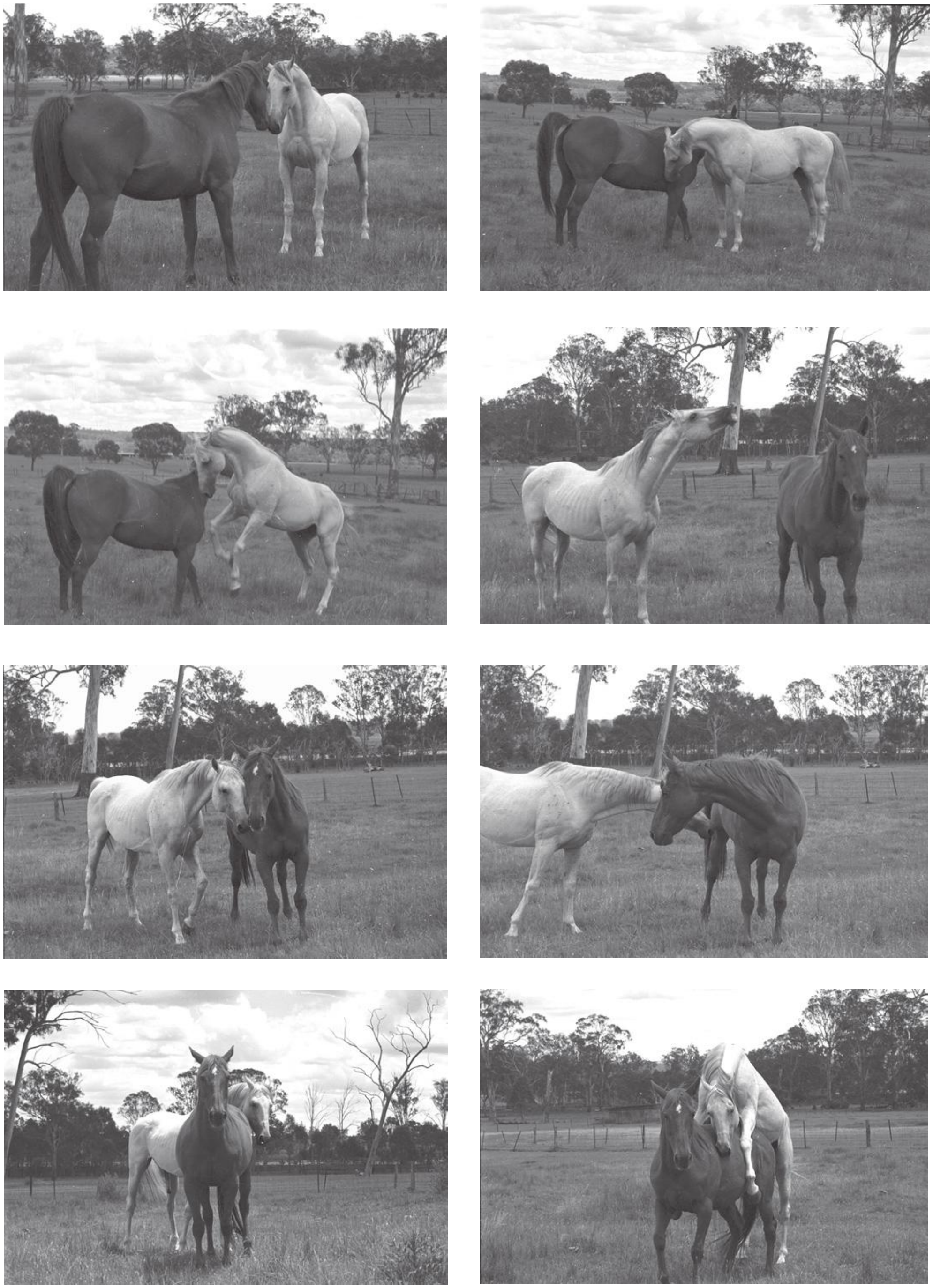


Figure 11.1 Courtship and copulation in the horse. *(Photographs courtesy of Michael Jervis-Chaston.)*

the responsiveness of stallions to sexual cues increases in spring and is maintained until the beginning of autumn but never completely disappears. The seasonality in testosterone concentrations[15] is reflected in semen quality and can also influence the number of mounts per ejaculation, latency to achieve intromission, frequency of biting and striking.[30] The prevalence of spontaneous erections in masturbating stallions also increases with day length.[31]

Table 11.2 Typical frequency and latency of copulatory behaviors by young and adult domestic stallions

	Typical value	Range
Frequency of responses		
Sniff or nuzzle	3	0–80
Lick	0	0–20
Flehmen response	2	0–10
Nip or bite	0	0–25
Kick or strike	0	0–10
Vocalization	3	0–35
Number of mounts	1	1–3
Number of thrusts	7	2–12
Latency of responses (seconds)		
Time to erection	10	0–500
Time to first mount with erection	15	10–540
Time from mount to insertion	2	1–5
Time from intromission to first emission	15	8–20

After Waring et al[24] and McDonnell.[2]

The artificial breeding season that starts in late winter for many breeds (such as the Thoroughbred, Standardbred, Quarterhorse and Arabian) may contribute to reports of low sexual vigor. The physiological season can be brought forward in young and middle-aged stallions by placing them under artificial lights, which can increase testicular size and sperm output.[32] It is interesting to note that no deleterious effects on fertility have yet been reported in shuttle stallions that work two seasons per year by being shipped between northern and southern hemispheres.[32]

Traditional stallion management

The value of many stallions and the risk of injury through fighting are the principal factors that drive their owners to stable them and minimize unsupervised contact with other horses. By clipping out elements of the harem stallion's sociosexual behavioral repertoire, hands-on stallion management can leave the entire male equid with the opportunity to perform only brief pre-copulatory interactions (Fig. 11.2).[20] The resultant arousal and thwarted motivation can contribute to the handling difficulties some stallions present.

Figure 11.2 A stallion testing olfactory stimuli from an estrous mare.

Domestic breeding stallions are generally maintained in physical isolation, either stabled alone or near other stallions.[33] Breeding farms with more than one breeding stallion often stable all the stallions together, away from the mares, in a stallion yard. This management regime has the potential to impose some characteristics of the bachelor group on some occupants of the yard. McDonnell[20] found that the bachelor status of stallions could be effectively reversed by housing them in a barn with mares or in a paddock adjacent to mares. Regardless of the season, libido, testosterone concentrations, testicular volume and efficiency of spermatogenesis increase once the trappings of bachelor status are removed.[3]

While most stallions over 20 years of age retain their libido, few maintain competitive sperm counts. The decline of this fertility parameter begins at approximately 10 years of age. Testosterone concentrations 36 hours before and after injection of human chorionic gonadotropin (HCG) may help to detect declining reproductive function in aged stallions.[34]

Domestic stallions are generally permitted to copulate in three situations:

- pasture mating
- in-hand breeding (Fig. 11.3)
- semen-collection (for artificial insemination).

While pasture mating usually follows the template of free-ranging horse behavior discussed above (except that stallions are sometimes separated from their mares during anestrus), in-hand breeding and semen-collection involve some radical departures from the normal ethogram.

Figure 11.3 If the mare has been properly teased and is truly receptive, minimal restraint is required for in-hand breeding. *(Photograph courtesy of Michael Jervis-Chaston.)*

Compared with equids breeding at liberty, in-hand breeding stallions show lower rates of sexual vigor and fertility and higher rates of sexual behavior dysfunction. This may be because the selection of breeding animals adopts inappropriate criteria and perhaps favors stallions that would not achieve harem stallion status in a free-ranging context. Stallions at pasture are generally capable of breeding nine times (every 2.5 hours) throughout the day and night with sustained fertility, while in-hand breeding stallions show diminished rates of fertility when bred more than once or twice daily.[20,22,35]

Ginther[36] found that a stallion will copulate with one estrous mare repeatedly, even when more than one mare is in estrus. Stallions breeding at liberty have been observed to copulate twice with the same mare during a 7-minute period, while other stallions have copulated three times with two mares during a 2-hour period.[2] While free-ranging equids are able to interact year-round on a moment-to-moment basis, domestic stallions are typically allowed minimal contact with mares other than brief limited interactions immediately before copulation.[20] McDonnell[20] concludes that it is remarkable that stallions denied the natural length of interaction are considered to have a normal breeding career. Human success in maintaining a stallion's performance under these conditions relies on most stallions being able to respond to suboptimal stimuli, either naturally or as a result of conditioning.

Vesserat and Cirelli[37] found that the conception rates of in-hand breeding were in the range 55–60%, while with pasture-bred horses conception rates per cycle were 75–85%. This is largely because more matings are performed at pasture than is expected with in-hand mating.[22] Pasture-bred pregnancy rates at the end of the breeding season can reach 100%,[38] but herd management must be optimal. The best foaling rates (in Icelandic horses) on pasture are achieved when no more than 15 fertile cycling mares per stallion are run for one heat cycle, or a maximum of 20 fertile cycling mares per stallion if they remain as a group for two heat cycles (6 weeks).[39]

Factors affecting sexual responses in the stallion

The quality of sexual responses in domestic stallions may vary considerably because it is under the influence of a number of factors, including previous experience and current stimuli.

Individual preferences

Occasionally, stud owners report a stallion's preference for small mares. In these cases, it pays to conduct a thorough examination of the musculoskeletal system before assuming that this is an innate response. Intriguing color preferences have also been reported. For example, there is a report of a stallion selecting and running with only buckskin (dun) mares.[28] One must remember, however, that the affiliation between mares and their filly daughters is often very strong indeed and the effect this has on the color distribution of a natal band may offer an alternative explanation for the apparent preference.

Visual stimuli

In most stallions, an overtly estrous mare will elicit a stronger sexual behavioral response than a breeding dummy or ovariectomised mare.[2] Movement of the receptive mare as she turns from a head-to-head to hips-to-head presentation can have a strong arousing effect on stallions.[20] It is likely that restraining the mare reduces the extent to which she can send solicitous expressive movements.

Typically the receptive mare urinates frequently and takes longer than normal to step out of the urination straddle. With her tail raised and slung to one side (most notably if she is a horse, rather than a pony) she winks her vulva repeatedly to deliver a flashing signal. A stallion responds to all of these cues by approaching and starting to tease her, which elicits further visual cues that signify receptivity in his prospective mate. Hostile signaling by a non-receptive mare includes laying back her ears, tail-swishing, kicking and biting. This is usually accompanied by squealing. A receptive mare is largely passive once she is in a hips-to-head position, but may actively present herself with a raised tail in response to the stallion's nuzzling.

Olfactory stimuli

The odor of an estrous mare's genital region and her urovaginal discharges contributes significantly to a stallion's arousal.[40] This accounts for the use of such fluids when training stallions for semen collection. The fluids cause a generic rather than specific response, since although stallions have been shown to discriminate between the urovaginal secretions of individual mares,[8] olfaction appears to contribute to sexual arousal less than vision.[41]

Learning

Sexual behavior of domestic stallions is clearly influenced by experience and learning (Fig. 11.4), with breeding stallions learning by classical conditioning (see Ch. 4) to respond sexually to non-sexual stimuli associated with breeding. For example, in stallions bred in-hand, the service bridle, the service area and even key personnel can become conditioned stimuli that can cause arousal and erection.[9] The importance of voyeurism in educating novice stallions should not be overlooked (see Fraser Darling effect in Glossary) since many free-ranging colts show keen interest when the harem stallion copulates.

Stallions used for semen collection are expected to show sexual responses to a dummy. While occasional stallions will respond immediately to the dummy, most require the supportive effect of a transitional stimulus mare as an adjunct to several ejaculations with the dummy before reliable conditioning takes place. Teasing the stallion with a mare across the rear of the dummy is a particularly useful technique for developing the correct association.

Well-trained stallions distinguish themselves in the breeding shed by their tolerance of human interventions such as penis washing, while remaining responsive to conditioned commands used in the service area. The strength of innate responses and the role of learned associations have been quantified by comparing the responses of naïve and sexually experienced stallions

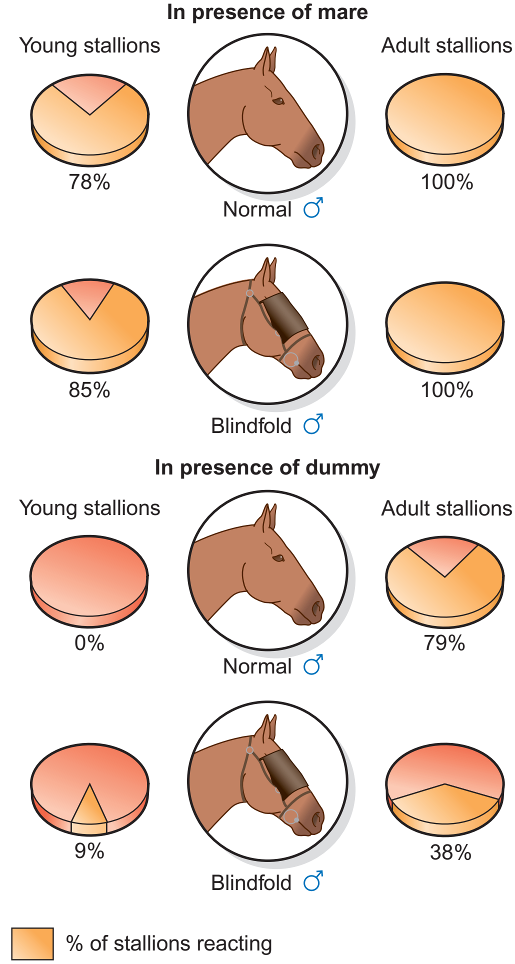


Figure 11.4 Stimuli affecting the sexual responses of naïve and experienced stallions (after Wierzbowski[42]). Stallions visually assess mares (and dummies) as they approach to mount. Without the benefit of learning, naïve stallions may be more likely to mount when blindfolded because they are unaware of visual stimuli that are discouraging to them (e.g. threats in the case of mares) or simply inadequate (in the case of a dummy).

when presented with a variety of stimuli.[42] Sometimes libido becomes dependent on such conditioned stimuli and a program of generalization (see Ch. 4) is required to break down the association between such discriminative cues and sexual outcomes. While weaning these stallions off their discriminative stimuli, changes in routine have to be introduced very slowly.

Learning applies equally in the development of abnormal sexual responses. Many stallions that learn to associate the breeding area with negative experiences (such as harsh discipline) will eventually become problem breeders and will require retraining.[30] As a result of inadvertent and inappropriate conditioning, fertile stallions may show minimal libido, so sexual responses are not reliable indicators of fertility.

Sometimes a change of service area can be sufficient to overcome context-specific reluctance to mount.[9] Simple changes to management practices that allow greater mobility of the mare and less alteration of her normal estrous posture, seem to make her more attractive and enhance the sexual responsiveness of the stallion.[3]

Safety concerns are paramount when dealing with breeding stallions and mares, but modification of sexual congress in domestic equids to resemble more closely that of their free-ranging counterparts has been shown to increase sexual arousal and to reverse sexual dysfunction.[2]

Pharmaceuticals

Descriptions of the effects of numerous pharmaceuticals on stallion behavior appear elsewhere in the literature.[35] That said, relatively little is known about endocrine control of reproduction in the stallion, but gonadotropins are considered pivotal in the regulation of libido and spermatogenesis. This is supported by the effects of Antarelix, a potent GnRH antagonist that reduces libido and plasma concentrations of gonadotropins, testosterone and estradiol within 48 hours of administration.[43] Gonadotropin and testosterone secretion can be stimulated by GnRH analogues, but chronic treatment can impose a reversible drop in sperm production and libido.[44] It has been suggested that because exogenous testosterone proprionate implants reduce spermatogenesis, they may be useful in controlling fertility, for example, in feral horses.[45]

Anxiolytics may reduce fearfulness in stallions that have developed negative associations with breeding.[46] The stimuli that are most commonly responsible for reduced libido are linked to the presence of humans.[46] However, the use of anxiolytics in the absence of behavior modification is not recommended.

Some pharmaceuticals have side effects that may profoundly compromise the usefulness of breeding stallions. For example, reserpine has been associated with penile paralysis and paraphimosis, when used repeatedly (5 mg s.c. every 2 weeks for 2 months) to control unmanageable behavior.[47] Other agents, such as trimethoprim-sulfamethoxazole and pyrimethamine, may affect the pattern and strength of ejaculation (e.g. by altering lumbar flexibility or reducing coordination).[48] Anabolic steroids depress luteinizing hormone concentrations and hence libido and semen quality,[49] while sometimes causing a simultaneous increase in aggression.[9]

Castration

In some senses it is possible to consider geldings as domestic analogues of bachelor stallions (e.g. in terms of their testosterone profiles and behavior toward mares). Most castrations occur between 3 months and 2 years of age, and behavior manipulation is cited as the most common reason for the procedure.[50] Because early castration increases carpal and tarsal measurements,[51] it would be interesting to explore the consequences of prepubertal castration on morphology of the brain.

The social rank of geldings often correlates with the age at which they were castrated. This suggests that experience in male horses prior to neutering influences the behavior afterwards.[52] But surprisingly, delaying castration until a stallion matures has been demonstrated not to increase the risk of stallion-like behavior after castration.[53] Castration reduces the intensity of normal male sexual behavior by reducing testosterone concentrations.[54] Houpt[55] states that the testosterone concentration of a gelding should be < 0.2 ng/mL. Geldings are more responsive to the pacifying effects of progesterone than are stallions. Approximately 90% of mature stallions show low sexual activity within 8 weeks of castration.[56] That said, experienced adult stallions can maintain normal sexual responses for more than a year after castration.[53] McDonnell[20] estimates that up to 50% of geldings show some stallion-like behavior to mares. Indeed we should not expect castration to eliminate all traits that may be considered characteristic of a harem stallion. After all, some sexual behaviors, including teasing, mounting and performing elements of the elimination marking sequence (see Ch. 9), are frequently observed in foals and adolescents of both sexes.[57] Occasionally, geldings in their teens, with normal estrone sulfate and testosterone concentration and no history of use as studs, achieve intromission.[58] Such animals may become more libidinous in response to stilboestrol.[59]

Although the possibility of supplementary hormones generated by the adrenal gland has been raised, aggressive masculine behavior after castration is not usually dependent on hormones.[53,56,58] These significant outliers in the distribution of sex-related responses demonstrate that the brains of male horses are masculinized before birth.[55] Agonistic responses reinforced prior to castration may also contribute to some of the aggression seen in geldings.[60]

There is no evidence for the traditionally held belief that epididymal remnants perpetuate sexual responses after castration.[61] Because castration of cryptorchids can be difficult, it is possible that some testicular tissue and therefore testosterone production can remain after surgery.[62] Plasma estrogen concentrations are useful in discriminating between cryptorchids and geldings.[63] In horses over 3 years of age, estrone sulfate concentration is significantly greater (>10 000 pg/mL) where castration is incomplete than in geldings (>10 pg/mL).[64] For horses under 3 years of age, a single assay of estrone sulfate is not sufficient to make a definitive discrimination. Instead, blood samples for testosterone concentrations must be taken before and 2 hours after the administration of HCG (10 000 IU i.v.).[55] Cryptorchids typically have concentrations >2000 pg/mL, whereas geldings have concentrations <500 pg/mL.[55]

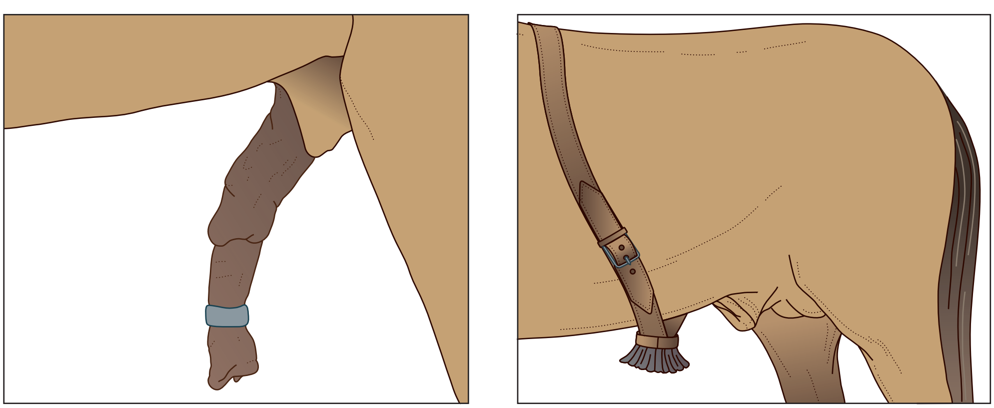
Chemical castration trials, e.g. using GnRH super agonists to down-regulate the pituitary-gonadal axis, have shown some promise.[65] The transient castration of horses is likely to increase the flexibility with which potential breeding animals can be managed.

Masturbation

Many horse breeders traditionally consider masturbation to be an abnormal behavior. However, studies have shown that all free-running male equids, regardless of age, sociosexual environment and harem status, display frequent erections and penile movements (including the penis being bounced against the abdomen) referred to as masturbation, once every 1–3 hours.[2] The extent to which penile engorgement and movement are gratifying in a directly sexual sense is questionable. Either way, spontaneous erection and masturbation are now considered normal responses.[66] Furthermore it is now accepted that ejaculation is seen in only approximately 0.01% of such erections, thus dispelling the myth that masturbation leads to lower fertility rates.[31] Indeed, field and laboratory studies confirm that the levels of spontaneous erection and masturbation are not associated with loss of fertility. Observations of confined stallions have shown that there may be some association between masturbation and REM sleep (see Ch. 10), which occurs only during recumbent rest.[67]

Despite reports that designate the behavior as normal and harmless, many devices exist for discouraging stallions from masturbation (Fig. 11.5). The multiplicity of devices suggests that none of them works universally. Most devices attempt to employ punishment to discourage masturbation. A stallion ring or a brush can be fitted. A stallion ring is a metal or plastic device that is placed on the shaft of the penis, inhibiting erection by physical restriction. The brush is a stiff-bristled brush that is strapped to the belly. These devices can cause abrasions and scarring of the penis (Fig. 11.6).[2] It is not surprising to learn that electric shocks have also been employed to modify erections. Anti-masturbation devices rarely reduce spontaneous erection and penile movement, but in many cases increase the frequency and duration of episodes and often cause penile injury.[20]

Conversely, while arousal may be unwelcome in most horses that are not currently required to mount a mare, it is actively encouraged in teasers. Circumcision of the prepuce and the penile epithelium with subsequent



(A) (B)

Figure 11.5 (A) Stallion ring; (B) brush. *(After McDonnell.[2] Redrawn with permission of Sue McDonnell.)*

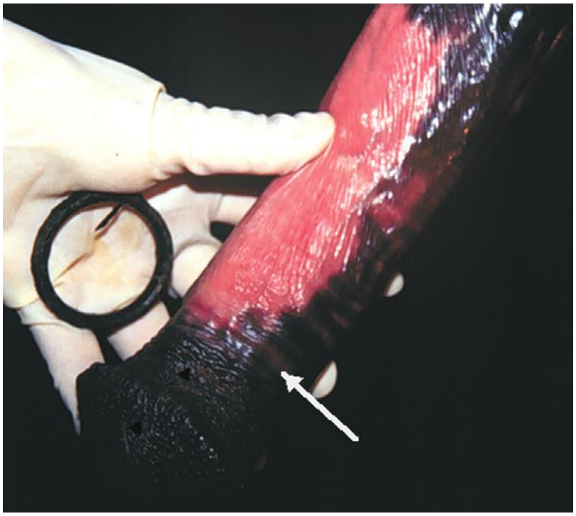


Figure 11.6 A stallion ring (in hand) and penis with a mild circumferential lesion (arrow) caused by abrasion. *(From McDonnell.[2] Photograph by Sue McDonnell reproduced with permission.)*

suturing is still practiced in parts of the world to create teasers.[68,69]

Sexual behavior of male donkeys

Male donkeys are more likely to be found alone than in an organized social unit.[70] They show courtship of a similar duration to that of *E. caballus* stallions but within a territorial sociosexual structure.[71] They also demonstrate significantly more vocalization and posturing (Fig. 11.7) as a prelude to copulation and seem to rely on more overtly active involvement of the female than horses do.[72] Several periods of sexual interactions interspersed with periods of male withdrawal from the female's company are typical.[72] It is a characteristic of male donkeys to take their time to mate. Experienced donkey breeders note that this is a delay that can be extended when the jacks detect novel stimuli. Such apparently innocuous differences as the presence of strangers or even particularly strong wind can cause procrastination for hours.[73]

In some populations, groups of donkeys include subordinate males that are allowed to mate with some of the jennies within the territory of a dominant jack, but this usually takes place only after mating by the dominant jack.[74] Subordinate jacks play a useful role in territorial defense and marking the excrement of the jennies.[74]

Typically jacks develop an erection only after mounting without an erection,[75] and as a normal feature of donkey sexual behavior this should be expected in managed matings. That said, for some, erection is most frequently achieved when they stand at a distance from the jennies.[75] So experienced breeders of donkeys provide males with sufficient space and liberty to approach and retreat from their jennies during courtship.[75]

When selecting jacks for interspecies matings it is usual practice to separate them from other donkeys at weaning and rear them with at least one horse. Although requiring closer scientific scrutiny,[75] this is said to have a profound effect on their later choice of partner to the extent that it is common for a jack raised in this way to refuse to mate with a jenny.[73]

Behavior problems in the stallion

Failure in reproductive behavior

Broadly speaking, there are four aspects of failure to perform in the service area: libido, erectile, ejaculatory and coordination (Table 11.3).[76] Most classes of dysfunction involve both psychogenic and physical factors that must be addressed at the same time. An interesting technique to help distinguish between the psychogenic and physical causes of impotence is to observe the stallion for nocturnal bouts of masturbation because their absence may help to rule out extraneous impediments to performance such as fear of aversive stimuli in the service area.[77]

The serum concentration of testosterone in normal and impotent stallions can be similar.[78] Because the causes are not always distinct from one another, there may be some overlap in treatment. In most cases, behavioral approaches are recommended with the occasional need for pharmacological support. As with all behavior manifestations, a clinical examination may reveal a somatic cause or contribution to the problem. For example, as a result of insufficient lubricant (a result of excessive washing or excessive smegma), a stallion that fails to draw may have a reflected penis that engorges within the sheath.[3]

The web site http://research.vet.upenn.edu/HavemeyerEquineBehaviorLabHomePage/ReferenceLibraryHavemeyerEquineBehaviorLab/LabPublications contains a tremendous amount of information and advice on the behavior and management of stallions. Before attempting to modify the sexual responses of stallions, e.g. for semen collection purposes, readers are advised to visit this site and study the research papers it offers.

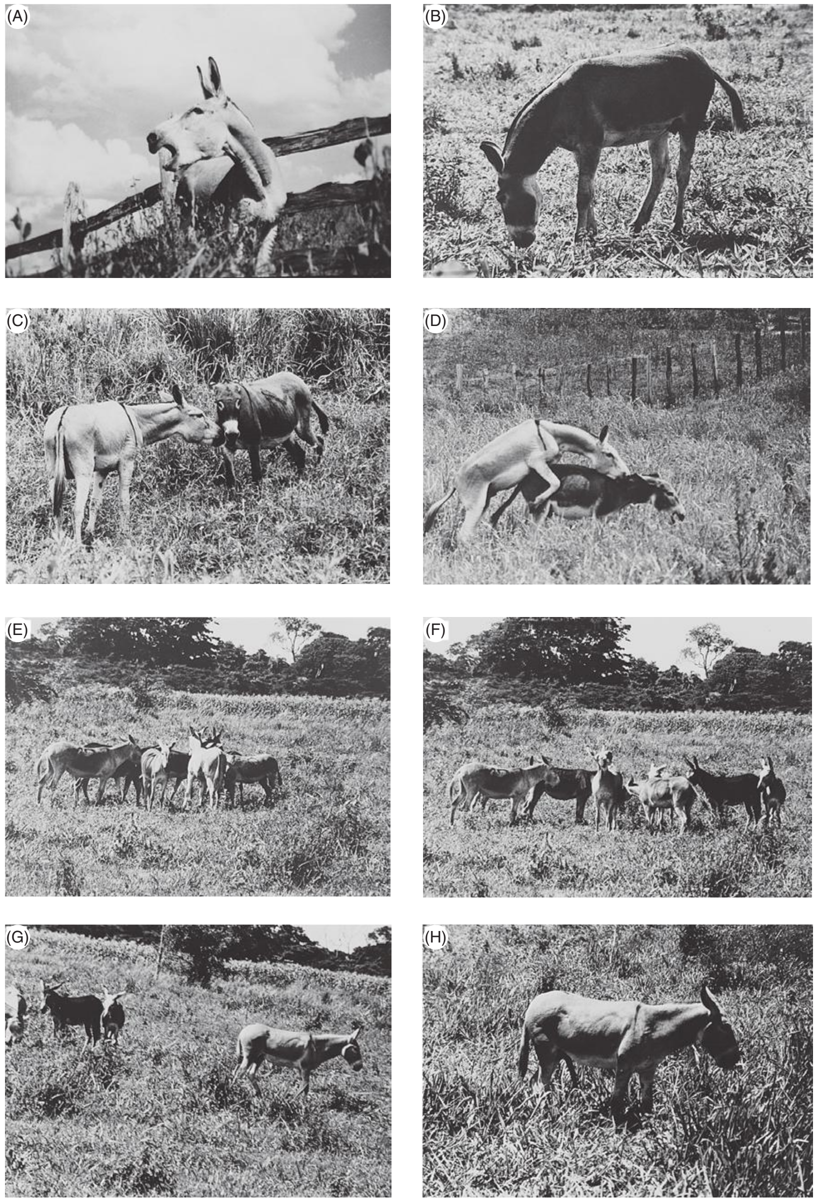


Figure 11.7 Courtship and copulation in donkeys: (A) vocalization by the jack; (B) jack smelling and/or marking feces or urine; (C) individual teasing of an estrous jenny; (D) mount without erection; (E and F) estrous jennies approaching and teasing the jack; (G) jack retiring from the estrous jennies; (H) jack attaining erection while retired. *(Reproduced, with permission of Elsevier Science, from Henry et al.[72])*

Aggression and other handling problems

Prancing and vocalization are normal responses made by a stallion that has seen a mare and should never be discouraged. Nipping and striking are less welcome and can be modified by negative punishment whereby the stallion is led away from the mare or the dummy as an immediate consequence of these responses.[79] Aggression by stallions during sexual congress is associated with freshness at the time of the first matings of the season[31] or failure to ejaculate.[36] Overuse at stud can also result in a stale attitude that manifests as aggression to both mares and handlers.[9]

Table 11.3 **An overview of the ways in which sexual behavior in the stallion may be compromised or mitigated**

Problem	Approach
Reduced libido	
• Prior discipline for erection or masturbation during an earlier career as performance horse • Excessive use of stallion as a teaser • Isolation of stallion • Persistent presentation of a mare the stallion has rejected • Rough handling during matings • Exposure of a young stallion to hostile, unreceptive mares • Move to novel environment • Unstable dummy • Previous or current lesions on penis	• Eliminate any causative factors, including the presence of humans associated with negative stimuli • Behavior modification: gradual shaping of approach and arousal with positive reinforcement and tolerance of minor flaws in sexual response • If using an artificial vagina, increase stimulation of penis after identifying individual stallion's preferred liners, and temperatures within the artificial vagina • Expose stallion to receptive mare(s) • Develop ritualized breeding routine • Retain conditioned stimuli that are known to assist in arousal • Reduce distractions in breeding area
Erectile	
• Reluctance to approach and mount • Absence of erection • Failure to maintain erection • Abnormally prolonged refractory period	• Behavior modification as above • GnRH 50 mg Cystorelins c. 1 and 2 hours before breeding • Diazepam 0.05 mg/kg slow i.v.
Ejaculatory	
• Incomplete intromission • Inadequate pelvic thrusts after intromission • Failure to ejaculate • High threshold to ejaculate • Neurological lesions (e.g. in hypogastric and pudendal nerves)	• Behavior modification as above • Analgesics • Imipramine 500–1000 mg/kg orally in concentrated feed (lowers threshold to ejaculate) • Imipramine 2.2 mg/kg i.v. (induces ejaculation when given to subjects standing quietly in the stall) • Xylazine 0.66 mg/kg i.v. • Prostaglandin F2a 0.01 mg/kg i.m. 10–15 minutes before breeding may help to induce smooth muscle activity in the accessory glands
Physical and coordination	
• Fatigue/poor condition/obesity • Physical trauma from kicks, stallion rings, priapism, paraphimosis • Current lesions on penis • Musculoskeletal disease • Reflected penis	• Analgesics • Modify dummy or mount mare's height • Weight loss and exercise • Lateral support of hips during mounting • Collect semen on ground

GnRH, gonadotropin-releasing hormone.
The doses are derived from reference material and should be modified according to veterinary clinical assessment. A number of the drugs have additional applications at different doses not discussed in this text.

That said, offering stallions so many opportunities to mate that they become sated is one approach to the hyperlibidinous state. However, in modifying any unwanted behavior, it is especially important for the breeding stallion to retain desirable (sexual) responses.

When being handled in company (e.g. at a show) stallions are less likely to be aggressive to conspecifics if they are not allowed to sniff other horses' feces.[80] By the same token, the application of odor-masking substances to the nostrils of stallions is reported to make them more tractable under circumstances when stimuli from novel mares are being inadvertently presented.[80] When introducing mares to geldings as field mates, it pays to ensure they are not in estrus, since this occasionally precipitates stallion-like responses, including herding and aggression. Male sexual behavior can be reduced with oral (altrenogest) or injectable (medroxyprogesterone acetate) progestins.[61]

By retrieving straying youngsters and occasionally playing with foals and yearlings, stallions play a role in parenting especially after the first week of life.[81] Before then they allow the mare and foal to bond by reducing disturbances. However, although it seems unlikely to have any adaptive significance, infanticide has been reported in Przewalski stallions[82] and Camargue horses[83] as have isolated incidents of aggression toward foals by domestic stallions and even geldings.[61] This may have contributed to the perception that stallions are innately aggressive.[17] However, it is worth remembering that, in contrast to donkeys, in which the territorial adult males are dominant over all their conspecifics,[84] *E. caballus* stallions in the free-ranging state are generally not the dominant nor the most aggressive members of natal bands.[85] Despite this, the perception that stallions are inherently dangerous and therefore should be isolated prevails in many human traditions.[17] If aggression does emerge in the behavioral repertoire of a stallion, it is paradoxically preferable for personnel that he is consistently aggressive rather than being unpredictable.

Hyper-reactive and so-called frenzied stallions benefit from management changes that help to resolve fizzy riding horses. Turn-out and reduced grain intake are especially helpful when used in combination with behavior modification and are always worth trying before hormonal approaches, e.g. use of progesterone or tranquilizers, are attempted.

Self-mutilation

Frustration in stallions restrained from estrous mares can be directed towards personnel, anestrous mares, youngstock and even their own bodies. Self-mutilation shows some seasonality and is most commonly seen in stabled stallions and very occasionally in geldings, mares and foals.[61] In stallions, severity can be life-threatening and prevalence can reach 2%.[86] Self-mutilation manifests as rubbing, biting, kicking, and lunging into fixed objects. McDonnell[86] identifies three categories of self-mutilation based on their putative ontogeny and form. Type I is categorized as a normal behavioral response to intermittent or persistent physical discomfort (such as abdominal discomfort, skin allergies and limb pain) and can be eliminated by relieving the discomfort. Type II, found in males is self-directed inter-male aggression. Characteristically, it involves the elements of the interactive sequence seen in encounters between two stallions. Type III is more typical of a stereotypy, being repetitive, invariant and often rhythmic.

Physical restraint, such as the traditional neck cradle, is largely counterproductive[9] and while Shuster & Dodman[87] suggest that clomipramine (1.0 mg/kg p.o.) reduces self-biting attempts by approximately 50%, attempts to enrich the animal's environment are pivotal to successful therapy. Regardless of the type of self-mutilation, treatment should certainly aim to counter environmental factors that trigger the responses. The strategic presentation of ample forage in place of concentrated feed, providing company, preferably equine, and exercise should all be explored[86]. For type II, treatment should also reflect an understanding of the inter-male interactive behavior of horses. It should not include the use of mirrors, as has been advocated for weavers and box-walkers.

The combined use of stallions as breeding and performance animals has advantages and disadvantages. While helping to meet the behavioral needs of a stallion, exercise also enhances fertility and prolongs a stallion's working life by maintaining cardiovascular and musculoskeletal fitness.[38] By keeping the breeding stallion in ridden work, it may be possible to temper his explosive displays after periods of stabling and maintain his responsiveness to vocal commands. By contrast, there are some data to suggest that forced daily exercise can reduce libido in young stallions.[88] Despite the notable exception offered by several world-class stallions, many stallion handlers feel that such attempts to combine work can have deleterious effects on performance or fertility or both. It would be useful to identify the inter-relationships between fertility, biddability and competitive flare.

SUMMARY OF KEY POINTS

- Management regimens on studs should meet the behavioral and physiological needs of the stallion and the mare.
- In the free-ranging state, a harem stallion interacts with his mares almost continuously and the mare plays a pivotal role in the timing of copulation.
- The reproductive function of stallions is subject to social modulation.
- Free-ranging stallions protect foals in their natal band.
- If safety can be maintained, increased contact between mares and stallions can reduce the prevalence of unwelcome behaviors in stallions and improve herd fertility.
- Stallions can be allowed to mount without an erection. If it becomes necessary to force a stallion to dismount, this should be accomplished without aversive stimuli that can have unpleasant associations later.
- Allowing the mare to facilitate the stallion's dismount by walking forward reduces the risks of unwelcome associations with copulation.
- Masturbation is part of the normal ethogram of male horses.

Case study

A 10-year old Dartmoor x Shetland stallion, called Topper, showed a guarding behavior when placed with other horses, especially mares. The absence of good handling allowed this to become a dangerous default response to humans and other animals.

