The Quest to Conserve Rare Breeds

Setting the Record Straight

Lawrence Alderson

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'It must be hoped that honest unbiased opinions will prevail, even if they are unpalatable at times, so that our work will be portrayed accurately to future generations.'

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CABI is a trading name of CAB International

CABI
Nosworthy Way
Wallingford
Oxfordshire OX10 8DE
UK

Tel: +44 (0)1491 832111
Fax: +44 (0)1491 833508
E-mail: info@cabi.org
Website: www.cabi.org

CABI
WeWork
One Lincoln St
24th Floor
Boston, MA 02111
USA

T: +1 (617)682-9015
E-mail: cabi-nao@cabi.org

A catalogue record for this book is available from the British Library, London, UK.

The views expressed within the book are the author's own and do not necessarily represent the views of CAB International.

References to Internet websites (URLs) were accurate at the time of writing.

Library of Congress Cataloging-in-Publication Data

Names: Alderson, Lawrence, author.
Title: The quest to conserve rare breeds : setting the record straight / Lawrence Alderson.
Description: Wallingford, Oxfordshire ; Boston, MA : CAB International, [2020] | Includes bibliographical references and index. | Summary: "Biological diversity is essential for sustainability, and in this book, Lawrence Alderson CBE corrects misconceptions while recounting the creation and development of the rare breed conservation movement. He addresses extinctions, endangered breeds, and safe-guarding genetic diversity while considering our future - challenged as it is by climate change, sustainability and feeding the world"-- Provided by publisher.
Identifiers: LCCN 2020023621 (print) | LCCN 2020023622 (ebook) | ISBN 9781789247114 (paperback) | ISBN 9781789247138 (epub) | ISBN 9781789247121 (ebook)
Subjects: LCSH: Rare breeds--Conservation. | Rare breeds--Breeding. | Sustainable biodiversity.
Classification: LCC SF105.27 .A43 2020 (print) | LCC SF105.27 (ebook) | DDC 636.08/2--dc23
LC record available at https://lccn.loc.gov/2020023621
LC ebook record available at https://lccn.loc.gov/2020023622

ISBN-13: 9781789247114 (hardback)
9781789247121 (ePDF)
9781789247138 (ePub)

Commissioning Editor: Alexandra Lainsbury
Editorial Assistant: Lauren Davies
Production Editor: James Bishop

Typeset by SPi, Pondicherry, India
Printed and bound in the UK by Severn, Gloucester

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Preface

Since the middle of the 20th century the world has witnessed a succession of political and social eruptions with dramatic aftershocks felt in every part of the globe. Major multinational industrial trading companies, flexing financial muscle, have wrested effective control and power from elected national governments under the camouflage of globalization. Digital domination by the netherworld of social media, with Facebook, Twitter, Linkedin, Instagram and similar fora, has circumvented traditional democratic routes of communication and exercised increasing influence over political decisions and ethical attitudes. Significant disaffection with the established ruling class in several regions and countries paved the way and opened opportunities, giving political leadership a different complexion and in some cases leading to mass demonstrations by minority factions. World consumption of fossil fuels tripled in 50 years (1965–2015) with China in the forefront, and the inescapable impact of global warming has excited increasingly passionate debate and triggered waves of human migration, often exacerbated by war or ethnic conflict, which have disrupted the tenor of life across most continents.

In the midst of those major human issues it is not surprising that the role and relevance of conservation of animal genetic resources, otherwise known as 'saving rare breeds', has been neglected. Yet biological diversity is an essential ingredient of sustainability and quality of life on earth. Quality of life afforded by the multifaceted beauty and variety of our planet is a bonus we seek and covet, but sustainability is non-negotiable and no one can afford to shirk a responsibility to protect biological diversity. Flirtation with short-termism, the antithesis of sustainability, confers only dangerous indulgence and deceptive gratification. It was an easy option for me at university in the heady euphoria and ongoing inspiration of the 'golden helix' discovery, but later throughout my association with Rare Breeds International as founder president, and with the Rare Breeds Survival Trust (now known simply as RBST) as founder, scientific advisor, director and chairman, it was impossible to ignore the priority of long-term policy. I have been in the vanguard of the rare breeds movement since the 1960s and saw its beneficial effects gradually unfold. It often was a stormy passage. The superficially smooth progress concealed inner tensions

and conflicts as the early impact of non-governmental initiatives was subsumed by governmental authority until some sense of stability was restored in symbiotic cooperation. It was an enlightening experience to be in the midst of such a crucial movement where discreet disagreement, and occasionally more obvious confrontation, circled every stage of progress. Genetic conservation provides a febrile arena to highlight the frequent incompatibility between practical methodologies of livestock owners and theoretical procedures and modes of geneticists, and to contrast the passionate free-wheeling of visionaries with the strict authority of governmental edicts.

I have had the privilege of working with many dedicated and talented colleagues whose contribution often has not been properly recognized. Although I derived much satisfaction and inspiration from our achievements, even there I found disturbing inconsistences which I felt should not be allowed to distort a true record. Credit for those achievements sometimes has been diverted from meritorious organizations and individuals and focused on others who played a lesser role but either inadvertently or deliberately appropriated much publicity and limelight. The primary purpose of this book is to describe the development of the important and invigorating movement for genetic conservation, but I undertook the task in the full knowledge that inevitably it would involve challenging several accepted tenets and setting the record straight on the roles of those who participated – validation 'from the horse's mouth'[1]! Many of the issues and developments have been illustrated by examples from Britain, as that is where the early progress was realized, but interactions with friends and colleagues from around the world have allowed me to record the global perspective that is essential for an international movement.

There is no room for complacency. It is proving a monumental task to shift the mindset of those duped and entrapped by persistent misinformation. In particular, continual and uncompromising repetition of false propaganda regarding climate change on most major channels of communication has condemned extensively grazed ruminants in the minds of both politicians and public. That traditional and beneficial farming practice, although much maligned, actually helps to control global warming in Britain. The public is fully aware of the dangers that face wildlife as a result of high-profile publicity of poaching and loss of habitat, perhaps less aware that botanical variety is threatened despite regular reports on destruction of the rainforest, but awareness of the immediate impact of genetic erosion in domestic livestock has filtered only slowly through the congested fora of news and advertising and reached much smaller segments of the public. A survey in 2017 by Ceva Santé Animale revealed that only 20% of French people are aware of the threats to

[1] **'From the Horse's Mouth'.** Information directly from the original source in person, or another authoritative dependable source. This expression first became popular around the 1920s. It may come from the practice of examining a horse's teeth to determine its age. Alternatively, it may refer to a racing tip which is so reliable that it is as if the horse itself has told you how well it is going to perform

endangered breeds of livestock, although 83% would be prepared to help those breeds by paying more for their products. France has an enlightened attitude to biodiversity and therefore awareness in many other countries is likely to be less than 20% of the population. Yet wildlife, plants and domestic livestock are all legitimate components of overall biological diversity. Effective and accurate delivery of that message is a global imperative.

Lawrence Alderson, 2019

1

A Blank Canvas
The world as it was in the mid-20th century

Extinct and Endangered

Fascination with the Dodo is engendered almost entirely by its extinction. The phrase 'As dead as a Dodo' has become a well-used expression of absolute finality. There is no chance to see it, touch it or rescue it, only a feeling of vexatious regret and a few haunting images and decaying remains. It incites related sentiments that drive the desire to prevent the extinction of animals we know and love. I retain a deep affection for all the breeds that surrounded me as a young boy on our hill farm in the Yorkshire Dales and I am prepared to exert rigorous effort to prevent the extinction of sturdy Dales ponies that provided all the draught power, thrifty Northern Dairy Shorthorn cattle whose Cotherstone cheese filled the stone-shelved pantry with herb-rich meadow redolence, and massive Teeswater sheep with fleeces falling in long pirled ringlets. Now they are endangered breeds and I have learnt it needs more than sentiment to save them. There must be a stronger *raison d'être*. At the end of the 20th century in the 3rd edition of *World Watch List* (Scherf, 2000), which listed 6379 breeds, the Food and Agriculture Organization (FAO) of the United Nations calculated that 12% of domestic breeds (mammalian and avian) had become extinct, 26% were endangered and the status of 21% was unknown, leaving only 39% not at risk. Comparison with a later analysis (Bélanger and Pilling, 2019) could indicate that the first two decades of the new millennium had seen a significant decline in the status of breeds. It applied a different classification which suggested a much higher proportion of breeds were at risk, although it appeared to confirm the earlier extinction data.