In the year before he arrived at his current home, Topper had killed four dogs as they were walked through his field. Poor fencing allowed him to wander from his paddock on many occasions. His visiting and guarding of other horses in his area had taken him out of his home paddock and this was causing significant disruption in the local village. He had been beaten repeatedly for displays of aggression but this had not helped matters. On the day of his prehension at the request of the police, three experienced personnel and an RSPCA officer spent 6 hours driving him into a corral, then a further 2 hours in the pen with him before they caught him.

Topper was castrated 2 weeks before he arrived at his new home. On arrival at the new home Topper would not tolerate being touched. He was very aggressive when humans in his vicinity engaged eye contact with him, even if they were not approaching him. Rather than run away from such challenges he would, instead, charge straight towards the humans then rear and attempt to strike their heads.

After one month of passive habituation to the presence of humans, Topper would allow two key personnel to enter his yard as he watched suspiciously. He eventually discovered carrots and showed a tremendous liking for them. Carrots were therefore used first as lures that could be shown to him and then given to him if he approached. Soon Topper learned to look for carrots and to follow carrot-bearing humans while remaining a distance of a meter or so behind them. Clicker training (see Ch. 4) was used to shape desirable responses in the presence of humans. Using carrots as primary reinforcers, his responses were shaped so that he remained still with humans around him. Interestingly, because it was clearly rewarding for him, the departure of humans from a zone around him was also offered as reinforcement contingent on the sound of the clicker. This system is akin to the advance-and-retreat method used by many roundpen trainers. It gradually modulated his aggression and allowed him to develop an alternative response when overwhelmed by the proximity of humans: he learned to run away.

After one month Topper was safe with the two people who fed him, as long as they did not corner him. He would tolerate being touched as long as he was approached and handled very slowly. Although he would generally rather not be near people, aggression became extremely rare. However, his owners took the precaution of never allowing children into his box with him. Three years later, he still sounded very much like a stallion when he roared at mares in season in neighboring paddocks but gradually this response tended to occur only in early spring rather than in summer.

Whereas he was initially safe to groom only when tied up, now he can be groomed while standing loose in the stable. His owner notes that as long as Topper is shown each brush before it is used he now seems to quite like being groomed, although she remains convinced that he would prefer to be dirty. The vestiges of head-shyness remain, and handling the ears continues to be a problem.

Although Topper is content in the company of most horses and ponies he is persistently fearful of donkeys. He is kept with a gelding that he mutually grooms but does not guard. Through clicker training, Topper is used for demonstrations of liberty training in which he performs Spanish Walk (see Fig. 4.12) and jumps, bows and rears on command.

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Behavior of the mare

CHAPTER 12

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Sexual maturation

The onset of puberty and reproductive activity during a filly's first ovulatory cycle is affected by her season of birth. Spring-born fillies tend to ovulate during the late spring when they are 12–15 months old, whereas late-born fillies show surges of luteinizing hormone (LH) and progesterone that allow some (but not all) of them to display estrus and ovulate at younger ages.[1] When planes of nutrition are marginal, such as in the free-ranging state, puberty may not occur until the filly's third spring.[2] Although fillies show a characteristic seasonal pattern of plasma follicle-stimulating hormone (FSH) and LH fluctuations even when ovariectomized, probably as a result of secretions by the adrenal cortex,[3] their breeding season appears to be shorter than that of adult mares.[1] In their free-ranging state, fillies usually seek contact with bachelor stallions or with unfamiliar harem stallions. When seeking sexual activity with resident, and therefore familiar harem stallions, fillies are likely to be ignored, especially if more mature mares are concurrently receptive. This allows subordinate stallions to consort with these young females and perform so-called 'sneak matings' (which are associated with low conception rates).

In terms of their social integration with other horses, mares can be categorized as being loyal to a single stallion, part of a multi-stallion band or social dispersers (females in transit – so-called mavericks).[4] Interestingly, compared with the mares in single-stallion bands, the disperser mares have been shown to have a greater parasite burden and poorer body condition despite spending a similar amount of time feeding.[4] Compared with all other mares, they also have the lowest fecundity and the greatest offspring mortality rates. A mare is thus much more likely to pass on her genes if she retains the companionship of at least one stallion. Beyond that, the stability of the mare–stallion relationship in single-stallion bands, with its resultant containment of agonistic behavior, contributes considerably to reproductive success and therefore biological fitness.[4,5]

Mares will regularly interfere with other mares during courtship and mating. The behavior of a mare in response to seeing another mare having contact with her stallion depends on her rank and reproductive state, being most obstructive when she is in estrus.[6]

In general, mares become increasingly receptive towards stallions as they age and will continue to breed until their early twenties.[7]

Reproductive cycles

Being seasonally polyestrus, mares show a cyclical active estrus[8] (7.1 ± 4.2 days) and quiescent diestrus[8] (16.3 ± 2.9 days) throughout the breeding season[8] (152 ± 50 days). Season lengths become more restricted as one travels nearer the Poles.[7] Of all ungulates, horses have highly variable cycle lengths[9] and for this reason variations in estrous cycle are completely unreliable as a means of diagnosing ovarian dysfunction. Cycles, of which there are a mean of 7.2 ± 2.0 per year,[8] vary in length and behavior, with some mares showing a shift in temperament from normally placid disposition to irritability and vice versa. More common in fillies than in mares, protracted estrous periods of up to 50 days have been reported,[10] while their contraction as a result of veterinary examinations per rectum has also been noted.[11]

The duration of estrus decreases at the height of the breeding season (Fig. 12.1), the trend being matched by reciprocal increases in diestrus duration that keep the length of the whole cycle relatively constant.

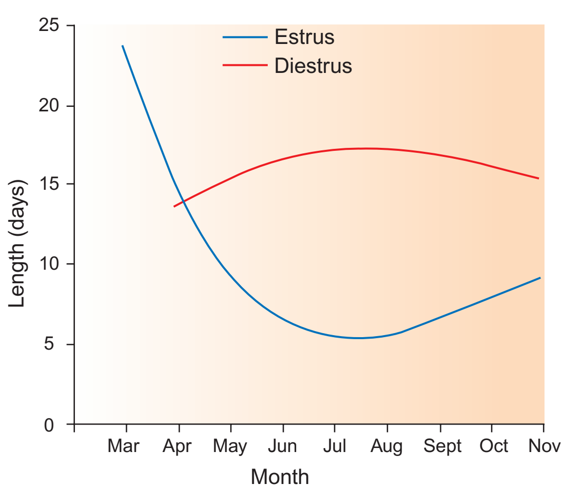


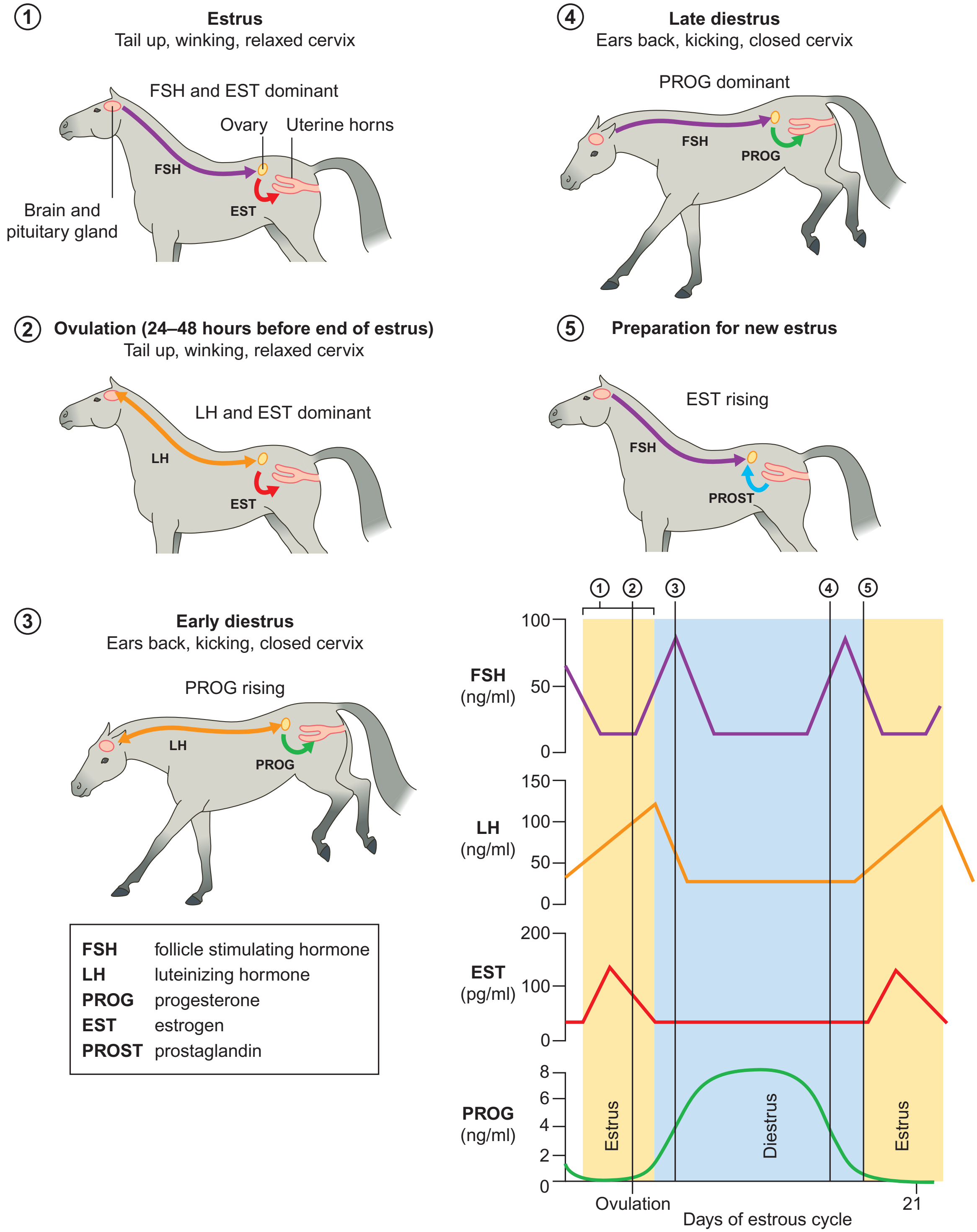
Figure 12.1 Variation of estrus and diestrus duration during the northern hemisphere breeding season. *(After Ginther.[8] Redrawn, with permission, from Waring.[2])*

Mares reject advances by stallions and show relative disinterest in their company during diestrus and during periods of rising and high plasma progesterone concentrations.[12] A diestrous mare approached by a stallion becomes restless, switching her tail and flattening her ears as she threatens to kick, strike or bite (Fig. 12.2). Because behavioral responses associated with estrus may persist to varying extents in mares in anestrus,[13,14] it is important for stud personnel to take repeated measures of responses to teasing so that changes in frequency of responses, rather than the presence or absence of responses, can be monitored.

Even when a mare is receptive, squealing and strike threats may occur as a preliminary part of the nasal contact phase of a successful sexual encounter. Estrus in the mare is characterized by courtship behaviors such as abrupt halts during locomotion, approaching and following stallions, lifting the tail (before being mounted or after being mounted), clitoral winking (Fig. 12.3) especially during teasing, urinating (up to 21 urinations in an hour have been recorded[15]), and tolerance of the stallion's pre-copulatory behavior such as sniffing and nibbling. Depending to some extent on individual differences between mares, receptivity peaks 1–3 days prior to ovulation (although this has been disputed[16]). Above all, estrus in the mare is defined by her standing firmly with her tail up while being mounted.[13] Ovulation typically occurs 36 hours before the end of estrus and is marked by the decline in the mare's receptivity.

Estrous mares frequently follow and place themselves in the vicinity of a stallion, especially if contact with him is intermittent.[6,17] If their solicitations are ignored, mares may display the estrous stance nearby periodically or, if this fails to attract the attentions of the harem stallion, they may even disperse in search of other males. Occasional mares exhibit signs of colic during estrus to the extent that they are presented for bilateral ovariectomy.[18,19] There are also occasional instances of estrous mares mounting or being mounted by other mares.[2] Strangely, in Icelandic mares, this response is regarded as normal even when a stallion is present and is used by stud managers as an indication of early estrus. The estrous mares are almost always mounted, while the mounting is most usually performed by pregnant mares (Machteld van Dierendonck, personal communication 2002).

While prolonged tail-raising, the urination-like stance and clitoral winking in combination with the increased vascularity of the vaginal mucosae seem to provide



FSH	follicle stimulating hormone
LH	luteinizing hormone
PROG	progesterone
EST	estrogen
PROST	prostaglandin

Figure 12.2 Illustration of the ways in which the mare's behavior changes throughout the estrous cycle. FSH, follicle-stimulating hormone; LH, luteinizing hormone; PROG, progesterone; EST, estrogen; PROST, prostaglandin. *(After Noakes DE et al, eds; Arthur's veterinary reproduction and obstetrics; London: WB Saunders; 2001.)*

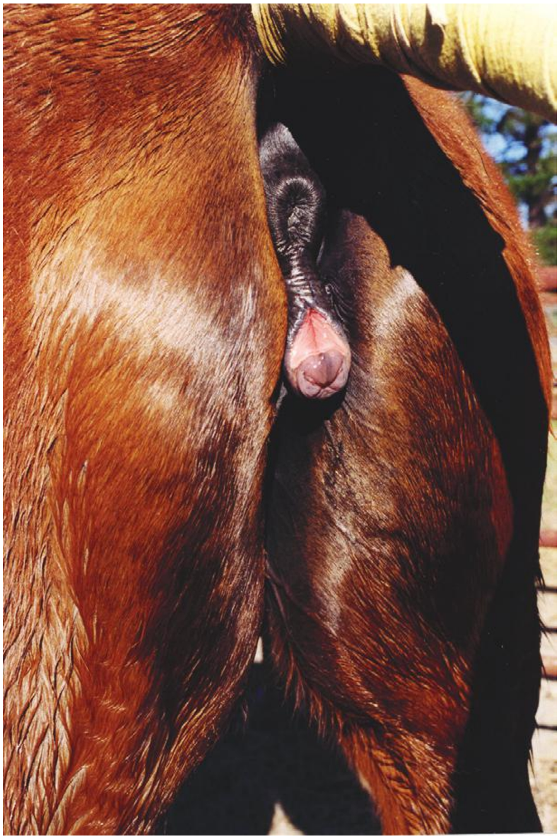


Figure 12.3 Clitoral winking in an estrous mare.

Figure 12.4 Drawing of two successive stages in the threatening *Rossigkeitsgesicht* response of a Grant's zebra (*E. burchelli boehmi*). *(Redrawn from Waring GH, Wiersbowski S, Hafez EFE; The behaviour of horses; In: Hafez EFE, ed; Behaviour of domestic animals; 3rd edn; London: Baillière Tindall; 1975.)*

strong visual attractants for stallions, facial expressions in estrous mares have also been noted. Open mouths and bared teeth are common in the females of wild asses that adopt forced mating styles. Called 'Rossigkeitsgesicht' in zebras (Fig. 12.4), this accompanies the characteristic urination stance to contribute to the composite attractive signal to stallions.[20] The response is also seen in occasional mares,[21] with Standardbreds more likely to demonstrate it than Arabians.[22] Likened to the snapping response of juveniles in the presence of a threat, this response is interpreted by some observers as a sign of submission[2] or conflict[21] while others have demonstrated that it can elicit aggression from observing horses.[23]

Although pony mares have been described anecdotally as having more distinct ovulatory and anovulatory behaviors,[2] other data suggest that cold-blooded mares are more likely to have silent estrus than other breeds.[24] Meanwhile, reduced antagonism to teasing when not in estrus and generally subdued manifestations of estrus are also reported in association with compromised thyroid function.[25] The average interval between the first signs of estrus and ovulation is 5.16 ± 2.65 days.[26]

Although they are irregular, estrous cycles are common in mules and the extent to which these hybrids are functionally infertile varies considerably.[27] Mules often have follicles that ovulate and luteinize but they generally lack oocytes (Lee Morris, personal communication 2002). That said, they do very occasionally bear live foals.[28]

The importance of auditory perception in eliciting typical estrous responses has been highlighted by studies of the relative effects on mares of audio recordings of the characteristic stallion nicker versus the presence of a stallion.[29] In response to these recordings, estrous mares, especially barren ones, showed overt estrous behavior including tail-raising, clitoral winking and abduction of the hindlegs. Maidens and mares with foals at foot exhibited some of these reactions but at a lower frequency. There are reports of reasonable efficiency in detecting estrus in mares by playing back recordings of stallion vocalization with and without added stallion scent. That said, for this to be a useful part of stud management in the absence of a stallion or teaser, a minimal schedule of three times weekly would be required. In a four-week study of 11 mares estrus was detected with the stallion auditory and olfactory stimuli method, on average more than four days before 80% of ovulations.[30] Although the usefulness of stallion vocalization recordings used in isolation in estrus detection has been contested,[31] when used in combination with palpation of the inguinal region of mares this approach was reported to be 97% accurate.[32]

The length of courtship a mare receives from a harem stallion depends on her rank. A high-ranking mare may be courted for several days before a series of matings takes place. Only then does she tolerate the stallion attending to other mares in the group.

During copulation the mare adopts a characteristic base-wide stance that helps her to balance. Although her neck is usually lowered, she remains very alert with her ears upright. She may look round slightly to monitor the stallion, especially during ejaculation.[15] Dismounting is often assisted by the mare moving forward.[32] The couple remain reasonably close to one another after copulation and the mare continues to raise her tail and urinate until grazing and social interactions with others take priority.[33] In the free-ranging state, matings will occur approximately six times per heat in single-stallion groups.[34] It is important that we recognize the many ways in which hand-breeding can so easily compromise a mare's ability to behave normally during courtship and copulation (Fig. 12.5).

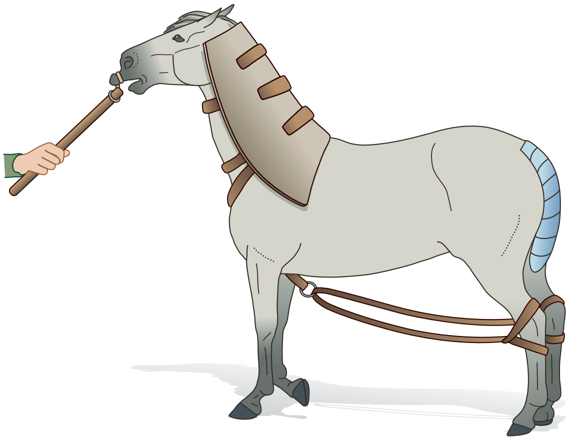


Figure 12.5 Restraint in the hand-bred mare often involves the use of a twitch and service hobbles, which may alter her locomotory behavior and ability to signal. Meanwhile, her appearance may be further affected by the use of a breeding cape to prevent her from being damaged by the stallion's teeth as they are used to grasp her neck, and by the use of tail wraps. It is not clear how much these interventions influence the mare's physiological stress response and the stallion's performance.

Artificial influences on the breeding season

It is broadly accepted that the breeding season imposed by humans on horses, most notably Thoroughbreds, is artificial and does not entirely coincide with most mares' maximal reproductive efficiency.[35] As a result, sexual receptivity without ovulation occurs during the early stages of the artificially advanced breeding season. The use of lights (not to mention GnRH, allyltrenobolone or progesterone) to induce ovarian cycling is now commonplace and reasonably sophisticated but it necessitates stabling and therefore may have deleterious effects on the social needs of mares. The imposition of artificial social groups is likely to have an effect on behavior since herd size is known to affect reproductive efficiency.[6]

The primary advantage of bringing mares into stables for exposure to 16 hours of artificial lighting is that it advances the onset of cyclicity early in the breeding season. In addition it facilitates supplementary feeding. Insufficient or inconsistent planes of nutrition may compromise sexual behavior and ovarian activity.[8,36,37]

It has been noted that a higher percentage of non-palpated mares conceive earlier in the breeding season compared with palpated mares,[11] but it is not clear whether a causal relationship exists or whether mares are more likely to be palpated because they are more likely to be failing to show behavioral manifestations of estrus. Follicular immaturity leading to behavioral estrus without ovulation (so-called 'spring estrus'), an ovarian dysfunction diagnosed in as many as 40% of infertile mares, is one of the most common causes of infertility in the horse and has been associated with unsatisfactory nutrition or management.[9] The most common cause of infertility is pregnancy loss.[38]

The length of estrous periods in a managed context is longer than in the free-ranging state, apparently because of the psychic effect of the separation of mares and stallions.[9] Data on herd mating activities suggest that stallions are twice as active sexually during 0600–0800 and 1600–1800 hours than during 1800–0600 and 0800–1600 hours.[39] Perhaps, as efforts are made to reduce the effects on horses of intensive management, the times of day at which stallions and mares are joined for breeding purposes should be brought into line with these times of peak natural activity.

While transportation induces hormonal and ascorbic acid responses indicative of stress,[40] it does not alter estrous behavior, ovulation, duration of the estrous cycle, pregnancy rate or pre-ovulatory surges of estradiol and LH.[41] Artificial influences on fertility also include attempts at birth control, most notably in feral populations. Single inoculations with microspheres of porcine zona pellucida vaccine have reduced feral mares' reproductive rate to approximately 11%, a finding that offers some support for alternatives to culling.[42]

Foal heats

Characterized by their intensity as well as their association with diarrhea in the foal, foal heats occur on average 8 days after parturition[43] as a result of a decline in the blood progesterone/estradiol concentration ratio that begins at the time of parturition, and an initial surge followed by pulsatile releases of LH post-partum.[44] While free-ranging mares have been observed mating within hours of foaling,[2] most ovulate between 4 and 18 days post-partum. Similarly, mares display estrus 2–6 days after injections of exogenous prostaglandins (5 mg PGF2α, i.m.), given to induce abortions.[45] Daily progesterone injections have been used to delay the onset of foal heats.[46] Meanwhile, the beta-blocker propanolol has been reported to increase the exhibition of foal heat and the pregnancy rate at this heat. The mechanism for this effect is thought to involve increased myometrial motility and enhanced uterine involution.[47]

Silent heats

It is recognized that ovulation may occasionally occur without behavioral heat.[9] Approximately 6% of ovulations occur without overt signs of estrus.[8] Some mares are predisposed to such silent heats (also known as subestrus) without any disruption of their cyclicity. The role of social rank in mares' behavior at estrus is not as clear as that of cattle, but it appears that high-ranking mares may bully subordinates when in estrus. Mares that show no sign of cycling (see the case study at the end of this chapter) should have their diets investigated as part of a full clinical work-up that includes gynecological and endocrinological investigations.

Split heats

When a mare exhibits behavioral estrus that is transiently interrupted by an uncharacteristically brief period of quiescence, she is said to have had a split heat. This phenomenon occurs with reasonable frequency (12% of ovulations[8]) and as such justifies at least daily teasing in commercial breeding operations. Meanwhile, the appearance of a prolonged estrus may arise in oliguric mares secondary to irritation caused by the persistent presence of urine.[2]

Anestrus

In late autumn and winter, most (but not all) mares become sexually dormant and are said to have entered anestrus (214 ± 50 days[8]). Entry into anestrus can be considered complete if a mare does not exhibit cyclic estrous behavior, has no follicles with a diameter of 25 mm or larger, and has progesterone at concentrations of 1 ng/mL for at least 39 days.[48] The transition into the breeding season occurs once a threshold in LH concentration within the anterior hypothalamus is reached.[49] Meanwhile, the onset of individual estrous cycles may be delayed by psychological influences over behavioral activity, spontaneously persistent luteal function, endometritis and granulosa cell tumors.[34]

The influence of hormones and exogenous factors on reproductive behavior

Hormonal control of ovulation can be achieved by using exogenous steroids with or without prostaglandins.[50] Estrous displays can be induced by administering exogenous steroids.[50] For example, estradiol elicits soliciting behavior within 4 hours of injection, while progesterone usually results in the absence of sexual behavior.[3,51] Altrenogest can be given orally to regulate estrous behavior early in the year, and its withdrawal will synchronize estrus in cycling mares and those previously exposed to artificial light.[52] Conversely it has been suggested that endometrial edema as appreciated by ultrasonography may indicate the optimal time for coitus and provide an instant indication that the basal concentration of progesterone is <1 mg/mL.[53] But estrus is not purely a product of hormonal flux, since estrous behavior reflects a combination of other factors, including the presence of a stallion, social rank and duration of teasing. For example, when mares are stimulated by restrained teasers, their estrous display lengthens.[9] Similarly, failure of estrus can often be due to the absence of exogenous factors such as odors, sounds, sight and touch[9], e.g. that arise with appropriate attention from stallions.

Pregnancy

The gestation period of the mare is approximately 11 months or 340 days, with generally slightly shorter periods in smaller breeds.[54] Gestation duration in a large study of Australian Thoroughbreds[55] (n = 522) ranged from 315 to 387 days (mean 342.3 days). The survival rate of Thoroughbred foals delivered at less than 320 days of gestation is approximately 5%.[56]

Factors that influence the duration of a mare's gestation include her plane of nutrition towards the end of her pregnancy and the sex of the foal. Howell & Rollins[57] found that mares on higher planes of nutrition tend to foal earlier than those on maintenance diets. In the free-ranging state, mares normally foal in mid to late spring, a strategy that usually ensures sufficient feed being available for lactation. By showing that foals conceived in early spring had longer gestations than those conceived in mid to late spring, Hintz et al[58] confirmed the importance of seasonal effects on the biological fitness of foals (a similar trend was reported by Campitelli et al[59]). The sex of the foal contributes to the duration of gestation, in that fillies are generally born 1–2 days before colts.[55] Mares lose more condition prenatally when carrying a colt if they were originally in good condition at the time of conception, but more when carrying a filly if they were in poor condition.[60]

While some mares become actively aggressive to approaching stallions during pregnancy, others may remain friendly[61] and raise the suspicion that they are returning to estrus. After between 40 and 70 days of pregnancy, follicles are produced in response to eCG.[62] They are generally large in size and remain active, ovulating to form accessory corpora lutea. Estrogen produced from these follicles is thought to prompt some pregnant mares to consort with stallions and exhibit some estrous behavior during the first trimester of pregnancy. The response occurs more frequently in mares bearing female foals than in those bearing males.[63] Up to 35% of ovariectomized mares,[18] and also mares in an anovulatory period, show sexual responsiveness.[1,3] This suggests that mares' ability to dissociate sexual behavior from ovulation may persist even when they are pregnant. However, these manifestations (which may occur a mean 1.76 times per pregnancy[39]) often lack the usual potency associated with ovulation. Asa[17] suggests that non-reproductive sex may serve to influence stallions to remain with their bands during the non-breeding season.

Asa et al[62] examined the effect of adding a stallion to an established group of 12 pregnant pony mares. After the experimental introduction of stallions into random harem groups, full estrous behavior was not observed. Instead, only weak signs of estrus were noted, with only four mountings recorded and only a single tail raised. Social interactions such as grooming between the mares increased, while the only approach between mares and the stallion was an initial ritual greeting early on in each exposure.

Foaling

Although the behavior of the mare does not change markedly in the months leading to parturition, significant differences arise immediately before foaling.[2,62] Shaw et al[64] examined mare behavior 2 weeks prior to parturition. A total of 52 pregnant mares in box stalls were observed at 30-minute intervals between 1800 hours and 0600 hours. In the 2 weeks before foaling, mares spent 66.8% of their time standing, 27% eating, 4.9% lying in sternal recumbency, 1% lying in lateral recumbency and only 0.3% walking. Challenging the notion that the mare reduces her ingestive activities immediately prior to parturition,[9,61] eating was the only behavior unaffected by the imminent foaling. On the night of foaling, mares spent less time standing (53.3%) and more time in sternal (8%) and lateral (5.3%) recumbency and walking (5.3%).[64] This reflects the restlessness of mares when they are about to foal and the fact that they almost always choose to foal in a recumbent position (a characteristic that led to the development of foaling belts that can detect recumbency).

In their free-ranging state, mares about to foal often become parted from the herd either by seeking relative isolation (sometimes accompanied by older offspring or another adult mare) or by being left behind. Along with the other peri-parturient behaviors, this strategy provides a nurturing environment for the foal and helps to avoid mis-mothering, in accordance with the 'binding theory' offered by Klingel.[65] Average time spent walking tends to increase on the day of birth (most notably the 30 minutes prior to parturition), with higher-ranking mares tending to try to separate themselves furthest from the herd, and maiden mares remaining reasonably close.[66,67] Mares confined in a box stall, on the other hand, may be required to foal within auditory, olfactory and visual contact of other mares. They are often described as being alert, uneasy and restless before parturition.[9] This may be due, at least in part, to their motivation to separate themselves by locomotion being thwarted. While physiological changes include swollen teats, distended udder and softening of the cervix, behavior changes may also include swinging and rubbing the tail against fixed objects as the vulva becomes relatively flaccid.[61]

It seems that regardless of the bond they may have with particular personnel, most mares prefer not to foal in the presence of humans and, perhaps in a bid to ensure isolation, may delay foaling by prolonging the initial stage of parturition.[2,64] When left undisturbed, most mares foal at night (e.g. in Shaw et al's study[64] 86% foaled between 1800 and 0600 hours), presumably as a means of avoiding daytime predators. Fraser[9] proposes that colts are born later in the night than fillies and rather unconvincingly suggests that this is for the 'good of the species' since fewer males are required for reproductive success of a group. There is evidence that the percentage of night births is higher in spring than in winter[59] although others report that seasonal daylength and onset of darkness have no effect on the mean time of foaling.[68]

Continual disturbance, especially at night may adversely delay the onset of foaling.[68] On many studs, laudable attempts to minimize human interference and reduce imposing unnatural delays include using one-way mirrors and video surveillance equipment. However, the avoidance response seen in most mares during foaling is by no means universal. Some mares even appear to seek human company at this time.[61] It would be interesting to see how attempts to 'imprint' fillies (see Ch. 4) affect their responses to humans when peri-parturient.

Immediately prior to parturition the mare's behavior increasingly involves stretching, yawning, repeated recumbency and standing, walking, tail-swishing, kicking, looking at flanks, pawing at the ground, crouching, straddling and kneeling. These responses all imply that she is undergoing abdominal discomfort[9] that may last from a few minutes to hours.[2] Patchy sweating on the flanks and girth area indicates that first-stage labor is about to commence. This and persistent raising of the tail seen at this stage gave rise to the emergence of parturition detectors (e.g. as described by Bueno et al[69]).

Depending on their force and timing, contractions induce different responses in the mare.[61] With modest contractions she may swish her tail or stamp a hindleg. Larger, more powerful contractions cause her to become transiently tucked up in the flank or to lift her tail over her back and lean backwards onto her hindlegs.

Usually, when the placenta ruptures and the allantoic fluid escapes, indicating the second stage of parturition, the mare lies down (a response often accompanied by the greatest passage of fluid) in preparation for forceful and repeated straining. Some mares may investigate the fluid and consequently exhibit flehmen and occasionally nicker.[10] Sternal recumbency is commonly adopted but it is not unusual for the mare to stand and reposition herself repeatedly, especially if she is disturbed.[70] Vigorous rolling is also reasonably common and is thought to represent attempts to correctly position the foal. The foal's forelegs either side of or to one side of its head engage in the vagina, then may emerge from the vulva covered by a veil of amniotic membrane (Fig. 12.6).

Straining efforts, numbering between 60 and 100 (n = 5), are required especially to expel the foal's forequarters and head.[70] Data from Thoroughbreds suggest that compared with experienced brood mares, maidens spend slightly longer in second-stage labor (mean of 21 minutes for primiparae versus the mean of 18 for experienced mares[71]), while pony mares take an average of 12 minutes.[72] Foals from primiparous mares are considered to be at high risk of thoracic trauma.[73] The final expulsion is usually achieved with the mare in lateral recumbency with legs extended. Expulsive efforts may cause the mare's upper hindlimb to become raised. With the emergence of the foal's head, forelimbs and hips, the second stage of parturition is complete. Unless disturbed, the mare then usually remains in lateral recumbency, often with the foal's hindlimbs still in the vagina.

The third and final stage of parturition involves the transfusion of blood from the placenta to the foal during the post-partum pause and the passage of the placenta.[9] If parturition occurs without difficulty then, after the post-partum pause which allows blood to leave the placenta and reach the foal,[74] the foal will free itself of fetal membranes by raising its head and will sever the umbilical cord as it moves away from the mare.

Third-stage labor is marked by signs of abdominal discomfort, including looking at the flanks, sweating and pawing – behaviors that seem to have a stimulating effect on many observing neonates. Approximately 1 hour after delivery of the foal, the placenta is expelled, often as the mare rises from a bout of rolling. Mares typically show some olfactory investigation of the membranes, which elicit flehmen responses and occasionally some perfunctory nibbling. In the free-ranging state, the mare and foal leave the site of foaling soon after the placenta is discharged. This is thought to contribute to biological fitness by avoiding predators that may be attracted by the odors of the fluids and membranes passed during parturition. It also marks the mare's return to the relative safety of her herd, which may be seen moving towards the fresh dyad to investigate. High-ranking mares have been observed to take longer to rejoin their affiliates than subordinates.[66]

Figure 12.6 Foaling sequence. *(Photography by Neil McLeod.)*

Mare–foal interactions

The mother–infant bond

Interactions between the mare and her newborn foal enhance the bond between them and contribute to biological fitness by facilitating the survival and full development of the foal. Bonding in the first few days is critical to the foal's survival because this is when mortality is highest.[75,76] The mare–foal bond seems to grow at the expense of the bond between the mare and her herd affiliates.[77] Indeed new dams put a distance between themselves and other adults, perhaps to reduce outside interference in the bonds they are forming with their offspring.[77] It is interesting to note that the attachment

Table 12.1 The mean times taken by thoroughbred foals (n = 390) to perform key behaviors[80]

Behavior	Mean time after parturition (minutes)
Umbilical cord rupture	6.2
Suckling reflex	36
Standing	49[a]
First suckling	94[b]
Elimination of the meconium	127

[a] *All foals stood up within 2 hours 23 minutes of parturition.*[80]
[b] *83% of foals suckled within 2 hours of parturition.*[80]

between primiparous mares and their male offspring (as estimated by the number of times colts return to their natal bands after dispersal) is significantly stronger than dam–filly combinations.[78]

Contact with the mare and urination along with various other behaviors listed in Tables 7.1. and 7.2 have been used to score foal health so that veterinary attention can be requested for those showing subnormal development or viability.[79] In addition the mean times taken by Thoroughbred foals[80] (n = 390) to perform key behaviors are shown in Table 12.1.

Soon after birth the mare begins to lick her foal, and any surface bearing amniotic fluid, and continues with some intensity for approximately 30 minutes.[2] This dries the foal, stimulates respiratory effort and blood flow and finally stimulates the foal to stand; it may also provide the mare with sensory information for later use via olfaction, allowing her to discern her foal from the others in the herd.[81] This function relies on the link between gustation and olfaction since horses do not lick one another during greetings, in contrast to many ruminants and carnivores. That said, the number of times a mare licks her foal is not an effective predictor of the quality of bonding between the two.[81] Once the mare has groomed the foal, removed the placental material and passed the placenta, suckling occurs. The mare assists the foal in locating the teats and may even push the foal towards them. The foal is innately driven to locate the teat and suckle – a response refined by learning. The suckling response can be stimulated by tactile stimuli around the muzzle and mouth, which cause the tongue to protrude. The foal displays this sucking behavior even before it stands.[82] Approximately 5% of foals need human assistance to suck[9] but intervention is scarcely warranted before 3 hours, since some foals, especially heavier ones, take this long to suckle naturally.[10]

Although the time the foal takes to stand is related to the time taken by the mare to expel the fetal membranes,[59] the physical interaction of the mare and foal begins immediately after parturition. Barber & Crowell-Davis[83] found that during the first day of life, upright foals and their mothers spent 96% of their time within 1 meter of each other. Ingestion of colostrum during the first few days of life is pivotal because the foal's intestine is capable of macromolecular uptake only until the foal is approximately 36 hours old.[84]

In the free-ranging state, it normally takes 2 weeks of close proximity and frequent interactions for the foal and mare to consolidate their bond.[81,85] The spatial relationship within the dyad can be characterized by the number of 'approaches' and 'partings' made by either member.[86] Although initially the mare's bond with the foal is much stronger than vice versa, foals do more work to maintain contact with their dams, but this tendency declines as they approach weaning age.[87]

The spatial distribution of the mare and foal is determined by the posture of the foal, in terms of whether it is recumbent or upright.[83] Until they reach 21 weeks of age, foals rest in a recumbent position for longer than adults do (this is possible because of their different pulmonary ventilation:perfusion quotients), and this, among other features of foal behavior, influences the extent to which their dams are likely to move away during this time. For example, during the first week of life, foals spend approximately 32% of their time in recumbent rest,[88] and so dams tend to approach and remain with newborn foals more than with older foals. Perhaps because of its perceived vulnerability, a mare spends a greater amount of time near her foal when it is recumbent (Fig. 12.7) but seems to relax when it is in an upright position. Grazing behavior of the mare is seen mostly when the foal is standing; when the foal is recumbent the mare spends most of her time resting upright.

Generally, foals will return to their dams whenever they have encountered a novel or aversive stimulus. This allows them to maximize their safety and to feed in a bid to supplement energy expended during flight responses. The positive reinforcement that occurs when foals suckle after returning to their dams also helps to consolidate the bond necessary for success in follower species.[81] Additionally, the mare provides protection for the foal and will herd it away from disturbances that may interfere with the bond. Dams use the unique calls of their foal to locate them when the pair is parted.[85]

Figure 12.7 When a foal is recumbent its dam remains particularly close. *(Photograph courtesy of Kate Ireland.)*

Figure 12.8 A fostering gate with hatch that can be closed to prevent overindulgence by hungry foals. *(Photograph courtesy of Amanda Kelly McCreery.)*

Fostering

Because a mare normally allows only her own foal to suckle, orphan foals must be introduced to surrogate mothers with tremendous tact.[89] The bonding that occurs as a result of the licking and nuzzling in the first hours of life is tremendously important. If a foal is separated from its dam (for experimental hand-rearing) within a few hours of birth, the reunion with its mother several months later is significantly different to its interactions with other mares.[90] Rather than relying on chance to provide lactating mares that have lost their own foals, horse-breeding centers are refining the process of nurse-mare husbandry. That said, this remains an area that merits considerable empirical study. Good nurse mares can rear up to three foals in a year, their first and own foal being removed after approximately 1 month.

To offer the mare some gratification from being suckled, the udder is allowed to become distended with milk by muzzling the mare's own foal. It is common to blindfold nurse mares before removing their own foals. The orphan can then be introduced and is encouraged to suckle. Once it has begun to drink, the blindfold can be removed. Scratching the mare's withers and feeding her are effective distractions during the introduction, while the safety of the foal can be optimized by using a fostering gate (Fig. 12.8), preferably one that the mare has previously come to associate with nursing her own foal and being fed.

The use of such a gate is not advised unless the mare has been thoroughly acclimatized. Some mares resist this level of confinement, and the ensuing struggle can be very dangerous for the mare, the foal and personnel. Furthermore some mares placed behind the gates become very preoccupied with getting out. A less obtrusive approach that is worth employing when the mare can be supervised is to place bales at the side of the mare to reduce the extent to which she is able to kick the foal. The potential for these adverse responses highlights the need for well-planned training programs for foster mares.

Regardless of the type of restraint used to render a foster or biological mother safe, it is advisable to habituate the mare to the apparatus before it is used to restrain her in the presence of a foal.[91] For mares that kick rather than bite, hobbles may be worth trying, but again the mare must learn that struggling is fruitless before such restraint is used in the presence of a foal. Deep bedding is obligatory whenever hobbles are used (see Ch. 14).

Foals use vision and olfaction to recognize their dams.[92] However, because olfaction is the chief sense a mare uses to recognize her foal, it is important, in the short term, to reduce a surrogate mother's ability to discriminate odors and to disguise the odor of the foal. The mare's use of vision to recognize her foal develops once the olfactory tags are in place, and therefore the visual cues offered by the foal are of secondary importance in the early stages of fostering.[93] If facilities are available, it is worth freezing the amniotic membranes from any foaling in case they are needed as an olfactory cue to be draped over the orphan for fostering. Often it is more practical to mask an introduced foal's odor by smearing it with the prospective surrogate dam's own milk and applying her own feces to its tail-head. Vaporous ointments are also sometimes applied to the nostrils of nurse mares prior to removing their own foals.

Probably because they are rewarded by the relief of udder pressure, mares accept foals within 1 to 12 hours of introduction, but it is not advisable to leave the pair unsupervised until they have been together for 3 days.[94] It is believed that, once it has passed through the foal's intestines, the characteristic odor of a mare's own digested milk is the key stimulant that mares must detect before the artificial mother–infant bond is cemented.

Happily there are some mares who will readily nurse more than one foal. For example, some feral horses or Przewalski horses occasionally suckle their newborn foal and one or two older siblings. There are also accounts of mares that, having lost their foals, will suckle other foals (orphaned or otherwise) (Machteld van Dierendonck, personal communication 2002). Clearly these types of mares are more likely to accept a surrogate foal. At the other end of the spectrum, some ambivalent surrogate mothers and those that have been treated for the signs of rejecting their foals may merely tolerate their foals for a matter of weeks before relapsing into active aggression.[95] The responsibility to nurture the bond between mother and infant is not entirely the mare's. Foals that fail to show sufficient attachment to their dams may prompt reciprocal ignorance and ultimately rejection.[89,96]

Lactation can be induced in non-pregnant, non-parturient mares via a combination of estradiol, progesterone and a dopamine antagonist (sulpiride).[97] Fostering latencies can be shortened in mares treated with this hormone cocktail, if they receive two 3-minute periods of vaginal–cervical stimulation because, it is believed, a release of oxytocin is triggered by this manipulation.[97]

Cardinal signs of a successful fostering bond include the mare standing over the foal when it is recumbent and protecting it from other horses. Interestingly the approach of a teaser seems to have the effect of consolidating the bond in some cases where the mare seems unconvinced of her attachment to the introduced foal.[94] Introducing a large dog is said to have a similar effect in stimulating maternal defensiveness.[95]

Suckling

Time spent suckling is a poor indicator of milk intake in foals because some suckling may be non-nutritive.[98] When the availability and quality of milk is compromised (e.g. because of reduced food intake by the dam) it is more likely to manifest itself in colts than in fillies.[99] Given that the interval between births increases after a mare has reared a colt, it appears that it may be more costly to raise sons than daughters.[99] As described earlier, dams in better condition generally favor sons whereas those in worse condition favor daughters.[60]

Figure 12.9 Prematurely weaned foals, like this 3-month-old Thoroughbred cross, can be difficult to nourish correctly and can retain a pot-bellied appearance for much of their juvenile period.

Intriguingly the parity of a mare can influence her foal's future. For example, fascinating insights into the relationship between age of a dam and the racing success of her offspring have led to the radical suggestion that mares should be removed from stud once they pass their reproductive peak, i.e. at the age of about 12–15 years.[100] Perhaps appropriate supplementation of the dietary intake of these foals would resolve the trend for older dams to have less successful foals. It is possible that some studs already electively cross-foster foals from older dams to young mares with premium lactation characteristics in a bid to counter the older-dam effect on racing performance. Unfortunately this may lead to welfare problems for the mare and her own foal which must be weaned prematurely (Fig. 12.9).

The number of sucklings peaks at approximately 48 hours, with a concurrent increase in grazing.[101] In the first 8 weeks of life, colts spend 40% more time suckling than fillies, a strategy that presumably helps them to compensate for their performing significantly more locomotory activity and interactive play.[102] In early lactation, the foal usually adopts a position parallel to the dam for a concerted suckling session,[103] while any position may be adopted if the drink is brief. A mare will often nuzzle and groom the foal as it drinks. This affirms the bond between them in the long term but may also reduce

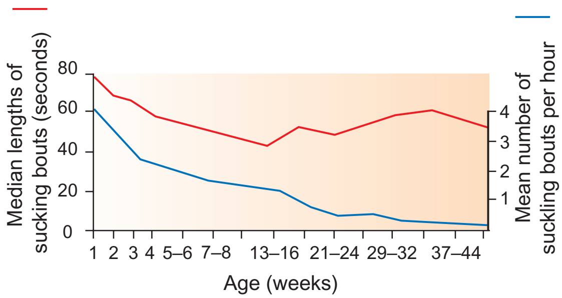


Figure 12.10 Changes with age in the length of sucking bouts and the number of bouts of nursing. *(After Tyler.[32])*

Figure 12.11 By resting the contralateral hindleg, a mare can help the foal locate the udder. *(Photograph courtesy of Kate Ireland.)*

the likelihood of the foal being disturbed by extraneous stimuli.

It has been stated that the time spent in each suckling bout does not vary significantly with age.[104] This may be because gastric volume increases at a similar rate to suckling strength and thus the volume that must be consumed for satiation can be taken with appropriate speed (Fig. 12.10). The frequency of nursing bouts decreases rapidly from 7 per hour during the first week of life and then continues to gradually decline until the 17th week (Fig. 12.10).[82,105] Generally, successful suckling bouts outweigh unsuccessful ones throughout the suckling period. Barber & Crowell-Davis[83] state that nuzzling with no attempts to suckle may act as a comforting behavior for both the mare and foal.

The teats of the mare can become extremely sensitive around the time of parturition, and this may make a dam transiently reluctant to allow her foal to suckle. Maternal aggression is seen when the foal is nudging at the udder before suckling. Once the foal begins to suck, the mare is rarely aggressive towards it. It has been suggested that mares employ a number of strategies to hinder suckling activity during weeks 2 and 3, perhaps because suckling is painful at this time.[82,83] Notwithstanding agonistic behavior during this sensitive period, the mare and foal show complementary behaviors that ensure the foal receives adequate nutrition. For example, mares appear to initiate nursing bouts by approaching the foal and standing nearby. A mare can also facilitate nursing by adopting a slouching stance with her hindlegs that tilts the udder to the side on which her foal is standing (Fig. 12.11).

Mild aggression by the mare during the post-suck portion of the bout is frequently associated with the nuzzling activity of the foal. Waring[2] notes that a mare, especially with offspring less than 1 week old, will terminate a nursing bout by rocking her hindquarters, an activity that seems to prompt the foal to move its head away.

Lactation compromises the body condition of mares, which in any case is generally poorer than that of stallions.[106] Especially in late lactation, mares play an active role in regulating the time spent suckling, by simply walking away from the foal.[102] As the foal matures, maternal aggression tends to increase and often initiates brief bouts of mother-directed foal aggression.[105]

Waring[2] states that, in a box stall, the foal is more likely to nurse on one side of the mare than the other. However, the observation of any preference is rarely recorded in the free-ranging state and has not been examined experimentally. It may be that the walls of the box prompt lateralization of the mare's behavior.

Other maternal behaviors

There are frequent interactions between a mare and her foal during play. Initially the mare is the main focus of the offspring's activities.[2] She endures the nibbling, kicking and pawing antics of her offspring but shows little playful activity herself. The focus of the foal's activity shifts from its mother to other companions (especially peers) from approximately the first 7–8 weeks of life, and the time spent playing steadily increases over this same period (see Ch. 10). As the foal ages and becomes gentler towards the mare, she may respond to the foal's playful overtures by nibbling, a response that often results in mutual grooming. Play between foals and mares (especially older ones) that are not their mother is rarely seen.

Weaning

Individual mares show differing amounts of maternal aggression especially around nursing bouts and as the time of weaning approaches. Two-thirds of maternal aggression produces negligible response from foals.[83] Waring[2] noted that as foals age, mares become more aggressive towards them. Maternal aggression seems to peak as the foal's primary source of nutrition shifts from mother's milk to grass (see Ch. 8). Aggression may punish nursing behavior in the foal (see Ch. 4) and hence facilitate the change in diet.

Regardless of the sex of the foal, suckling occurs for 35–40 weeks in pregnant multiparous mares, with weaning usually taking place 15 weeks before the next foaling.[102] However, weaning may take place as close as 8 weeks to the next foaling.[107] Towards the end of the weaning process the mare may drive her foal away when it attempts to suckle. Primiparous mares lactate for longer and wean 5 weeks closer to the next foaling than multiparous mares.[102] Occasionally, intermittent suckling by the previous year's foal may be permitted even though a new foal is at foot.[108] In the free-ranging state, weaning is a gradual process characterized by dietary changes in the foal and the social dislocation of mother and offspring. Additionally, since weaning is usually followed shortly by the arrival of a new foal it is accompanied by an abrupt shift of the mare's attention and social activity away from her previous offspring. In a study of Misaki feral horses, 17 of 22 dispersing colts and 29 of 39 dispersing fillies left their natal groups around the birth of their siblings.[109]

The spatial separation of mare and foal at enforced weaning thwarts seeking and giving comfort responses by the dyad and therefore contributes to the behavioral and physiological stress response displayed by both mare and foal.[101] Behavioral changes associated with physical separation of mare and foal may include an increase in vocalization, aggression and physical activity (e.g. walking around a stall, yard, paddock, etc.) as well as reduced appetite – responses that diminish with time post-weaning. The effects of weaning on ingestive behavior are considered in Chapter 8.

Management practices prior to weaning

Handling and feeding practices prior to weaning have been developed primarily to reduce the deleterious effects of weaning and post-weaning stress.

Handling

Because horses of all ages can show signs of distress when separated from their group, a system that provides some form of habituation program that may help foals to avoid separation-related distress at weaning and in later life merits scientific investigation. Pre-weaning handling regimes designed to ameliorate foals' flight responses in the presence of humans and increase the ease with which foals can be managed have had mixed results. Results have ranged from failing to have any effect[110] through to foals displaying a marked improvement in their manageability.[111] Similarly the optimal pre-weaning age at which to begin handling foals in order to enhance learning ability or manageability has yet to be determined (see Ch. 4).[110]

Feeding

An abrupt change of diet is thought to contribute to the distress of weaning. The behavioral response of anorexia and related increases in cortisol concentration may result in weight loss and possibly an increased susceptibility to disease. Post-weaning anorexia in foals can even result in death.[112] Hence the appeal of pre-weaning creep feed and partial weaning that allows the foal to contact its dam through the fenceline.[112] The advantage of feeding concentrates to reduce weaning stress may be linked to their mineral contents. Thus supplementary concentrates may help foals meet increased requirements for phosphorus, iron and zinc. These elements are thought to help combat the physical effects of fatigue, trauma and infection often associated with weaning.[113]

Foals accustomed to eating concentrates prior to weaning are more likely to maintain their feed intake throughout the early post-weaning period (Fig. 12.12). Foals that have received a feed concentrate before undergoing weaning, in addition to the available pasture and mother's milk, have been observed exhibiting fewer stress-related behaviors at the time of weaning than foals that did not receive any concentrate before weaning.[114] Access to pre-weaning creep feed resulted in less activity than no pre-weaning creep feed, but no change in vocalization frequency.[115] This may be because, if it has been established as a relevant substrate, creep feed offered after weaning may allow the foal to redirect its oral behavioral needs so that it eats instead of trotting round in attempts to rejoin its dam. The persistence of vocalization, however, suggests that the motivation to rejoin the dam is similar to that of control foals that were not offered creep feed.

Figure 12.12 Habituating foals to buckets and concentrated feedstuffs can reduce distress at the time of weaning.

Using an adrenocorticotropic hormone (ACTH) challenge, Hoffman et al[113] monitored serum cortisol responses in foals on a pasture, hay and concentrate diet compared with foals fed a pasture and hay diet. Both diets had comparable energy and protein levels that exceeded maintenance requirements. Foals receiving the pasture and hay diet exhibited a poorer response to the challenge, possibly as a result of adrenal depletion arising from protracted distress. These foals also exhibited behavioral indications of distress, with more vocalization and less rest. However, despite its apparent appeal and the frequent need for supplementation because of poor pasture, caution should be used when considering the inclusion of concentrates in diets of youngsters before and after weaning (see Ch. 8). Sympathetic weaning should focus on providing a smooth transition from milk to grass and the tactful introduction of concentrated diets, preferably those least likely to precipitate problems of gastric acidity. Creep feeding has been identified as an important cause of oral stereotypies such as wind-sucking and crib-biting[116] and in the light of this finding is likely to become less popular unless diets that counter associated gastrointestinal symptoms can be formulated.

Management practices at weaning

The practice of weaning is itself likely to cause profound stress that may compromise immune responses. Furthermore it seems likely that there could be long-lasting effects of weaning method and age at weaning on learning ability.[117] Horses are commonly weaned at 4–6 months of age,[107] and Thoroughbred breeders tend to wean earliest. Best practice in weaning should aim to reduce distress in foals to avoid the consequent need for them to adopt coping styles that include stereotypic and overt redirected behaviors. Although some weaning techniques depend on there being more than one mare–foal dyad, a number of approaches to artificial weaning exist. Foals can be isolated entirely, penned in pairs, or they can remain in a larger natal group that has mares gradually removed from it. A number of studies (referred to below) have attempted to measure the distress involved in these techniques.

Foals weaned abruptly show greater signs of stress than foals weaned more gradually.[107,113,115,118,119] Studies have shown that group weaning has clear benefits for the foals when compared with complete isolation.[115,120,121] A pre-weaning practice that uses familiarity rather than habituation to blunt the response to the final separation of mare and foal involves the abrupt removal of mares from foals when running in a herd situation.[122] In this system the foals are left together without their dams but in familiar surroundings.

When the behavioral development of 218 foals was tracked for 4 years,[123] informal observations about the effects of isolation were confirmed. The risk of developing stereotypies was greater in foals weaned individually than in group-weaned foals.[123] While this study showed the prevalence of locomotory stereotypies such as box-walking and weaving to be similar to that found in previous surveys, it found twice as much crib-biting and wind-sucking as expected. That said, the median age of onset of weaving was 60 weeks, the median age of onset of crib-biting was only 20 weeks, i.e. before weaning. This indicated that the physical act of weaning had less impact than the change in diet from milk to solids. Additionally, at this age, a highly significant risk factor for developing oral stereotypies was feeding concentrates. After weaning, foals given concentrate feeds were four times more likely to crib-bite than foals on grass-only diets (see Ch. 8).

Significantly, the study showed that many youngsters begin to weave after they have been sold from the stud to new homes.[123] Therefore we should recognize two discrete distressing episodes in the life of most young horses: the distress of nutritional weaning and the distress associated with dispersal.

Weaning methods

Confinement at the time of weaning is associated with a rise in frequency of aberrant behaviors including pawing, bucking, rearing and kicking at the stable walls, which may also be the target of licking and chewing behaviors.[121] These responses seem to reflect thwarted kinetic and foraging needs. Partial separation of the mare and foal that allows fenceline contact is associated with less vocalization and locomotion than total separation.[121] Abrupt separation is therefore losing favor in studs that can group mares and foals together and subsequently withdraw individual mares from the group. It would be good to see online liaison services that would allow small-scale breeders to employ the same system by putting them in touch with one another, thus allowing them to coordinate weaning their foals.

Because of the social attachments formed between foals within peer groups, it is believed a familiar companion will ease the stress associated with weaning.[2] For this reason foals are often weaned in pairs. Such paired foals have been observed displaying a lower frequency of vocalization compared with foals weaned into individual stalls.[113] This is considered helpful for the mare–foal dyad since a lower level of vocalization from the foal will elicit fewer vocal responses from the dam if she is located within hearing distance and reduce the chances of a vocal exchange contributing to escalating distress in the pair. However, the reduction in vocalization does not necessarily reflect passivity. Paired foals have been observed performing agonistic behaviors towards each other, including ear-flattening, biting or threatening to kick.[113] This activity may take place despite the foals spending time together prior to weaning and suggests that for some breeders the possibility of injury to either foal may outweigh the benefits of companionship. This certainly merits further investigation.

Aggression, along with pawing and non-nutritional suckling, is a normal consequence of frustration in freshly weaned foals. Non-nutritional suckling (i.e. of the other foal in a pair) starts within 2 hours of weaning and persists for up to 2 weeks.[115] It is suggested that a disadvantage of pair-weaning that is easily overlooked is the second episode of separation-related distress that occurs when the pair is eventually split[112] or when the foal leaves its birth stud.

Social problems may arise in barned situations because of the restricted environment and the imposition of new social groupings. Because the risk of bullying is increased indoors, Waters et al[123] recommend that foals are not box- or barn-weaned but are turned out whenever possible. Since wood-chewing has been reported to accompany the withdrawal of exercise,[124] one would expect to see less of this behavior emerge in pastured horses. Hay replacers and concentrates should be introduced to the diet of youngsters gradually and in combination with ad libitum supplies of hay.

Sexual behavior in female donkeys

Some jennies show negligible signs of estrus unless approached by a jack.[125] Others may show marked changes in feeding and social behaviors that are especially apparent if other jennies exhibit estrus in synchrony.[125] Asinine estrus is characterized by a lowered head with the neck extended forward, ears pinned back against the neck, hindlegs splaying, standing with one foreleg slightly back and the other slightly forward, tail raising, and presentation of the perineum toward the jack (see Fig. 11.7).[126–129] However, perhaps the most conspicuous feature of the jenny's estrous display involves her opening and closing the mouth with lips relaxed. These jaw movements make a characteristic sound that is audible to humans at a distance of up to several meters[128] and is known as jawing, yawing or clapping. They are usually accompanied by head lowering, extended neck, and pinning the ears back against the neck (see Fig. 12.4).[130]

Some of the rituals of donkey courtship suggest ambivalence on the part of the female. For example, quick movement away from the jack tends to be followed by an abrupt stop and solid estrus stance, which is followed by mild tail-swishing, abbreviated double hindleg lifts (reminiscent of kick threats), and hip swaying.[130] It is proposed that the transition from muted non-receptive to clearly receptive behaviors may be pivotal in eliciting mounting by the jack.[130]

Maternal behavior in female donkeys

Jennies stay very close to their newborn foals but gradually approach them less frequently and develop an overall tendency to move away, especially when their foals reach 10 months of age (Fig. 12.13).[87] The foals respond by moving towards their dams but are less persistent as they mature, regardless of their sex. In the free-ranging state this begins the process of weaning and allows for the possibility that they can become separated by some external event. Meanwhile, in domestic contexts characterized by confinement, unlimited resources, and reproductive inactivity, the jenny–foal dyad does not dissolve at weaning. Instead their spatial relationship reverts to the close relationship seen between jennies and neonatal

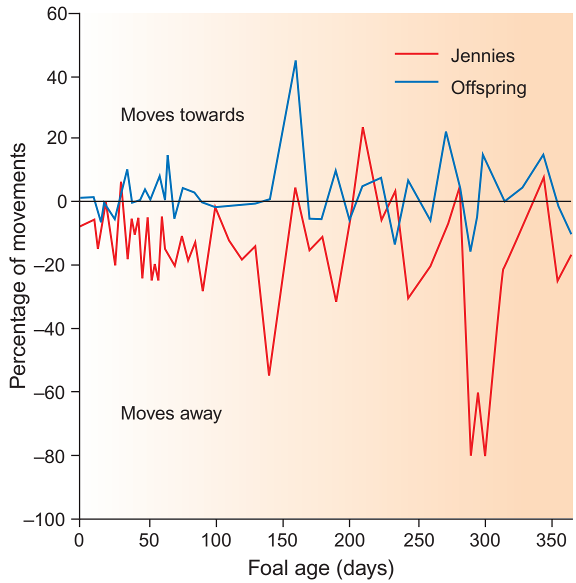


Figure 12.13 Spatial relationship between jennies and their offspring. The lines are composites of all the pairs and have been smoothed for clarity. They represent the number of approaches an animal made minus the number of times it left, and are plotted as a percentage of all movements the animal made during the hour's observation. Points above the x-axis indicate a net movement towards the other member of the pair. Points below the x-axis indicate a net movement away.[86] *(Reproduced with permission from Elsevier.)*

foals.[87] This largely reflects a shift in the jennie's behavior from leaving to approaching and, to a lesser extent, an increased number of approaches by the foal. The resultant pairings mean that related adult donkeys often stay very close together and are equally active in maintaining contact. Because it can lead to separation anxiety, this close relationship may prove undesirable for owners if the pair is parted, but it may provide many benefits including mutual grooming and the potential for the pair to develop a coalition for future support, e.g. in mutual defense.[87]

Reproductive behavior problems in the mare

Foal rejection

Persistence on the part of some newborn foals is often required for several hours before mares, especially maidens, will tolerate suckling. Mares sometimes squeal, bump and pivot their hindquarters, to avoid being suckled. While some use their stifles in rudimentary attempts to dislodge a foal as it approaches the udder, others even bite and kick. These responses, representing rejection of suckling (rather than rejection of the foal) and apparent fear of the foal, are likely to subside in subsequent parities. Grogan and McDonnell[89] recognize six unwelcome outcomes that may arise in place of successful nursing: ambivalence of the mare towards her foal; fear of the foal; avoidance of nursing only; extreme protectiveness; true rejection; and stealing or adopting another mare's foal (most of these are described in Table 12.2).

If mares do not lick their foals and vocalize towards them, they are more likely to reject.[131] Foal rejection is defined as the combination of refusal to allow suckling *and* of aggression towards the foal. Abnormal maternal behavior leading to foal rejection occurs with varying prevalence among breeds.[95] Arabian mares seem to be more predisposed to foal rejection than Thoroughbreds, with the presence of one of two related sires being statistically more common in the pedigrees of rejecting versus non-rejecting mares.[132] Juarbe-Diaz et al[131] state that rejecting mares had not experienced more than three foalings, and that of 135 rejection cases, 75% of rejectors were primiparous mares. The beneficial aspects of past maternal experience may improve the mare's maternal performance. These findings need to be treated with care, because they could reflect the breeders' decision not to breed from mares with a history of foal rejection. Juarbe-Diaz et al[131] also found that, in a few extreme cases, the rejecting mares might injure or kill their foal. Mares that rejected foals exhibited less post-partum licking of foals and were less likely to show protective behaviors towards them. The rejectors moved away from the foals as they approached and displayed threatening, squealing at, biting, chasing, or kicking behaviors. Three of 16 mares that rejected their foals injured or killed them within the first few days post-partum.[131]

Periods of separation associated with veterinary intervention (e.g. for intensive care of the foal) can allow the mare to 'forget' her relationship with her foal, and for this reason veterinarians should provide neonatal care facilities with transparent partitions that allow dams to maintain visual contact with their offspring.[91] Other causes of foal rejection are not well understood. Hormonal priming with progesterone during pregnancy, estrogen and oxytocin, olfactory cues, exposure to neonatal offspring of other mares, and previous maternal experience have all been shown to play a role in developing normal maternal behavior. When compared with normally behaving mares, the serum concentrations of

Table 12.2 A summary of the features that may distinguish various forms of maternal behavior problems[89]

Label	Distinguishing features	Predisposed mares	Predisposed foals	Management approach
Ambivalence of the mare towards her foal	• Lack of attention • Lack of bonding • Lack of protectiveness	• Sick, weak, medicated • Subject to transient separation from infant	• Sick, weak, medicated • Subject to transient separation from dam • Over-manipulated	• Check for improvement after momentary separation • Trial threat, e.g. with restrained dog
Fear of the foal	• Lack of bonding • Lack of protectiveness • Mare moves away from foal as she would from an unfamiliar quadruped	• Young, maiden mares	–	• Above techniques • Ensure paddock is large enough for mare to remove herself safely without injuring foal • Gradual desensitization • Medication with sedatives (such as acepromazine) or anxiolytics (such as diazepam)
Avoidance of nursing only	• Bonding and protectiveness are normal • Aggression isolated to attempts at nursing	• Those with pain disorders including retained placenta, mastitis, engorged udder or mammary edema	• Those that bite the teat or excessively bunt the udder	• Diagnose and eliminate any source of pain associated with nursing • Mild: physically restrain with headcollar • Severe: physically restrain with fixed infrastructure (e.g. with nursing gate) until resistance to nursing abates (up to 7 days can be required)
Extreme protectiveness	• Problematic only in the context of domestic confinement • Mare lunges excessively at perceived threats	–	–	• Ensure paddock is large enough for mare to respond to threats safely without injuring foal • Desensitize mare to threats
True rejection	• Can occur after normal bonding • Savage offensive attack with lowered head and open mouth	• Maiden mares • Possibly some familial tendency	–	• Tranquilization and restraint are worth trying but relapse is common • Likely to need hand-rearing or adoption

progesterone in foal rejectors were lower immediately pre-partum.[131] Mares may have an innate predisposition to reject their foals that is elicited by as-yet unidentified concurrent stimuli. It has been speculated (Katherine Houpt, personal communication 1996) that this unhelpful genetic trait has been perpetuated in Arabians by the practice of hand-rearing. Although breeding from affected mares may be unwise, those that are predicted to be at risk of demonstrating poor maternal behavior may be treated with reserpine (2.5–5.0 mg orally s.i.d. to b.i.d.; see Ch. 3) 3–4 days before expected parturition.[133] Time spent habituating such mares to tactile stimuli in the inguinal region and counter-conditioning with food is well spent.

The presence of people at foaling was found not to have any effect on foal rejection by their mothers. However Juarbe-Diaz et al[131] state that there have been cases of mares redirecting aggression toward their foals – aggression that was originally aimed at another horse or human that had come too close to the mare–foal dyad. In a bid to mimic the peri-parturient mare's departure from the herd, it is therefore desirable to allow mares to see their group but to keep other horses beyond physical contact around the time of parturition. By the same token, if mares demonstrate aggression to personnel, human contact should be kept to a minimum.

While normal maternal and infant interactions are reasonably well understood, further studies, especially into hormonal concentrations around parturition, could assist in understanding foal rejection.

Nymphomania

Whereas it is used by many horse owners to describe excessive estrous manifestations during a normal estrous period, the term nymphomania is familiar to veterinarians as the behavioral outcome of truly cystic ovaries. Common in cattle, this disease process, characterized more by the length of the estrus than its intensity, is very rare in horses.[9] As long as debate and confusion about this term and what constitutes a normal ovarian rhythm prevails, overzealous intervention is a likely consequence.

In Sweden, treatment of racehorses with mild nymphomania using progesterone implants is permitted, with owners reporting good responses that last up to 5 months.[134] To prevent behavioral 'problems' during estrus in performance mares, a 15-day course of altrenogest (0.044 mg/kg p.o.) starting 3–4 days before competition will reduce the time spent in estrus.[135]

Mares are ovariectomized for various reasons, including behavioral modification and use as embryo-transfer recipients and dummy mares for semen collection.[18] Of 12 spayed mares used for performance events after ovariectomy, 10 were judged by their owners to be competing at greater than pre-operative levels.[18] It would be useful to see an unbiased assessment of these mares' pre- and post-operative athletic performance.

Some interesting correlations between behavior and reproductive fitness have emerged from studies of free-ranging horses (e.g. Linklater et al[4]). Empirical studies have highlighted interesting relationships between the same parameters in domestic mares.[136] Mares classified retrospectively as less excitable produce significantly more foals in their breeding careers, with placid, mildly excitable and excitable mares having average lifetime foal productions of 8.5, 7.2 and 6.2 respectively. The relationship between these figures could be causal in that mares with more foals may be older and therefore less responsive to aversive stimuli, simply because of habituation. However, infertility showed a similar relationship, with 2.1% of placid mares, 2.2% of mildly excitable mares and 2.4% of excitable mares being infertile.[136]

Mounting

When a new mare arrives in a group, she may be mounted by resident mares.[137] Mares in heat may occasionally be mounted by estrous and non-estrous female companions, most notably in the absence of stallions. This has been described as a redirected behavior associated with frustration in some circumstances.[15] Other stallion-like traits, such as snaking movements of head and neck, herding, teasing, flehmen and trumpeting, which are associated with elevated plasma concentrations of steroids, including androgenic steroids, are a normal finding in some pregnant mares.[138] As with similar aberrations caused by anabolic steroid preparations, which can evoke more stallion-like responses in mares than stallions normally show, these signs may persist long after hormone concentrations have returned to normal.[139] It is usually recommended that mares being treated with these compounds are housed individually and not used for breeding.[140]

Although the normal value for plasma testosterone concentrations in mares is considered to be less than 50 pg/mL, natural elevations sometimes occur and are often associated with aggressive behavior.[141] Additionally, some granulosa cell tumors may cause mares to exhibit stallion-like behavior, especially when plasma testosterone concentrations exceed a nominal threshold of 100 pg/mL.[142] Since the same tumors can secrete progestins, estrogens and proteins, their effect on behavior is not isolated to masculinization.[143] Cases may present with abortion, erratic heats, continuous heats as well as physical changes that include the development of male secondary sex characteristics and abdominal distension.[144] Fortunately these neoplasms rarely metastasize, are most commonly unilateral and their removal brings about the return of normal behavior patterns and ovarian activity in from 115 to 393 days.[142,145,146]

Investigations into the use of anabolic steroids for creating teaser mares for estrus detection suggest that such androgenized mares are of variable utility, with some studies showing an ability to elicit estrous responses in only one-third of estrous mares even when running with the group.[147,148] Intriguingly, true hermaphrodites with bilateral ovotestes are not reported to show stallion-like behavior. This implies that they are passive in the presence of normal stallions.[149] However, antisocial behavior towards stallions and geldings has been reported as a result of gynecological abnormalities such as uterus unicornis in combination with atresia of the tubular genital tract.[150]

Aggression in mares

When not in estrus, mares may be aggressive to courting stallions, especially when first introduced. This is also a time when mares may show synchronous urination and kicking out with their hindlimbs in response to being herded (by stallions). Peri-parturient pain, including that associated with the passage of the placenta, is thought to predispose mares to acts of aggression by transiently lowering their pain threshold so that they respond agonistically.[95] Mares with foals at foot are also primed to defend their foals and may make aggressive responses when approached by an alien foal or unfamiliar adult. This is significant because aggression may be directed to personnel and the mare's own foal at these times. Mares that are fearful of their foals are sometimes misdiagnosed as foal rejectors because they use defensive aggression to keep the foal away from them (see Table 12.2). This sometimes abates if the dyad is presented with an approaching threat stimulus such as a leashed dog or an unfamiliar conspecific, restrained or simply in an adjoining paddock. However, this should be conducted with caution since some mares will rush at a threat with such vigor that foals can be trampled.

SUMMARY OF KEY POINTS

- Free-ranging mares can be categorized as either:
  - social dispersers (so-called mavericks)
  - loyal to a single stallion
  - part of a multi-stallion band.
- Normal courtship often involves the mare seeking the stallion and is characterized by:
  - nose-to-nose greeting
  - tactile and vocal communication
  - estrous display by the mare
  - eventual passivity on the mare's part.
- The mare's behavior does not change markedly during gestation until immediately preceding parturition, when obvious changes include increased time spent walking and in recumbency.
- Some mares may exhibit estrous behavior during pregnancy as a result of high estrogen concentrations from accessory corpora lutea.
- Social attachments, such as the mare–foal bond, are the cement that holds social units together.
- Foals are chiefly responsible for determining proximity between mares and foals.
- Although creep feeding foals prior to weaning has been shown to reduce some forms of distress and optimize the post-weaning growth rate of the foal, it has been strongly linked with the emergence of oral stereotypies.
- Improper handling during pre-weaning and weaning can create undesirable behavioral characteristics.

Case study

A 5-year-old Thoroughbred mare with anorexia and weight-loss was presented, 4 weeks after the abrupt weaning of her first foal at 4 months of age. The results of a physical examination and hematological and serological profiles were normal. History included persistent running along the fenceline and daily episodes of aggression towards other mares in the paddock. The mare had not been in estrus since weaning.

The weight loss was attributed to the locomotory activity at the fenceline, an energy expense that was not supplemented with adequate nutrition. Uterine involution was satisfactory and, in the absence of ovarian abnormalities, the failure to cycle was considered a consequence of the weight loss and poor nutrition. The mare was diagnosed with separation-related distress. The aggression was a result of her agonistic responses to mares that were in the way when she was route-tracing.

The therapeutic approach was designed to remove context-specific stimuli that were linked to the locomotory response and increase the mare's motivation to feed. She was kept with her original group but they were all moved to a different paddock several kilometers away. This seemed to help by breaking the association with the route that the mare had previously traced alongside the fence. The mare was brought in twice daily with her closest affiliate for supplementary feeds. The social facilitation of feeding and the competition offered by her companion helped to stimulate her to eat. The flushing effect of the nutritional changes brought her into estrus within 3 weeks. She was teased regularly throughout estrus and was served twice. After the season, her behavior returned to normal, although her attachment to the affiliate was the strongest of all the bonded pairs in the group. Her weight was maintained, pregnancy was diagnosed and no further symptoms were reported. The owners adopted a group-weaning technique on their stud the following year and the separation of the mare's next foal was unremarkable.

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Equitation science

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CHAPTER 13

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Background

There are a number of reasons for training problems. Many of them are considered from an ethological perspective in Chapter 15. They also include inconsistencies in the terms that are used, what is understood by them and the way in which training techniques are applied. The current chapter explores what horses can learn from their interactions with humans and encourages readers to engage with the emergent discipline of *equitation science*.

What can be learned?

Behavior is the product of the interaction of an animal's genes and its environment. As with all mammals, genetics only *predispose* the horse to behave in certain ways – actual behavior on any occasion will be the result of a combination of that predisposition and learned behavior in the environment or context. Learning can emphasize or suppress genetic tendencies, so that all equine behavior can be modified by experience. For example, the sex drive of a stallion can be modified by learning to the extent that a well-trained stallion behaves obediently around mares. In general, horse riders and trainers give far too much credence to genetic predispositions and pay insufficient attention to the potential for learning. Rather than being destined to be that way, vicious stallions, 'crazy' horses, horses that pull, shy, kick, bite or whatever are products of their life experiences and training.

Horses for courses

It is important to be mindful that the behavioral responses required of horses, even at the highest level of dressage, are not beyond their physical capabilities. While physical limitations due to conformation may affect the *quality* of the training outcome (see Ch. 7), dressage movements are essentially derived from natural movements innate to the species.

The sorts of conformation problems that limit performance in dressage and jumping generally involve the height ratio of the wither and the croup. If the wither is substantially lower than the croup, then horses generally have some difficulty collecting, which is a critical

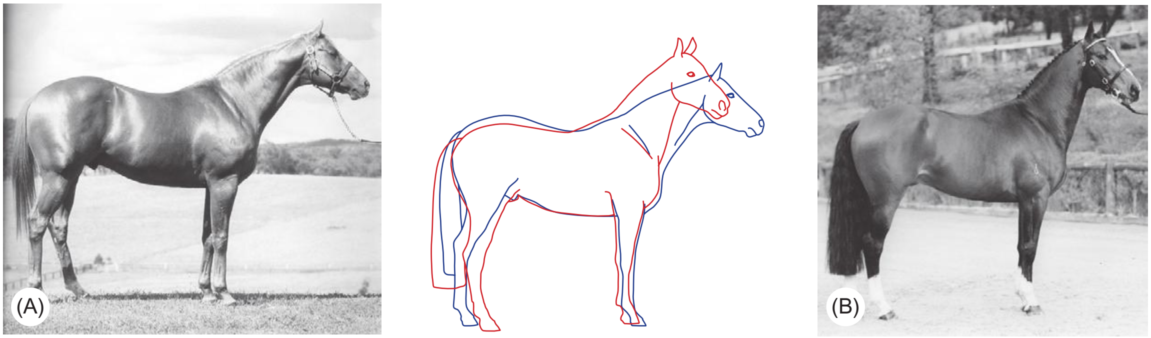

Figure 13.1 Examples of (A) a croup-high and (B) a wither-high horse. The central superimposed image illustrates the relative proportions (the blue line representing the outline of the croup-high Thoroughbred). *((A) Thoroughbred stallion 'Rancher', photography by Neil McLeod. (B) Warmblood stallion 'Rohirrim Tintagel Magic' owned by Victoria Kendall-Hawk, photography by Julie Wilson.)*

component of dressage and jumping training. Such croup-high horses are frequently found in the breeds selected for speed, such as Arabians and Thoroughbreds, and incidentally in the plains zebra (*E. burchelli*). Conversely, wither-high horses, such as all of the draft breeds, have formed the genetic basis of the modern performance dressage and jumping horse (Fig. 13.1). Interestingly, as the speed and endurance phase of three-day-eventing has become progressively reduced due to welfare considerations and, correspondingly, the relative influence of dressage phase on overall performance has increased, the predominance of the Thoroughbred in that sport is now giving way to the slower and less enduring but dressage-designed warmbloods (draft and Thoroughbred crossbreds). The emphasis in dressage on so-called uphill (i.e. withers-high) conformation is likely to have contributed to the breeding of foals that, quite without training, show a positive diagonal advanced placement at the trot in that the hindfoot of a diagnonal pair commences the stance phase before the corresponding forefoot. Horses with this action even before any training seem to command a premium price but whether this type of gait truly remains a trot (which, by definition, has a two-time beat) is the subject of current debate. Some commentators are concerned that selection of extraordinarily flamboyant forelimb action that can impress dressage judges may compromise the purity of gaits.