The information in the *World Watch List for Domestic Animal Diversity* (or *WWL-DAD*) on extinct breeds was gleaned from *A World Dictionary of Livestock Breeds, Types and Varieties* (Mason, 1996) and more than 70% of listed extinct breeds were native to Europe, where more rigorous recording was undertaken. Therefore, the global figure is likely to be understated until further information is obtained from other continents. On the other hand, although we can accept

the claim that no British breed has become extinct since 1972, European extinctions may have been overstated if the 72 British breeds listed in *WWL-DAD* as extinct reflect the application of a similar methodology in other countries. Several very similar local varieties, listed as separate breeds, often were amalgamated into a new breed such as Aberdeen Angus cattle or Shropshire sheep. South Devon and Devon Longwoolled sheep were indistinguishable to the untrained eye and came together as the Devon and Cornwall Longwool in 1977. The British Saddleback pig had been created 10 years previously by amalgamation of Essex and Wessex pigs although they shared only a common colour pattern. Some entries on the *WWL-DAD* extinct sheep list (Kent Halfbreed and Yorkshire Halfbred) were not genuine breeds; the entry for 'Five-horned cattle' beggars belief (Mason, 1996, had referred to Fife Horned); and Chester White pigs were a foreign breed imported from USA in 1978. Probably only 85% of British breeds listed as extinct were genuine cases of extinction. It should be noted that a figure of only 26 breeds of large livestock in Britain is commonly quoted as becoming extinct in the 20th century before 1973. If those figures are accepted it would indicate that about 35 recognized breeds or types became extinct in Britain before 1900, with the qualification that conflicting reports from commentators in the 19th and 18th centuries make conclusions less reliable.

Creation and Re-creation

Creative instincts of livestock breeders are evident from the earliest reports of commentators on agriculture and livestock. Even without the benefit of the work of Gregor Mendel, 'the father of modern genetics', they were seeking to improve their livestock and the search often extended into procurement of new genetics to achieve their objectives. The Colling brothers, who farmed near the River Tees, were famed for using proven animals, notably Hubback and Duchess in the 1780s, in a policy of linebreeding to superior ancestors such as the Studley bull (born in 1737), and Robert Bakewell is remembered best for breeding 'like to like' to improve his Longhorn cattle, but his success also was based on crossbreeding. The foundation for his sheep-breeding project was the existing slow-maturing, long-legged, coarse Leicester used solely for wool production. He created the New Leicester breed in the late 18th century by infusing genetics from faster-maturing, fatter Ryeland sheep and from the old longwoolled Lincoln sheep. It was a style of breeding adopted by many others who created new breeds such as Bonsmara cattle (Afrikaner × Hereford × Shorthorn) and Beefmaster cattle (Brahman × Hereford × Shorthorn) in the 1930s, Santa Gertrudis cattle (Brahman × Shorthorn) and Columbia sheep (Lincoln Longwool × Rambouillet) in the 1940s. They mated breeds with contrasting traits in order to find new and desirable combinations of genes.

Although it was a continual process, the two decades after 1950 witnessed an outburst of ingenuity and innovation. The discovery at Cambridge

University of the 'double helix' structure of DNA in the early 1950s (Watson and Crick, 1953) was an inspirational event that launched a new surge of biological research. It was also a critical time for both the creation and extinction of breeds. Beevebilde cattle and several breeds of sheep, including Cadzow Improver, Eastrip Prolific and Cobb 101, were created in the 1960s before becoming extinct after a relatively brief presence as peripheral members of the livestock industry. At the same time established British breeds became extinct. Cumberland, Ulster White, Bilsdale Blue, Oxford Sandy-and-Black and Dorset Gold Tip pigs and Blue Albion cattle were among their number, and the last British extinction was the Lincolnshire Curly-Coated pig in 1972. Two of those breeds (Oxford Sandy-and-Black pigs and Blue Albion cattle) are not listed as extinct by FAO because re-created populations adopted the name of an earlier genuine breed. The fifth edition of Mason's *World Dictionary of Livestock Breeds, Types and Varieties* (Porter, 2002) describes current Blue Albion cattle more accurately as 'crosses' and re-created Oxford Sandy-and-Black pigs as 'reconstructed'. The Blue Albion became extinct as a result of the foot-and-mouth disease (FMD) outbreak in England in the 1960s: the new population is derived from blue cattle of unknown breeding purchased in auction marts and elsewhere. The Oxford Sandy-and-Black also became extinct in the 1960s and the new population has developed from a welter of crossbreeding between a medley of breeds.

Re-created types are also found elsewhere in Europe. In Italy remnants of the Mucca Pisana were crossed with Chianina in 1980s (Fig. 1.1); and the lyre-horned Garfagnina was crossed with Brown Swiss soon after I saw the last 24-year-old purebred cow in 1980 (Fig. 1.2). In France the ancient lyre-horned Froment du Léon (Fig. 1.3) was very localized and in 1983 was crossed with Guernsey bulls; and the traditional Bordelaise in Aquitaine (Fig. 1.4), with its distinctive *pigaillé* (speckled) colour, having originated from crossing local animals with Bretonne Pie Noire and Durham cattle, was declared extinct in 1960 before a new population was built in the 1980s on Friesian and Limousin crosses. Switzerland claims the Fribourg (Fig. 1.5), black-and-white sister breed of the popular Simmental, but it became very inbred and was crossed with German Friesian so that it is now a new breed listed as 'Swiss Holstein'.

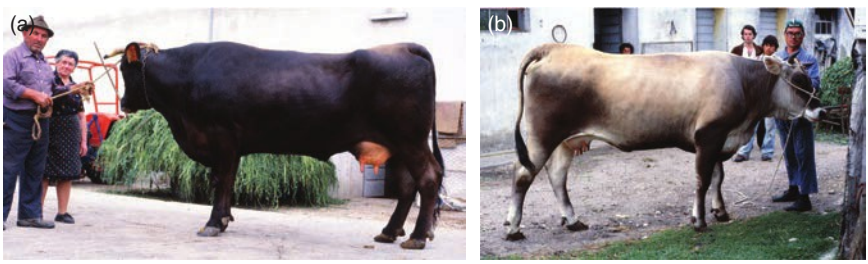

Fig. 1.1. **(a)** Mucca Pisana cow in Tuscany. **(b)** Chianina × Mucca Pisana 2-year-old in-calf heifer.

Fig. 1.2. **(a)** Garfagnina 24-year-old cow near Lucca, Tuscany, in 1980. **(b)** Brown Swiss × Garfagnina heifer in 1980.

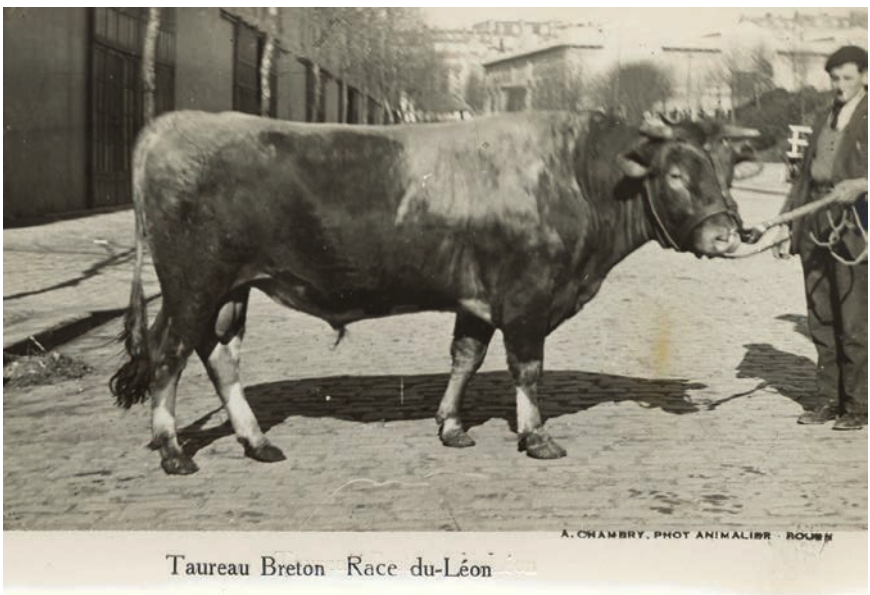

Fig. 1.3. Froment du Léon bull at Concours Général in 1925.