Another effect of the selective breeding of 'uphill' horses with more showy paces has been the emergence in the past few decades of young horse classes and so-called 'auction riding'. This has encouraged the temptation to rush the young horse's training so that it appears collected at a younger age than in earlier times. This has led to trainers abandoning the age-old tenets of taking years to train horses to reach higher levels of dressage and to avoid some of the principles of correct training such as shaping.

Traditional dogma

It is appropriate here to challenge some of the central features of traditional equine educational dogma. In some sectors of horse-training, such as the sport of dressage, the cues and signals used to elicit alterations in the mobility and posture of horses are known as 'aids'. This word is antique in origin, derived from the French verb 'aider', meaning 'to help'. The notion that cues in any way offer assistance to horses is anthropocentric and has been abandoned in our text because it nourishes the notion of the 'benevolent' horse, the horse that is a willing partner. Horse-trainers should respectfully recognize that training is an act of equine exploitation rather than equine enlightenment, and modern equitation must take full account of the cognitive processes of the horse.

Despite empirical data that demonstrate the phenomenal memories of equids[1,2] and the likelihood that horses do not need to be reminded how to execute their schooling tracks, trainers remain committed to regular schooling activities that usually comprise repetitive maneuvers involving 10-m circles, 20-m circles, serpentines and so on. If horses can indeed learn after a single trial only,[3] it could be argued that these exercises are of more importance to riders than to horses. At the same time many riding tutors maintain that through such drilling the horse develops the musculature required to maintain self-carriage (see Glossary) without having learned anything. This circumvention of the need for any understanding of learning theory is unfortunate because

Figure 13.2 Horse being schooled. *(Reproduced by permission of the University of Bristol, Department of Clinical Veterinary Science.)*

it contributes to the mystification of equestrian technique by denying the central role of negative reinforcement.

Horses are adept at habituation to riding-related stimuli such as the girth, saddle, bridle, boots, the sight and general movements of a person on their backs, as well as to environmental aspects of their habitat. Trainers must ensure that horses *do not* habituate to the training signals, an outcome which commonly shows up as hard mouths and laziness to the rider's leg signals. The schooling aspect of training sessions should make it possible to elicit maneuvers with increasingly subtle signals, providing that the subtle signal precedes and is contiguous with the reinforcement. With stimuli (rein, leg, whip-tap) using the pressure-release system, there is already an inherent subtle cue: the initial light increase in pressure. This precedes an immediate increase in pressure if there is any lack of response from the horse. The pressure is subsequently released immediately when the horse gives the desired response. The initial light increase is the mild cue that signals each intervention and the period of stronger pressure disappears. Later on, through repetition of this protocol, the horse responds to extra cues, including the subtle changes of the rider's seat and position, through classical conditioning.

An industry survey (reported by Harris[4]) notes that 25% of the time owners spend with horses involves schooling (Fig. 13.2). Riders should be clear about the purpose of this activity. The aim in the preparatory work for each schooling session should be to assess the progressive qualities of the horse's basic responses within each gait (immediacy of reaction, reaction to the light cue, rhythm, straightness, adjustability, suppleness and unconditional responses – does the horse give the same response wherever and whenever the rider signals?). Clearly, optimizing these outcomes will tend to improve the horse's dressage scores. Show-jumping and eventing, if executed correctly, also rely on the same principles, i.e. rhythm (self-maintained rhythm and speed), straightness (self-maintained line and body straightness), and contact (self-maintained leg, seat and rein connections and outline). At any speed, the more correct the execution of turns and lines, the better the performance. Therefore, instead of slavishly tracing circles in the manège*,* riders should aim to refine the horse's responses through a process of shaping (see Ch. 4). Effective shaping relies on the trainer delaying the reinforcement until the animal offers a closer approximation of the desired response than has been established in the past. In equitation, it demands attention to the placement of each foot to obtain exquisite control of locomotion, preferably before the trainer focuses on qualities such as neck flexion and outline. The concept of a training scale in equestrian manuals often departs from the notion of linear improvements. For example, the German scale (Table 13.1) does not address the acquisition of a basic attempt or stimulus control and therefore lightness of the pressure signals. In the German scale, straightness is designated to be trained after impulsion. Since impulsion requires bilaterally uniform power from the horse and straightness implies even power of the legs (a horse that is not straight is drifting), we challenge the veracity of the German scale. Straightness and rhythm are interdependent and as such should be adjacent on a training scale.

Having acknowledged the undoubted benefits of absolute obedience for many competitive disciplines, it is also worth remembering that horses that retain some innate responses may be much safer in some novel and complex environments such as may be encountered during trail-riding.

Shifting the mindset

The prevailing mindset throughout history has been to abandon, one way or the other, the less 'willing' equids because they have been regarded as having some moral (and even spiritual) involvement in the training process so that they are assumed to have 'decided' that they would not comply. These are the horses that, instead of learning what is required of them, learn to resist and escape and become the bolting, jibbing, balking, refusing, rearing, bucking and shying animals that are regularly described in books on so-called problem horses. These are the animals that change hands rapidly with the consequent addition of different commands and consequences that exacerbate the inconsistency of earlier

Table 13.1 Examples of some traditional and contemporary training scales for horses in equitation

Item	German training scale[5]	Baucher's training scale[6]	Australian Equine Behaviour Centre shaping scale[7]
1	Rhythm	To train and adhere to lightness	Basic attempt – the horse offers a basically correct single response, e.g. one step
2	Looseness	To obtain obedience to the legs	Lightness – the horse initiates its response to a light cue immediately, e.g. one stride
3	Contact and acceptance of the bit	To obtain straightness	Speed control – horse offers multiple strides; intra-gait variations elicited by the rider or handler are persistent
4	Impulsion	To get the horse to maintain responding without help from the cues	Line control – the directional line chosen by the rider or handler is persistent
5	Straightness	To collect and engage the horse	Contact – rein, leg and seat connection and the head, neck and body posture are sustainable
6	Collection		Stimulus control – the horse responds every time it is cued and only when it is cued, with all of the above qualities in new environments and circumstances

training and increase the pressures that have caused the problem in the first place.

Learning theory provides principles and guidelines for training. While these are usually adhered to by good trainers, they are not proposed as the first principles in contemporary horse-training literature. It seems strange that throughout the world, the language of learning theory is almost never taught as a basic first principle in riding schools. We submit that these omissions precipitate confusion and therefore conflict in horses and ultimately contribute to welfare problems and wastage.

Training is most rapid and consistent and training-related stress is minimized when training practices exactly match an animal's mental abilities. This is evident in the results of great scientific animal trainers such as Marian Bailey, a student of Skinner, and those largely responsible for the tremendous advances in training cetaceans, pinnipeds and canids. The International Society of Equitation Science (ISES, www.equitationscience.com) has proposed eight principles as a means of identifying horse-training systems that align with what we know about learning theory as well as encouraging those who do not to employ them. The application of these principles is not restricted to any single method of horse-training, and ISES does not expect that just one system will emerge. There are many possible systems of optimal horse-training that adhere to all of these principles.

1 Understand and use learning theory appropriately

Learning theory explains positive and negative reinforcement and how they work in establishing habitual responses to light, clear signals. (Note that 'positive' and 'negative' when applied to reinforcement are not value judgments, as in 'good' or 'bad', but arithmetical descriptions of whether the behavior is reinforced by having something added or something taken away, e.g. pressure. For example, when the horse responds to a turn signal and the rein pressure is immediately released (taken away), negative reinforcement has been applied.)

It is critical in the training context that the horse's responses are correctly reinforced and that the animal is not subjected to continuous or relentless pressure. Prompt and correct reinforcement makes it more likely that the horse will respond in the same way in future. Learning theory explains how classical conditioning and habituation can be correctly used in horse-training.

2 To avoid confusion, train signals that are easy to discriminate

There are many responses required in horse-training systems but only a limited number of areas on the horse's body to which unique signals can be delivered.

From the horse's viewpoint, overlapping signal sites can be very confusing, so it is essential that signals are applied consistently in areas that are as isolated and separate from one another as possible.

3 Train and shape responses one-at-a-time (again, to avoid confusion)

It is a prerequisite for effective learning that responses are trained one-at-a-time.

To do this, each response must be broken down into its smallest possible components and then put together in a process called 'shaping'. As learning becomes consolidated, responses may be elicited increasingly closer together, but not simultaneously.

4 Train only one response per signal

To avoid confusing the horse, it is essential that each signal elicits just one response. (However, there is no problem with a particular response being elicited by more than one signal.)

Sometimes a response may be complex and consist of several trained elements. These should be shaped (or built up) progressively. For example, the 'go forward' response is expected to include an immediate reaction to a light signal, a consistent rhythm as the animal moves in a straight line and with a particular head carriage. Each of these components should be added progressively within the whole learned response to a 'go forward' signal.

5 For a habit to form effectively, a learned response must be an exact copy of the ones before

For clarity, a complete sequence of responses must be offered by the horse within a consistent structure (e.g. transitions should be made within a defined number of footfalls).

Habit formation applies to transitions in which the number of footfalls must be the same for each transition and this must be learned.

6 Train persistence of responses (self-carriage)

It is a fundamental characteristic of ethical training systems that, once each response is elicited, the animal should maintain the behavior.

The horse should not be subjected to continuing signals from leg (spur) or rein pressure.

7 Avoid and dissociate flight responses (because they resist extinction and trigger fear problems)

When animals experience fear, all characteristics of the environment at the time (including any humans present) may become associated with the fear. It is well-known that fear responses do not fade as other responses do and that fearful animals tend not to trial new learned responses.

It is essential to avoid causing fear during training.

8 Benchmark relaxation (to ensure the absence of conflict)

Relaxation during training must be a top priority, so when conflict behaviors are observed in the horse, we must carefully examine and modify our training methods so that these behaviors are minimized and ultimately avoided. Relaxation does not imply dullness but instead, clear consistent training should result in a horse that is attentive. For example, while the horse's tail should be loosely carried, the ears should move as each cue is elicited.

To recognize the importance of calmness in enabling effective learning and ethical training, any restraining equipment, such as nosebands, should be loose enough to allow conflict behaviours to be recognized and dealt with as they emerge.

In the normal distribution curve that constitutes the components of what is termed 'trainability', the range of horses that are 'good', 'eager-to-please' and in fact easy to train in the ad hoc systems that comprise contemporary training, occupy a relatively small portion at the top of the trainability scale (Fig. 13.3). It would seem that this could be significantly increased by introducing a scientific approach to training and management and utilizing the principles of learning theory so that we can expedite training, reduce training-related stress and vastly improve horse–human interactions. Equitation science aims to demystify the training of horses. Furthermore, by exploring best practice in horse training, it complements some of the techniques in behavior modification that appear elsewhere in this book (see Chs 1, 4 and 15). Equitation science has an extremely promising future since arguably it is more humble, global, accessible and accurate, and less denominational, commercial, open to interpretation and misinterpretation than any rigid methodology. It has the potential to be the most enduring of all approaches used to train the horse.

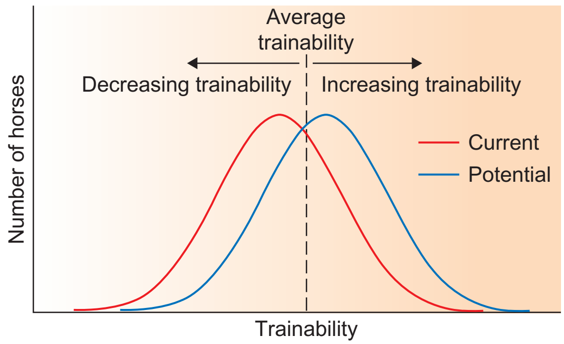

Figure 13.3 Theoretical normal distributions to show how the number of horses that cope with training may be increased by using more enlightened approaches including greater clarity of cues, better timing, greater consistency and more flexibility in educational approaches. *(Courtesy of Peter Thomson.)*

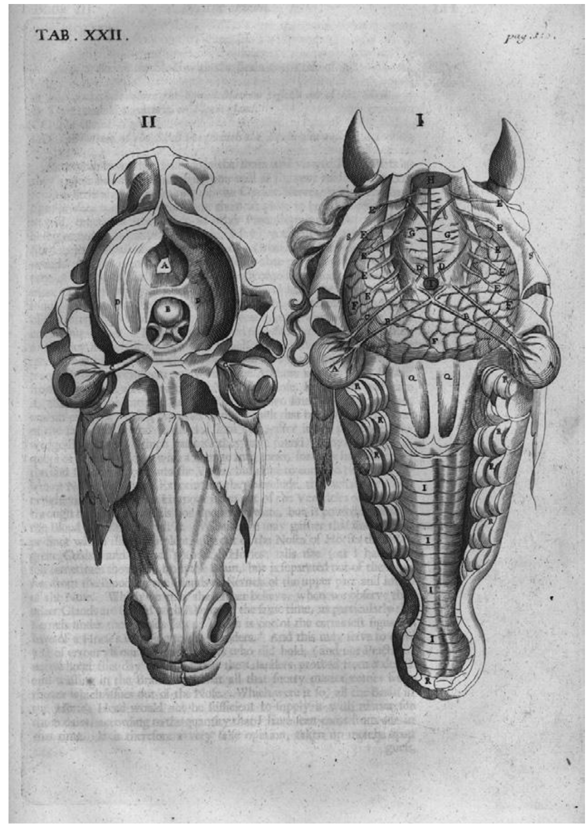

Figure 13.4 Etching of cranial dissection of the horse showing how 17th-century veterinary anatomists attributed to the horse a much larger brain than it truly has. *(From The Anatomy of an Horse, by Andrew Snape, published by J Hindmarsh, Cornhill, 1686.)*

Welfare and wastage

There are welfare implications in failing to identify adequately the mental abilities of all animals in the care of humans. Overestimating an animal's mental ability must be seen as a major contemporary welfare issue when it manifests as abuse, wastage, stress and conflict behaviors.

As horse trainers and handlers, our understanding of the horse's mental abilities is based largely on a centuries-old tradition of horsemanship. Horse-training textbooks (including pony club texts) throughout the world take their reference from traditional horse practice or from the 'great masters' of horsemanship who lived in the past 500 years. Such texts generally abound with words to describe horse behavior that imply reasoning abilities (Fig. 13.4). They generally assume that the horse 'understands' his training rather than simply responding through reinforcement. Training a horse within the traditional anthropomorphic framework has a number of potentially negative implications for horse welfare, as well as for the safety of riders and handlers. For example, if you believe that a horse complying with your commands is showing a willingness to please you, then you may also believe that when the same horse fails to comply he is actively seeking to displease, defy, undermine and even embarrass you. This belief system explains why so many riders feel justified in physically punishing horses for failure to perform. So while a coach may instruct a child to whip her pony as a punishment when it fails to jump a fence, an equitation scientist primarily sees the lack of response as evidence of pain or a training deficit. A scientific approach acknowledges that lack of forward movement over the fence is but one of myriad other responses that the pony failed to offer, and that whipping after the error is not going to help the pony identify the correct response in the future. [We offer this specific example, not least because this issue of children whipping horses is emerging as an important topic in animal welfare debates that are being informed by equitation science.]

Furthermore, the anthropomorphic view of the horse is not supported by scientific examinations, which suggest that equids possess little or no higher mental abilities. Mindful of this, equine ethologists avoid interpreting responses as reflections of human emotions and values. They do not do this to demean horses but to recognize that there are often simpler and more plausible explanations for most of the horse's responses.

Training does not always go according to plan. Some horses are predisposed genetically to trial undesirable responses rather than desirable ones. Some horses learn to evade stimuli most effectively when the stimuli are predictable by association, e.g. in a schooling context. Horses that have been subjected to inconsistent signals, such as the lack of release of pressure, or to the pain of bad schooling, often acquire the reputation of being difficult and are sold on to homes where more often than not the harshness of schooling is escalated. This contributes to disturbing slaughter statistics. For example, in a French study of more than 3000 non-racing horses, some 66.4% died aged between 2 and 7 years.[8] Unlike data from the racing industry,[9,10] this wastage was not attributed to orthopedic or respiratory disease but more likely to inappropriate behavior. The welfare implications of this wastage suggest that veterinarians and equine scientists should become well versed in learning theory since it is the basis of good training, continuing education and behavior modification. The wrong approach to training can have consequences far worse than simple time-wasting.

The emotiveness in the horse-riding welfare debate has fostered empirical research into the ethics of equitation and an analysis of some of the more unorthodox interventions that arise during handling, training and competition. According to Derkensen and Clayton,[12]

> *'Knowledge of equitation science may help veterinarians play a more effective role in preventing injuries to horses and their trainers, and in recommending more effective methods of treating and retraining equine athletes when injuries do occur, thereby improving sport horse wellbeing.'*

The relevance of learning theory

Modern behavioral psychology has established learning theory as the cornerstone of elegant training programs in many laboratory and performance species, but is only now beginning to become incorporated in any significant way into contemporary equine training or into the education of equestrian coaches. Because horse-training was well entrenched in its ways by the time Pavlov, Thorndike and Skinner came along, riders have not been altogether receptive to these scientists' findings.

The assumption that the horse is a willing partner and that the aim in coaching is largely to train the rider's biomechanics to merge into those of the horse is widely accepted in dressage circles. While it is not disputed that, after the consolidation of operant responses, this ideology plays some part in the later development of horse training, the overall approach neglects trial-and-error learning (operant conditioning). Problems arise when equestrian methodologies focus on classical conditioning *before* or *instead* of the more deeply ingrained pressure-release responses through trial-and-error learning. This is because confusion (and therefore conflict) often arises in horses unless the basic responses have been installed thoroughly in the first place by trial-and-error learning through negative reinforcement. The fundamental trial-and-error responses under-saddle comprise stimulus control of acceleration and deceleration in gait, limb tempo and stride length, turns of the forequarters from each rein and turns of the hindquarters responses from the rider's legs. Training the horse by simple cue associations neither ensures controllability in all environmental contexts, nor provides the range of responses that is required for ultimate control in the Olympic equestrian disciplines of show-jumping, horse-trials or dressage. Furthermore, the randomness in behavioral response that horses are able to exhibit when not under complete handler/rider control results in inconsistent stimulus–response relationships which frequently cause chronic stress.[16] It is assumed that the prevalence of such methodologies has arisen in the absence of a logical framework based on learning theory.

The cognitive revolution of the 1970s rejected behaviorism. Its legacy is the 'tendency to underestimate the power of Skinnerian conditioning to shape the behavioral competence of organisms into highly adaptive and discerning structures'.[11] This probably contributed to the resistance to the understanding of learning theory in those domains within animal training where it had not already been accepted. Indeed, many texts on equine behavior seem to imply subjective mental experiences in horses.[13–15] It would be a scientific error to assume the existence of abilities in the absence of data. Even if there are no data supporting the negative or affirmative case, assuming subjective mental experiences in animals would constitute an unacceptable rejection of the null hypothesis.[11] Moreover, most of the published peer-reviewed data strongly indicate that horses lack insight into their instinctive behaviors. As we shall see in the discussion of equine mentality that follows, there are strong selective pressures for this lack of insight to occur.

Horse whisperers

It should be acknowledged that, when trainers apply the principles of learning theory, they generally achieve desirable results. Throughout history, there have been riders who were adept at putting learning principles into practice, but who did not have the advantage of a theoretical basis. They were considered 'natural horsemen'. Biographies of gifted riders repeatedly suggest that they were at a loss to explain their talents. Unfortunately, this has led to the myth of horse whispering and the mistaken belief that training is more art than science. This set of beliefs has led to a consequent denial of the benefits of applying structured behavioral principles to horse training.

Although the equine industry is steeped in tradition, its stakeholders have demonstrated that they can nonetheless take heed of new information, especially when it is demonstrated convincingly. The new global wave of horsemanship, as expounded by the 'horse whisperers' and 'new age' trainers, is slowly raising awareness of alternative ways to view the horse and approach horse-training. By approaching the so-called 'problem horse' with a different set of tools, these trainers have provided some enlightening solutions to problems that have presented difficulties for traditional equestrian ideology.

Sometimes the horse-whispering myth provides an irresistible superhuman kudos to the practitioner. But perhaps the greatest limitation of many horse-whispering systems is that training practices are once again locked into *method* without the illuminations and extrapolations provided by learning theory. Their techniques have arisen from the historical trials of practical horsemanship. Furthermore, the paranormal mystique that surrounds horse whispering and the tremendous variety of techniques tend to confound any search for a unifying principle. Thus horse whispering is often applied without the sort of paradigm shift in thinking about the cause of the problems that we have seen in the behavior modification of other domestic species such as dogs. For this reason much of the current wave of 'new age' horse training remains within an anthropocentric and anthropomorphic framework. This is unfortunate because any assumption that the horse is motivated by anything other than its instinctual drives adds an unnecessary layer of complexity to its training. Anthropomorphic explanations of how compliant horses 'understand' and 'oblige' us are unhelpful for at least two reasons: first, they mystify the training process for novice riders; and second, they imply that non-compliant horses are somehow malevolent. This explains why in one text of equine behavior modification, some horses have even been described as 'depraved'.[18]

Some practitioners convey an appealing message: that horse training is simply a matter of demonstrating leadership or dominance in a manner analogous to that shown among horses to each other. Anthropocentric labeling of human–horse interactions makes the interpretations by some proponents of natural horsemanship sound irrefutably plausible and humane. Unfortunately, such labels can be misleading, contradictory and constitute potential barriers to effective training. They can also lead to misunderstanding, conflict and reduced welfare for human and equine participants. One of the potential dangers in adopting an anthropocentric framework to explain horse motivation is that the trainer/rider may assume that a horse knows what the human wants. This assumption permits humans to issue unclear cues, leading to frustration and perhaps even feelings of deception when these fail to produce the desired outcome in the horse.

For example, some practitioners insist that horses in roundpens signal to their human trainers as they would to high-ranking herdmates, and further that they are motivated to be with those humans simply because they 'respect' them. In contrast, it is possible that horses in roundpens are showing distance-reducing affiliative signals that are being misinterpreted.[18] However, recent empirical studies suggest that the responses of horses to humans in confined areas, such as roundpens, are context-specific[19] and may rely more on negative reinforcement than on innate equine social strategies.[20] These findings prompt scientists to question the interpretations of horse responses to roundpen interventions commonly offered by some practitioners and offer more scientific, measurable interpretations in horse handling and training.

Unfortunately, some of the 'modern' training systems are simply recycled in that they are just old horsemanship skills repackaged in a pseudo-scientific wrapper. Predictably, these systems do not always follow the principles of the psychology of training as clearly as they should. Some retain familiar pitfalls such as: multiple signals given concurrently; different responses for a single signal; lengthy delays in reinforcement.

Finally, a note about the increase in the popularity of roundpens that has resulted from the global interest in 'whispering' and relies on an understanding of the flight zone of an animal. A tame animal has a flight distance of zero. Animals are acutely aware of this zone of safety around them so that when it is breached, they move away. In a roundpen situation the horse stops moving when the trainer retreats from the flight zone (Fig. 13.5). It seems that there is sometimes a perceived notion that creating an emotional crisis during roundpen training is actually desirable, probably because it forces the horse to offer a change in 'attitude' after which it accepts the human as 'leader'. The simplest explanation of this change is that the horse's running away in the roundpen

Figure 13.5 Round-pen work relies on an appreciation of the horse's flight zone. *(Photograph courtesy of Portland Jones.)*

does not increase the distance between it and the human, thus allowing the trainer to use actions and postures to reinforce slowing and shape the horse to approach. Similarly, the practice of lungeing (see Glossary) hyper-reactive horses before training can be seen as problematic as it is often little more than an opportunity for the horse to learn and practice flight-related behaviors.

We must exercise caution before advocating approaches to equine training that involve chasing horses and causing them to associate fear responses with any human interactions, because we now know that fear responses and associations are not as prone to extinction as other learned responses.[21] The horse may well learn to approach humans, but the means does not justify the end, because, if Le Doux's findings are to be given any credence, the experience of being chased can leave the horse with a more 'hair trigger' flight response. The danger is in the retention of flight-response associations, and its translocation to other interactions with humans. The implications for rider safety are profound.

The problems with contemporary training

By tailoring training strategies to the species' mental ability, we can increase the efficiency of training and minimize misunderstandings in human–animal interactions. For example, when humans have expectations that animals 'understand' what is required, they often give inappropriate signals to the animals (such as delayed, inconsistent or meaningless reinforcements) that result in deleterious behavioral changes.[22] Wiepkema[16] indicates that unpredictability in the stimulus–response relationship causes conflict behaviors such as redirected and displacement behaviors. If these behaviors fail to satisfy the animal's current motivation, the animal may learn that it is unable to improve its well-being. Not surprisingly, learned helplessness has been identified in domestic horses.[23,24] Classically, this takes the form of reduced responsiveness and the appearance of lethargy. In essence, the animal shows evidence of having given up any attempt to improve its welfare. For that reason, it is sometimes assigned the synonym learned hopelessness. Although learned helplessness is a manifestation of compromised welfare,[25] it is often referred to as 'staleness' in equestrian texts.

Trainers are frequently at a loss to explain the origin of the seemingly 'naughty' or 'bad' behavior in their horses. Their dilemma arises from the fact that they believe the horse has a temperament problem or 'vice', rather than seeing that it has a training problem, an enlightened view that releases the horse from responsibility for the problem and puts it squarely at the feet of the trainer. In most cases, and with the exception of horses that are responding to a painful lesion, the fault indicates that the signals trained by pressure-release in the early training of the horse were either incompletely installed or have since deteriorated through lack of attention to their integrity.

Equine mentality

Horses pass with flying colors the experimental tests of: their excellent memory;[2] their ability to learn through instrumental conditioning (sometimes rapidly);[14] their ability to discriminate; their powers of stimulus generalization; and how one learning experience can enhance their uptake of another.[14] However, empirical evidence suggests that they have little or no capacity for reasoning or insight.[22] From an anatomical perspective, Bermond[26] uses the argument from analogy to propose that animals without well-developed prefrontal cortices (including horses) would be unable to perform the mental abilities (such as reasoning) conferred by such brain features. Furthermore, he contends that reasoning has a maladaptive downside in that it allows animals (i.e. humans) to project and prolong their worst fears, and develop psychotic behaviors. He states that 'the prolongation of the emotional feeling (in humans) is a well known phenomenon and psychological defence mechanisms such as displacement, projection and suppression are, for example, unlikely to occur in the absence of this process'.[26]

Throughout evolution, grazing animals have been on the menu for predators. Being aware of such a plight would be maladaptive in terms of stress and interrupted foraging if a horse were slow, young, ill, lame, in foal, fearful of darkness or had a foal at foot. But horses never required higher mental abilities such as reasoning because, as Budiansky[27] points out, grass (unlike a mouse!) doesn't hide or require planning or ambush to catch it.

Reasoning is an expensive luxury and is most likely not selected for by the grazing niche. Brain tissue is many times more expensive to fuel than other tissues[28] and is subject to strong selective pressure.[29] The impoverished grazing niche that the horse has evolved to exploit adds an extra imperative for neural efficiency. Moreover the lack of higher mental abilities is adaptive for grazers such as equids, because it allows the formation of repetitive behavior patterns such as escape routines. The advantage of these 'habits' over more reflective mental processes lies in their speed of acquisition, and the immediacy and stability of reactions.[22]

Horse handlers frequently witness that horses have little or no insight into their own instinctive behavior. As humans we are astounded that an animal would maim or kill itself in the execution of pulling back from a tie-up post, thrash itself to bits in a trailer (float), or literally bolt towards solid obstacles, as is sometimes seen in cross-country phases of horse trials competition. The riders in the latter instance frequently believe that these horses are simply 'keen'. Another sign of horses' apparent lack of insight is that they have little concept of 'form'. For example, many horse people have noticed that some horses show tremendous fear when confronted by changes in form of objects or even in conspecifics. If such horses have never seen a small white pony, they seem unable to extrapolate that it is a horse. Similarly, some horses (such as Topper in the case study in Ch. 11) seem unable to interpret correctly the form of their closest relative, the donkey, and react as if it were a potential predator. In a further example, if a familiar human enters a field occupied by horses and drops to her hands and knees to move quadrupedally among them, they will reliably flee. This shows that they fail to work out how the familiar biped transforms into the unfamiliar quadruped. Importantly, we cannot be sure at this point that the horses flee because they are in fear of predation. A simpler explanation is that they are responding to an aversive stimulus without necessarily assuming that it could catch and consume them.

Hard-wiring and habits

The horse is born with a neural template for all the different instinctive behaviors that it will require throughout its life. In a sense, the horse's brain has the neural architecture of a ready-made internalized structure of the external world. Here the neural pathways are predetermined – the animal is born with a motor-pattern to walk, trot, canter, flying-change, suckle, startle at certain shapes, be especially aware around water, caves and ditches and be preprogrammed for sex later in life. This has been referred to as hard-wiring. An obedient horse is one that offers desirable learned responses which, under the control of humans, override instincts such as to run, eat, socialize and copulate in the presence of eliciting stimuli.

In the early stages of learning, associations form in the brain as simple, fragile pathways and networks. The more a particular response is practiced as a consequence of its eliciting stimulus, the more that neural network develops. After a number of repetitions, a repetitive behavior pattern (a habit) forms. Learned responses in mammals modify instinctive drives, and thus can override or enhance their expression. For example, horses can learn to jump obstacles by being trained to maintain forward locomotion and straightness when presented with jumps of steadily increasing height and aversiveness that they would otherwise avoid. Equally, with enough practice, unwelcome responses such as shying (Fig. 13.6) is shaped by learning, in that it frequently develops into a faster and larger leap sideways and may even evolve into a rear and spin away.

Horses are highly motivated to seek freedom from confinement, pressure or effort. Panic and fearful

Figure 13.6 Shying horses learn that evasive responses are effective means of reducing their exposure to aversive stimuli. *(Photograph courtesy of Sandra Hannan.)*

Figure 13.7 In many cases, patting may be irrelevant to horses. *(Photograph courtesy of Sarah Brooks.)*

responses are often the vehicles of their freedom and, when horses bolt, buck or rear, the freedom associated with shedding predators from their backs is highly rewarding. It is therefore not difficult to understand why *expressing* the flight response is inherently reinforcing. Evolution has bequeathed to the horse automatically hard-wired patterns of behavior, such as bucking, because of their high survival value. It is not surprising that these patterns of behavior may be subject to one-trial learning, and that they themselves are modified by experience, so the horse can begin to adopt natural responses (that profit it) rather than the responses the rider wants. Such equine strategies prompt traditional horsefolk to label the horse as nasty or vengeful while in truth it is simply expressing a summary of its genetic predispositions and previous training.

Ineffective rewards

Patting the horse (Fig. 13.7) is an overrated reward endemic among equestrians. One of the dangers of patting the horse as a reward is that it can become the focus of our reinforcement system to the detriment of the release of pressure. Indeed some riders can be seen patting their horses while still pulling on the reins. Sometimes too the distinction between patting as a reward and slapping the horse on the neck as some kind of punishment is a blurry one indeed.

Horses are not born with an innate understanding of patting; it is at best a secondary reinforcement. As a secondary reinforcer, it would need to be associated consistently with a primary reinforcer (such as food) after an act (and just before the food). However, scratching at the lower neck and withers is a different story altogether (see Ch. 10). Feh and de Mazieres[30] propose that because grooming at this site lowers heart rate more than grooming of any other area of the body, it produces relaxation.

If we touch the horse and say, 'good boy' (secondary reinforcer) whenever we feel pleased with it, we run the risk of extinguishing associations with primary reinforcers (see the section on using reinforcers in Ch. 4, p. 102), and thus at best these things can come to mean 'I like you', but not 'well done!'. In animal training, failure to consolidate the attachment of rewards to responses will render such rewards as background noise. Thus the most optimal use of 'good boy' is to use it as a secondary reinforcer at the precise moment of the desired behavior and follow it up with food or wither caressing.

Conflict behaviors – the manifestation of problems

Conflict

In the natural habitat or indeed in many domestic contexts, horses are rarely frustrated for long because they are free to attend to their basic motivations. For example, in agonistic encounters they can compete and resolve disputes with other horses. When frightened, they can flee. If faced with hunger, they can search for and consume forage. Whichever way, the conflicts between competing motivation will usually be resolved very rapidly.

Behavioral responses have evolved to address their current motivations (primary reinforcers), including hunger, thirst, sexual desire, and freedom from predators, pain and discomfort. Throughout their lives horses learn to offer responses that satisfy these needs. Domesticated horses learn during their early training that the pressure of the bit via the reins disappears when they stop or slow. They learn that the pressure of the rider's legs or spurs disappears when they go forward. However, when horses consistently cannot obtain their freedom from such pressures, chronic conflict may arise which is detrimental. Importantly, chronic conflict as a result of training manifests in situations where the horse receives constant pressure or pain; it tends not to arise directly as a result of mild cues, although it does arise when random behaviors appear that are not under the stimulus control of those mild cues.[31] Such conflict leads to greater and greater amounts of tension and a frustrated flight response (Fig. 13.8).

A useful example of conflict in equitation arises when horses are trapped between the rider's 'go' and 'stop' signals. Unable to resolve the pain, they may resort to shying, spinning away, leaping, or bucking, depending on their genetic make-up. Shying may evolve progressively to rearing if a horse receives sufficient practice, motivation (pressures are not resolved) and reinforcement in the form of dislodging the rider and thus switching off the presure cues. In the absence of pain, bucking is a conflict response that arises from unclear installation of the 'go' signal when the reins are also pressuring the horse to stop to some extent. It is also made more likely when the leg signals are incompletely and inconsistently trained and when the horse has been poorly trained by benign cues (such as voice commands) that have no operant basis and the rider later has to resort to hitherto unused leg pressures. Most behavior problems in-hand and under-saddle can be resolved by retraining the pressure-release responses of 'go' and 'stop'. This entails training these responses so that they are immediate, occur from a light version of the pressure, and that speed, direction, and consistent leg and rein connections are retrained.

As we see in the case study at the end of this chapter, problems loading into a trailer (float) are similarly resolved when the horse is retrained so that the 'go' signal from anterior lead rein pressure and the 'stop' signal from posterior lead rein pressure are re-established.

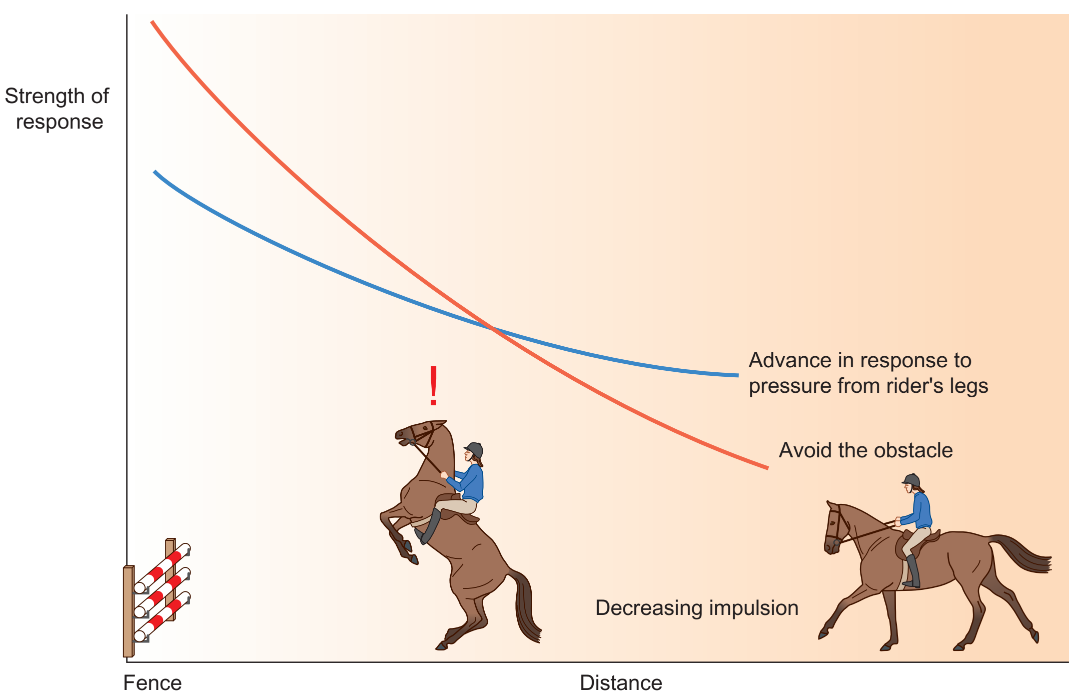

Figure 13.8 A horse that is reluctant to jump a fence may enter conflict if it fails to resolve the competing motivation to avoid the fence and to respond to pressure from the rider's legs.

In training situations, chronic states of stress and conflict increasingly emerge when the association between cues and outcomes is not sufficiently predictable for the horse. An example of this is when a stimulus does not always lead to the same response and a deteriorated state of pressure-release responses prevails. It is within this schema that most manifestations of the so-called 'problem horse' arise. Therefore conflict behaviors, including loading and traveling problems, tension in-hand and under-saddle, and many other problem behaviors may have their roots in the confusion or incomplete installation of one or more of the basic pressure-release responses that are derived from their interactions with humans.

The more horses experiment with resistances and evasions and associate them with positive outcomes, even on a variable reinforcement schedule, the more they are likely to extinguish other learned responses.[31] They are driven by their hard-wired instincts to escalate tension when they enter behavioral conflict. This can have the effect of alarming or annoying the rider, with a resultant loss of relaxation in the horse. This is contraindicated because better learning performances are achieved by horses that are calm, probably due to reduced interference in the learning process.[38]

The potential contradiction of rein and leg contact

The nature of the sport of dressage predisposes it to creating training-related conflict.[31] Dressage requires the horse to maintain a constant contact with the rider's hands (via the reins and bit), to be 'on the bit' (see Glossary), which entails the horse maintaining a flexed neck, while simultaneously responding to signals from the reins (Fig. 13.9). Because the horse is highly motivated to seek release from pressure (especially in his sensitive mouth), the process of habituating the horse to the rein contact is often problematic within a traditional training regime. The problem is that the horse must habituate to the level of normal 'contact' *and* learn to differentiate this from 'stop'.[31] The rules of dressage issued by the sport's peak body, the Fédération Equestre Internationale, frequently state that the nasal plane should at all times be in front of the vertical.[32] So it is fair to assume that this posture is desirable if horses are being prepared in a way that aligns with FEI rules. Unfortunately, the contemporary framework for dressage training places less emphasis on maintaining a light contact than on other aspects of the outline and locomotion of the horse. Thus, instead of training the horse to carry his head and neck freely on a light contact, it is not uncommon to find that the horse is heavy in the rider's hands and develops conflict behaviors.

It seems probable that many riders see neck flexing as a proxy for evidence of training. A study of photographs of ridden horses advertised in a popular Australian horse magazine (n = 378) found that 68% had their nasal plane behind the vertical.[33] Theoretically, however, a vertical nose does not necessarily mean that the horse is 'on the bit', especially if it is being held in that position by the rider's hands.[34] By definition the horse that carries itself

Figure 13.9 Horse being ridden with a 'strong' contact. *(Photograph courtesy of Sandra Hannan.)*

'on the bit' is adjusting to the additional weight of the rider by caudally shifting its nose, shortening and arching its neck to some extent, and bringing its hocks underneath it, and thereby is assumed to be shifting its center of gravity caudally[35] with minimal contact or pressure from the reins. This postural change seems to have been predicated on the observation that the horse is able to show more impulsion in this posture.

It is worth considering how the concept of being 'on the bit' may have been corrupted by common equestrian parlance. It is a poor translation from the French '*mise en main*', which meant, literally, '*put in the hand*' and refers to the relaxation of the jaw and of the poll[36] so that the horse 'releases the mouth softly and loyally accompanies the hand wherever it moves'.[37] The *mise en main* does not imply that the bit is necessary nor that the nasal plane should be vertical or that behind the vertical is desirable. The neck and head position of the horse, in what is considered to be correct schooling, where dorsoventral flexion of the proximal cervical vertebrae and atlanto-occipital joint (flexing at the poll, poll flexion or roundness) results in the nasal plane being approximately 6° in front of the vertical or 12° at walk.[34]

In addition, the poll should always be at the highest point of the neck, and this posture should be trained to be self-maintained by the horse, achieving what is known as self-carriage. This self-maintained posture is intended to optimize the balance of the ridden horse and its readiness to respond to the signals transmitted by the rider. Alterations to this carriage correlate with the horse's level of education. As the dressage horse's capacity to collect develops, his poll raises further and the neck arches more, which brings his nose somewhat closer to his chest than in less-educated horses. This results in changes in the topline physique of the horse over a period of time. These alterations are achieved through the anabolic effects of changes in velocity.[7] It is likely that such changes facilitate the constant accelerations, decelerations and changes of line that characterize the horse in the sport of dressage as opposed to horses at liberty (which have been shown to carry their heads at angles that depend on the gait: walk 30.7 ± 11.5° in front of the vertical; trot 27.3 ± 12.0° in front of the vertical; and canter 25.5 ± 11.0° in front of the vertical).[33] Furthermore, contemporary dressage training where the nasal plane is frequently behind the vertical obscures the signs of the onset of learned helplessness and offers few strategies to prevent it.[31]

Contact in the purist sense is simply the rider's feel of the horse's lips and tongue but not the premolar teeth or diastema so it therefore involves no pain, just a mild sensation. This level of contact should be targeted over the life of the horse in training. While seeking mild contact, which is implicit in the traditional notion of self-carriage, there will of course be times when the contact is escalated to produce a learned response, via operant conditioning, but the escalation is fleeting and is therefore unlikely to result in any learned helplessness. Sadly trainers and riders frequently prefer a much stronger pressure on the horse's mouth that includes pressure on other parts of the mouth and therefore is more likely to involve pain and learned helplessness.

It is frequently, but erroneously, believed that the horse should be ridden with strong mouth pressure and then at some point later, sometimes years later, the horse will discover its own self-carriage. This notion defies the learning principle of habituation. Bloodlines of horses that have habituated to heavy rein (and spur) pressures and make it to the top in dressage, with seemingly few side effects, may be inadvertently selected for pain tolerance and possibly a propensity for learned helplessness.[31]

Such pain habituation may come at the price of deleterious effects on the horse's mental well-being and deterioration in his behavioral repertoire. These changes may be easy to pinpoint (e.g. the horse may cease to turn or stop properly) or may be rather more obscure and general. For example, the horse may become generally sour and the manifestation of this may range from aggression during saddling to rearing or bolting. Since conflict typically manifests when the horse is least secure, he might develop separation anxiety, horse-shyness or 'panic' attacks away from home. We see a clear need for the empirical study of the relationship between training and stress responses.

The solutions

There is a series of ideas and strategies that practitioners can adopt to avoid and eliminate conflict in horses. By clarifying thinking and simplifying the messages that are sent to horses, we can ensure that their responses become more predictable.

The science of training

Although tradition has meant that learning theory has been overlooked by most equestrians, it is appropriate that readers acknowledge the extent to which scientists have developed ways of understanding the changes that occur in animals when they learn. Using the language of learning theory, some of the inconsistencies that confuse riders, and therefore ultimately horses, can be eliminated.

How to use negative reinforcement

Stimulus control can be defined as the degree to which a response occurs in the presence of a specific stimulus and does not occur in the absence of this stimulus.[34] In horse-training, achieving stimulus control of the basic locomotory responses generally involves negative reinforcement, and the following steps have been proposed:[31]

1. The response to be trained is 'targeted' by the trainer. It is important that *only* the targeted behavior results in the removal of pressure/discomfort.
2. The pressure (aversive stimulus) should be increased during the 'incorrect' behavior until the targeted response emerges. During this phase, the pressure must not fluctuate or decrease because this constitutes a lowering of pressure and thus could be perceived as rewarding and thus be reinforcing.
3. If intermittent pressures are used (such as nudging by the rider's legs or tapping with a dressage whip) there should be no increases in time-gaps between the intermittent pressures so this transient relief is not reinforcing.
4. At the *completion* of the targeted response, the aversive stimulus should immediately be removed. Removal of the aversive stimulus must be contingent upon the completion of the 'correct' behavior (Fig. 13.10).

A continuum of reinforcing possibilities

One of the interesting characteristics of negative reinforcement is the sliding scale of aversiveness (Fig. 13.11). If pressure B is greater than pressure A, then it follows that relief from pressure B is more reinforcing than relief from pressure A. For example, consider mouth pressures on a linear scale from 1 to 10 where 1 represents the mildest of aversive stimuli and 10 represents the most painful, fearful and unendurable level of aversiveness, intolerable even for the shortest duration. At some point along the scale lies a threshold where the tolerable escalates to the intolerable.

In practical horse-training these mouth and body pressures are real; light cues occur in the lower scale, while the more motivating aversive pressures lie in the higher scale. Because equitation generally relies on a foundation of aversive stimuli, it is important to mention that, as most highly skilled trainers have noted, best

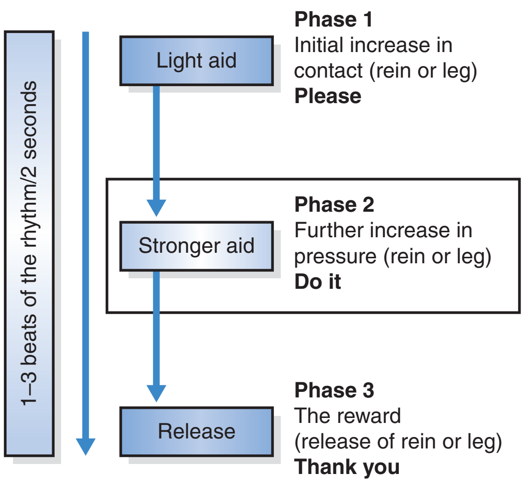

Figure 13.10 In horse-training using negative reinforcement, the operant contingency is expressed in this sequence: light signal, increasing pressure, release of pressure. In a short time the period of stronger pressure is removed and the horse readily responds to light signals. *(Reproduced with permission of Australian Equine Behaviour Centre.)*

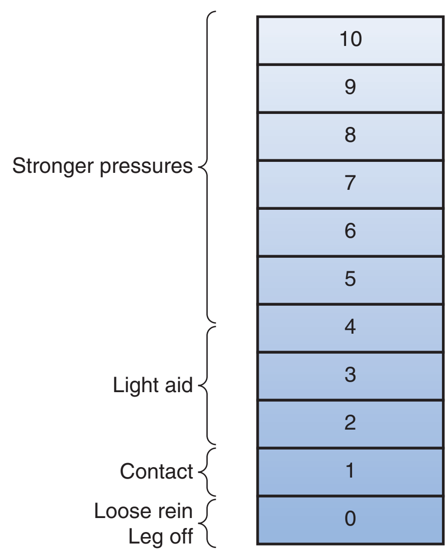

Figure 13.11 An arbitrary scale showing that the neutral stimulus, the discriminative stimulus (the light pressure signal) and the stronger motivating level of pressure can be imagined as a linear scale of pressure. *(Reproduced with permission of Australian Equine Behaviour Centre.)*

practice is embodied in the use of the least aversive stimuli (the lightest cues). Furthermore, there are problems with using high levels of aversiveness because of its associations with the amygdala. Fear and aversiveness are interconnected, and because fear responses are resistant to erasure, trainers must be very cautious about invoking fear responses during training.

When horses have unfortunately habituated to the bit or to the rider's legs through incorrect negative reinforcement, effective trainers can rehabilitate such horses by increasing the motivation of the aversive pressure for a short duration and then releasing the pressure at the correct response. In other words the operant contingency (cue, motivation/response, reinforcement) must be re-established. It is not sufficient to hope that horses might forget the aversiveness of stimuli to which they have habituated. Retraining responses that were incorrectly trained originally by negative reinforcement unfortunately requires deployment of greater motivational aversiveness than would otherwise be the case. This is why it is imperative that learning theory becomes part of every horse-trainer's education, so that it may be applied consistently both at the start and throughout every horse's training.

Trial-and-error (operant) conditioning or classical conditioning?

Most systems of horse training, especially traditions of classical dressage, focus on classical conditioning in the belief that this appeals to the horse's sensibilities. Indeed, there are numerous dressage discussion sites on the Internet devoted to classical conditioning.

While no mammalian habit is totally unconditional, many great riders have understood that the more habits are clear and consolidated, the less horses are at the mercy of their instincts. Stallions with good training of basics will work under-saddle in the presence of estrous mares, and throughout history the most reliable horses in the butchery of battle and across country are the well-trained ones – those with clear consistent and deeply entrenched responses.

When we consider the mechanisms of learning involved in training horses in-hand and under-saddle, it becomes clear that all trained responses in 'breaking-in' or, more correctly, foundation training, are products both of trial-and-error (operant) conditioning and classical conditioning alone. Trial-and-error learning with both positive and negative reinforcement is the mechanism underlying the training of the basic responses in-hand (lead forward, stop, and so on) and under-saddle (go forward, stop, turn forequarters, turn hindquarters).

Trial-and-error learning in response to pressure from the reins or the legs of the rider allows greater controllability of the outcome than could be achieved by classical conditioning.[31] For example, the greatest chance of stopping a bolting horse is with the reins, provided the 'stop' response is sufficiently trained through trial-and-error learning. This is because a horse that has been operantly conditioned to slow down or stop to bit pressures of variable aversiveness, is able to apply that learning even in face of the adrenalin-charged flight response. In contrast, a horse that has been trained only by classical conditioning to obey a previously neutral 'stop' cue such as a shift in the rider's weight transmitted through the saddle is less likely to respond appropriately in the face of novel fearful stimuli. The singular importance of seat cues as espoused by some dressage purists as a form of clear communication to the horse defies logic when one considers the amount of human flesh, rigid saddle structures and padding that separate the rider's seat bones from the horse's back (Fig. 13.12).

Positive reinforcement

The fundamental reason negative reinforcement is used so extensively in horse-training is because of the enforceability of signals such as rein pressure, compared with the difficulty of positively reinforcing ('stop' and 'go') responses after they have been randomly produced (see Ch. 4).

Positive reinforcement certainly has a role in horse-training, especially in the form of secondary reinforcement that takes the form of target and bridge training (clickers, clicker words, etc.). Because of its enormous value in rapidly reinforcing otherwise hard-to-reward behaviors, and behaviors offered by animals at a distance from the trainer, this approach should be incorporated into training. It is also of great value in counter-conditioning a horse's attempts to avoid aversive objects. Positive reinforcement is optimally used when the horse responds from light signals. Delaying positive reinforcement until this stage of the horse's training is consolidated avoids clashing of negative and positive reinforcement and hastens the horse's responses to light signals (Figs 13.13 and 13.14).

Strategic timing of training sessions

McCall et al[39] examined the effect of the number of trials per training session on avoidance learning and found that, regardless of the total number of learning opportunities, moderate repetition of training activities is needed for efficient learning. However, learning occurs throughout life in parallel with any training regime. It is unlikely that the horse regards training or schooling sessions as opportunities to concentrate on important lessons. Instead, it is more likely that it is simply aware of an

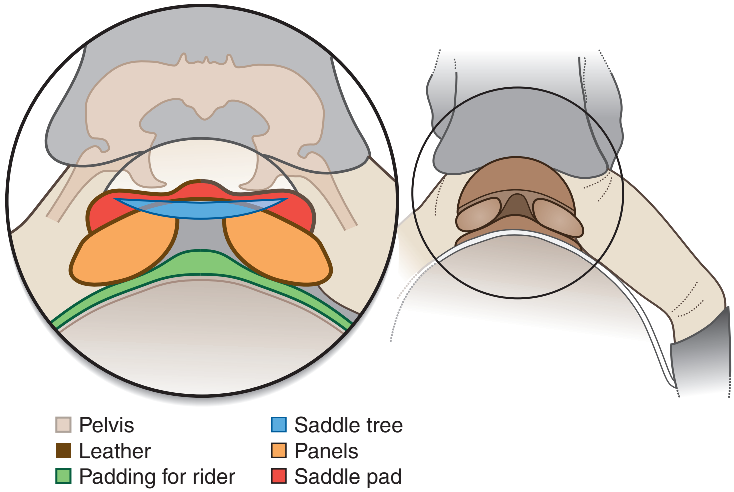

Figure 13.12 Whereas the reins and legs of the rider are in relatively close contact with the horse, the rider's seat is separated from the horse's back by layers of padding. This prevents back injury to the horse but also disperses signals from the rider. This compromise renders the rider's seat a less salient signal locus than the reins or legs. *(Reproduced with permission of Wiley Blackwell.)*

Figure 13.13 (A) A horse stretching (i.e. making an operant response) toward a target, as a part of being trained to traverse a ground-based obstacle. (B) A horse trained to piaffe using positive reinforcement. *(Reproduced with permission of Australian Equine Behaviour Centre.)*

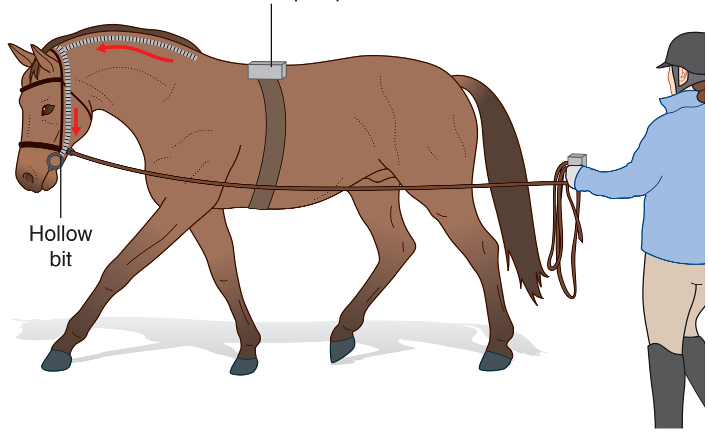

Figure 13.14 Remotely controlled reward devices (delivering positive reinforcement) can be used in combination with bit pressure (negative reinforcement). *(Reproduced with permission of Wiley Blackwell.)*

increased intensity of signaling from its rider, provided that it has not habituated to the signals.

The temporal distribution of training trials influences equine learning abilities. Experimentally this was demonstrated when ponies subjected to a single weekly training session (to clear a small hurdle in order to avoid a mild electric shock) achieved a high level of performance in fewer sessions than ponies trained twice weekly or daily.[40] This would seem to highlight the importance of giving horses breaks from intensive schooling so that they can better process information. Turn-out periods after intensive training are thought to allow maturation and consolidation of associations. However, from a neurological viewpoint, it is not clear exactly how or why this should occur. It would appear to involve the transformation of operant actions into habits and so may be connected with the maturation and consolidation of neural pathways. That aside, giving young horses significant breaks during training certainly seems to help avoid sourness (the psychological effects of over-training).[41]

One stimulus for one response

It is important to train a single response from a single and distinct signal, where possible. Pavlov coined the term 'overshadowing' to describe the diluting effect a stronger signal has over another if applied simultaneously.[42,43] Overshadowing is a common error in contemporary horse training. So in early training 'go' should *always* be elicited by both of the rider's legs, without the simultaneous application of other signals, such as a click of the tongue or a shuffle of the seat. To do so may reliably overshadow the critical signal from leg pressure and result in the horse appearing 'dead to the leg'. The 'stop' signal should initially be trained only by pressure from both reins equally, and 'turn' with pressure from the rein on the side to which the turn is to be made (direct turn). Later on, the horse may also learn to turn from the closing (toward the midline) of the rein (indirect turn). These things must be consolidated; it is incorrect to use the seat for stop before the horse has a consolidated stop response from the reins. Similarly it is important that the horse leads proficiently from pressure on the head collar rather than simply 'following' (classical conditioning) the handler, as this affords greater control in all situations and prevents the horse from practicing and making a habit of undesirable behavior. It also affords consistent stimulus control compared to the vagaries of the human gait as a form of stimulus control.

One response at a time

If the basic trial-and-error responses are not consolidated, then two or more signals should not be applied simultaneously. Moreover, it can be particularly destructive to the horse's learned responses if 'stop' and 'go' pressures are applied at the same time at any stage of its life. This is the most common cause of chronic conflict in performance horses. The elements of half-halt cues (see Glossary) should not be simultaneous but be fractionally separated in time. As the horse's learned responses become more consolidated over time, signals can be given closer together, because their effects have proceeded beyond operant action to become habit. However, even with potentially less-destructive combinations of responses, conflict can develop and training efficiency plummets. For example 'go' and 'turn', or 'go' and 'leg-yield' ('turn hindlegs') should also not be applied simultaneously, otherwise the integrity of the constituent responses becomes dulled.

Foundation training under-saddle

Importantly, there are three phases to the training of the basic responses both in-hand and under-saddle during 'breaking-in' or, more correctly, foundation training in horses:

- the mild cue, followed contiguously by
- an increase in pressure of the signal, and ending with
- release of the pressure at the completion of the desired behavior.

This scheme is negative reinforcement, and it induces a small amount of stress by design, so that the animal is propelled to trial various behaviors. Generally speaking, all resources that satisfy an animal's motivation raise alertness. Subsequently when the horse trials the behavior deemed 'correct' by the trainer, the pressure must be released immediately. In all pressure-release training, it is important to *increase* the pressure if there is no response; and to release the pressure *immediately* at the onset of the correct behavior. The release of pressure is the intrinsic reinforcer. Contiguous verbal praise is largely redundant and may even be counter-productive if it has the potential to confuse the horse.

The rider's aim should be to reduce the stress by aiming to increase the subtlety of the signals once successful trials have taken place. This mechanism, pressure-release training, is the broad scheme by which all the basic locomotory responses are established in foundation training, and re-established in eliminating problems. These locomotory responses cover the basic movements of the horse in the two dimensions (anterior/posterior; lateral forelegs/hindlegs). In-hand these are 'go', 'stop' and 'turn hindlegs'. Under-saddle, 'go', 'stop', 'turn forelegs' and 'turn hindlegs' encompass all the possible movements of the horse in the two dimensions. Generally speaking it is not essential to train the turn of foreleg responses as part of in-hand training as there are no sharp turn requirements in that modality.

In under-saddle training the rider draws the reins toward his hips by closing the fingers on the reins and when the horse stops/slows the rider releases that pressure. The rider squeezes the horse's sides with both his calves and when the horse goes forward, the squeezing stops. Similarly, a single rein trains the turn steps of the forelegs (Fig. 13.15A), and the single leg application trains the turn steps of the hindlegs (Fig. 13.15B). The timing of this sequence of operant cues is critical. Problems right across the board in training (ranging from horses not leading into trailers to rearing under-saddle) result from the violation of this sequence, yet a description of it is a rarity in contemporary equine training texts.

Foundation training in-hand

Training the horse in-hand is best begun with the trainer facing the horse, on the horse's nearside, holding the lead rein in the left hand 20 cm or so from the horse's chin. The horse should be wearing a thin rope halter so that the pressure is more readily perceived than with a thicker leather halter. If the horse has no leading response the entire lesson should be conducted in an enclosed yard. Generally the 'go' and 'stop' responses can be trained simultaneously through their various qualities because they arise in the training of each other.

During training in-hand, the handler pressures the lead-rein in the anterior direction for 'go', and in a posterior direction toward the horse's neck for 'stop'. For 'head down' the lead direction is vertically downwards, and for 'turning the hindlegs' the long whip is used for tapping the relevant hindquarter.

Go and stop

When training a young horse to lead for the first time, it is sensible and safe to stand facing the horse (but not directly in front of it) to the side at approximately 45° to the midline. Forward leading pressure is then applied and released as soon as the horse completes a single step. This is repeated until the horse steps easily from light pressure. The horse is then trained to move two steps of the forelegs (one stride). When two steps can be elicited from light lead rein pressure, further steps are trained. Similarly, the stop is trained through increasing the pressure significantly during the time when the horse is not stopping or slowing, and releasing it as soon as locomotion has ceased. However, training a step backwards from the 'stop' pressure deepens the stop response because it isolates the appropriate muscles that are implicit in stopping and slowing responses. Again, it is essential that pressure

Figure 13.15 (A) A single rein trains the turn steps of the forelegs. (B) A single leg application trains the turn steps of the hindlegs.

is released as soon as a single step backwards is achieved. When the horse responds to light signals throughout his training in-hand and under-saddle, positive reinforcement should be used to further reinforce responses. Secondary positive reinforcement is the most convenient. It is now appropriate to face in the same direction as the horse and elicit the same forward and stopping/slowing leading signals with lead rein pressure.

When the lead response is trained so that many steps are offered immediately from an initial light lead pressure, this will result in the horse maintaining speed (rhythm) in its stride. However if the horse slows down during leading, this is retrained by pressuring it more strongly during this loss of rhythm and releasing at the completion of the quicker step. On the other hand, if the horse quickens its pace, slowing signals are applied. Training the horse to offer faster and slower steps by pressure and release consolidates training of speed maintenance. Next it can be trained to move forward in a straight line. This is achieved by stopping and repeating any drifting steps until the horse steps straight ahead. A consistent contact is trained by stopping the horse as soon as the contact becomes inconsistent. Longer steps can be trained so that they also occur from a light contact, and finally these responses are tested and trained in different environments.

Increasing the pressure when the horse is slow to respond results in an obedient response. Vibrating the lead rein during the period of enforcement is sometimes more effective than pulling it, because it increases the aversiveness of the intervention. A byproduct of successful training of rhythm in 'go' and 'stop' responses is that the horse will stay in the one place without being maintained by pressure. The handler should be able to move away without the horse following. If the horse steps forward, the handler should correct him so that the horse learns to be under stimulus control. In other words, he shouldn't move until the correct signal is given. It is important to test that the pressures move the horse to go forward and stop, and this can be achieved when the handler is standing still (so as not to cue the horse) and pressuring the horse to go forward and stop. When this has been achieved, horses become relaxed and obedient.[31]

Drifting sideways can be corrected by increasing the lead pressure in the opposite direction during any drift.

Figure 13.16 Train the horse to step sideways from pressure on his hock with the tapping of the light whip.

Figure 13.17 Head lowering is achieved by pressuring the horse's head directly downwards with the lead or reins until the horse lowers a little, and releasing the pressure immediately.

The 'stop' response should also be trained to be adjustable so that the stride can be shortened. The final quality to be trained is that the horse stops anywhere. Therefore the handler should gradually increase the challenges of the training environment.

Sideways

It is also useful to train the horse to step sideways, away from the handler from pressure on its hock with the tapping of the light whip (Fig. 13.16). (It is important the whip is never used as a punishment as it will transform from a signaling device to one that triggers panic and precipitates conflict.) At first even the slightest step is reinforced with the cessation of the tapping, but after some success, progressively larger steps across the midline are shaped. The response is trained through the cessation of the whip-tap until it is offered immediately after a very light double-tap of the whip. During the early training of this response the horse will often curl its neck. The aim should be to make it move smoothly, with a straight body and neck.

The tapping at the hock can progressively move up the sides of the leg and to the ribcage so that soon the handler's fingers or eventually a voice command such as 'Over!' can initiate the step across. The use of the whip on the flank at the outset is inadvisable since it tends to promote flinching and kicking-out because, typically, this area is extremely sensitive.

Lowering the head

It is also useful to train the horse to lower its head in response to pressure, because of the relaxing effect of this posture as a result of the baroreceptors in the carotid artery that lower heart rate and blood pressure when the head is lowered. In addition, given the horse's apparent lack of higher mental abilities, it seems possible that posture can affect arousal and therefore responses by association. So, because a lowered head position is associated with activities that occur when horses are calm, such as grazing and drowsing, training the horse to lower its head is often associated with a rapid and dramatic reduction in tension. Operant conditioning of head lowering is achieved by pressuring the horse's head directly downwards with the lead or reins until the horse lowers a little and releasing the pressure immediately (Fig. 13.17). Thus the horse consistently finds comfort, and calmness results. As with all responses, it is important to reinforce every good try according to the rules of shaping (see Ch. 4). Then progressively more immediate responses can be targeted, followed by the ability to lower all the way down to the ground in one smooth response.

Any lack of straightness in the neck is attended to by using the rein to straighten the neck. The use of the rein in this way reduces the unhelpful effect of random neck movements laterally. Next, slightly faster downward movements of the horse's head are targeted, and then finally the horse is tested and trained in various other environments.

Refinement under-saddle and in-hand

Refinement of the basics includes the conditioning of appropriate responses to signals of increasing lightness. The extent to which this can be achieved is often limited only by the handler/rider's ability to deliver more subtle signals. Unfortunately, as balance is a skill that takes time, practice and coaching to achieve, many riders struggle to be consistent when applying mild signals.

Assuming the horse has learned the basic responses, it can be trained to offer them in response to increasingly subtle signals. Lightness in all the signals is extremely desirable for both in-hand and under-saddle training. This is why self-carriage is so critical and why it should occur from the beginning of training.[31] The horse's neck and head should be in the desired outline when it learns to go forward and stop. The rider should frequently release the reins to test that the horse is comfortable to carry its head in whichever position. If not, the horse will be leaning on the bit or straining to maintain an impossible head carriage and the resultant pain will lead to some adverse behavior, habituation or learned helplessness.

Other features of refinement involve combining basic responses to build advanced movements and providing additional signals for these and indeed basic responses. For example, the half-pass involves a cascade of responses of 'go', 'lateral flexion and bend', 'turn forelegs' and 'turn hindlegs'. If such combinations do not arise from the lightest of pressure signals, then conflict behaviors are possible and the single constituent responses are subject to detraining.

It is tempting for novice trainers to use many cues at once with none being consolidated properly. They often use voice commands haphazardly together with leg or rein aids. In breaking-in or retraining the basics, trainers must train one stimulus for one (shaped) response. Before adding other cues, trainers must be sure that the basics are well established and alternative behaviors are no longer trialled.[31] When the basic responses are consolidated and are under stimulus control (see Discrimination in Ch. 4), it is possible to add an extra signal to elicit a particular response. For example, a vocalized command may be added to the rein signal for the horse to stop.

Resolution

Unwelcome behaviors (see Ch. 15) can be seen as dysfunctions in negative reinforcement and so can be successfully modified by retraining the pressure-release regime of the problematic learned responses. For problem behaviors that are induced by dysfunctions in negative reinforcement, these constitute 9 operant responses:

1. Upward transitions from light lead rein(s) signal [in-hand], or light leg signals from both of the rider's legs [under-saddle].
2. Faster tempo of the steps from light lead rein(s) signal [in-hand], or light leg signals from both of the rider's legs [under-saddle].
3. Longer steps from light lead rein(s) signal [in-hand], or light leg signals from both of the rider's legs [under-saddle].
4. Downward gait transitions (including step-back) from the light lead rein(s) signal [in-hand], or both light reins signal [under-saddle].
5. Slowing the steps from the light lead rein(s) signal [in-hand], or both reins [under-saddle].
6. Shortening the steps from both reins from the lead rein(s) [in-hand], or both light reins signal [under-saddle].
7. Direct turn of the forelegs (light opening rein away from the midline) [under-saddle only].
8. Indirect turn of the forelegs (light closing rein toward the midline) [under-saddle only].
9. Yielding (turn) sideways of the hindlegs from the light double whip-tap [in-hand], or the rider's light single leg signal [under saddle].

One of the most important things to remember is that each of these operant reponses must be easy for the horse to discriminate from other signals. It is also important that (re)training progressively targets consistent outcomes. The aim is to consolidate certain responses so that they become habits.

Retraining in-hand and under-saddle

With a young horse, or a horse in retraining, it is fundamental to (re)train the horse to go, stop, turn the forelegs and turn the hindlegs. But these responses must not be produced haphazardly with different outcomes each time or the horse will become confused. Targeting consistent outcomes is achieved by progressively deleting random behaviors that arise from the handler/rider's signals. However, because of the range of qualities of desirable behavior, the trainer must progressively train each separate quality of response. This involves ignoring the less salient undesirable qualities (such as head carriage) that can be successively targeted at a later point in the training process or that may rectify themselves because they are emergent properties of other qualities. For example, a rounded head carriage is directly related to lightness of stimulus control and maintenance of speed and line.

Shaping requires that the trainer initially reinforces every 'good try'. The horse may or may not trial all sorts of undesirable responses as a result of the maintained or increased pressure but it rapidly learns that the pressure is released only when it offers specific responses. Then the trainer can begin to target those specific responses so that the *same* response is reinforced. This brings the desired response under stimulus control.

When responses arise from light signals, it is useful for both consolidation purposes and deeper relaxation to use positive reinforcement. Generally, secondary positive reinforcement is the most convenient. For example, use of a clicker or the distinct utterance of 'good boy' at the exact moment of the correct response followed a couple of seconds later by a primary reinforcer such as food or tactile rewards such as wither caressing.

Training the basic responses in-hand and under-saddle involves gradually gaining complete control of the horse's locomotory responses. When this is achieved, random movements of the neck are generally absent. If they do occur, they can now be deleted and horses universally show relaxation with the predictability of the signals and the controllability afforded to the horse by his now secure umwelt (behavioral world). The order in which qualities are trained should reflect the problem potential they offer. The first quality is simply to produce a basic attempt at the response. Then obedience is trained so that an immediate response arises from a light pressure signal.

The next quality to be targeted is the speed of the body and the subsequent rhythm of the leg responses. Faster and slower steps are reinforced and, later on, longer and shorter steps. Then the exact direction of the horse is targeted so that any drift off the chosen line of the handler/rider is corrected. This results in the body and neck becoming straight, thus eliminating crookedness and drift. Next, the connection to the handler/rider is refined to be consistent. Finally, the horse is trained in various environments of increasing challenge potential so that it performs all the responses with all of the above qualities wherever and whenever required. The desired qualities of the basic responses should be shaped as follows:

1. basic attempt – an attempt or crude response
2. obedience – immediate and light
3. rhythm – self-maintained speed (tempo and stride length)
4. straightness – self-maintained line, straight neck and body
5. contact – self-maintained leg and rein connections
6. proof – performs response with above qualities whenever and wherever.

It is important to progressively target responses of the same quality in each session, or progressively build on the quality during each session, and not to relax standards during training. Once modified, 'problem' behaviors can be managed by trainers through the frequent checking and refinement of the basic operant responses.

Sometimes, certain pressures applied with conventional equipment are insufficient to produce a response. This is particularly true when retraining a horse that has habituated to a pressure-release signal. For example, in leading the horse forward, the horse may not be sufficiently motivated to step forward from lead pressure. Therefore the lead signal may require extra empowerment from an accompanying whip-tap on the shoulder. The horse must be able to lead reasonably well before you attempt this. Also, if you cannot touch your horse with the whip without him showing an excessive flight response, then habituate him to it by laying it on him then stroking him with it until he is relaxed.

It is important that strong lead pressure is *not* used in conjunction with the whip-tap, but instead mild pressure of the lead accompanies the whip-tap so that the whip-tap adds extra motivational power to the lead pressure. Such empowerment may be necessary in the case of leading a resisting horse into a float. Assisting the lead response with the whip-tap is inadvisable in early training of the lead forward response in a naïve horse because adding the whip-tap to a *novel* lead stimulus can result in overshadowing and therefore no learning of leading from the lead-rein.

When the six qualities of each response are trained and then consolidated, the horse is secure as it will have no source of confusion in its training.[31] Like the well-adjusted horse in its natural habitat, his umwelt is predictable and controllable. As we saw in the case study of police horse training (see Ch. 4), calmness is a feature of horses that have established consistent and predictable learned responses. Establishing calmness is not always an easy or speedy task in retraining.

When the relationship between stimulus and response is variable, confusion is the result and conflict behavior involving tension is almost inevitable. This is particularly true since training horses inevitably involves the use of the pressure/pain continuum. If pain is inescapable, unpredictable and uncontrollable, it is small wonder that the horse employs inbuilt antipredator mechanisms to actively remove the incursion into his otherwise tranquil life. If these coping mechanisms fail, then the horse may seemingly give up, become less vigilant and begin the downward spiral to learned helpessness. While the trainer might rejoice in the transformation of the horse to a seemingly more unperturbed state, the calmness has come about for the wrong reasons. It is therefore every horse owner's responsibility to recognize the exploitative nature of human/horse interactions, and to ensure that all interactions are as humane as possible and ubiquitously centred on learning theory and the training principles that arise from it.

SUMMARY OF KEY POINTS

- One of the abiding obstacles to effective training of ridden behavior is the rider's poor understanding of learning theory.
- Equine education is clouded by unhelpful terms such as 'natural' and 'unnatural' 'aids', and the use of anthropomorphic terminology in describing horse behavior as well as the implication that the horse has some moral culpability in its training.
- Contemporary horse-training dogma provides many obstacles to effective equine learning such as training too many responses simultaneously and overshadowing of one signal by another.
- If novice riders used the principles of operant conditioning so that they did not apply conflicting signals as they learned to balance, many riding school horses would feel the immediate benefit.
- Trainers should employ positive as well as negative reinforcement in their training.
- Trainers should become aware of the priority and importance of operant conditioning and remember the 9 operant responses that form the core of the horse's training in-hand and under-saddle and that dysfunctions in these signal response entities are central to problem behaviors.
- Horse riders, coaches and trainers should recognize their ethical obligation to train horses in ways that align as closely as possible with learning processes.

Case study

Unexpectedly, a 12-year-old half-bred gelding refused to load at the end of a show. The two-horse trailer being used that day was the vehicle in which he normally traveled. Despite an enormous variety of attempts to cajole him into loading, he continued to back away from the ramp. He was eventually forced in with a combination of ropes and whips. Since then he seemed phobic of the trailer and required considerable coaxing even to feed near it. The owners felt that he may have worked out a way of avoiding going to shows.

Conferring subjective mental machinations on a horse that refuses to load into a trailer is an unconstructive approach. Even with the most difficult horses, trailer loading is a relatively simple process if it is considered a function of the leading response. When the horse is relatively unconditional in its leading responses, it will lead anywhere, including into the trailer.

The gelding was retrained to lead, using a thin rope halter. This provided maximum control of his 'stop' and 'go' responses. First he was tested in the qualities of the 'go' and 'stop' responses away from the trailer. Subsequent retraining also took place away from the aversive stimulus that the trailer represented.

The 'go' response was thoroughly trained as there was an inherent weakness in the normal leading stimulus supplied by the lead-rein pressure. Because the lead-rein pressure at the top of the gelding's head was not sufficiently aversive compared with the aversiveness of the stimuli he was expected to face, such as the trailer, his response to it needed to be deepened. This was achieved by *combining* the lead pressure with incessant tapping from a long whip between the elbow and shoulder.