There can be no dispute regarding the principle that re-creations, although they may bear a superficial resemblance, never can be genetically the same as the genuine original breed. If official lists are unable to avoid error or misinterpretation, a tipping point may be reached when observers are unable to distinguish fact from falsification, and the latter may be held to be true even then because it is expedient to do so. In some cases, it may be difficult for FAO, as a relatively remote body in Rome, to reach a decision on a local question. Irish Moiled cattle are found throughout Northern Ireland, Wales and England and are classified as a native breed of the UK, but the Republic of Ireland also listed Irish Maol as a native breed although its 'Country Report' to FAO in 2002

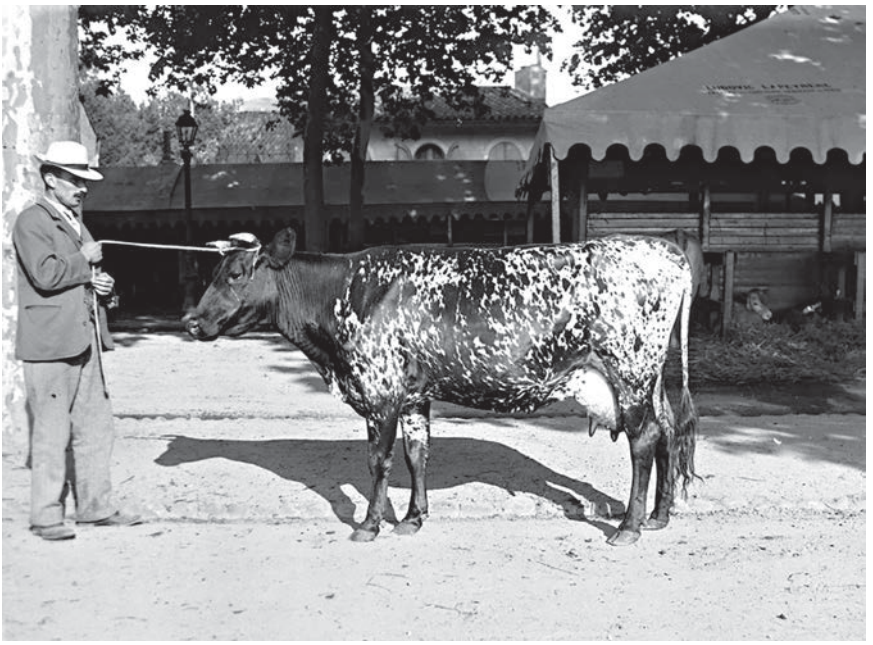

Fig. 1.4. Bordelaise cow in 1920.

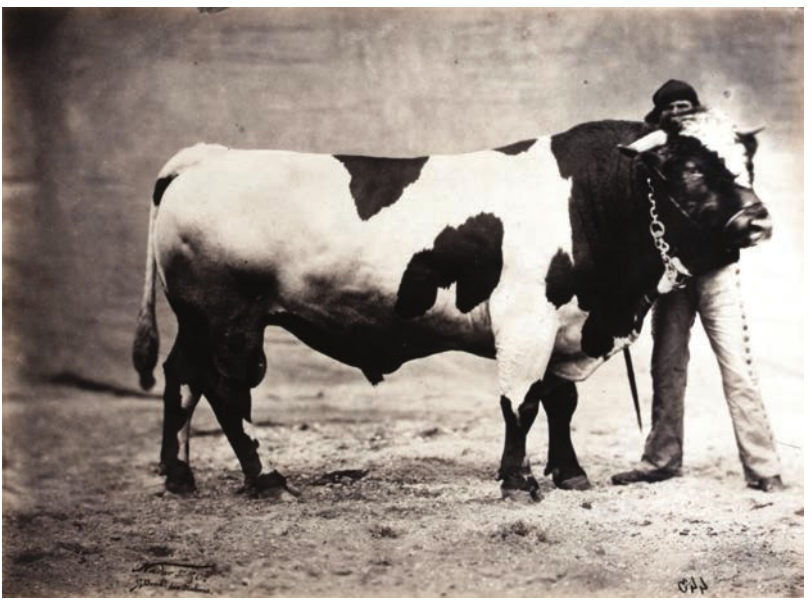

Fig. 1.5. Fribourgeoise bull at Concours Universel Paris in 1856.

confirmed that there were no cattle of that breed in the Republic in 1987. It is clear that all evidence must be sifted carefully.

Creation of a new breed is a formidable undertaking. The development and application of a breeding programme requires imagination, expertise and some good fortune, but the major obstacle is breaking into the strongly defended territory of established breeds. Success depends primarily on identification at the beginning of the project of a gap in the market that can be exploited. Some breeds created during the period 1950–1975 merely survived. The Lacombe pig, developed in Canada in the 1950s from Berkshire, Landrace and Chester White foundation stock, enjoyed initial success but is now an endangered breed because existing breeds occupied and defended the targeted market. Other breeds have thrived but success in all cases was hard won. Dorper sheep (South Africa, 1950, Dorset Horn × Blackface Persian) are a hairy meat breed which has been successful. Simbra cattle (USA, 1960s, Simmental × Brahman) are a dual-purpose breed which has spread beyond its country of origin. Polypay sheep (USA, 1960s, Rambouillet, Targhee, Dorset, Finn) are a dual-purpose breed which has expanded its range. British Milksheep (UK, 1970s, Bluefaced Leicester, Dorset Horn, Eastrip Prolific, Lleyn and others) is a highly prolific multi-purpose breed which has developed markets for meat and wool (Fig. 1.6) (Thwaites, 2019). The creation of the last two breeds employed a complex programme, involving more than three breeds, and both have been able to follow a successful path of development.

Philosophy of Livestock Production

Fine-woolled Merino sheep were probably the first breed to establish a precedent for domination of an industry. They burst out of their guarded Spanish stronghold in the mid-17th century, a feat repeated from the early 19th century when

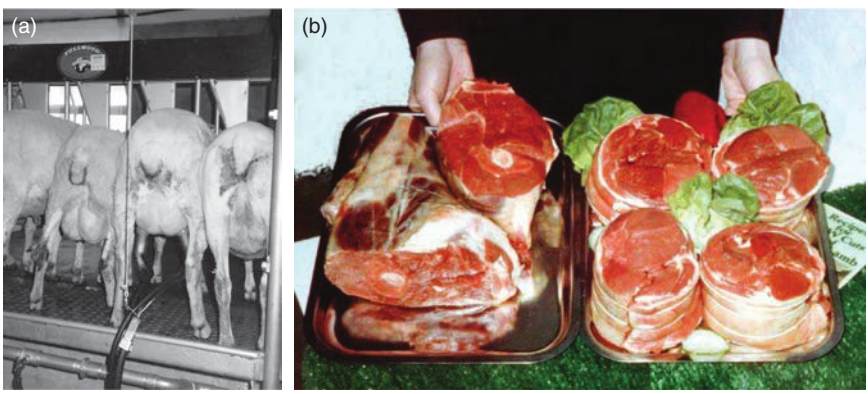

Fig. 1.6. **(a)** Circle flock of British Milksheep ewes in milking parlour. **(b)** Meat products of British Milksheep.

they colonized Australia, North America, Russia and eastern Europe (Garron and White, 1985). But a more enduring seminal change in the philosophy of livestock breeding and improvement was heralded in the mid-20th century. At that point there was an unmistakeable shift from general-purpose breeds to specialist, single-purpose breeds with animals capable of high product yield or other extreme traits. It was facilitated and accelerated by advanced technology, particularly artificial insemination, which transformed the dairy industry from the 1950s. The trend continued and escalated in succeeding decades as demand for greater production of food stimulated intensification of the livestock industry, with marked emphasis on high-input systems. Multinational breeding companies intervened and focused their attention on a small number of breeds, and on selected lines within those breeds. Effective population size (N_e), which is linked closely to heterozygosity, was reduced by intensive selection and widespread use of preferred breeding males, thereby creating a developing genetic threat masked temporarily by a growing population and increased yields in the selected breeds and lines.

The collateral was continuous marginalization of other breeds, and of lines within all breeds. Genetic erosion occurred on a massive scale. It was illustrated most clearly by the impact of Holsteinization on the global bovine dairy industry in the final decades of the century as the Holstein, which concurrently was experiencing loss of within-breed diversity, reduced many native breeds to a critically small nucleus of purebred animals. In Britain in the 21st century Charles Castle, Tony Howe and Chris Ball worked desperately to save the relics of Dairy Shorthorn, Northern Dairy Shorthorn, Ayrshire, Guernsey and Jersey (Fig. 1.7), the genetic integrity of the latter breed having been compromised on its eponymous island by imported animals in 2008. Similar damage had been inflicted on the diversity of European pig breeds by the fashion for lean pig meat, which stimulated breed substitution by the Danish Landrace. Many native breeds of beef cattle were relegated to the fringes of mainstream farming from the early 1960s onwards by exports from continental Europe to Britain of large cattle such as Charolais, Limousin, Maine-Anjou and Belgian Blue (Fig. 1.8), while infusion of the distinctive phenotype of Arabian horses changed the character of swathes of the equine population across the world. The demography of livestock changed with dominance of intensively housed white pig breeds, Arabian elegance being seen more frequently in the equine show rings, beef breeds focusing selection on production of large lean carcasses and many dual-purpose breeds shifting to the suckler-cow category within the beef sector. The drift of dual-purpose breeds, and even dairy breeds, was an ongoing process. In Norway the five most sorely endangered dairy breeds experienced a 63% shift to suckler-cow status in the period up to 2010 (Martyniuk *et al.*, 2011). Devon (Red Ruby) cattle (Fig. 1.9) in England were originally a triple-purpose breed and their draught function and the milking type can still be found in USA, but in their country of origin they have been polled and developed into a specialist beef breed.