At first the horse did not 'go' and 'stop' immediately from the respective pressures, so stronger pressure and quicker release at the onset of correct behavior were deployed. This also resulted in his becoming maximally responsive to a light pressure. The obedience of the 'stop' response was enhanced by training a step-back from the halt using pressure-release. When the gelding was obedient, the long whip was introduced to fortify the lead response that was already installed. This association was established because it was considered likely that it was going to be necessary when it was time to face the trailer. As the 'go' lead pressure was employed, he was tapped on the ribcage as in under-saddle training (Fig. 13.18).

The leading response was deepened by making him step back using a light signal then immediately applying forward lead pressure coupled with mild tapping as above. Crucially, the trainer was careful not to cease the mild lead pressure and tapping until the horse stepped forward, no matter what resistance he offered. Secondary positive reinforcement ('Good boy!' at the precise moment of the correct response followed by wither caressing) was used to reinforce responses from light lead signals.

Figure 13.18 Horse being re-trained to lead and load.

Next the gelding was trained to move his hindquarters sideways from both sides. This was established to assist in straightening the horse if he trialed crookedness during loading onto the trailer. Facing the hindquarters of the horse, holding the lead with the hand that was closest to the horse, and holding the long whip with the other hand, the trainer used the lead rein with the appropriate pressure to prevent him going forward, rather than sideways with the hindlegs. Using the whip to tap the tarsal region, the trainer increased the tapping intensity until the instant the horse stepped across. This was repeated until the response was reliable. The horse was then ready to be trained to load onto the trailer.

Facing the trailer for the first time, the gelding stopped and therefore failed his *basic attempt*. Although training him to load into the trailer was the ultimate goal, the proximate targets were simply to take steps forward toward the trailer. To achieve this, the trainer:

1. Only ever tapped when he also had forward direction pressure on the rein (this fortified the lead response by *association*).
2. Only ever tapped when the horse was not going forward (never when he was).
3. Increased the intensity of the tapping, but not the lead pressure, when he felt there was no response within a reasonable period.
4. Never had increasing gaps between taps.
5. Softened both lead rein and ceased tapping the very instant the horse moved his foot/feet forward.
6. Used the ‘stop’ response to delete leaping onto the trailer; allowed him only to step onto it.
7. Immediately applied mild lead and whip-tap pressure if the horse rushed during backing out of the trailer and continued to do so until he stepped forward, no matter how far back he went.
8. Used secondary positive reinforcement (‘Good boy’ followed by wither caressing) when he stepped from light lead signals.

Further repetitions and mild pressure of rein and whip-tap resulted in the horse developing a *rhythm* in his steps onto the trailer. Whenever he slowed or quickened, these inappropriate responses were dealt with progressively. With the focus on training *straightness*, it was important to step forward and back all over the trailer, especially the area of the roof overhang. (This is often a problem area where horses learn to balk). The gelding was trained to go forward and demonstrate he was willing to place his front feet anywhere in the trailer region. At this stage, wither scratching and voice praise associations were employed profusely to reinforce his learned responses. The horse no longer shows any evidence of reluctance to approach or enter the trailer.

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Handling and transport

CHAPTER 14

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The principles of good handling

Horses are potentially dangerous because of their size, strength and speed. Using the responses that have evolved as part of their agonistic ethogram, they can kick, strike, bite and barge humans as readily as they do conspecifics. Additionally, they may deploy anti-predator strategies, such as charging, on humans.

Working with animals presents various dangers, so animal handling is a critical skill for veterinary students and veterinarians. In an Australian study of 2800 veterinarians, 51% reported a significant work-related injury during their career and 26% reported having an injury within the past year. In addition, large animal practitioners were most likely to have chronic or significant injuries.[1] In a similar US study, 65% of veterinarians had sustained a major animal-related injury and 17% had been hospitalized within the previous year.[2]

In a survey of equine veterinarians in Australia, a list of frustrations with their work included unreasonable and disagreeable clients as well as those who provided inadequate facilities and/or could not control their horses. The risk of injury and the physical demands of equine veterinary work were also listed as distracting from the enjoyment of their career choice.[3] From the moment they graduate, junior veterinarians not only have to take responsibility for their own safety but also that of the patient, their personnel and the client. This is a significant responsibility, especially when the patient requires sedation, anesthesia, euthanasia, suturing or is in behavioral extremis (e.g. upside-down in a horse trailer after a road-traffic accident). In addition, animals such as horses can be large, and with size comes greater power. Because horses are flight animals and therefore prone to hyper-reactive defensive behaviors, the danger to human handlers is exacerbated. So horses that are presented to vets can be fractious not only as a result of their disorder but they may also be largely unhandled or, worse, may have acquired dangerous responses to traditional handling techniques. Finally, there may be considerable variation in the safety of facilities, competence of handlers and the extent to which the horse is already primed with adrenaline secondary to trauma, pain or behavioral extremis.

Horses themselves are excellent barometers of handling skills in that they may struggle more and become generally distressed when poorly handled. Those that are handled correctly are easier to both examine and treat. Veterinarians who cannot handle animals are mostly unable to teach their clients how to do so, a state of affairs that clearly leads to an unfortunate spiral with the animal's health and welfare ultimately suffering. However, handling the patient quietly and efficiently raises the image of the treating veterinarian in the eyes of those present.[4]

Thus, handling the patient is a fundamental additional aspect of the communication curriculum because building a relationship with the client through his or her animal, by acknowledging and relating to the animal, is a critical element in veterinary consultation models.[5] Inappropriate handling can affect diagnostic parameters[6] and even play a critical role in a compromised patient's ability to cope.

Aggressive horses have usually learned that threats and attacks on humans are reinforcing because they effectively reduce the threat posed by the presence of humans. However, learning can be turned to our advantage since, for example, neonatal handling has a beneficial effect on the subsequent general tractability of foals.[7]

Naïve horses are usually frightened of being handled but are seldom actively aggressive, preferring to avoid contact. (This is central to early roundpen training.) They will be less distressed if they can be handled with educated conspecifics, preferably those with whom they have already had social interactions that have led to the more experienced animal emerging as the leader of the dyad.

The prior experience and temperament of a horse are significant for prospective handlers whether they be riders, trainers, farriers or veterinarians. However, even without a full history or the benefit of an owner to advise them, experienced personnel can predict the most likely response by studying the body language of horses. Regardless of the presence or absence of alarm bells in a horse's history and warning signs in its behavior, it pays to reduce risks when handling all horses, e.g. by ensuring that during all procedures, equipment and personnel within a stable are kept to a minimum and that personnel remain on the same side of the horse as one another (Fig. 14.1).

Tact and subtlety are the cardinal markers of good horsemanship. Young, naïve and fearful horses demand the greatest tact. Personnel should avoid making sudden movements so that one can clearly identify which responses can be elicited and controlled by a steady approach. Correct handling procedures can lower reactivity levels in horses, and may facilitate learning in some circumstances.[8]

Since horse handling is commonly based on negative reinforcement (see Ch. 4), it is worth remembering that

Figure 14.1 Hazard reduction should be undertaken before horses are handled. At the very least, personnel should all try to remain on one side of the horse.

for as long as force is used it will continue to be needed. It is fundamental therefore that the application of pressure must be followed by release (see Ch. 13). Under ideal conditions this means that just as the pressures applied during the most desirable forms of equitation are minimal, the very least force should be used to lead and control a horse when one is on the ground. It is incumbent on the horse handler to use a minimum of force because each episode of handling represents a learning opportunity. The horse that has learned to struggle and has been reinforced by being allowed to escape is more likely to offer the same behavior in future. Excessive force or the failure to release the pressure when the horse responds appropriately are likely to cause problems related to conflict and habituation.

It is always worth remembering how useful positive reinforcement can be in shaping desirable responses (Fig. 14.2), especially when aversive stimuli have been used previously. For example, horses that are reluctant to load into a trailer (float) can first be trained to approach a target and then the target can be moved to various locations inside the vehicle.[9] The lessons learned this way rapidly generalize to novel conditions, such as different handlers and vehicles. A limited-hold procedure and the presence of a companion horse seem to facilitate training.

The use of the voice in horse handling has been both over-rated and under-rated. Horses respond to a handler's body language and voice. When both are consistent in all handling sessions, the horse's response becomes increasingly predictable as one would expect with any classically conditioned response. By using the same

Figure 14.2 Wither scratching can be used in shaping horses to remain still and can be helpful in calming horses that are in pain.

voice cues when training responses, a trainer can give a horse auditory cues that help to identify the required response (such cues become discriminative stimuli; see Ch. 4). If the human is conversing with the horse, there is the possibility that the horse may habituate to the noise and become reasonably calm if required to do little more than relax. However, the opportunities for associations between a verbal command and a certain response are diminished since the horse is challenged by the need to filter commands out of the conversation. In other words, discrimination becomes more difficult.

Since consistency is the cornerstone of all good training programs, the use of a routine is helpful in early training of basic responses that are fundamental to so-called manners. After these have been instilled, the horse can be trained to generalize the learning from these lessons to other contexts. Among other things, this should include being taught to lead from both sides.

For many vets the pleasure of equine work is somewhat offset by the reality that horses are often very fearful of such practitioners. With their ability to learn quickly from aversive events and their formidable memory, horses can remember individual veterinarians and demonstrate accurate recognition of their colleagues from a given clinic because of uniforms or even more generically because of odors (such as surgical spirit) frequently associated with members of the profession. The increased use of chemical rather than physical restraint may reduce the fearfulness of the average equine patient. At the same time, owners can help by habituating horses to being handled in the way a veterinarian handles them. Following the model offered by puppy pre-schools, it is preferable to do this before rather than after a problem has developed.

The color of clothes worn for handling horses is immaterial when compared with the stimuli horses associate with certain clothing.[10] In the wake of reports that synthetic pheromones can modify behavior in other species,[11] it is worth considering ways in which odors may be used to calm horses. Perhaps the role of familiar odors helps to explain why horse-lore makes mention of the pacifying effects of rubbing one's hands on the chestnuts of a horse prior to 'befriending' it. On a more scientific basis, early reports of the effects of a synthetic 'equine appeasing pheromone' in reducing behavioral and cardiac indicators of fear during a fear-eliciting test (return to familiar conspecifics by parting a curtain)[12] are exciting and suggest that horses may be effectively calmed before novel husbandry and training experiences. By the same token it may be that angry and frustrated humans emit characteristic odors in their sweat that signal to horses the emotional states of their handlers and thus increase the horses' arousal.[13] The effects of different handlers on the behavior of horses are sparsely reported, but it has been proposed that by looking for excessive ear movements when horses are led around an obstacle course, one can detect inexperienced handlers.[14]

Donkey handling

The differences between the behavioral repertoires of donkeys and horses should be considered when handling donkeys and mules. Some of these differences are inherent; for example, donkeys tend to have different responses to fear-inducing stimuli, tending to freeze more readily than horses (a distinct advantage should they become stuck in barbed wire). Other differences are related to the amount of training and human contact experienced by the individual.

When faced with frustrating situations and forced to respond with aggression, donkeys tend to give fewer warning signs than horses. Additionally it should be borne in mind that because of their enhanced ability to balance, donkeys can easily cow-kick. Few donkeys have been taught not to lean when having their feet examined. This makes veterinary examinations of the hooves and farriery generally more difficult in donkeys than in horses and ponies. Despite their agility, restraining most donkeys is straightforward if their head can be controlled. Unlike some other species, such as pigs, all equids follow the general rule of 'where the head goes, the body will follow'.

Generally, when compared with horses, donkeys tend to have experienced less close human contact because they are less likely to be ridden and, as a result, they tend to be less well trained. For instance, in the absence of any need, they are rarely taught stable manners. On the other hand, it appears that because fewer people are nervous of donkeys, they are likely to have been handled with more confidence (Jane French, personal communication 2002).

Approaching the horse

Until we can, with certainty, unpick the relationship between horses and humans, we are likely to vacillate between explaining a horse's responses as those used with a predator or with a conspecific. Arguably, horses do not have a concept of predation or their own mortality so much as an ability to categorize other animals as non-threatening and threatening. If horses view humans as a threat, the chances are that their fear responses will be rapidly extinguished if humans do nothing to justify their anxiety. Then it is possible that, during the gentling process, the representation of humans as a threat can be replaced by one of companionship.

The use of the voice can be helpful when approaching equids since it may alert and disarm them. Compared with human clothing, which changes regularly, voices can be a constant cue that assists horses to recognize their owners. As it happens, horse owners tend to use similar calls when calling horses (one of the more common ones being a drawn out 'come on'). While this can have helpful consequences in horses that are happy to be caught, since they respond by traveling toward the sound, it may alert others to the intentions of the approaching humans and prompt them to move away. In the case of horses that are being retrained to accept being caught, it is appropriate to abandon established cues completely so that new associations can be built.

When attempts are made to corner horses, the same principles of driving and blocking that are used in other herding species, such as cattle or sheep, apply. However, the speed and agility of horses means that this rarely works as a means of catching them. A horse in a confined space may attempt to escape either by scrambling over the fence or turning on approaching personnel to drive them away.

To avoid emerging from horses' blind spots (see Ch. 2), personnel should always approach them from the side. Convention is that horses are approached from the left. The merit of this tradition may be substantiated by research showing that horses generally use the left eye to observe novel stimuli.[15] However, this convention can be revisited in horses that are being trained to extinguish fearful responses associated with handlers. By avoiding staring at horses one may be able to reduce the chances of this being misinterpreted as a prelude to predation or the challenge of a conspecific. That said, there is some evidence from a study of well-handled horses that eye contact does not necessarily affect a horse's latency to approach humans.[16] The speed with which humans move can certainly influence equine responses, e.g. walking quickly past the point of balance at the animal's shoulder in the direction opposite to desired movement is an easy way to induce an animal to move forward.[17]

Generally it is helpful to approach an unfamiliar horse slowly in a non-menacing stance, with the body relaxed and slouching slightly. If a penned horse is facing away from the stable door or yard gate, handlers should make noises to encourage it to face them. This prevents handlers from being kicked as they approach the horse and is even considered by some to be an important sign that the horse is showing 'respect'. If horses ever regard humans as analogous to conspecifics, they could be excused for having problems reading our body language unless we are regarded as issuing constant (and often hollow) threats (because our ears are permanently pinned back).[18] Regardless of this, it remains unclear why horses would need to show 'respect' to other horses, and therefore submission or subordinance are perhaps more appropriate terms for displays of social deference. That said, most riders want their horses (whether they are companion or performance animals) to be compliant first and foremost, so interpretations of rank may be entirely irrelevant.

Restraint

Once they have begun to exhibit a flight response, most horses that are restrained by the head will continue to struggle until the pressure around the head is released. Horses should be tied up with a secure halter (or head-collar) and rope and never by the reins or a lead attached to the bit. The rope should be tied to a length of bailing twine, which is attached to a solid object. Because it is more readily broken than regular lead ropes and reins, bailing twine is used in combination with quick-release knots in case a struggle ensues. Many serious injuries have been inflicted on both horses and handlers when horses have thrown themselves to the ground in a bid for freedom (Fig. 14.3) or when rails have broken or posts

Figure 14.3 A horse that has fallen in an attempt to escape from physical restraint. (The horse was physically unharmed by this incident, but the possibility of it becoming an habitual puller as a result of panic could have been avoided if breakable twine had been used to secure it.) *(Photograph courtesy of Claire Ruting.)*

have come out of the ground, so it is important that the bailing twine is weaker than the fixed object to which the horse is tied. Nevertheless, some horse-trainers disagree with this advice since they claim that a breakable connection between the horse and the fixed object actively encourages horses to pull back. The extent of flight responses among horses that are tied up means that the act of releasing horses can be very dangerous, even if they are secured only by quick-release knots. The danger is magnified when more than one horse is tied up and a wave of socially facilitated hysteria crashes over them.

Generally, it is best practice to tie horses at wither height so that normal head movement can be maximized within the limits set by the length of rope between the horse and the fence. This should be such that the horse can turn its head sufficiently to examine objects that would otherwise be in its blind spot, but cannot put a leg over the rope.

There is clear evidence that, as creatures of flight, horses value being able to remove themselves from the threat of discomfort. The danger of horses fighting against physical restraint by blindly paddling their limbs in pursuit of freedom means that hobbles and ropes should be avoided wherever possible. Even under conditions of best practice, rope-burns and even fractures are among the recognized sequelae of roping, strapping and hobbling techniques.

The various roping techniques developed by horsefolk who had no chemical agents with which to pacify horses during aversive interventions have been catalogued elsewhere.[19–21] While one cannot deny the inventiveness of the horse handlers who developed these approaches, the necessity that bred it may have passed. While it may be convenient to keep a horse still and safe for a given procedure, the crudity of these forms of physical restraint should be questioned in the light of current thinking about analgesia in companion animals. There is no justification for allowing animals to undergo pain.[22] Ethically, one could argue that psychological threats are as aversive as pain itself. By the same token, there is no justification for allowing horses to fight against physical restraint when there is no evidence that they can predict that the episode will ever end.

If, during a handling procedure, a horse is not likely to learn good associations with personnel, there is a very strong argument for avoiding it learning anything. In practice, while emergencies may necessitate using physical restraint before veterinary assistance arrives, chemical agents are indicated more often than force. It is inevitable that some veterinary interventions with horses will be painful, so some level of physical restraint is usually needed to control equine patients, even if it is only to allow administration of chemical restraint. Since horses show a peak in plasma beta-endorphin concentrations[23] (and so are likely to be least sensitive to noxious stimuli) in the early morning, it has been suggested that this may be the preferred time to undertake elective aversive procedures.[13]

The natural inclination of horses to run from trouble makes them difficult to deal with in the open. Although attempts are sometimes made to hold horses in a corner of a field or yard for interventions, horses are usually much safer in a stable, especially one with enough bedding on the floor to prevent them slipping. Anything that may get in the way during a struggle or a forced retreat by the handler, most notably water buckets, should be removed from the stable before any invasive handling or veterinary procedure. Stables with low ceilings are sometime helpful when handling horses that are inclined to rear or have learned to throw their heads up to avoid a twitch. Ceilings suitable for this application have no projections (such as jutting beams) from them that might damage a horse's head or neck. The presence of the ceiling prevents the horse from gaining momentum as it swings its head up. Though the horse might throw its head up once, it is likely that it feels the ceiling with its ears, and rarely bothers a second time. Rectal examinations may be safely carried out by working round the side of a door. Temporary stocks can be built by placing bales of straw around the horse's hindquarters.

Equipment for restraint

For most veterinary procedures all that is needed is a reliable attendant to hold the horse firmly with a halter and reinforce appropriate behavior by stroking the animal in anatomical areas associated with stress reduction, including the forehead, neck and withers. Cupping a hand over a horse's eye on the side on which it is being treated is often very helpful, especially for needle-shy horses (Fig. 14.4). Tying horses up for aversive procedures is inadvisable since their tendency to fight against such restraint usually precipitates an attempt to flee and ultimately increases fear and the likelihood of damage to equipment or, worse still, injury to themselves or personnel.

Figure 14.4 A hand cupped over the eye of a horse can reduce fearful responses to veterinary personnel. *(Reproduced from Rose & Hodgson.[21])*

Physical restraint should not be used in ways that directly compromise horse welfare. When increased restraint is required, hobbles, a tail rope or service hobbles (see Fig. 12.5) may be used, but these should be seen as emergency measures rather than routine approaches. Horses may be controlled completely by being cast and tied with ropes, but this is rarely necessary since the same result can be achieved more readily by methods of general anesthesia. Occasionally it is suggested that a twitch or rope gag, often found useful when dealing with the hindquarters of a fearful horse, may work by distracting the animal. This is something of an understatement since, at least in the short term, the distraction is pain. However, the pain may be rapidly modified by endorphins.[24]

The twitch

A time-honored method of restraining horses is to apply a constriction to the upper lip as a so-called twitch (Fig. 14.5). It has the merits of being simple, effective and easy to apply, and is comparatively safe for the horse and the operator. For mildly painful, brief procedures, a twitch will give some added security. It certainly has a place in the protocol for nasogastric tubing of many horses since it seems to reduce their ability to flick the advancing tip out of the esophageal sphincter (Ken Sedgers, personal communication 2002). Twitches come in a variety of forms, from a simple loop of rope attached to a bull's nose ring, through to a pair of metal pliers called the humane twitch (because it may be associated with less tissue damage in the hands of a novice than a homemade twitch). As with any means of applying pressure, the narrower the element that makes contact with the horse the greater the chances of pain and even permanent damage. Twitches with soft, thick rope and light (i.e. plastic) handles are generally safest.

Figure 14.5 Application of a twitch. *(Reproduced from Rose & Hodgson.[21])*

Snaring as much of the upper lip as possible when applying a twitch seems to increase its effectiveness and reduce the chances of it slipping. The constriction should be loosened every 15 minutes or so to maintain perfusion of tissues distal to it. Additionally this is sound practice since the effectiveness of the twitch tends to wane after this period in many cases.

Twitching the lip is an approach that should be adopted only when chemical restraint is not available and is best regarded as a last resort of restraint justified only by a bid to inject a psychotropic drug. In very difficult horses, the ear can be grasped transiently (Fig. 14.6) as a brief means of controlling the horse while a twitch is put on the upper lip. Twitching the ear should always be avoided as it may scar the skin, paralyze the ear or make the animal head-shy.[13]

The central mechanism (thought to be mediated by beta-endorphins) by which the twitch is believed to work is discussed briefly in Chapter 3. However, regardless of the pathways involved, there is little doubt that the twitch works because it hurts.[25] Horses undergo a transient increase in heart rate when twitched.[18] Intriguingly, heart rate returns to baseline values more rapidly in the crib-biters than in normal horses.[26] Also crib-biters are reported to be less reactive to being twitched than normal horses, being more likely to remain calm.[26] This has prompted the proposal that twitching be used to detect covert stereotypers,[27] but more empirical data are needed before the management or fate of horses should rest on responses to such a crude intervention.

Broadly speaking, the effects of a nose twitch can often be achieved by 'twitching' a generous fold of skin on the side of the neck (Fig. 14.7). Using this technique, handlers can often restrain fearful horses well enough to facilitate the administration of injectable forms of restraint.

Figure 14.6 Grasping of the ear can have unwelcome long-term behavioral consequences and should therefore only be used with caution. *(Photograph by Vince Caligiuri, reproduced by permission of the Sydney Morning Herald.)*

War bridle (or rope gag)

A rope or chain passed over the poll and under the upper lip and then threaded through a loop at the side of the face to form a running noose (Fig. 14.8) acts in a similar way to a twitch when pulled tight. Many variations on this theme arise in the literature and are sometimes even advocated for problems in the ridden horse, even though they are simply vehicles for escalated force and should therefore be avoided. A piece of rubber tubing slipped over the portion of the rope that presses on the under part of the lip reduces any risk of injury and does not seem to interfere with the device's effectiveness. The appealing claims made for the efficacy of commercial versions of this device (e.g. Stableizer®) in calming horses even when ridden suggest that its function deserves scientific scrutiny.

Figure 14.7 A skin twitch (or gaucho twitch) involves grasping and twisting a good handful of skin from the area cranial to the shoulder. *(Photograph courtesy of Greg Hogan.)*

Figure 14.8 A war bridle. *(Reproduced from Rose & Hodgson.[21])*

Service hobbles

These are designed to limit a mare's ability to kick the stallion during mating. They also offer some protection to veterinarians performing rectal or vaginal examinations (see Restraint of hindlimbs, p. 316), though a physical barrier is more usual for this purpose. Various patterns of service hobbles have been described elsewhere in horse-management literature. All limit the motility of the hindlegs by attaching them by ropes to a band around the horse's neck and most are fitted with some form of quick-release device. Because they occasionally cause horses to fall (usually while struggling) they should be considered for use only in combination with deep, soft bedding materials.

Restraint of the head

Generally speaking, horses are not dealt with unless some harness is put on the head. If a horse darts forward, experienced handlers can hold their ground, with the benefit of a pair of strong gloves, and pull the horse's head toward them to arrest the horse's forward movement. An excitable, reactive or flighty horse is best controlled if the handler is standing caudal to the horse's head and cranial to its shoulder. With this approach, any horse can be controlled in an open space as its momentum can be thrown off course by a sharp tug on the lead rope. When applying this technique, one should keep in mind that the horse's rump will tend to swing out away from the handler, exposing it to the possibility of collision with objects to the side. Equally, the maneuver brings with it the risk of the horse being placed in an ideal position to rear, strike or bite the handler. The use of a horse rug slung around the cranial pectoral region as a barrier to striking forelimbs has been proposed,[21] but the associated risk of the horse becoming entangled by the rug as a consequence of a flight response means that this approach has limited appeal.

It has been suggested that simply lowering the head may have a pacifying effect on horses (see Ch. 13).[28] Lowering the height of a horse's head relative to the thorax has been shown to decrease mean arterial blood pressure.[29] Additionally, some studies have noted that certain behavioral states, such as resting[30] and relaxation,[31] are associated with head lowering. McBride et al.[32] reported that behavioral responses of horses to massage included lowering the head. However, most of these studies have been conducted on horses at liberty and therefore have not investigated the effects of pressure-mediated head lowering as a training intervention. A number of researchers concur that a lowered head position is the postural opposite of a recognized signal of alertness.[33] However, head lowering should be considered in context, e.g. stallions will lower their heads when 'snaking' mares.[34] It has also been described as a sign of 'submission' when meeting conspecifics during[35] which licking-and-chewing also occur.[36,37] Furthermore, it is propounded that licking-and-chewing in association with head lowering is a sign of the horse communicating with, or being submissive to, the handler.[38,39] That said, there is little evidence that forced head lowering assists in calming an aroused horse in training. Contrary to popular belief, there seems to be no association with licking-and-chewing and head lowering, or with these behaviors and response acquisition.[40]

A halter is designed to be placed on the horse from the near side. It should be tight enough to prevent the horse from removing it, and the nosepiece should not rest below the nasal bone. The noseband should be loose enough to allow the horse to open its mouth and chew. When designed to allow tightening around the head if the horse resists, this works especially well, in the right hands, within the pressure-release framework (see Ch. 13). However, it is often knotted to prevent it becoming dislodged should the horse struggle. This safety measure often does little to improve the halter's usefulness because few handlers seem to understand the importance of releasing pressure immediately to reinforce leading responses. As discussed in Chapter 7, it seems likely that there are left- and right-handed horses, so although horses generally lead better from the near side, this is simply because this is what they are accustomed to. By leading horses from both left and right, one can determine whether one side suits the horse better.

A headcollar is stronger than traditional rope halters but does not pull tight. Although the straps that comprise a headcollar give alternative hand-grips for the attendant, best practice is to attach a rope so that, if the horse throws its head up violently, control is not completely lost (since the attendant has a length of rope to pay out). Consistent pressure-release conditioning (as explained in Ch. 13) quickly trains horses, by applying exceptionally subtle downward tension on the lead rope, to lower their heads. As with all pressure-release training, simply pulling until a response occurs is contraindicated since this leads to habituation. Instead, it is necessary to escalate the pressure until a motivating pressure is being applied. Ropes should never be wrapped around the hand or fingers because serious injuries can occur. If the horse snatches its head back with such speed and force that the handler finds it impossible to let go, skin burns and even fractured bones may result.

If the mouth is not being examined, a bit and bridle may be used for restraint. When considering the effect of different pieces of tack, the broader the area in contact with the horse the less discomfort it causes and the less readily it can be used in the negative reinforcement paradigm. This is why horses can easily be trained to pull against harnesses, breast-plates and collars used on well-muscled areas, such as the shoulders and pectoral regions, but are reluctant to fight pressure from bits in the mouth (especially if they make contact only in small areas as is the case with the bladed and twisted bits). When used only occasionally, chains in the curb groove or in the mouth are likely to have a strong effect, especially in the short term. Anti-rearing bits usually have reasonably fine elements and therefore a more severe action than normal riding bits, such as a regular snaffle. Working on several parts of the mouth, these bits help to control particularly reactive animals such as naïve youngsters that may readily toss their heads (Fig. 14.9) and stand up on their hindlegs, but they must be used with sensitivity. Again, the emphasis should be on using light pressure that is released as soon as the desired response has been made. They should never be used in attempts to punish a horse, e.g. by reefing on a lead rope. The inverted 'port' on many anti-rearing bits makes them more severe and potentially more harmful than many handlers seem to appreciate.

Restraint of forelimbs

Roping techniques are mentioned in this book only for use in emergencies that arise in the absence of veterinary support. Interested readers can find detailed accounts of such techniques elsewhere.[41]

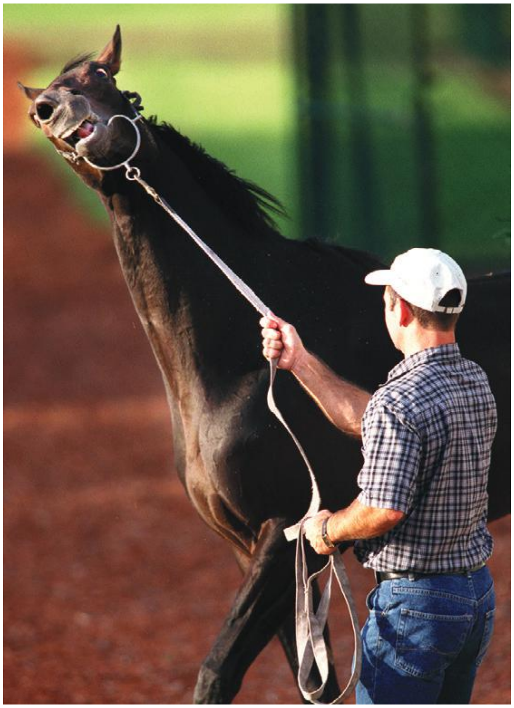

Figure 14.9 Despite the use of an anti-rearing bit, many horses in behavioral conflict will continue to rear. *(Photograph by Vince Caligiuri, reproduced by permission of the Sydney Morning Herald.)*

During a veterinary examination of a potentially fractious horse, movement and risk of being kicked can be decreased by restraining one of the forelimbs. An additional purpose of raising the forelimb arises when injecting it, e.g. for a peripheral nerve block. A forelimb can be lifted and the hoof brought up to the height of the horse's elbow and held there by a handler. When holding the forefoot of a horse in this way, handlers must avoid teaching the horse to lean, because this defeats the object of transiently disabling the horse. A light grip on the foot is desirable, but it is important to avoid giving the horse an opportunity to snatch the foot away, which often happens before a horse kicks out at the veterinarian. After due consideration of the hazardous responses it can evoke (especially in naïve horses), the use of a 'knee strap' placed around the forearm and just proximal to the fetlock may be considered to hold the leg off the ground. A soft surface underfoot, such as deep bedding, is a prerequisite for this approach because many horses fall before learning that stoicism is the preferred response when normal locomotory responses are compromised in this way. Generally speaking, however, chemical restraint is the preferred option.

Restraint of hindlimbs

Hindlimb hobbles are often used on mares during mating (see Fig. 12.5) or pregnancy testing. Each hindlimb is attached to a collar around the horse's neck so that the horse can move the legs forward but not backwards. The straps around the pasterns should be made of soft but strong material, such as leather, that is unlikely to burn the horse's skin. The collar must be of sufficient width to prevent undue pressure being concentrated on a small region of the neck.

Farriers and horse breakers sometimes teach a horse to pick up a hindleg by a modification of the breeding hobbles. A strap is placed around the horse's hind pastern and a rope attached to the strap. The rope is then run through a padded collar placed around the horse's neck. The rope may be run back through the strap (if the horse's leg can be approached), and then pressure on the pulley system lifts the hindleg off the ground. For horses in a situation where the hindlegs cannot be handled (i.e. in the absence of veterinary support), a slip loop can be made in the end of the rope and placed on the ground. The horse is then walked over the rope so that the targeted hindhoof is located within the loop. The rope is then pulled so the loop tightens around the pastern. Once the rope is through the collar, it is shortened until the horse's leg is at the required position. Unfortunately, rope burns may arise at this point, so the use of a soft rope is critical. The rope is then secured so that the handler can approach and handle the hindlimb safely. Because it is akin to one method of casting a horse, it is unsurprising that, when undergoing this method, many unhandled horses throw themselves on the ground. For this reason the procedure should take place only in a safe paddock arena with a soft landing (e.g. a roundpen containing deep sand). The extent to which the horse also undergoes learned helplessness in this situation is worth considering. With horses that have thrown themselves to the ground, it is said that holding the nostrils closed is an effective means of getting them to struggle to get to their feet. However, adding asphyxiation to the woes of a restrained horse may be ethically questionable.

Donkey restraint

Some donkeys tend to move towards negative stimuli,[42] and this may help to explain why they have been found useful in guarding other species, such as sheep, from predation by dogs.[43] Being less inclined to flee, donkeys are regarded as stoical, but this reflects a higher threshold to respond, not necessarily a higher threshold for pain or, for that matter, fear. This must be borne in mind when practitioners weigh up the apparent need for chemical restraints in donkeys.

While a horse's first response is to flee and, if it cannot, to rear and kick, donkeys more usually freeze and simply stand their ground when confronted by aversive stimuli. As a result they have attracted a reputation for being difficult to force into situations. Indeed, it is often the case that the more a handler tries to push them, the more forcefully they will move towards that person.[42] Since donkeys cannot easily be forced towards hazards undetected by riders, their resolve makes them safer than horses as riding animals in certain sorts of terrain. If donkeys become entangled in wire or rope, they do not thrash about like horses and so are far less likely to injure themselves, e.g. injuries from barbed wire are less frequent in donkeys. By the same token, when tied securely, to the point at which they accept that they cannot leave, donkeys usually accept most veterinary procedures.[42]

It is important to note that the twitch is far less effective on donkeys. It is said that it can do no more than distract them from aversive procedures and may do so only transiently before they lower their heads and attempt to drag their handlers away.[42] This is especially likely to be an effective and therefore learned evasion in mammoth breeds.[42]

In cases of lameness, the stoicism of donkeys may make them challenging patients when veterinarians use hoof testers to locate a seat of pain. Foot-care in donkeys presents other interesting challenges because they are so sure-footed and therefore dislike having their balance compromised. This is why they are more likely than horses to refuse to pick up a foot or, if they do oblige, to snatch it back or lean on the handler. One solution to leaning and snatching during foot-care is to capitalize on the tendency of donkeys to accept physical restraint, albeit after a struggle. So, using quick-release knots, one can tie the patient up short and use a sideline for a hindleg and an over-the-back rope or elbow strap for a foreleg.[42] Most importantly, before the foot-care procedure commences, the donkey should be allowed time to test its predicament and convince itself that it can stand on three legs. It should also be taught this lesson separately for each leg, since donkeys do not appear to automatically transfer to the remaining limbs acceptance of the tying up of one leg.[42]

Chemical restraint

The innate inclinations of horses to react strenuously when control is applied is sometimes referred to as 'opposition reflex'. This explains in part the escalation of force that is required when horses are said to panic. It is always preferable to use drugs to modify a horse's behavior than to use force. Just as pre-operative analgesia reduces the need for sustained post-operative analgesia,[44] so reducing fearfulness seems to reduce the need for sedation. The psychological state of the animal before administration of tranquilizers may markedly affect the degree of sedation achieved. Animals that are intractable and in a state of excitation are likely to need very high doses before becoming manageable, so for routine procedures such as clipping, owners are well advised to avoid a struggle of any sort before the administration of chemical restraining agents. Of course, where the intention is to clip the horse's hair, the need to avoid sweating makes chemical restraint without any prior arousal especially appealing.

Chemical agents with a variety of pharmacological mechanisms make it possible to alter a horse's behavior by tranquilization, sedation or immobilization (see Ch. 3). The distinction between sedatives and tranquilizers is reasonably subtle and focuses on the extent to which an agent causes central nervous system (CNS) depression (what would be described in humans as clouding of consciousness). Tranquilizers, such as the benzodiazepines, dissipate anxiety without CNS depression. Meanwhile, sedatives such as phenobarbitone induce a dose-dependent spectrum of CNS effects.[45] To complicate matters, the classification of various psychotropic drugs used in horses can also depend on dose, i.e. some tranquilizers, such as the alpha-2 agonists, can cause sedation. Generally, horses are not good subjects for those tranquilizers that cause muscle weakness or ataxia because these outcomes can evoke 'panic' responses.[46] By the same token, if sedatives are used to produce manageability, high doses should be avoided since these may result in ataxia, depressed response to stimulation and some respiratory depression. Tranquilization during transportation can be dangerous with horses since some react adversely under novel circumstances.[47]

Transportation of horses

Factors that influence horse behavior and welfare during transportation include:

- preparation of the horse and vehicle
- the extent of social isolation
- sex of, and familiarity with, traveling companions
- experience of the driver
- travel duration
- hydration status
- ventilation and air quality
- temperature and humidity
- previous transport experience of the horse
- medications
- the horse's temperament and orientation
- the means of restraint.

Although research efforts have focused on road transport, much of the information derived from research into transporting horses by road is also applicable to transportation by sea and air. For many handlers the most unwelcome behaviors arise in their horses during loading and occasionally unloading. Many horses refuse to load and thus add considerable stress to and delays in travel, while a few rush during unloading, sometimes injuring themselves or personnel. Both of these problems should be seen as problems with being led. The case study in Chapter 13 gives a detailed approach to a loading problem. As part of the therapy, the horse is trained to stand still in any spot on the ramp and floor of the vehicle. This rapidly resolves rushing in any direction and is the preferred approach for unloading problems.