Sheep were affected much less severely, although the specialist carpet wool breeds of Australia (e.g. Drysdale and Elliottdale (Fig. 1.10)) became critically

Fig. 1.7. Herd of Jersey cattle in Northumberland in 1965.

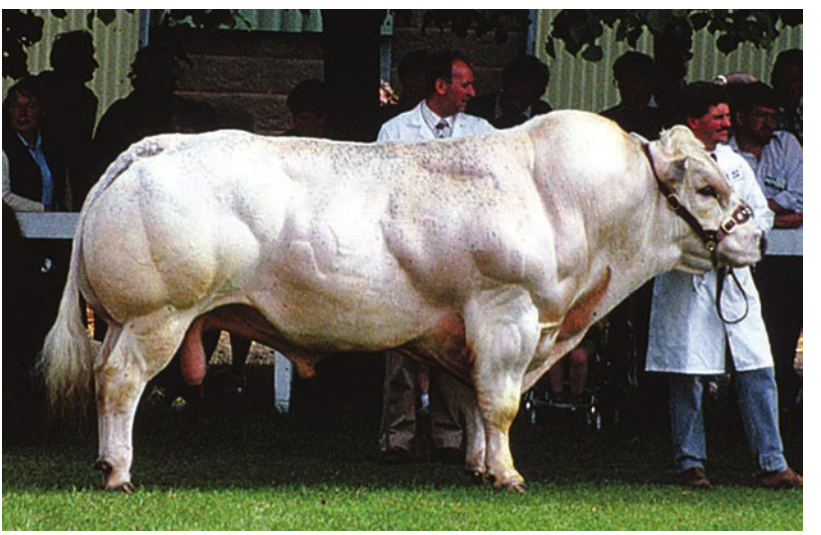

Fig. 1.8. Culard (double-muscled) Belgian Blue bull at Three Counties Show in England.

endangered. The reduced value of wool, including fine Merino wool, made sheep less competitive, and numbers also declined where intensive livestock systems of production focused attention on other species. Nevertheless, sheep continued to find favour in parts of the world where their meat and milk remained important products, especially where they fulfilled a cultural role.

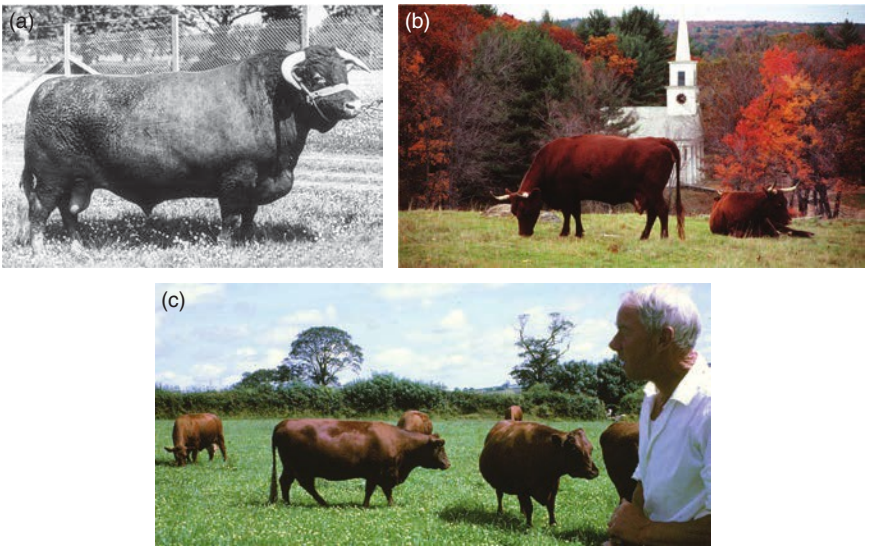

Fig. 1.9. **(a)** Traditional type of Devon bull in 1950. **(b)** Milking Devon cows in New England in 1970s. **(c)** Stanbury polled herd of Devon cattle in 1967.

Fig. 1.10. Rams of Elliottdale carpet-wool breed in 2019 (S. Curliss).

Genetic Plateaux

The possibility that higher yields might be approaching a genetic plateau in some species had not yet been articulated clearly. Theoretical or abstract debate in academic circles questioned whether levels of production could continue to increase ad infinitum or, more pragmatically, whether a limiting factor

would place an inhibiting cap on further progress. The average lactation yield of milk by dairy cows at the beginning of the 21st century was 2050 gallons (9320 litres), almost 250% higher than it was in 1950, with some cows now peaking at more than 20 gallons (91 l) per day. If the same rate of progress was maintained for another half-century the average yield per cow would be more than 5000 gallons (22,730 l), which equates to a daily average of more than 16 gallons (73 l) in a 305-day lactation – a seemingly preposterous concept. The likelihood is that the answer will never be known as considerations of animal welfare, cost of inputs and global warming will terminate the process. Similar arguments can be advanced for other species. In 1950, broiler chickens were slaughtered at 10 weeks of age with a weight of 1.3 kg. Now they reach 2.75 kg at less than 7 weeks of age and it is pertinent to ask how far such a trend can be maintained. Maybe an equally important question is how far it would or should be tolerated. A major element of the search for higher yields is focused on selection of elite breeding stock, especially small cohorts of superior males identified by evaluation of their progeny. The inevitable outcome is an ongoing loss of genetic diversity and increased inbreeding, and that eventually may prove to be the critical limiting factor which prevents further progress.

Thoroughbred racehorses are not a rare breed but they may provide some clues. Successive bouts of inbreeding to Eclipse, St Simon and Northern Dancer may be one reason why the record time for the Derby Stakes, set by Mahmoud in 1936, was not broken until 1995 by Lammtarra. They also may partly explain symptoms of unsoundness and tragic mortality seen increasingly in the breed. Possible outcomes of inbreeding, and the associated increase in homozygosity, are inability to change, a decreased ability to adapt to evolving conditions and, at times, the expression of recessive alleles with exposure of serious defects. On the other hand, the cheetah, a very specialized species, probably descends from only one breeding pair. It might be expected to exhibit extreme symptoms of inbreeding, but despite its small founder base there is an opinion that it may not be more endangered than other predators (Merola, 1994). Other research, working with 20 strains of white mice, demonstrated that only one strain survived 12 generations of full-sib matings but it remained viable and fully productive at 93% inbreeding (Bowman and Falconer, 1960). In contrast in semi-feral Chillingham cattle, tested at 24 microsatellite markers of which only one was not homozygous, genetic faults have become an integral part of the genome. Although they continue as a breeding population, they have fertility defects often associated with inbreeding depression, and their almost total homozygosity leaves no room for adaptation or elimination of defects. They are stranded on a genetic plateau.

Virtual Absence of Policies

In 1950 Europe had just emerged from a brutal war. Genetic conservation, biological diversity and ‘rare breeds’ of livestock were not on the agenda of

governments, and the attention of leading non-governmental organizations (NGOs) was focused on wildlife. FAO was founded in 1945 but the first Global Technical Consultation on Genetic Resources ('animal genetic resources conservation and management') did not take place until 1980 in Rome. The first edition of *WWL-DAD* was not published until 1993, and the first report on the State of the World's Animal Genetic Resources was not published until 2007. The tardy progress by FAO during those 60 years attracted widespread criticism and placed greater responsibility on the shoulders of NGO initiatives to save endangered breeds.

There had been earlier spasmodic initiatives. Two thousand years ago the hunting chase or farm park concept was evident in a description of 'inclosing a park for cattle': 'Wild cattle sometimes serve for the magnificence and splendour and pleasure of their owners – in order to hunt them' (Columella, AD 41–68). A century ago, two reserve herds of Texas Longhorn cattle were established in Oklahoma and Nebraska by Congress in USA in 1927; and a dedicated breeding area for Kerry cattle (Fig. 1.11) was created in Ireland in 1925. But they were isolated events. Some notable individuals showed resolute commitment to a breed. William Garne (born 1879) conserved the only flock of Cotswold sheep (Fig. 1.12); J.D. Sayer owned the only flock of Norfolk Horn sheep from 1919 to 1939; and Miriam Milbourne protected Golden Guernsey goats (Fig. 1.13) at great personal risk during German occupation of the island in World War Two. Although they attracted little attention at the time, they now are properly recognized, but other endeavours passed under the radar almost completely unnoticed. In the 18th century the Teeswater (Fig. 1.14) was a local longwool breed with imposing credentials. 'Teeswater sheep differ from the Lincolnshire in their wool not being so long and heavy; in standing upon higher, though finer-boned legs, supporting a thicker, firmer and heavier carcase, much wider upon their backs and sides; and in affording a finer-grained carcase of mutton' (Loudon, 1826). Rams could grow to a great weight of

Fig. 1.11. Dehorned single-suckler herd of Kerry cattle at Muckross in 1977.

Fig. 1.12. Cotswold ram lambs owned by William Garne in 1954.

Fig. 1.13. Golden Guernsey billy, Kingcup of l'Ancresse, in Channel Islands.

more than 265 lb (120 kg). In 1802, 24 ewes produced 70 lambs to confirm their most important quality, prolificacy, which enabled rams to sire the highly productive Masham halfbred ewe when mated with local hill sheep. However, the breed fell into decline and verged on extinction, until it was rescued in the 1920s by my grandfather, Matt Hastings (Thwaites, 2019). He remains one of the unsung heroes to whom a great deal is owed. It was not until the 1960s that a more concerted effort was evident when the embryo concept of a campaign devoted to saving British rare breeds began to develop.

On a related front, neither the agricultural industry nor governmental agencies were prepared for the rude awakening that followed the publication in the early 1960s of *Silent Spring* (Carson, 1962). An environmental science book, it documented the adverse effects caused by indiscriminate use of

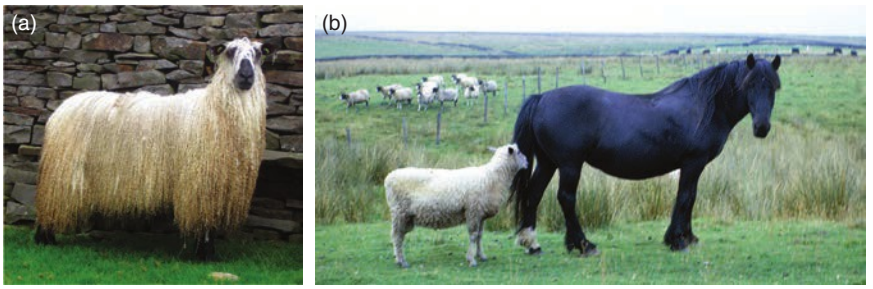

Fig. 1.14. **(a)** A Teeswater ewe hogg in her native environment in 2019 (Teeswater Sheep Breeders Association). **(b)** Shorn Teeswater tup with Swaledale ewes and Dales pony in 1967.

pesticides, accused the chemical industry of spreading misinformation and condemned public officials for accepting without question the industry's marketing claims. Shortly afterwards there was an equally profound impact on public opinion when *Animal Machines* was published (Harrison, 1964). It gave a shocking account of intensive farming, raising questions of animal welfare and sustainability, and was reprinted by CABI in 2014. The criticisms of global industrial organizations and intensive farming made by Rachel Carson and Ruth Harrison remain equally valid today and relevant in many parts of the world. They did not delve into the realms of biological diversity, but the issues they raised were implicit in the decline of locally adapted native breeds of livestock. Thus, a sympathetic chord had been struck when the first stirrings of unease began to disturb the thoughts of some livestock students in the 1960s, but it was almost a blank canvas on which they could develop their philosophy.

2

Visionaries – a Concept is Born
The philosophy of genetic conservation

The Visionaries

The visionaries set out the guiding principles for the conservation of animal genetic resources and launched the movement in the late 1960s. It was for them a time of momentous significance and excitement, a precursor to the wave of fervour that swept through some sectors of the population. Initially the visionaries based in Britain were more prominent, as that is where the movement first took root, but too often they have been forgotten. Memories of some of the most important personalities have faded, especially those whose attention was focused on their mission. They did not seek personal acclaim or aggrandisement, while others, who played a lesser role but coveted publicity and fame, basked in media attention. Therefore it is pertinent to record the significant role of Ian Mason, a 'solitary visionary' in the 1950s, author of the first four editions of the *World Dictionary of Livestock Breeds, Types and Varieties*, whose warnings of the threats to local breeds in developing countries were not addressed seriously. John Hodges, a former senior employee of FAO, paid tribute to visionaries for the formation of Rare Breeds Survival Trust (RBST) as the first rare breeds NGO: 'credit for this initiative goes to Lawrence Alderson and his associates' (Hodges, 2002). Bill Stanley OBE was a quietly modest man who chaired and led the committee which created RBST in 1973; Sir Dudley Forwood Bt and Christopher Dadd OBE brought support and cooperation from the Zoological Society of London and Royal Agricultural Society of England, and Ann Wheatley-Hubbard OBE was a respected figure throughout the farming community. They all were honoured for their work, together with Michael Rosenberg and myself, who were awarded the CBE for our contribution to conservation (Thwaites, 2019).

Creation of RBST

The creation of RBST was the trigger for an explosion of interest in endangered native breeds of livestock. FAO acknowledged the prime significance of the event and, noting the passion radiated by an NGO, quoted the eminent Canadian conservation geneticist, Prof. Roy Crawford: 'the first major milestone was laid in 1973 when Lawrence Alderson started the RBST in the UK' (Kubbinga *et al.*, 2007). It almost assumed the guise of a crusade as I was invited to meet advocates in other countries. A meeting in Paris in 1974 with the Société d'Ethnozootechnie led to an assessment of the status of French livestock and publication of a list of 76 endangered native breeds. The following year I had a similar meeting in Groningen with Dr Anneka Clason, leading to the formation of Stichting Zeldzame Huisdierrassen, and a meeting with Ridge Shinn and Tina Bielenberg at Old Sturbridge Village in Massachusetts was a prelude to the formation of the American Minor Breeds Conservancy (AMBC) in 1977. The tempo then accelerated with new organizations in Germany (GEH, 1981), Switzerland (Pro Specie Rara, 1982), Canada (Joywind Farm Conservancy, 1986), New Zealand (Rare Breeds Conservancy, 1989), Spain (SERGA, 1989), Belgium (Zeldzame Huisdierassen, 1989), Australia (Rare Breeds Reserve, 1990), Greece (IDAAM, 1990) and South Africa (FACT, 1994). As the concept expanded into a wider movement the NGO model was copied in most countries, although Scandinavia, Austria, France, Italy and Brazil opted for greater governmental involvement in a 'hybrid' arrangement. It became a global force operating under the umbrella of Rare Breeds International (RBI) (Fig. 2.1) which had an elected multinational board of directors and four trustees from England, Hungary, Canada and Austria. *The Chance to Survive* (Alderson, 1978) was published only 5 years after the creation of RBST and became the first major reference work to record and analyse the birth of the movement; and its analysis of fundamental principles and practical programmes remains valid 40 years after publication.

The Justification for Saving Rare Breeds

The justification for saving rare breeds, and the process of categorizing the degree of endangerment, later detailed in *The Chance to Survive*, was first devised

Fig. 2.1. **(a)** RBI meeting at Cordoba for Christopher Columbus quincentennial in 1992. **(b)** RBI 5th (Millennium) Global Conference at Brasilia in 2000.

and expounded in the September 1975 issue of *The Ark*, a specialist magazine I published privately with Michael Rosenberg, with our first issue in May 1974. Our primary objective was to provide clear guidelines enabling effective prioritization of support for endangered breeds, and the justification for saving them was based on four main arguments:

1. Insurance. Rare breeds provide an insurance against future changes in the environment or market place. Since the end of World War Two intensive systems of production, typified by high inputs and high yields, had become the dominant and fashionable style of farming and had discarded traditional native breeds which are designed for efficiency of production and product quality. The turn of the wheel of fortune, almost half a century later, is evidenced by herds of ark-housed outdoor pigs, flocks of free-range hens and conservation grazing with herds and flocks of native breeds. A resurgence of demand by consumers for products such as 'slow food', 'pasture-fed' beef, free-range eggs and coloured wool has fully justified the retention of traditional breeds and may have saved some from extinction.

2. Quality traits. The breeds have distinctive 'commercial' traits, especially local adaptation which makes them suitable for conservation grazing and nature management. Humpless Kuri cattle are an ecotype with large bulbous horns which give them buoyancy when swimming between islands on Lake Chad in search of grazing. Recent research confirms that Icelandic *forystufé* (leader sheep), a distinctive sub-population, not only have softer wool and longer legs but also possess special and distinctive traits, especially a sixth sense with exceptional perception of direction and prescient warning of bad weather. They act with intelligence to lead the flock to safety through blizzards and fog. Several sheep and cattle breeds have an ability to convert coarse herbage into premium products and to thrive on extensive grazing, a system that has been shown to confer the significant benefit of sequestering carbon and thereby countering global warming (Alderson, 2008). 'Quality' is their watchword rather than 'quantity', and thrifty efficiency rather than high energy dependency.

3. Scientific research. The breeds often have value for scientific research. Ossabaw pigs are very important and useful animal models in understanding the development and progression of obesity and diabetes in humans; and North Ronaldsay sheep are a possible animal model for copper-associated liver disease, especially non-Wilsonian hepatic copper toxicosis of infancy and childhood. In a practical farmyard context there is a need for deeper study of minority breeds to improve breeding and management techniques. Procedures that have been established by studies of popular breeds may not be applicable to other breeds. The ideal timing of insemination in relation to signs of oestrus and sexual receptivity varies between breeds; and the accepted interval, which is suitable for Holstein cows, results in lower rates of conception in many local breeds. Some breeders of Gloucester or White Park cattle deliberately delay insemination to achieve the best results.