Horses brace themselves against and in anticipation of the changes in momentum during road transport by adopting certain body postures (notably the base-wide stance). Panic can arise in horses that have insufficient space to adopt this posture, so in some cases a switch to a wide float is all that is needed to remediate nervous travelers. Efforts expended by horses as they continuously adjust their posture during transit reflect both muscular and emotional stress related to road conditions and the driver's behavior.[48] All of these effects are readily evaluated by monitoring heart rates during transport.[48] Horses have been shown to have higher heart rates in a moving vehicle than in a stationary vehicle[49,50] and, although heart rates decreased significantly during a road journey, they did not return to resting levels.[49,51] Transport stress may increase susceptibility to diseases, including an equine herpes virus 1[52] and salmonellosis infections.[53,54] Other common problems resulting from transportation include traumatic injuries, dehydration and pleuropneumonia. With adequate preparation and care, the incidence and severity of these disorders and their complications can be reduced. Previous experience largely determines the response of the horse to being transported, and it is worthwhile spending time accustoming the horse to the vehicle before transport is required. The calmer the horse remains during loading and transport, the less likely are injuries. Beyond that

Figure 14.10 Horse that has tried to force its way out of a vehicle. (The horse made a complete recovery.) *(Photograph courtesy of Michael Watiker.)*

there is a need for vehicles of strong construction in case horses struggle (Fig. 14.10).

The longer a journey, the more one can expect to find increases in a horse's white blood cell count,[55] weight loss,[56,57] level of dehydration[58] and body temperature.[59] Body temperatures as high as 39.9°C have been reported in clinically normal horses after a 41-hour road trip.[60] Unsurprisingly, with longer road journeys, the risk of horses developing shipping fever also increases.[61] A report describing 6 horses following a 9-hour flight noted elevated white blood cell counts, dehydration, and the loss of 4.1 ± 0.8% bodyweight that took 7 days to return to a pre-flight range.[62] So it is most likely as a result of the environmental conditions imposed on them during a 39-hour flight, that 7 of 112 horses developed pleuropneumonia (shipping fever) 1–2 days after arrival in one study.[63] Air temperature and humidity tend to peak when planes are stationary, e.g. during loading, unloading, refueling and delays. It is important to keep the latter to a minimum.[64] Frequent monitoring of rectal temperature is indicated in horses during transit because an elevated temperature is a familiar finding in dehydrated horses[59] and may also signal respiratory disease.[65]

The following discussion will focus on behavioral aspects of transportation and how research is providing data on best practice when horses are transported.

Orientation

When facing forward during transport, horses may incur damage to the head, throat and neck as a result of being propelled forward by braking. Many owners report that traditional forward-facing transportation makes some horses lean back against the rear of the vehicle and sometimes even sit down. In contrast, horses facing backwards are thought to absorb deceleration with their haunches and are better able to maintain stability.[66] This explains why rear-facing horses have fewer side and total impacts and losses of balance.[67]

Several attempts have been made to determine the best orientation of the horse during transport. Untethered horses in transit spend significantly more time facing the rear, and several horses have displayed strong individual preferences for rear-facing orientation during travel.[68] Horses facing forward tend to move and vocalize more frequently and have higher heart rates than when facing the rear.[51] While Gibbs & Friend[69] found no significant preference for facing forwards or backwards, they noted a slight preference for traveling at about 45° to the direction of travel. Some studies have failed to find significant differences in heart rate and plasma cortisol concentrations between horses facing forward and backward during transport.[49,67] While this suggests that the imposition of forward-facing travel is not distressing, it does not rule out the possibility that it is tiring and increases the likelihood of injury.[70]

When a horse with an orthopedic injury must be transported, it should travel with the injured leg to the rear of the vehicle to protect it from the effects of deceleration. So a horse with an injured hindleg should travel facing forwards, and one with an injured foreleg should travel facing the rear. The head should be able to move freely to enable the horse to remain balanced while shifting weight off the injured leg. Horse slings, either commercial or homemade, should be used only in vehicles strong enough to support the weight of the horse in such a manner.[71]

As horses attempt to balance during changes in speed and direction, they tend to move their heads and feet rapidly. Leg wounds can occur through loss of balance when the vehicle brakes, while traveling around corners, and on uneven surfaces. The most common injuries are to the pastern and coronet.[72] The risk of injury can be minimized by the use of protection such as a padded headstall or a poll guard (head bumper in the USA) and protective leg bandages, thoughtful driving and generous tie ropes.[72] Bandaging the tail can protect it from damage resulting from repeated contact with the tailgate or wall.

Head position

Equine pleuropneumonia can result from contamination of the lower respiratory tract by normal pharyngeal microflora and has been closely associated with transport. In enclosed containers the respiratory system is often further challenged by increased humidity, ammonia concentrations[73] and numbers of airborne microorganisms,[74] while in especially dry conditions the mucociliary clearance capacity may be further reduced by desiccation. Depression of cellular immunity may also occur due to stress-induced elevations of cortisol concentrations.[74]

Horses have evolved to spend long periods with their heads to the ground. Maintained elevation of the head facilitates the introduction of normal pharyngeal flora into the lower respiratory tract and hinders their removal by forcing the mucociliary transport system to work against gravity. When transported horses have their heads restrained, restricted head movement can compromise their ability to both balance and avoid respiratory disease.[75] Horses traveling individually in stalls are commonly cross-tied for road transport to stabilize them, but this is not recommended for long-term transportation because it involves elevation of the head. When compared with transportation loose in small groups, cross-tying causes white blood cell counts, neutrophil:lymphocyte ratios and glucose and cortisol concentrations all to become significantly elevated.[76]

While frequent breaks when traveling help prevent fatigue and dehydration, allowing horses to lower their heads for brief intervals (30 minutes every 6 hours) is ineffective in preventing the accumulation of bacteria and mucus in the respiratory tract.[77] In one study,[77] at least 8 hours was required to clear the secretions that accumulated after maintaining an elevated head position for 24 hours.

Permitting the head enough freedom to allow the cranial trachea to be below the caudal trachea is the most effective way of preventing accumulations of mucus and bacteria and assisting the mucociliary transport system.[78] In a horse that is tied, one method of facilitating this head position and indeed horizontal and vertical head movement is to use a ‘log and rope tie’. This involves passing a lead rope through a loop fixed to the inside of the vehicle and weighting the other end with a block that the horse cannot pull back through the loop.[72] Other appropriate measures include lowering hay and food containers, and soaking hay to minimize the inhalation of spores and bacteria.[79] It has also been suggested that allowing horses to face away from the direction of travel means that they are more likely to relax and hold their heads down.[70]

Preventing dehydration

Dehydration is associated with transport because voluntary intake of water during transit is low and, in any case, water is rarely offered during transport. While up to 5% dehydration may pass undetected, even 2–3% dehydration can affect the performance of competition horses.[72] Dehydration has also been implicated in the onset of acute laminitis and colonic impaction after extended road travel.[72] Horses are sometimes given electrolyte solutions via nasogastric tube to prevent gastrointestinal impaction. Familiarity with and frequency of transport are regarded as important risk factors in colic. Horses that travel one to six times per year have a higher risk of colic than those not transported.[72] Interestingly, more than six trips per year are associated with reduced risk of colic.[72] It is suggested that this reflects the effect of habituation and correspondingly reduced distress that facilitates adequate drinking and general hydration.[72]

Breaks in journeys are recommended every 4–6 hours. They offer the opportunity to give the horse some exercise, to allow it to urinate (a response that is strongly inhibited by being on a moving platform), to offer it water and even to give it electrolyte solutions via nasogastric tube if a veterinarian is present. Horses can tolerate 6–8 liters of electrolyte-enriched water by nasogastric tube every 15 minutes, for up to 2 hours if required.[72]

Studies in hot weather have shown that providing water during transport in summer can have favorable effects on several physiological parameters of hydration and distress.[80] Compared with watered horses, unwatered horses showed greater weight loss, higher plasma cortisol concentrations and elevated respiratory and heart rates. Their plasma concentrations of sodium, chloride and total protein, and their plasma osmolality greatly exceeded normal reference ranges, indicating severe dehydration.[80]

While providing water to group-transported horses (viz. slaughter horses, see below) reduces the incidence of dehydration,[81] it is not straightforward because high-ranking horses may prevent others from gaining access to the water. Furthermore, there is a risk of water spillage that would make the flooring more slippery and compromise the horses' ability to maintain their balance. Providing water on both sides of vehicles and ensuring that bedding is sufficiently absorbent may help to resolve these problems.

Restraint of horses during air transit

The differences between road and air transport are few. In level flight, horses being transported in enclosed containers (Fig. 14.11) regularly doze and rest and their heart rates are close to resting levels.[64] Horses seem distressed by movement only during cargo handling, take-off and landing.[82] Agitation at these times can include regular changes in body posture to maintain balance and agonistic responses, such as aggression and appeasement.[64] Aggression may indicate distress as a result of certain environmental stressors[83,84] and is accompanied by increases in heart rate. Fortunately, these episodes do not seem to be frequent or long enough to raise significant welfare concerns.[64] They are not accompanied by any changes in hematological or blood biochemical values that would suggest any detrimental effects.[82]

Persistent pawing and stamping may be features of some horses' response to air travel.[85] It is interesting that this behavior prior to a race is seen as one of several characteristics of poor performance in racehorses.[8] Although rare, the occasional possibility of a horse becoming truly panicked in mid-air merits consideration and forward planning. Even if it may result in the horse being disqualified from competition on arrival, the use of tranquilizers in an airborne horse is preferable to manual restraint.[74] With the availability of potent equine psychopharmaceuticals, it is rarely necessary nowadays to euthanase transported horses in emergency situations.[74]

Figure 14.11 Horse being loaded into an enclosed container for transportation by air. *(Photograph courtesy of International Racehorse Transport.)*

Transport of horses for slaughter

The welfare of slaughter horses is of concern because inadequate head-room, high stocking rates, poor ventilation, dehydration and long travel times are common. Additionally, the pre-transport condition of slaughter animals is often suboptimal,[86] which compromises their ability to cope with transit stressors. It is suggested that even when governments attempt to regulate the conditions under which horses are transported and slaughtered, such rules are often flouted.[87] Horses destined for the abattoir are most commonly transported by truck, unrestrained and in groups. A study comparing two densities of horse groups in transit found that more horses fell and more were injured in the higher-density group.[88] This reflects the fact that it was more difficult for fallen horses to get to their feet in the higher-density group.[88] Horses traveling loose in small groups exhibit less physiological distress than those tied up,[75,76] but economies of scale dictate that sufficient individual space is rarely given to horses bound for slaughter. A study of unhandled ponies during road transport showed that more slips, falls, stumbles and collisions occurred at higher stocking rates and that there was less aggression and fewer indicators of poor welfare in group sizes of 4 than 8.[89] At lower density ponies tended to align with the pen walls, indicating that these may have offered support.[89]

Fighting during transportation is a major cause of injuries,[86] many of which are incurred during transport through aggression between freshly mixed animals. This may explain why the condition of established bands of feral horses after transport is often better than that of domestic horses from a variety of origins, such as arise in groups of horses traveling from saleyards to slaughterhouses. Clearly, one of the easiest means of reducing such injuries is to avoid mixing horses. Where this is not possible, it is appropriate to separate stallions and particularly aggressive animals from the main group.

SUMMARY OF KEY POINTS

- Regardless of whether or not they realize it, good handlers of horses are students of equine behavior.
- By keeping horses as calm as possible, the type of restraint required for current and future handling can be kept to a minimum.
- Horses rarely forget aversive procedures.
- Horses should never be punished for showing flight responses.
- Donkeys respond differently from horses during restraint and veterinary procedures.
- Numerous factors associated with transport can compromise health and welfare.
- Preventing dehydration is a priority in transported horses.

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Miscellaneous unwelcome behaviors, their causes and resolution

CHAPTER 15

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Introduction

Physical causes of unwelcome behavioral responses should always be ruled out before any purely behavioral therapy is adopted. Painful lesions and other physical abnormalities should be eliminated because beyond their effects on horse welfare and development of annoying habits, they are likely to compromise athletic output (Fig. 15.1). For example, it has been proposed that undiagnosed pelvic or vertebral lesions could be important contributors to poor performance in horses.[1] While occasional disorders such as 'cold-back syndrome' and the relationship between dental problems and behavior under-saddle have yet to be thoroughly explored, the treatment of most physical disorders that reduce performance is considered in detail in the veterinary literature.

Since most problem behaviors that emerge in stables or at pasture are considered elsewhere in this book, the current discussion will focus on handling problems and problems with the ridden horse. In combination with Chapters 1, 4 and 13, this chapter aims to help veterinarians and equine scientists in their creation, from first principles, of humane and effective therapies for unwelcome behaviors. The current chapter indicates the basic approaches to therapy that can be tailored for each affected horse, defines some of the more common problems and offers a framework for understanding the origins of these problems.

Unfortunately, as discussed in Chapter 13, there is a lack of scientific data in these realms. This may reflect the importance we place upon the performance of the horse under-saddle and the consequent development of riding instruction that tends to focus on outcomes rather than mechanisms. Since the ideals of equestrian technique combine art and science, students of equitation encounter measurable variables such as rhythm, tempo and outline alongside many more elusive qualities such as so-called submission.[2,3] This mixture and the dearth of mechanistic substance frustrate attempts to express equestrian technique in empirical terms[4] and account for some of the confusion and conflict that arises in many human–horse dyads. With time, the application of science to the plethora of undesirable behaviors that horses trial and learn to adopt will undoubtedly reduce the ill-considered demands for quick fixes and ultimately decrease the wastage in the industry. In terms of prevention, we will, in time, fully appreciate the importance of consistent, low-stress foundation training as the bedrock of any horse's training and the best means of avoiding dangerous traits subsequently emerging.

Figure 15.1 A horse making a so-called dirty stop (getting very close to a fence before refusing). Horses refusing fences may have learned that they are physically unable to clear the top rail or that landing is a painful consequence of taking off. *(Photograph courtesy of Sandra Hannan.)*

Mechanical approaches

Most naïve horses respond to humans as they would to any predator. They behave in ways that help them avoid physical or psychological pressure, by moving away bodily or posturally. These basic evasive responses can be modified successfully to produce a highly responsive equine performer or unsuccessfully to produce a problem horse.

When trainers encounter horses that rapidly enter conflict and as a result do not comply, they often experiment with increased pressure to overcome resistance. Mechanical restraints and stimulants may be used to magnify the pressure that riders can apply. Because of the perceived need to force horses into an 'outline' and make them work 'on the bit' (see Glossary), the tendency is to use ever-stronger bits as the first approach to solving any resistance. This accounts for the multiplicity of bits on the market. As with any device, it is true to say that if there are many of them available, the chances are that none of them provides all the answers. Furthermore, enlightened trainers recognize that where aversive stimuli have failed to elicit the desired response and have begun to cause behavioral conflict, the application of more force is contraindicated. They rarely reach for such gadgets.

Frustrated trainers often try bits that apply pressure to different parts of the mouth or to the same area of the mouth but with greater severity (Fig. 15.2). Even though they can and sometimes do sever the tongue,[5] saw-chain bits (so-called mule bits and correction bits) are readily available to riders who are having problems getting horses to respond to milder bits. If changing or increasing mouth pressure is unsuccessful, an alternative or additional means of making the horse adopt the desired shape is to apply pressure to other parts of the head, so training devices such as curb chains, gags, hackamores, bosals, draw reins, balancing reins and chambons may be employed. Unfortunately the tendency is to develop a reliance on these extra pulleys, rather than use them solely for retraining as the name might imply. Martingales and tie-downs are similar in that they apply pressure to prevent evasive raising of the head and are rarely dispensed with.

If the horse fails to show sufficient forward movement or impulsion, trainers direct their attention to the flanks where they can increase the pressure and more effectively drive the horse forward or simply away from the rider's leg using whips and spurs. Although, for some, these stimulants are distasteful, they are not necessarily contraindicated since they can be used with subtlety and employed transiently to empower the rider's leg signals. In contrast, tying horses' heads down (with side reins and draw reins) and clamping their jaws shut with nosebands[6] are counter-productive in the long term. Indeed there is growing concern that these approaches can automatically compromise welfare by virtue of their inflexibility and inherent absence of pressure-release.[7]

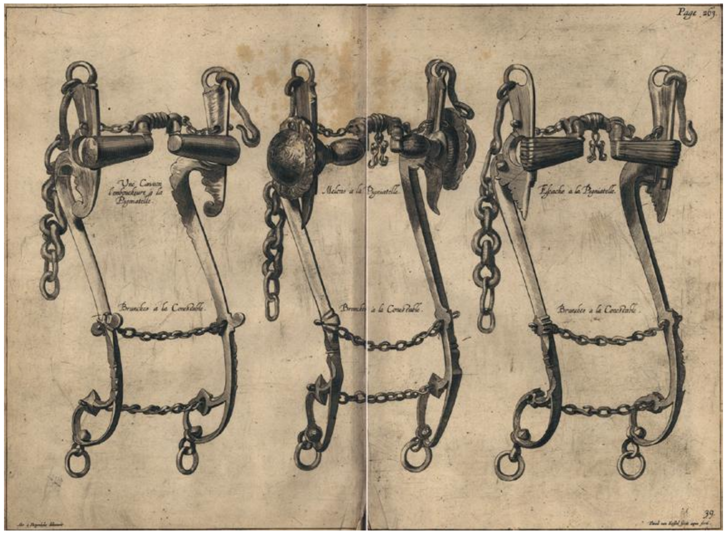

Figure 15.2 Etching of 18th-century bits. At times it seems that more effort has gone into designing bits than addressing poor equitation.

Behavior modification

Behavior therapy can help overcome undesirable equine responses that may have an innate component but are largely learned. The temptation may be to treat such traits in isolation. However, a holistic approach has tremendous merit since better results tend to occur if the human–horse relationship is nurtured when the rider is both on the ground and in the saddle. Time spent training horses in-hand seems to pay dividends even in the ridden horse,[8] presumably through a process of generalization. Achieving stimulus control in-hand seems to facilitate stimulus control under-saddle.[9] Inter-specific communication may help horses overcome fear and therefore reduce their tendency to use counter-predator responses. It is important that the translation of trained responses from cues in-hand to cues under-saddle is better understood by practitioners. It may simply be that an unconfused horse in-hand is a better prospect for training than a confused one. In any case, correctly identifying the effects of reduced confusion and fear and distinguishing stimulus control from mere compliance may allow us to describe and even measure the bonds that form between horses and their trainers.

By the same token, punishment is regarded by many owners as unenlightened, since it presupposes that horses know the difference between good and bad behavior. So, it is increasingly inappropriate for veterinarians to advocate punishment as a response to

Figure 15.3 Horse being clipped in the presence of food – an example of counter-conditioning. *(Reproduced with permission of Australian Equine Behaviour Centre.)*

undesirable behavior in the horse. It undermines the human–horse bond and carries the risk of injury, which may place any practitioner who advises it in a legally liable position. Examples of acceptable techniques used for behavior modification include habituation and counter-conditioning (see Chs 4 and 13). Habituation is the key to overcoming fear-related responses such as traffic shyness but it can be expedited with counter-conditioning, an approach that relies heavily on the shaping of alternative responses through operant conditioning (see also Fig. 15.3). At its most elegant, equine operant conditioning takes the form of positive reinforcement and subtle negative reinforcement. Consistent use of negative reinforcement is the key to retraining the basics, but is notably more likely to work in horses that have not habituated to pressure. Techniques for restoring sensitivity to pressure cues demand exquisite timing of pressure-release. Meanwhile, clicker training employs positive secondary reinforcement that is particularly useful for refinement of responses, once negative reinforcement has established the basics.

Horses with innate or learned evasion responses may have the rewarding outcomes of these responses removed by a process of extinction. Furthermore they can be trained to associate the fear-eliciting stimuli with positive outcomes in the same way that laboratory primates can be trained to voluntarily present their forelimbs for intravenous injections. (A case study that required a pony to learn to cope with hypodermic injections appears at the end of this chapter. It followed the injection desensitization training technique developed by ethologists at Pennsylvania State University.[10]) A far less humane approach to fearful horses is to flood them by exposing them to an overwhelming amount of the fear-eliciting stimulus in the hope that their responses are exhausted. For example, so-called 'tarping', a method of breaking by flooding, involves evoking learned helplessness by casting the horse, covering it with a tarpaulin and beating it until it no longer resists.

Practitioners are strongly encouraged to become extremely conversant with learning theory (see Ch. 4) before counseling owners on the application of these techniques. All of the undesirable responses in the current chapter can be remedied by behavior modification. But a prerequisite is to correctly identify the motivation for a given response. Readers are urged to consider the ethological content of this entire volume when determining causal factors. Beyond that the success of behavioral therapy depends on the consistency of administration and compliance of owners, who must be counseled that the latency for desirable outcomes depends largely on the number of times the horse has trialed and learned from the unwelcome response. With a thorough knowledge of learning theory, practitioners can customize behavior modification programs, modify advice in the light of initial responses and counsel owners when proximate results surprise the uninitiated. So, for example, when as a result of an extinction protocol, undesirable responses become more frequent, the accomplished student of learning theory can explain that this is a manifestation of the frustration effect (see p. 103 in Ch. 4) and that it is transient.

Handling problems

As discussed in the previous chapter, physically restraining horses during painful procedures is often possible but rarely preferable to chemical restraint since it tends to escalate the aversiveness of the procedure and is therefore ultimately likely to compromise the horse–human bond and make the horse less compliant for future procedures. Many handling problems are the legacy of previous (often unintentional) abuse. Others can have proximate causes in physical pathologies, so practitioners should always check first (with an examination and a thorough case history) for the involvement of these anomalies before embarking on any course of behavior therapy, e.g. a horse that is reluctant to step backwards must be checked for wobbler syndrome.

Horses fearful of clippers may have had a cutting injury or heat damage during clipping. Head shyness can be the manifestation of partial blindness, dental anomalies and, occasionally, spinose ear ticks.[11] Girthing and saddling problems may be related to thoracic and spinal lesions. Horses that are eager to rub their heads against handlers may have lice or, very occasionally, flying insects or spinose ear ticks that make them generally itchy and sometimes irritable. In a similar vein, when acute in onset, hypersensitivity to being touched may be attributed to strychnine poisoning and even lightning strike.[11]

Assuming that painful pathologies have been ruled out, the role of learning is of tremendous significance in emergent handling problems. Horses showing fear of veterinarians may simply remember them as the immediate precursors of pain or of unpleasant physical restraint prior to painful interventions. Similarly, those showing fear of farriers (Fig. 15.4) may have received a nailing injury in the past. The horse's ability to form general relationships between certain activities and pain should not be overlooked. For example, painful lesions (e.g. subclinical orthopedic disorders that are exacerbated by riding) may make a horse generally reluctant to work and, by a process of backward chaining (see Ch. 4), difficult to catch.

As with all behavior problems, it is the responsibility of handlers and therapists alike to establish that the horse is not only capable of an appropriate response but that it is also free from pain. Furthermore, the horse must know what is being asked of it, i.e. it must have learned the cue. Only when these prerequisites are in place can the horse be helped to unlearn the inappropriate associations (Table 15.1). Techniques in behavioral therapy can be used in combination so the suggestions that appear in Table 15.1 should not be considered the

Figure 15.4 A horse attempting to escape from a farrier.
(Photograph courtesy of Sandro Nocentini.)

complete or sole approach. Attention to the horse's dietary, social and environmental needs helps to advance the effects of appropriate behavior modification.

Problems with the ridden horse

Horses can demonstrate various unwelcome behaviors under-saddle, often in combination. However, for the sake of simplicity, inappropriate responses are considered separately in this chapter.

Inappropriate obstacle avoidance

It is appropriate for horses to avoid hazards that may jeopardize their safety, but such innate self-preservation

Table 15.1 Common handling problems, their interpretation and suggested approaches to therapy that can be employed after any primary physical causes have been removed

Problem	Interpretation	Approaches to therapy
Barging (trampling)	• Agonistic response to displace personnel	• Avoidance learning or shaping of lateral movement in response to being touched on the flank
Biting and bite threats	• Aggression to deter approaching personnel	• Total refurbishment of the human–horse bond,[a] e.g. experienced personnel may make great strides with such horses in a roundpen
Claustrophobia	• Innate fear of enclosed spaces such as stalls, stables and trailers (floats) • Learned fear of aversive and coercive human responses	• Clicker training to approach, stand beside and enter enclosures[c] • Reinstall leading cues[d]
Difficult to bridle	• Learned evasion of discomfort from bit, crown-piece and brow band	• Partially dismantle bridle and apply in parts to identify the most aversive element • Counter-conditioning[b] • Clicker training to stand quietly in usual area used for bridling[c] • Shape tolerance of key elements of the bridling process
Difficult to saddle-up	• Learned evasion • Response to past pain	• Counter-conditioning[b] • Clicker training to stand while being saddled[c]
Difficult to shoe	• Learned evasion from fear	• Extinction of fear responses by habituation and counter-conditioning • Clicker training of appropriate responses, such as approaching farriers and their equipment[c]

(Continued)

Table 15.1 (Continued)

Problem	Interpretation	Approaches to therapy
Dislike of grooming	• Innate ticklishness • Learned evasion	• Habituation • Counter-conditioning[b]
Fear of being clipped	• Learned evasion and sometimes learned aggression	• Counter-conditioning.[b] Clicker training to approach and stand beside clippers[c]
Fear of veterinarians	• Innate aversion to pain and learned evasion of associated stimuli	• Extinction of fear responses by habituation and counter-conditioning.[b] This should involve the owner in the first instance and then the practitioner • Clicker training of appropriate responses, such as approaching veterinarians and their equipment[c]
Hard to catch	• Learned evasion	• Clicker training of appropriate responses such as approaching personnel[c] • Extinguish associations with being removed from group. Therefore habituate the horses to being caught but not necessarily brought in from the paddock or ridden
Head rubbing	• Innate response to irritants • Learned association with gratification from rubbing against personnel	• Extinguish gratification. Offer visual cues (such as a body brush) that allow the horse to discriminate times when rubbing against a more appropriate object (such as a brush) is worth trying, i.e. is 'permissible'
Head shyness	• Learned evasion, e.g. of being twitched or being struck around the head	• Clicker training of appropriate responses such as approaching personnel, especially their hands and hand-held equipment[c]
Kicking and kick-threats	• Aggression to displace personnel	• Extinguish fear and then undertake total refurbishment of the human–horse bond
Pulling	• Motivation to ignore or override pressure from headcollar or halter (headstall) • Habituation to pressure from headcollar or halter	• Reinstall leading cues[d]
Pushing	• Agonistic response to intimidate personnel	• Reinstall leading cues[d]
Rearing	• Learned evasion • Habituation to pressure from headcollar or halter • Aggression	• Reinstall leading cues[d]
Refusal to back	• Learned evasion	• Reinstall leading cues[d]
Refusal to leave company	• Lack of training • Excessive bonding usually with one particular field-mate	• Consider restructuring social group • Reinstall leading cues[d] • Counter-conditioning to develop positive associations with temporary isolation[b]
Refusal to load	• Learned evasion ± claustrophobia	• Reinstall leading cues[d] • Clicker training of appropriate responses, such as approaching and entering vehicle[c]

(*Continued*)

Table 15.1 **(Continued)**

Problem	Interpretation	Approaches to therapy
Refusal to stand while being mounted	• Learned evasion of bit pressure and anticipation of kinetic behavior	• Reinstall leading cues[d] • Clicker training of appropriate response[c] • Shape the horse to stand quietly for increasing periods before moving forward
Striking	• Aggression	• Refurbishment of the human–horse bond

[a]*Refurbishment of horse–human bond is also discussed in the case study in Chapter 11, p. 252.*
[b]*Counter-conditioning is explained on p. 89 (see Ch. 4) and also in the case study at the end of the current chapter, p. 338.*
[c]*Clicker training is explained on p. 97 (see Ch. 4).*
[d]*Reinstallation of leading cues is explained in Chapter 13 and highlighted in the case study in that chapter on p. 304.*

Figure 15.5 A horse avoiding obstacle despite (or perhaps even as a result of) the efforts of a novice rider. *(Photograph courtesy of Mellisa Offord.)*

responses sometimes inconvenience riders (Fig. 15.5). Examples include avoidance of ground hazards, manifested as running out and refusal of fences, ditches and water jumps, while avoiding lateral confinement may prompt a horse to refuse to enter starting stalls. Unfortunately, the original causes of these responses may be obscured and the subsequent application of aversive stimuli may simply confirm to the horse the need to avoid such obstacles because they become associated with pain.

In other words, riders and handlers may focus on a given hazard and, through the use of pressure cues, may inadvertently make it increasingly aversive. It is therefore preferable to first work on deficits in the quality of operant responses such as leading to a light cue and straightness in less challenging contexts. Again, the sequential steps in a linear scale of training (see Ch. 13) should end in proof only after the preceding steps in the scale have been achieved repeatedly. Shying behavior is most rapidly learned and incorporated into the horse's behavioral repertoire when it permits complete escape. As the horse escalates its shying behavior, the reinforcement from escape is compounded by the incremental loss of control by the rider.[2] Additionally, riders who predict the responses may inadvertently apply pressure that may increase the horses' motivation to find freedom.[2] Re-training the 'go' response in such horses (see Ch. 13) is the preferred remedial course of action.

The importance of rhythm and direction in basic training is explained when one considers horses that learn to refuse jumps. Habitual losses of rhythm and tempo or directional line often lead to stalling while approaching fences.[2] When horses learn to stall in the jumping effort, outright refusal is generally their next step.

Hyper-reactivity responses

While innate obstacle avoidance responses may paradoxically help to ensure the safety of riders (e.g. by prompting the horse to steer around a hazard unseen by its rider), other innate self-preservation action patterns of horses, especially those that keep them safe from predators, are sometimes triggered too readily or are performed with speed that riders are unable to predict. These are chiefly flight responses motivated by a need to get away from the stimulus, rejoin a group of conspecifics or return to the home range. Depending on the human observer, horses that readily offer theses responses are variously described as sharp, keen, fizzy or flighty.[12] Of course, these labels blame the horse rather than identifying deficits in its training.

There are several common examples of hyper-reactivity in the ridden horse. As discussed above, shying is an avoidance response that sends horses leaping laterally or backwards away from auditory, olfactory or visual stimuli. Many horses in unfamiliar surroundings offer this response innately but some adopt it as their default response to novelty. Traffic shyness is a particularly important example. The most successful approach to this dangerous problem involves a process of habituation, but the challenge for trainers is to present a comprehensive range of diverse stimuli (a model for habituating former racehorses appears in the case study in Ch. 4).

Jogging, on the other hand, is largely learned and manifests as a horse that is unresponsive to signals to walk (Fig. 15.6). This undesirable gait is often accompanied by persistently repeated extension of the neck to pull the reins through the rider's hands in horses that have learned to 'pull'. These horses demonstrate a clear need for reinstallation of the 'stop' cue. Similar unresponsiveness takes an extreme form in horses that bolt, i.e. that gallop with no response to rein pressure. These animals may learn to ignore bit pressure whenever they wish to remove themselves from a perceived threat or return to their home range or social group.

Agonistic responses to conflict

When faced with discomfort or a threat, most horses move away. If horses cannot escape from such a stimulus, they enter behavioral conflict and increase their kinetic effort in a bid to relieve the pressure (Table 15.2). Some horses develop seemingly irrational phobias by becoming sensitized to associated stimuli and anticipating the escalation of bit or leg pressure that riders use to make them 'behave'. The therapeutic approach to conflict is discussed in detail in Chapter 13.

Evidence of pain and irritation

When a horse fails to respond as requested by the rider, the innate human tendency is to repeat the cue with greater force in a bid to increase the animal's motivation to relieve the pressure. However, it is important that

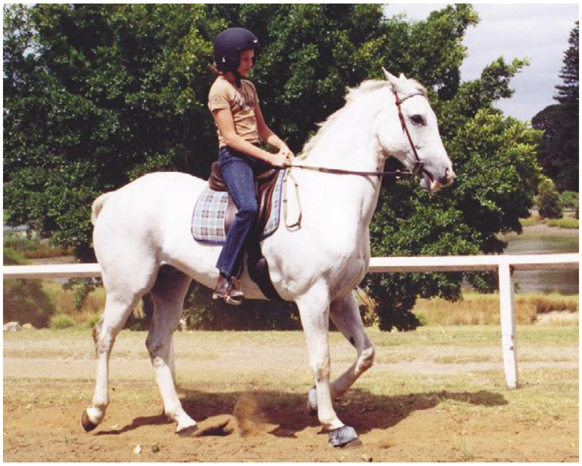

Figure 15.6 A jogging horse. Jogging is a choppy trot that wastes energy and often indicates the need for better training of clear transitions.

Table 15.2 Selected examples and descriptions of agonistic responses to conflict

Response	Description
Bucking	Response used to fight conspecifics and dislodge predators
Rearing	Response used to fight conspecifics and predators
Balking, bolting home, napping and jibbing	Motivation to return to home range or social group is greater than motivation to respond to rider's signals
Rushing fences	Although the behavioral mechanism is unclear, horses choosing to travel too rapidly toward fences are thought to be making a perverse attempt to reduce the aversiveness of the stimulus by running towards it
Falling out through the shoulder	Failure to turn appropriately on command

somatic causes of a horse's disinclination to respond are eliminated before more aversive stimuli are applied. There is a strong argument for the attending veterinarian to use analgesics as a diagnostic probe when horses fail to respond appropriately, especially if this departure is sudden. Pain is recognized as an important contributor to unwelcome behavioral responses.[13] Occasionally horses may learn to relieve pressures caused by riders by removing the riders themselves, e.g. by bucking (Fig. 15.7), rolling or even rubbing the riders against fixed objects.

Figure 15.7 A horse bucking under-saddle. *(Photograph courtesy of Andrew McLean.)*

Gentle snorting is usually a good sign in horses under-saddle because it tends to be accompanied by signs of relaxation such as spontaneous head lowering. In contrast, grunting and groaning are expiratory noises associated with tenesmus and abdominal guarding. As such they reflect low-grade discomfort in the very general region of the horse's forequarters. Far more profound an indication of thoracic and lumbar pain is seen in 'cold-back' syndrome during girthing and mounting. This often includes responses to being saddled, mounted and especially to being girthed that vary from aggression to recumbency.

Horses commonly learn to reduce the discomfort of the bit by manipulating it to lie in relatively insensitive parts of the mouth. Common names for these evasions include raking, boring, getting the tongue over the bit and seizing the bit between the teeth (Fig. 15.8). Mouth pain is usually associated with heavy-handed riding or inappropriate equipment, e.g. the action of some jointed bits is thought to cause pinching between the commissures of the lip and the second premolar. Some maintain that in the event of a horse fighting the bit, comfort in this part of the mouth can be maximized by creating a 'bit seat' or 'cheek seat', i.e. removing an appreciable portion of the second premolar.[14] While one study reported improved athletic performance in most horses after the creation of bit seats,[14] an abiding question is whether a simple change of bits (e.g. to an unjointed design) would be just as effective. Alarmingly, some overzealous equine dentists suggest that partial tooth removal should be considered for all horses that are

Figure 15.8 A draft team in which several horses can be seen evading the bit. *(Photograph courtesy of Les Holmes.)*

Table 15.3 **Selected examples of inadequate performance under-saddle that reflect poor physical ability**

Response	Description
Fatigue	Lack of energy as distinct from lack of willingness to respond
Problems in transition	Congenital propensity, e.g. to disunite at the canter (see Glossary)
Tripping, toe-dragging, stumbling and clumsiness	Poor locomotion due to fatigue, conformation or excessive hoof growth
Forging, clicking and over-reaching	Inappropriate farriery, conformation problems and inattentive equitation
Brushing, speedy cutting and dishing	Inappropriate farriery and conformation problems
Hitting fences	Failure to elevate limbs, especially the leading foreleg, while jumping

required to wear double birdles. This is an outrageous suggestion since it effectively means that all horses competing in elite dressage should be surgically altered in this way. The use of double bridles (and the jaw-clamping nosebands that are frequently used with them)[6] should be questioned before horses' dental arcades are routinely modified to accommodate them.

Evidence of poor physical ability

While some horses do not comply with riders' signals because they associate the responses desired by riders with musculoskeletal discomfort, others are insufficiently athletic because of poor conformation or lack of fitness (Table 15.3). Clearly, as with those resulting from pain, these cases are unresponsive to behavior therapy. It is also worth checking that riders are giving signals in consistent anatomical sites, e.g. lack of consistency can explain why a short-legged rider may fail to prompt a satisfactory 'go' response from a horse that has previously been ridden only by long-legged riders.

Evidence of learned helplessness

Horses may learn that they are unable to help themselves when responses they use to relieve pain or discomfort or threats (or their precursors) are unsuccessful. By a process of habituation, such horses often become unresponsive to the stimuli, but it is unclear whether they all do so with a concurrent reduction in physiological distress.

Horses that exhibit general reluctance to work and resistance to signals from the rider are described as 'stale' or 'sour'. Specifically they may be referred to as being hard-mouthed (Fig. 15.9) or lazy and sluggish, whereas, more correctly, they should be considered to have habituated to rein pressure or leg pressure, respectively. It is difficult but not impossible to re-educate these horses (see Ch. 13). Classically, animals that have learned helplessness are generally unresponsive to multiple stimuli in their environment, not just training-related stimuli.

Figure 15.9 A hard-mouthed horse. *(With kind permission of Elvira Currie.)*

Causes of unwelcome responses in the ridden horse

Two broad sections are proposed here: unwelcome behavioral responses caused directly by humans, and those attributable more to the horse than the rider. However, it is accepted that while the dichotomy is not absolute, the responsibility for equine behavior problems ultimately lies with humans, since we have undertaken the domestication and exploitation of equids. Because humans are so directly involved in the first group, it is likely that interventions such as behavior therapy are more likely to work in these cases.

Human causes of unwelcome behavioral responses

Some unwelcome responses disappear if management deficiencies are corrected or if the rider becomes more skilled or is replaced by a more talented equestrian. Horses learn to evade discomfort in both appropriate and inappropriate ways. Sometimes, for example in rodeos, horses are required to produce exaggerated agonistic responses as part of their work. Indeed Schonholtz[15] points out that some horses are purpose-bred for a heightened anti-predator response (e.g. one line of buckers accounted for 30 horses used at the US National Rodeo Finals in 1996). While this is claimed by some to be evidence for the increasingly humane treatment of rodeo animals, it may simply indicate that hypersensitive horses can be bred. This means that selected animals are less likely to habituate to being ridden with a bucking strap in place because they continue to find the procedure aversive. So purpose breeding seems an unconvincing justification for the use of selected rodeo animals on welfare grounds.