4. Heritage. Many rare breeds are an integral part of the cultural heritage of their country of origin. White Park cattle (Fig. 2.2) are an ancient rustic breed with a history of more than 2000 years in Britain and an ancestral link through mitochondrial DNA to a cow with the same haplotype in the Middle East 10,000 years ago. Winston Churchill considered them to be such an important part of British heritage that he sent two pairs of breeding animals to Canada in 'Operation Fish' in the early months of the War in 1940 in case Britain was invaded. The breed survived two severe genetic bottlenecks in the 20th century, but now is flourishing and especially suitable for non-intensive grazing systems.

Other breeds have an established cultural status within a particular region or locality of their country of origin. Navajo-Churro sheep (USA), Herdwick sheep (England), the Marwari 'warhorse' (India), Suffolk Punch heavy draught horses (England), Caspian horses (Iran) and Reggiana cattle (Italy) have a compelling story to tell as localized breeds with a special function in a specific area within their country.

Navajo-Churro sheep, descended from Churro sheep brought from Spain in the mid-16th century, were adopted by the Navajo people who survived brutal government interference before working with Utah State University to develop a craft-oriented enterprise based on the double-coated fleece and multi-coloured wool of the breed. Herdwick sheep (Fig. 2.3) are an extreme example of a breed threatened by geographical endemism, as 90% of the

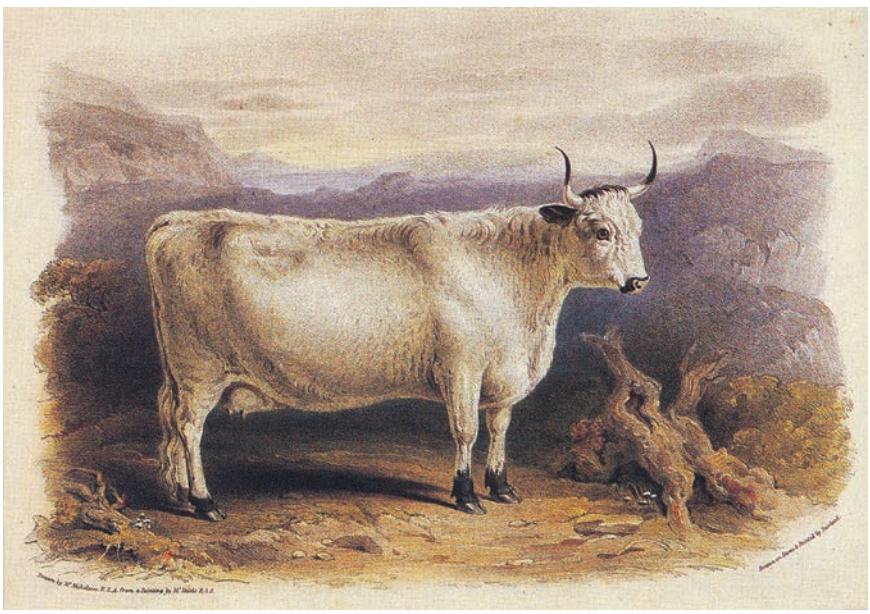

Fig. 2.2. White Park 8-year-old cow in West Wales in 1842.

Fig. 2.3. Herdwick ewes grazing on Maiden Moor in the Lake District (Simon Whitfield/shutterstock.com).

breed exists in an area less than 20 km from its mean focal centre on the mountains of the Lake District in north-west England, where their robust hardiness enables them to tolerate the severe climatic conditions (Brown, 2009). The Marwari in Rajasthan (Fig. 2.4), noted as an 'unflinching and brave' warhorse and bred 'to lift the heart in battle', has distinctive in-curved ears and is gaited with a unique four-beat lateral amble (*revaal*). Suffolk Punch horses, which have only one sire line tracing back to 'Crisp's horse' bred by Thomas Crisp of Ufford in 1768, are powerful, short, clean-legged and always chesnut (sorrel). The breed has been rescued from near extinction by effective cooperation between breeders in several countries. Caspian horses (Fig. 2.5) were (re)discovered as recently as 1965 on the Caspian littoral by Louise Firouz (Dalton, 1999). They are pony-sized but with the refined elegance and conformation of a 'blood-horse' and are considered to be an ancestral breed of the oriental horse alongside the Turkoman. Reggiana cattle (Fig. 2.6) are natives of Tuscany and owe their survival to the specialist manufacture of a cheese with protected designation of origin, PDO Parmigiano-Reggiano, which must be produced in a limited area around Parma. The cheese made from the milk of the Reggiana cow commands an especially advantageous premium price, which resulted in a doubling of the number of cows in the decade after 1993.

N'guni cattle in southern Africa (Fig. 2.7), Pantaneiro horses and cattle in Brazil (Fig. 2.8) and Iberic pigs in Spain (Fig. 2.9) are linked so intimately to their local environment that they can be described as ecotypes. N'guni cattle

Fig. 2.4. **(a)** Statue of Maharajah Jaswant Singh astride a Marwari warhorse at Jodhpur. **(b)** Marwari mare with in-curved ears at Rohet stud in 2015.

are adapted to grazing the Highveld by their resistance to disease, tolerance of heat stress and good fertility. Hides of the N'guni white-coloured pattern (*nhlopekati*) were selected specifically for his shield by the Zulu king, Shaka (1787–1828). Pantaneiro horses and cattle are adapted to the Pantanal wetlands in Brazil. Premium-priced Spanish *'jamon de jabugo pata negra'* can be produced only in a traditional agrosilvopastoral system by purebred acorn-fed Iberic pigs put out to pannage in the *dehesa*.

Endangerment classification of domestic breeds of livestock in Britain was defined by the severity of risk of extinction. At first it was a frantic search to identify breeds before they disappeared, but soon it was overtaken by the need to install an effective screening procedure when ineligible 'breeds' attempted to climb on the bandwagon as the benefits became clearer. Four categories were established based initially on numerical criteria: 'critical', 'endangered', 'vulnerable' and 'at risk'. The numerical threshold for inclusion on the lists, measured as the number of breeding females, differed for each species (Table 2.1). The existence of feral groups was noted, but wild animals and composite breeds of recent origin were not included. Poultry breeds were added later, in 1989, after prompting by Roy Crawford, an acknowledged Canadian expert on *Gallus gallus domesticus.*

Fig. 2.5. **(a)** Caspian horses depicted in a lion hunt on the seal of Darius the Great circa 500 BC. **(b)** Iranian postage stamps commemorating Louise Firouz in 2019.

Fig. 2.6. Reggiana 10-year-old cow, Organa, with 75 kg calf at 2 days old in 1971.

Fig. 2.7. The royal herd of N'guni cattle are always white.

The nomenclature used, and definitions applied, varied a little from country to country but followed a very similar philosophy, although some included rabbits and other small livestock in their remit. The AMBC classified livestock in the USA into four broad categories: 'Landrace' were native types (or breeds) with local adaptation but generally not selected for production traits; 'Standardized Breeds' corresponded approximately to recognized breeds used in farming systems which had become more uniform by the application of a breed standard; 'Industrial' groups, usually derived from standardized breeds or crosses, were selected for high performance in a controlled environment; and 'Feral' groups were derived from domestic stock of earlier importations which had escaped from human control and management. It could be difficult to distinguish 'landrace' from 'feral' in some cases.

Transboundary breeds may possess desirable traits that enable them to extend their range to more than one country, but alternatively they may have been divided and fragmented arbitrarily by political boundaries. Zaupel sheep were widespread in central medieval Europe but now are considered extinct. The last mention of the breed was in 1941 but derived populations were

Fig. 2.8. Old lyre-horned Pantaneiro cow on Pantanal in 2000.

Fig. 2.9. Iberic pigs foraging for acorns in *dehesa* in 2003.

rediscovered subsequently in Bavaria and Austria (Bavarian Forest), Hungary (Cikta) and Bohemia (Šumava). The relationship of those separated populations was confirmed by testing blood groups and biochemical markers. Their wide dispersal provides an insurance against the demise of one group, but

Table 2.1. Threshold for recognition by RBST as an endangered breed.

Species	Number of breeding females
Sheep	3000
Horses	2000
Cattle	1500
Goats	1000
Pigs	300

probably the ancient heritage of the Zaupel would be conserved most effectively in a cooperative programme. The high frequency of the ancestral ARQ allele at the scrapie locus in Cikta sheep reinforces the evidence for the historic importance of the group.

RBI later extended and refined the classification procedure to include both geographical endemism and within-breed genetic diversity as factors of endangerment. In the search for an agreed procedure the phrase 'saving rare breeds' was superseded in scientific and academic communities by 'conservation of farm animal genetic resources' (FAnGR) (Alderson, 2009). A significant seminar, convened and hosted by RBI in a London club in 2010, brought together invited specialists such as Prof. Michael Bruford (Cardiff University) and Jack Windig (Centre for Genetic Resources), regional representatives of NGOs and governmental delegates from FAO, European Regional Focal Point (ERFP) and the UK's Department for Environment, Food & Rural Affairs (Defra), to discuss the new criteria. They were adopted by FAO and applied in *In vivo conservation of animal genetic resources*, published in 2012. The original categorization set specific thresholds for each species based primarily on its reproductive rate and generation interval. Numerical criteria used the number of breeding females, although it was recognized that the number of annual replacements was a better indicator of the vulnerability of a breed. Geographical endemism (GE) was measured as the distance from the mean focal point of the breed in which 75% of the population were found, and genetic erosion (GD) was based on the rate of inbreeding per generation. It was felt prudent to simplify the system for wider usage and species were divided for numerical categorization according to reproductive capacity into 'low' or LR (cattle, sheep, horses, camels) and 'high' or HR (dogs, pigs, poultry, rabbits) (Table 2.2). Other possible refinements were suggested, such as the level of introgression, but were rejected in the interests of simplicity.

There was some evidence of urbane lobbying and jostling, and publication of a paper or two, as quantitative geneticists and other academics promoted alternative criteria. A proposal for 'Marker Estimated Kinships' (Eding and Meuwissen, 2001) used a 'core set' of breeds from which a benchmark of diversity could be derived, but the procedure depended on the correct choice of breeds to include in the core set, which also changed with time, and estimates of kinship between individuals required the analysis of more than 200 microsatellite markers. Although calculation of another proposal, genetic distance, required

Table 2.2. RBI thresholds for categorization of endangered breeds.

Category	LR	HR	GE	GD
Critical	< 300	< 100	< 12.5	> 3.0
Endangered	< 3000	< 1000	< 25.0	> 1.0
Vulnerable	< 6000	< 2000	< 50.0	> 0.5

LR, low reproductive capacity species: number of breeding females
HR, high reproductive capacity species: number of breeding females
GE, geographical endemism: distance (km) from mean focal centre containing 75% of population
GD, genetic erosion: rate of inbreeding per generation (%)

scientific input it still seemed to offer a simpler route to determining priorities. However, the distorting effect of genetic bottlenecks, and associated loss of diversity experienced by some breeds, was a complication which compromised calculations. An outline of the justification and methodology of genetic conservation was published in 2007 and re-published in 2018 (Alderson, 2018).

The application of arbitrary standards can be counter-productive. A criterion which proposed that a closed breeding population must maintain an effective population size (N_e) of at least 50 (Meuwissen and Woolliams, 1994) was based on an assumption that the rate of inbreeding must be less than 1% to enable survival. That broad concept may be correct and useful for general guidance and was applied by FAO in 2013, but there is a clear danger that its interpretation at face value by national coordinators could be used to deny support to a breed which fails to meet the threshold. Once again, pragmatic realism must take precedence and automatic use of the criterion should be avoided. There are too many breeds that fell short of the proposed threshold for N_e but still emerged successfully to add their contribution to genetic diversity. Irish Moiled cattle, having been introgressed by Shorthorn and Lincoln Red crosses in Northern Ireland in the herds of James Nelson and David Swan, survived in the 1970s only as a small nucleus of eight purebred closely related founders. They declined further to four pure cows by the end of the century, but survived with a supporting cast of grading-up animals in a supplementary register (Gill and Harland, 1992). The Lely line of Texas Longhorn cattle was based on a foundation of only one bull and ten related heifers. A more extreme example is the Vaynol herd of cattle, which has been a closed group since 1930, apart from the introduction of one bull from another White Park herd, and had an average N_e of 7.8 but continues as a viable unit. Perhaps the most amazing example is the survival of Enderby Island cattle as described below (see 'Case Studies' in Chapter 4).

Extinct Means Gone Forever

It is a fascinating human trait that impels the desire to circumvent an inconvenient constraint. Extinction may disrupt the ambitions of some breeders, but

it is not negotiable despite imaginative attempts to modify its definition. The extinction of a breed is a finite process from which there is no opportunity for recovery. The labyrinthine interaction of alleles, pleiotropy, epistasis and other contortions of the genome which are fixed in a breed or individual cannot be repeated even with precise mapping. Thus a breed re-created with intent to deceive is a perfidy with fraudulent motivation. Even if the error is committed unwittingly, the confusion should be removed promptly by the adoption of a new name to acknowledge it is a new breed, in the style of Bakewell who distinguished 'New Leicester' from 'Leicester'. Selection programmes may be massaged to breed animals which resemble the desired type in colour and conformation, but recombination of the genes (alleles) which determined the quality and traits of the original breed cannot be replicated. The parent breeds or types will have evolved and no longer possess the same traits, even if future technology at some time might seem to offer hope.

It may be asked whether extinction of a breed is an issue of any significance. Maybe a breed becomes extinct because it lacks merit or because it is superseded by a superior breed. That is a subjective judgement made at a specific time as a personal opinion. There may be other opinions and circumstances may change with time. The justification for conservation was described above in this chapter. The Galloway from south-west Scotland, a probable ancestor of the Thoroughbred, was a notable British racing pony and its genes still persist in Fell and Dales ponies. The Suffolk Dun (Fig. 2.10) was the outstanding dairy breed of its era and is a parent breed of the Red Poll. The Lincolnshire Curly-Coated (Fig. 2.11) was a fat pig with a woolly coat which lost its value

Fig. 2.10. Group of Suffolk Dun cattle in 1920. The breed is now extinct.

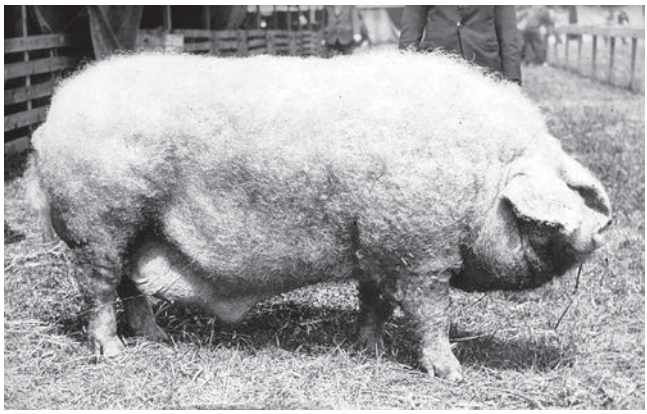

Fig. 2.11. Lincolnshire Curly-Coated sow. The breed has been extinct since 1972.

when lard went out of fashion. It is possible, although unlikely, that its genes might still be found in the Hungarian Mangalica. It is only justifiable to dismiss a breed as valueless if there is genuine ability to predict future conditions and requirements accurately, and clearly that is not the case. We only can guess how well the Galloway or Suffolk Dun might have performed in the environment of the 21st century.

Purity

The description 'purity', as applied to a livestock breed, denotes the absence of introgression or 'alien' influence which disturbs established patterns of the genome and reduces the ability to predict outcomes of a mating. Maintenance of the pure breed is defined in the constitution of most breed societies as a priority object and is a fundamental concept of genetic conservation in domestic livestock. It was adopted as a principle underlying the policies of 'rare breeds' organizations that were established from the 1970s onwards in order to conserve the unique combinations of genes embodied in each established breed. It also is important in commercial crossbreeding programmes, because mating purebred animals of different breeds gives the offspring hybrid vigour, an advantage that is lost in subsequent generations when further mixing becomes 'mongrel' mating. The principles of genetic conservation carried little weight with many government officials. Bull licensing regulations in the Netherlands prevented bulls being retained by owners of minority breeds such as Witrik, Lakenvelder (Fig. 2.12) and Groninger Blaarkop, so that their herd books were closed in 1932 and officially they were extinct. In Germany, breeds with a population of fewer than 100 animals were ignored in official records. In Norway, the attitude was even more draconian. In 1900 there were about 20 native breeds but a decision to concentrate breeding policy around the

Norsk rødt fe or Norwegian Red (NRF) resulted in rapid absorption of the Rødt Trønderfe (Red Trondheim) in 1960, Raukolle (Red Polled Eastland) in 1961, Døle in 1963, Vestlandsk raudkolle (Westland Red Polled) (Fig. 2.13) in 1968, and finally the Telemark, so that by the late 1970s 98% of Norwegian cattle were NRF.

Fortunately local conservation groups in all those countries in the 1980s rescued the few scattered fragments of the native breeds, but the damaging process had not stopped. Some breed societies neglected their primary object and some geneticists promoted a 'gene pool' concept whereby minor breeds

Fig. 2.12. Lakenvelder bull, cow and calf in 2011. The Lakenvelder is the origin of the belted colour pattern.