While schooling in the form of operant conditioning can make a horse respond desirably, it can also evoke resistance, conflict and learned helplessness when administered crudely, inconsistently or too rapidly.[16] Avoiding and resolving problems in the ridden horse have both already been explained in Chapter 13.

Poor riding technique

The importance of rider position is always stressed in riding manuals, with good reason (see Fig. 7.24). Without this prerequisite, riders attempt to maintain or resume a centered position and usually have a significant effect on the horse's movement and balance in the short term (Fig. 15.10). In the long term, a rider's lack of balance allows the horse to practice unrequested responses. The more opportunities the horse has to trial responses that are not under stimulus control, the greater it perceives its freedom from the control of the rider.

Figure 15.10 An inexperienced rider showing lack of balance, with the hands uneven and the legs placed too far forward. Typically these characteristics predispose the rider to being 'left behind' the horse whenever it moves forward with unexpected speed, an outcome that prompts many novices to compensate by using the reins to balance. *(Photograph courtesy of Sandro Nocentini.)*

This allows an escalating series of random behaviors to be trialed and possibly reinforced. These tendencies, in turn, can affect a rider's confidence and thus prompt the emergence of a so-called defensive seat, characterized by a forward tilt of the upper body with excessive rein contact and some gripping with the lower legs. For these reasons, novice riders should never be paired with uneducated horses.

Poor application of learning theory

Although horses are adaptable and therefore tolerant of poor handling and training, this does not obviate the need to use tact and sensitivity when applying aversive stimuli. Punishment and inappropriate negative reinforcement are prevalent because few riders appreciate the importance of learning theory (Table 15.4).

Unrealistic expectations

As the commercial value of a horse is often related to its ability to compete, many owners seek to push their horses to the limits of their performance. When the expectations of the owners are not met, this may account for some abiding dissatisfaction and the application of interventions that can elicit conflict. Coercion is ineffective and inhumane when the real problem is ignorance of the true limitations of the horse's ability. For example,

Table 15.4 Common rider faults that demonstrate poor application of learning theory and may serve to confuse horses

Rider fault	Example
Nagging	Repeated application of aversive stimuli regardless of response
Poor timing	Application of signals ***after*** the response has been offered
Inconsistency	Failure to relieve pressure to reinforce every desirable response
Failure to reinforce	Ignorance of the need to relieve pressure
Inappropriate punishment	Punishment for fear responses
Poor balance	Inability of the rider to balance without signaling to the horse
Pursuit of style at the expense of other appropriate goals	Prioritizing desirable outline over self-carriage

although the majority of Thoroughbreds are physiologically suited to fast work, one study demonstrated that only 10% win enough prize money to offset the purchase and ongoing expenses.[17] Such horses may be viewed as underachievers and may even attract more use of the whip than those that run fast enough to meet their owners' expectations.

The use of the whip in racing, in general, is being questioned, not least because there is significant risk that when whipping occurs, horses may be too tired to respond to repeated whippings and that this probably amounts to abuse. The effectiveness of the whip in steering a racing horse has been also brought into doubt.[18] Furthermore, recent evidence from races of 1200 m and 1250 m has shown that horses, on average, achieved highest speeds in the 600 m to 400 m section (from the finish) when there was no whip use, and increased whip use was most frequent in the final two 200-m sections when horses were fatigued.[19] This increased whip use was not associated with significant variation in velocity as a predictor of superior placing at the finish.[19] The same data set showed that horses were more likely to be struck in the penultimate 200 m of races if they were being ridden by apprentice jockeys and if they were drawn closer to the rail.[20] It is alarming that jockey inexperience is associated with increases in the use of an aversive tool. It is surprising that, regardless of their experience, jockeys were found to be using the whip more if their horses were drawn closer to the rail since there is evidence that those further from the rail have slower race times, so one would expect those horses to need more whipping if, indeed, it was effective in remediating deviations in path caused by having to run on the outside of a bend. Under an ethical framework that considers costs paid by horses against benefits accrued by humans,[21] these data make whipping tired horses in the name of sport very difficult to justify.

Hyper-reactivity

While reactivity is selected-for in some high-performance breeds, especially those used for racing, it is unwelcome in the breeding stock of others such as those used for draft purposes. Motivation to respond to pressure may be reduced in the more stoic animals that are commonly labeled sluggish. Perversely the so-called warmbloods may be so tolerant of bit pressures (Fig. 15.11) that they can perform in dressage competitions while subjected to bit pressures that hotbloods cannot ignore.

Hyper-reactivity may arise from inappropriate matching of horses with the work required of them. For example, some horses cannot be used in traffic because they are intolerant of large objects moving in their peripheral vision. Additionally, most traffic-shy horses learn to anticipate aversive stimuli from riders (including rein and leg pressures) when traffic is encountered. This means that instead of habituating to traffic as most horses do, they recognize the rider's alarm and become especially responsive to traffic-related stimuli, in other words, they become sensitized (see Ch. 4). As discussed with shying, even in the absence of anticipation, inadvertently applying pressure may increase the horses' motivation to find freedom (Fig. 15.12).[2,22]

Beyond mismatching horses for work, two general causes of hyper-reactivity are management and schooling. We know that the frequency of unwanted behavior during training is increased by stabling.[23] By feeding horses inappropriately and housing them without regard for their need for conspecific company and spontaneous exercise and play, humans increase the likelihood

Figure 15.11 Unfortunately, strong rein contacts are normal in contemporary dressage, perhaps because judges struggle to identify lightness. *(Reproduced with permission of Julie Taylor.)*

Figure 15.12 A rearing horse under-saddle. *(Photograph courtesy of Sandra Hannan.)*

of explosive displays of locomotory behaviors. So, the influence of intensive management should always be considered when a horse presents with training problems, e.g. because shying appears more likely in stabled horses, it is appropriate to consider the effects of post-inhibitory rebound[24] and the role of over-feeding high-energy foods as contributors to hyper-reactivity in the wake of confinement. As far as the role of schooling is concerned, it is worth remembering that some riders train their horses to be acutely sensitive to leg pressure. This is appropriate only if the horses are never ridden by novices who may trigger responses inadvertently, e.g. by using their legs to grip and balance.

Failure to consider social needs

Most equestrian pursuits require riders to thwart the horse's innate need to have constant conspecific company. Inattention to this need or inadequate training of the horse to cope without it can lead to undesirable responses under-saddle. Separation-related distress may cause bolting, while aggression to conspecifics while under-saddle may mean that a horse cannot be ridden in company. Providing insufficient space between horses that are strangers or occasionally even affiliates can cause horses to show aggression to conspecifics while being worked. This is unwelcome since it can cause injuries to both horses and riders. The more obedient a horse is under-saddle the less likely are these responses, so re-training the 'go' and 'stop' responses is clearly indicated. Due consideration should also be given to the social environment to which the horse is exposed at home and the relevance of this at exercise.

Horse-related causes of unwelcome behavioral responses

If horses continue to perform poorly, despite demonstrable improvements in management or technique, they may have innate or acquired physical anomalies that make them unsuitable for ridden work. This is not meant to suggest that the horses are at fault, since most of these problems can ultimately be attributed to human intervention or omission.

Pain

Applying pressure in sensitive areas is an implicit feature of traditional equitation, which relies on negative reinforcement. While humans routinely inflict discomfort on ridden horses intentionally with rein and leg pressure via bits and spurs, they may also do so unintentionally as a result of poor management or oversight (Table 15.5).

Physical inability

Some horses will never be able to excel in some fields (Table 15.6). Their inability should be identified rather than misinterpreted as disobedience or the absence of a 'will to please'.

Table 15.5 Selected examples of management factors that contribute to unintentional pain in ridden horses

Problem area	Example
Tack	Saddles can pinch the dorsal lumbar musculature
Hoof care	Inappropriate hoof trimming can contribute to bruising of the foot
Malnutrition	Overfeeding can increase the risk of rhabdomyolysis
Dental anomalies	Sharp spurs and hooks in the molar and premolar teeth may make jaw movement uncomfortable and therefore make the horse less likely to relax its jaw when ridden
Cranial discomfort	Trigeminal pain may cause headshaking with frenzied flexion and extension of the poll
Musculoskeletal pathologies	Navicular pain may make the horse resistant to work on hard surfaces
Exercise surfaces	Certain exercise surfaces may cause unnecessary pain

Table 15.6 Examples of some of the ways in which some horses are predisposed to poor performance

Problem area	Example
Anomalies in perception	Partial blindness can lead to generalized wariness
Conformation	Inadequate height or hindquarter strength can disadvantage a horse intended for jumping or dressage, respectively
Physiology	Inherently low thresholds for dehydration and fatigue
Gait anomalies	A familial tendency to trot may disadvantage some Standardbreds when asked to pace

SUMMARY OF KEY POINTS

- Equine behavior therapy relies on:
  - considering the ethological relevance of unwelcome behaviors
  - eliminating pain and discomfort as proximate causes
  - applying learning theory to resolve learned responses.
- The reasons for failure of behavioral modification include:
  - inconsistent application of learning theory
  - a lack of reconciliation of the task required of the horse with its physical ability to oblige.
- Riders often experiment with increased force before seeking professional help.
- Persistent application of traditional techniques that have contributed to the emergence of unwelcome behaviors makes the problems themselves more persistent.
- Clinical examinations are essential to rule out non-behavioral causes of undesirable behaviors.
- Consideration of the motivation for undesirable responses in ethological terms helps to identify causal factors.
- In all cases, the key to behavior therapy is sound application of learning theory.
- Clients should be counseled not to expect quick fixes, especially with long-standing problems.

Case study

A 5-year-old riding pony mare had developed a reputation for being impossible to inject. A veterinarian who was persuaded to inject her with a sedative prior to being clipped while she was restrained within a float had his spleen ruptured in the frenzied flight response that ensued when the mare appreciated she was going to be injected.

Injections
Because they had become associated with previous adverse experiences, raised voices and forceful restraint readily conveyed to this pony the message that any veterinary intervention was going to be unpleasant and that the person doing it was to be avoided and feared. Clearly, the use of force and punishment was inappropriate.

This case was approached in two phases. The first was to counter the mare's fear of injections, and the second focused on her fear of the clippers. The overall goal was to make the experience of both more positive than negative. Using the technique established by Professor Sue McDonnell[10] for achieving compliance with any intervention, the mare had to learn three basic lessons. These were that the intervention:

- does not really hurt that much
- could lead to rewards, if tolerated
- could not be stopped with regular flight or fight responses.

The first step was to ensure that the restraint was not causing genuine discomfort or fear, so the mare was handled in a large corral in which she could move without crashing into anything if she withdrew at speed during the procedure. To avoid conveying anxiety to the mare, it was important that personnel working with her were not tense or fearful. Many horses have learned that flinching or retreating on the part of personnel is a portent of their departure, which reinforces agonistic responses.

For injection shyness, it was important to ensure that the injections themselves were as painless as possible by using a small-gauge needle and a quick but gentle injection technique. Successive tolerable approximations of the procedure were patiently repeated. Initially, each improvement in compliance was rewarded with a primary reinforcer (see Shaping in Ch. 4). In this mare's case, carrots were demonstrably reinforcing, so they were used in the shaping process. Any adverse reactions were not punished. If she moved away, the mare was trained to find that this did nothing to help her avoid the procedure. Personnel stayed with her as much as possible, and calmly waited for her to stop recoiling.

The mare eventually learned to tolerate injections and even appeared to enjoy most normal non-painful veterinary or management procedures.

Clipping
Counter-conditioning was used to train the mare to associate the sound of the clippers with the arrival of her evening meal. The clippers were switched on every evening until the mare and her stable-mates were all responding to the sound of the clippers alone by demonstrating typical restlessness that one finds at feed times, e.g. when buckets are rattled. The next step was to introduce the sight of the clippers in combination with their sound. The mare had all meals presented only after the clippers had been switched on in her stable.

The final steps involved counter-conditioning the fear of the clippers making contact. With the attraction of the food, the mare was encouraged to move toward the clippers. When she did so they were switched off. In this way she was given some operant control of her fear. This was a form of negative reinforcement since the response was made more likely by the removal of the aversive stimulus. She was then target trained with food to move towards the clippers so that they developed associations with rewards.

The seasonality of clipping meant that the clippers would normally have been shelved for many months before being re-used. This was considered counter-productive since spontaneous recovery of the fearful response was a possibility. So, throughout the summer months, the mare continued to have the clippers presented and still has to approach them before they are switched off and she is fed. Now, when she has to be clipped, she can be clipped without any forceful restraint and, indeed, without any sweating.

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Readers who are interested in learning more about equine behavior may wish to join the international Equine Behaviour Forum (EBF). Founded in 1978 and based in the UK, the EBF is an entirely voluntary, non-profit-making group for people interested in equine (not only horse) behavior. Its membership comprises vets and scientists as well as professional and amateur horsepeople. The EBF produces the journal *Equine Behaviour,* which is a platform for both scientific and 'amateur' content. *Equine Behaviour* is written and illustrated mainly by its members and includes letters, articles, book reviews, views and experiences. To find out more visit http://www.equinebehaviourforum.org.uk.

Readers may also wish to consider joining the International Society for Equitation Science (ISES). Founded in 2005, the ISES is an entirely voluntary, non-profit-making group for people interested in the science of horse handling and training. Its membership comprises vets and scientists, as well as professional riders and coaches. The ISES holds an annual conference that provides a forum for the presentation of cutting-edge results from equitation science laboratories throughout the world. It aims to make its conferences as accessible as possible to lay people. To download free proceedings from previous conferences, and to find out more, visit http://www.equitationscience.com.

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Glossary

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Glossary of colloquialisms, ethological and equestrian terms

While it is clear that the use of unscientific terms has flourished in equestrian circles, the extent to which 'horsey' folk can agree on the meanings of these terms has been called into question.[1] The following glossary of terms is an attempt to demystify some of the terms that may confound novice practitioners on either side of the Atlantic.

Above the bit: A posture characteristic of a hyper-reactive ridden horse exhibiting conflict behavior in which the horse attempts to escape the aversive situation by raising its head, quickening its pace, shortening its neck and stride and bracing its back, which becomes dorsally concave. The horse thus assumes a posture appropriate for running and therefore does not show impulsion.

Aerophagia: Pathological and excessive swallowing of air.

Agonistic behavior: Any behavior associated with threat, attack or defense. It includes related aspects of behavior, including passivity and escape, as well as aggression.

Aid: Any of the signals used by riders to give instructions to horses. Now prefer Cue. *See also* Artificial cues *and* Natural cues.

Air above the ground: A group of advanced maneuvers in which the horse rears up in a controlled fashion onto its hindlegs, with its forelegs curled under its chest and then either holds this pose, or jumps into the air off its hindlegs. *See also* Ballotade, Capriole, Courbette, Croupade, Levade *and* Mezair.

Allogrooming: Grooming action directed from one herdmate to another and most commonly followed by mutual grooming (i.e. in which allogrooming is reciprocated).

Alter: To castrate (or geld) a horse.

Anorexia: Abnormal reduction of ingestive behavior, e.g. in depressed and toxic clinical states.

Appetitive: In the broadest sense, appetitive behavior represents the first phase of a series of behaviors that leads to the consummatory phase involving the actual behavior and the refractory period.

Artificial cues or aids: Equipment used to alter a horse's behavior under-saddle or in-hand, e.g. whips, spurs and martingales (q.v.).

Asking with the rein: Mild cues sent by the rider through the rein.

Aversion therapy: Treatment of an unwelcome behavior by associating it with an aversive stimulus such as an electric shock.

Aversive: Describes a stimulus that elicits avoidance or withdrawal.

Balanced seat: The position of the mounted rider that requires the minimum of muscular effort to remain in the saddle and which interferes least with the horse's movements and equilibrium. (*See also* Independent seat.)

Balk (or baulk): Refuse to move forward.

Ballotade: An air-above-the-ground in which the horse half rears, then jumps forward with its hindlegs tucked underneath it.

Barn: *See* Yard.

Bars: Area of gum between the teeth in which the bit lies (also called diastema).

Behind the bit: An evasive posture that thwarts the development of impulsion, in which the horse persistently draws its nose in, allowing the rein to go slack.

Biological fitness: The ability of an animal to survive and reproduce, a concept referring to one genotype's ability to succeed relative to another's.

Bitless bridle: Any of a variety of bridles designed without bits so that pressure is exerted on the nose, poll or curb groove instead of the mouth.

Blind bucker: A horse that bucks indiscriminately, sometimes heading toward obstacles, when ridden.

Blow up: (1) When a ridden horse either breaks from the pace at which it is meant to be traveling or misbehaves generally. (2) (US: To start bucking.)

Bolting: (1) Eating too rapidly. (2) Breaking out of control or trying to run away.

Bosal: The braided rawhide or rope noseband of a bosal hackamore.

Break: The basic training of a young horse to obey commands, and accept direction and control, for whatever purpose it may be required.

Breaking: The transition seen in trotters or pacers that leave their gait and start to gallop.

Bridle lameness: An appearance of lameness that arises when a horse is unable to free itself of bit pressure because of one or both reins being too tight and resulting in an irregular rhythm and a crooked longitudinal axis of the body.

Bronco: An unbroken or imperfectly broken feral horse.

Bronco-buster: A person who breaks and trains broncos (horses used for bucking competitions in rodeos).

Bucking: Leaping forwards and dorsally with speed while arching the back and descending with the forelegs rigid and the head held low.

Camp-drafting: A uniquely Australian rodeo contest in which a rider separates a bullock from a group of cattle and drives it at the gallop around a course marked with upright poles.

Canter: A rotary three-time gait in which the hooves strike the ground in the following order: near hind, near fore and off hind together, off fore (leading leg); or off hind, off fore and near hind together, near fore (leading leg).

Capriole: An air-above-the-ground maneuver (often considered the ultimate of all high-school and classical training) in which the horse half rears with the hocks drawn under, then jumps forward and high into the air, at the same time kicking out the hindlegs with the soles of the feet turned upwards, before landing collectedly on all four legs.

Cast: A horse's having fallen or laid down close to a wall or fence so that it cannot get up without assistance.

Causal factors: Interpretation of external change or internal state that form inputs to a decision-making center of an animal's brain.

Cavalletti: A series of small jumps used in the basic training of a riding horse with the intention of encouraging lengthened strides, improved balance and loosened up and strengthened muscles.

Circadian rhythm: A rhythm in behavior, metabolism or some other activity that recurs about every 24 hours.

Cold-back: (US: Cinch bound) Resentment or instability, sometimes to the extent of collapse, when the girth is tightened or a horse is mounted.

Collection: Shortening the pace by the application of light tension from the rider's hands and steady pressure with the legs to make the horse flex its neck and bring its hocks underneath it.

Combinations: In show-jumping, an obstacle consisting of two or more separate jumps that are numbered and judged as one obstacle.

Conformation: Features of the external morphology (i.e. relative musculoskeletal dimensions) of a horse that interest breeders and exhibitors, not least because they can affect its performance.[2]

Conspecific: Animals belonging to the same species.

Consummatory act: An act that reduces the levels of causal factors so that the activity is terminated.

Contact: A steady (and preferably light) tension in the rein(s).[3]

Coping: The short-term or long-term ability to have control of mental and bodily stability, an absence of which leads to reduced fitness and stress.

Coprophagia/coprophagy: Eating feces, a behavior that is regarded as abnormal, except in foals.

Core area: The area of heaviest regular use within an animal's home range.

Corn/concentrates: (US: Sweet feed) Dried, crushed or pelleted food.

Courbette: Rearing to an almost upright position, and then leaping forwards several times on the hindlegs alone.

Creep-feeding: Providing youngstock with concentrates or supplements via a feeding apparatus that denies access to older animals, including the dam, by having a small entrance.

Crib-biting: (US: Cribbing) Holding onto a fixed object with the incisor teeth, arching the neck and leaning backwards with or without engulfing air with a characteristic grunting noise.

Croupade: Rearing and then jumping vertically with forelegs and hindlegs well flexed under the body, to land again on the hind feet.

Cryptorchid: A horse with at least one testicle in an abdominal position.

Curb bit: A type of bit consisting of two metal cheekpieces and a mouthpiece with a central indented section (called the port) used in conjunction with a snaffle bit and a curb chain in a double bridle.

Cue: Any of the signals used by riders to give instructions to horses. *See also* Artificial cues *and* Natural cues.

Curb chain: A chain that lies in the curb groove of the horse's jaw when fitted to a curb or pelham bit and acts by applying pressure to this part of the horse's head in concert with regular bits in its mouth.

Cut: To geld or castrate a colt or stallion.

Cutting horse: A horse trained, and often bred, for separating selected cattle from a herd.

Depression: General state of behavioral atony, features of which can include sagged posture and unresponsiveness.

Diagonal: Refers to the forefoot's moving in unison with the contralateral hindfoot.

Direct flexion: A description of a horse that is correctly 'on the bit' (q.v.). For a horse to be showing direct flexion it must: first, be straight (i.e. not laterally crooked); second, be extending its hocks cranially; and finally, be relaxed in the jaw.[4]

Displacement activity: An activity performed in a situation apparently different from the context in which it would normally occur. This term is often of reasonably limited use because it is dependent on the observer's ability to correctly determine the relevance of the behavior to the current context.

Disunited canter: This undesirable broken gait, more often seen in horses with a tendency to pace, occurs when the hindquarters lose coordination with the forequarters, and the horse leads with one leg in front and the diagonally opposite one behind.[5]

Diurnal rhythm: A rhythm in behavior, metabolism or some other activity that occurs on a daily basis or during daylight).

Double: In show-jumping, a combination obstacle consisting of two separate jumps.

Double bridle: A bridle comprising two bits, a curb and a snaffle, which are attached by means of two cheekpieces and may be operated independently.

Double-gaited: A term applied to a horse that can both trot and pace with reasonable speed.

Ecological niche: The environment that a species occupies in nature and usually in which it performs best.

Eliminative behavior: Patterns of behavior connected with the evacuation of feces and urine.

Engaging the hocks: The horse's bringing his hindfeet underneath his body so that proportionally more weight is placed on the hindlegs.

Epimiletic behavior: The provision of care and attention such as nursing behaviors.

Ethogram: A detailed description of the behavioral features of a particular species.

Ethology: The observation and description of behavior that leads to improved understanding of its mechanism, function, development and evolution.

Evading the bit: Oral behaviors and neck postures that enable horses to reduce the discomfort caused by bits or the extent to which riders can apply pressure.

Exploration: Any activity that offers the individual the potential to acquire new information about itself or its environment.

Extension: A vigorous forward movement involving straightened limbs that allows the horse to cover as much ground as possible with each stride.

Fall: In jumping, when the shoulders and quarters on the same side touch the ground. A rider is considered to have fallen when there is separation between him and his horse that necessitates his remounting.

FEI: The Fédération Equestre Internationale (International Equestrian Federation), body governing the international equestrian sports of show-jumping, three-day eventing, dressage and driving.

Feral: Horses that have escaped from domestication and become free-ranging, or their progeny.

Flehmen: Elevation of the upper lip to introduce odors, especially volatile fatty acids into the vomeronasal organ.

Flexion: Of the neck, when a horse bends ventrally at the poll, preferably while retaining a relaxed jaw. Of the body, when the longitudinal axis of the body bends dorsoventrally. Lateral flexion describes bending to the left or right at the atlanto-occipital joint.

Flight distance: The radius of space around an animal within which intrusion provokes a flight reaction.

Foraging: Behaviors that increase an animal's likelihood of encountering and acquiring food.

Forehand: Those parts of the horse that lie in front of the rider, i.e. the head, neck, shoulders, withers and forelegs.

Fraser Darling effect: The stimulation of reproductive activity by the presence and activity of conspecifics in addition to the mating pair.

Frustration: The process thought to occur when animals are thwarted from performing highly motivated behaviors.

Gee: The driving term that signals a turn to the right.

Geophagia/geophagy: Ingestion of soil.

Good mouth: *See* Soft mouth.

Green: (1) An inexperienced horse that has undergone foundation training but is not fully trained. (2) A trotter or pacer that has yet to undergo a time trial.

Group effect: A change in the behavior of a number of animals brought about by common participation.

Habituation: The waning of a response to a repeated stimulus as a result of frequent exposure (not simple fatigue).

Half-halt: A sequential application of rein and leg pressure intended to warn the ridden horse that it is about to be given a new command.

Half-pass: A lateral movement in which the horse moves both forward and sideways, bent toward the direction of movement. Half-pass may be performed at walk, trot and canter.

Hard-mouthed: (US: Cold-jawed, tough-mouthed) Term used to describe the 'toughening of the bars of the mouth where the bit rests and the deadening of nerves because of the continued pressure of the bit' – more correctly this describes habituation to rein pressure.

Haute école: 'High school', classically the highest form of specialized training of the dressage horse.

Haw: The driving term that signals a turn to the left.

Head-pressing: Postural disorder usually linked to cerebral disease and characterized by apparent head stabilization through contact of the forehead with a vertical surface.

Hitch: (1) To fasten a horse, e.g. when hitched to a rail. (2) A connection between a vehicle and a horse. (3) A defect in gait noted in the hindlegs, which seem to skip at the trot.

Hollow: Extension of the vertebral column, considered undesirable in equitation.

Home range: Area that free-ranging animals use regularly. Though known intimately by its users, the home range may or may not be defended; those portions of it that are defended are called territories.

Impulsion: The response of an eager horse as it surges forward as soon as the rider signals. True impulsion, in which the horse conveys itself calmly and maintains a light rein pressure, is quite distinct from states of general excitement in which the horse pulls at the bit and requires forceful restraint to be controlled.

Independent seat: A rider's ability to maintain a firm, balanced position on a horse's back, without relying on the reins or stirrups. *See also* Balanced seat.

Ingestive behavior: Behavior concerned with the selection and intake of food, milk and water.

In-hand: In a routine of 'schooling in-hand', the trainer works from the ground rather than from the saddle, standing beside the horse and controlling it with rein, voice, and schooling whip.

Initiator: The first individual in a social group to react in a way that elicits a new group activity.

Inside/outside: Terms used to identify sides of the horse as it is being schooled but that require some qualification to designate whether one is referring to the relative position in the arena, to the curvature of the path, or to the bend of the horse.

Intention movements: The preparatory activity that an animal may go through when switching from one suite of behaviors to another.

Jog: A short-paced trot.

Leaning on the bit: A sign of habituation to bit pressure that manifests with the horse persistently pulling on the rein(s) as though relying on the rider to support the weight of its head.

Leg yield: Lateral movement of a horse in response to pressure from the rider's leg, used as a schooling activity before training more complex lateral maneuvers such as a half-pass.

Levade: A controlled half-rearing position, with the forelegs tucked well in toward the chest, the vertebral column inclined between 30° and 45° above the horizontal, and the hindlegs in a crouching position with deeply bent hocks.

Lightness: The bringing into action by the rider and the use by the horse of only those muscles necessary for the intended movement. Activity in any other muscle groups can create resistance and thus detract from the lightness.

Lignophagia/lignophagy: Wood-eating, which may include bark-chewing.

Long-reining: Driving the horse without any vehicle or load. Used to train the horse to move forward without being led, to respond to bit pressures, to habituate it to distractions and to classically condition it to respond to vocal cues.

Loosebox: Stall or stable in which the horse is free to move about, as distinct from a tie-stall in which the horse is tied.

Lope: The western version of a very slow canter, this is a smooth, slow gait in which the head is carried low.

Lugging: *See* Pulling.

Lunge (also Longe): Exercising a horse on the end of a long lead or rope attached to a lungeing cavesson (q.v.), usually in a circle.

Lungeing cavesson: Head-collar with a strong, cushioned noseband used for exercising and training horses.

Manege (menage): *See* School.

Martingale: A device that is attached to the girth and passes between the horse's forelegs to help keep a horse's head in the 'correct' position by attaching to the noseband (standing martingale) or to the reins (running martingale) or directly to the bit.

Mezair: A series of levades (q.v.) is joined together by the horse rocking smoothly forward on the forelegs to touch the ground between each levade.

Monorchid: A horse with a single descended testicle.

Motivation: The process within the brain that controls the occurrence and performance of behaviors and physiological changes.

Motivational state: A combination of the levels of all causal factors.

Mouthing: (US: Champing) The horse's playing with the bit, a response that is encouraged in bitting a young horse by using a bit with 'keys' attached to the mouthpiece, which facilitates saliva flow and keeps the mouth moist.

Napping: When a horse fails to respond appropriately to the rider's signals, as in refusing to go forward or to pass a certain point.

Natural aids or cues: The body, hands, legs, weight, and voice, as used in controlling a horse.

Neck rein: To guide or steer a horse by pressure of the rein on the neck.

Need: A deficiency in an animal that can be remedied by obtaining a particular resource or responding to a particular environment or bodily stimulus.

Numnah: (US: Saddle blanket) A pad placed under the saddle to prevent undue pressure on the horse's dorsum.

Observational learning: Learning that occurs when one animal observes another and acquires a behavior without its own direct experience.

Off the bit: The horse does not have contact or connection to the rider's hands through the reins. This is usually referred to as being above the bit or behind the bit, i.e. there is a lack of at least one of the three prerequisites for on the bit.

On the bit: The self-maintained neck and head position of the horse in correct schooling, where vertical flexion of the cervical vertebrae and atlanto-occipital joint (also known as poll flexion or roundness) results in the nasal planum being approximately 12° in front of the vertical at walk or 6° in other gaits. This posture is intended to improve the balance of the ridden horse (relocating extra weight to the hindquarters) and its willingness to respond to the signals transmitted by the rider through the reins. There are three precursors to the horse being on the bit. The first is longitudinal flexion, followed by lateral flexion and finally vertical flexion. To most people 'on the bit' means that the horse travels with its neck arched and nose tucked in. However, a vertical nose does not necessarily mean that the horse is on the bit, although many observers may be fooled by it.[4] On the bit is necessary in horse-training because, as a result of vertical flexion, the center of gravity shifts posteriorly toward the rider's center of gravity. There are various forms of false roundness where the horse is forced by the rider's hands or with the use of mechanical devices to flex his cervical vertebrae.

On the forehand: An undesirable form of locomotion that effectively involves the horse leaning forward and therefore carrying an inappropriate proportion of its weight on its forequarter, a posture that runs counter to impulsion (q.v.), collection (q.v.) and self-carriage (q.v.).

Open bridle: Bridle without blinds or blinkers covering the eyes.

Outline: (US: Shape, frame) An aspect of the horse's posture that refers particularly to the curvature of the vertebral column and the degree of flexion of the neck and poll. According to the ideals of equitation the nasal planum should be no more than 12° from the vertical at the walk and 6° from the vertical at other gaits and never behind the vertical, a fault which results in loss of self-carriage (q.v.) and lightness.

Over-crowding: A degree of crowding that reduces the biological fitness (q.v.) of individuals in the group.

Oxer: (US: Hog's back) a spread obstacle in show-jumping with three sets of poles: the first close to the ground, the second at the highest point of the obstacle and the third slightly lower than the second.

Pace: A two-time lateral gait in which the hindleg and the foreleg on the same side move forward together.

Pain: An extremely aversive sensation.

Parabola: The arc made by a jumping horse from the point of take-off to the point of landing.

Parallel bars: A spread fence used in both show-jumping and cross-country courses, comprising two sets of posts and rails.

Passada: A change of rein through a small half-volte performed in full-pass with haunches well in but moving on a somewhat larger circle than they do in a half-pirouette.

Passage: An haute école maneuver in which the horse shows an elevated, collected trot and appears to dance forward from one diagonal pair of legs to the other, elegantly pointing the feet to the ground during the movement of suspension when the legs are fully flexed at the top of each unsupported phase.

Pecking order: A hierarchy in which each individual is able to threaten, displace or attack individuals lower than itself.

Pelham bit: A bit with a single mouthpiece designed to produce the combined effects of the snaffle bit and the curb bit.

Piaffe: A very elevated, cadenced, collected trot, similar to a passage performed with minimal forward progression.

Pica: The searching-for and ingestion-of inappropriate substrates that may be toxic and cause obstruction.

Pig-rooting: Lowering the head, often as a prelude to bucking.

Pirouette: A turn within the horse's body length, on the center, the forehand or the haunches.

Pivot: A dressage maneuver in which the horse spins on its hindquarters, holding one hindleg more or less in place and side-stepping with the contralateral hindfoot.

Posting trot: *See* Rising trot.

Pulling: (US: Lugging) Evasive behavior by ridden or driven horses leaning on the reins or bearing to the left or right without being prompted.

Punishment: A decrease in the likelihood of a response due to the presentation of an aversive stimulus or, in the case of negative punishment, the removal of a reinforcing stimulus.

Quidding: Dysphagia.

Rack: The most spectacular movement of five-gaited horses, this is a very fast even lateral gait in which each foot strikes the ground separately in quick succession.

Redirected behavior: The direction of an activity away from the primary target and toward another less desirable substrate, a term to be used only with care because it implies that the observer knows what the primary target is.

Red ribbon: A strip of red material tied round the tail-head of a horse, especially when hunting, to indicate that it has been known to kick conspecifics in company.

Rein back: To make a horse step backwards while being driven or ridden.

Reinforcer: An environmental change that increases the likelihood that an animal will make a particular response, i.e. a reward (positive reinforcer) or removal of a punishment (negative reinforcer).

Renvers: A dressage movement on two tracks in which the horse moves at an angle of not more than 30° along the long side of the arena with its hindlegs on the outer and its forelegs on the inner track, looking in the direction in which it is going and being bent slightly round the rider's inside leg.

Rig: (US: Ridgeling): *See* Monorchid *and* Cryptorchid.

Rising trot: (US: Posting trot) The rising and descending of the rider with the rhythm of the trot.

Ritual behavior: An originally variable sequence of actions that may have lost some of its original meaning, become almost rigid in sequence, and developed a role in communication.

Saddle blanket: *See* Numnah.

School: (1) An enclosed area, either covered or open in which a horse may be trained or exercised. (2) To train a horse for whatever purpose it may be required.

Self-carriage: The characteristic way in which a well-trained horse deports itself with lightness of the forehand and reliance on the hindquarters for propulsion.

Sensitization: The increasing of a response to a repeated stimulus.

Shoulder-in: One of the lateral movements in which the shoulder is brought in from the track of the inside hindleg so that the forelegs travel on a separate, parallel but overlapping track and the horse's longitudinal axis is bent away from the direction of movement.

Slow gait: One of the gaits of the five-gaited breeds characterized by a prancing action in which each foot in turn is raised and then held momentarily in mid-air before descending.

Social facilitation: When a behavior is initiated or increased in frequency by the stimulus of another animal performing that behavior.

Soft condition: Easily fatigued.

Soft mouth: Sensitive mouth, responsive to bit pressure.

Spanish walk/trot: Extended gaits (usually trained in-hand) in which the forelegs are momentarily held out horizontally forward from the shoulder at each stride, the feet are brought to the ground without the knees bending and the head is held high to transfer weight onto the hindlegs.

Spooky: Nervous.

Spread fence: Any obstacle (such as an oxer, parallel bars, triple bar or water jump) in show-jumping and cross-country events that is wide as opposed to simply high.

Spur: A pointed device strapped on to the heel of a rider's boot and used to urge the horse forwards or laterally.

Star gazer: A horse that moves in-hand or under-saddle with its head elevated in an awkward position.

Stereotypy: A repeated, relatively invariant sequence of movements that has no obvious function.

Straight fence: Any obstacle (such as gate, post and rails or planks) in show-jumping and cross-country courses that has all its component parts in the same vertical plane.

Stress: All extra-individual events capable of evoking a broad spectrum of intra-individual responses mediated by a complex filter labeled 'individual differences'.

Stride: The set of changes occurring during a single complete locomotory cycle, which includes the stance phase and the swing phase of a limb, from the one landing of a particular foot to the next.

Territory: The area an animal defends by demarcation or by fighting.

Tonic immobility: A behavioral state of a few seconds or longer during which an animal makes no movement as a result of a pathological condition or an environmental event.

Transition: (1) The change from one gait type to another. (2) The changeover of support within a specific gait from one member of a diagonal pair of legs to the other.

Travers: A dressage movement on two tracks in which the horse moves at an angle of not more than 30° along the long side of the arena with its forelegs on the outer track and the hindlegs on the inner track, looking in the direction in which it is going and bent slightly round the rider's inside leg.

Turn on the forehand: A movement in which the horse steps in one spot with its forehand while describing concentric circles with its hindlegs. Usually executed with the same rhythm as the walk, turns on the forehand are commonly of 90°, 180° or 360°.

Turn on the haunches: A change of direction in which the hindlegs remain in one spot and the forequarters describe an arc. Unlike the lateral movement prompted by neck reining, a turn on the haunches is usually executed at the rhythm of the walk.

Twitch: A device used on a horse's upper lip that is tightened by twisting or pinching to pacify the horse for short periods by causing the release of endorphins.

Unlevel: A euphemism for abnormal action caused by either clinical lameness or a physical abnormality that changes the action of the horse.

Volte: (1) The smallest circle a horse is able to execute on either one or two tracks, the radius being equal to the length of the horse. (2) In dressage, a full turn on the haunches.

Walk: A four-beat gait of four time in which the hooves strike the ground in the following sequence: near hind, near fore, off hind, off fore.

Water jump: In show-jumping, a spread obstacle consisting of a sunken trough of water (with a minimum width of 4.2 m and a length of up to 4.8 m) with the option of small brush fence placed on the take-off side.

Wind-sucking: In Australia, the stereotypic gripping of a fixed object with the teeth while pulling back and engulfing air into the cranial esophagus. In the UK, engulfing air into the cranial esophagus without holding on to any fixed object.

Yard: (US: Barn) Accommodation for a group of horses.

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