Fig. 2.13. Western Red Polled cow in Norway in 2009.

were amalgamated to create a wider range of genetics for selection. The 'Viking Red' is a composite dairy registry which is drawing many red breeds into its net and the NRF is likely to be engulfed along with Swedish Red-and-White, Danish Red and Finnish Ayrshire in addition to the crossbred Blended Red and White Shorthorn and maybe even the Normande and Illawarra. Originally it was an attempt to compete with the Holstein, but the initiative was too late as many of the breeds already exhibited Holstein traits. The process is comparable to that of sport horse breeding where many local breeds supposedly keep their name but in practice have become part of a 'gene pool'. A gene pool may create a larger population but it leads inevitably to massive genetic erosion as the special qualities of many minor breeds are lost in the subsequent selection programmes. It is anathema to the maintenance of genetic diversity.

Purists argue that 'purity' should be interpreted as an absolute measure with no introgression since pedigree records were maintained. That is the policy adopted in USA for Native Milking Shorthorn, and also in Britain where such animals in the Aberdeen Angus, Dairy Shorthorn and Lincoln Red breeds were given the prefix 'OP' (original population). However, there is an equally strong opinion that a more pragmatic approach should not be dismissed. Where a breed has been reduced to a relic population it is better to permit a little infusion, ideally from a closely related type, if it is necessary for its rescue to succeed. It is preferable to have a breed that is 97% (or even 93.7%) pure, or more, rather than allow it to succumb to extinction. Thus a light flavour of Northern Dairy Shorthorn in the critically endangered Dairy Shorthorn was not a conservation sin. Similarly, the back-crossing programme for the Norfolk Horn in the 1970s recruited a daughter breed, the Suffolk, to minimize alien influence. Analysis of the founder effect in Norfolk Horn sheep in 2002 revealed that purebred founders had contributed 93.5% of the ancestry (primarily through the influence of rams '100' and '14'), with the Suffolk providing the remaining 6.5%.

The process can easily be taken too far. In the 19th century Shorthorn cattle were exported to France and crossed with the local Mancelle breed to create the Maine-Anjou, a large continental-type beef animal. In the late 20th century, when the breed society considered that the Beef Shorthorn (Fig. 2.14) needed more size, it felt justified in granting herd book status to imported Maine-Anjou animals. Zootechnical regulations applied by the European Union (EU), which enabled animals with only 87.5% purity to qualify for full herd/flock book status, did not prevent such a policy but it is not an acceptable threshold for genetic conservation programmes. It gave a green light to a breeder or society wishing to accelerate the change of type of a breed, and the Beef Shorthorn proved to be a susceptible medium. The green light option also resulted in significant introgression for several other breeds of cattle listed by RBST which experienced multiple introductions of 'alien' genetics. British White pedigree records betray Shorthorn and Galloway influence in the first half of the 20th century, followed by Belgian Blue and other continental infusions at the end of the century. The revival of the Gloucester breed (Fig. 2.15) was founded on the

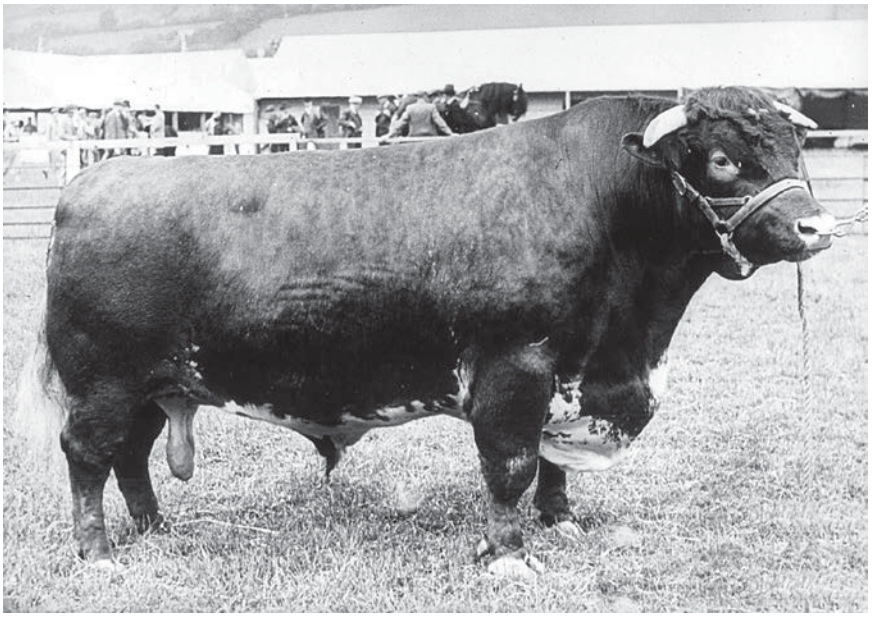

Fig. 2.14. Traditional type of Beef Shorthorn bull.

Fig. 2.15. Gloucester cow pre-1939.

only two surviving herds. The Wick herd had introduced Jersey breeding; and the Bathurst herd had used Shorthorn, Friesian and White Park animals to such an extent that, when the herd was dispersed in 1966 on the death of the owner, the Hon. W.R.S. Bathurst wrote, 'My late brother's herd includes a good many beasts that look like Gloucesters, but I doubt if any are of pure descent.' Irish Moiled cattle were crossed extensively with a polled Finnish bull in 1950, and in the 1970s the breed had been reduced to two herds, one introgressed by Shorthorn and the other by Lincoln Red breeding animals.

It is not an exclusively British problem, although export of British animals compromised the integrity of native breeds elsewhere. Durham cattle (an early type of Shorthorn) (Fig. 2.16) were crossed with Bretonne Pie-noire (Fig. 2.17) and Froment de Léon in the 19th century in Brittany and further southwards. The Bordelaise breed from the Gironde region in France was considered extinct in the 1960s when its native area had been invaded comprehensively by the Friesian. Its revival in the 1980s with crossbred animals prompted a description as 'Bordelaise nouvelle' in lists of breeds published in 2001. In northern Europe a sequence of introgression events saw the dual-purpose Polska czerwona (Fig. 2.18), which comprised 25% of the national cattle population in the 1930s, in a chain of genetic transfer between related breeds. It had already experienced introgression from the Jersey and Danish Red in 1959, but in the 1980s it was crossed with the German Angeln, which in turn had been crossed with the Danish Red, which themselves were crossed with the Red Holstein (Martyniuk *et al.*, 2011).

Purity has been measured historically by pedigree records, but it is valid to ask if that is the correct baseline for evaluation. Perhaps now it could be measured more reliably through DNA profiles and maybe analyses of ancient endogenous retrovirus have a part to play. Realistically it is difficult to delve

Fig. 2.16. Group of Durham cattle in France circa 1900.

Fig. 2.17. Bretonne Pie-noire cattle at Abbaye de Beauport in Brittany in 2017.

Fig. 2.18. Polska Czerwona (Polish Red) herd with Angeln and Danish Red influence in 1994.

further into history than the first records of a breed but pedigree records based on applications by breeders have been estimated to be 15% incorrect and therefore DNA testing can be used to verify old data. The value of DNA evidence is demonstrated by its application to resolve problems in two breeds of sheep.

Fig. 2.19. Portland ewes in the purebred Southover flock in Dorset in 2016.

Suspicions of introgression in a flock of Portland sheep were confirmed by DNA testing which identified seven aberrant alleles. Two separate studies revealed the presence of aberrant alleles in North Ronaldsay sheep on the British mainland and traced the fault to a few ewes, supposedly covered by ram '2042', but actually serviced by a ram of another breed in a farm park (Hughes, 1999; Thwaites, 2019). Parentage verification and assignment to breed by comparison with breed DNA profiles now are used routinely by some breed societies to prevent further inaccuracies (Fig. 2.19).

Genetic Diversity

Biodiversity is a fundamental and essential factor required to ensure sustainability. It gives the variation and flexibility which enables adaptation to a changing environment.

Monoculture is the antithesis of biodiversity. Intensive and continued use of the same crop variety in search of greater yields contributes to soil degradation and requires the use of more chemical fertilizer and pest controls. Its genetic uniformity makes it vulnerable to devastating attacks by

disease. It has caused infamous and well-recorded disasters in the production of some crops. The success of viniculture led to valleys and hillsides of densely packed vines in large areas in parts of Europe and America. From the mid-19th century they have been attacked by phylloxera (*Daktulosphaira vitifoliae*), a sap-sucking aphid which causes the death of vines and destruction of vineyards. In the 1980s 2 million acres (more than 800,000 ha) of vines in California were infected and replanted. The potato famine in Ireland was even more dramatic and tragic. The country was planted with potatoes as an easy form of food, but almost all were the genetically identical 'lumper' variety which proved susceptible to *Phytophthora infestans*, which caused the crop to rot in 1845 and following years. Starvation and poverty forced mass emigration. The eventual solution in both cases demonstrated the importance of biodiversity and retaining 'old' genetics. Modern vines now are grafted onto disease-resistant rootstock from old varieties; and potato breeders returned to South America, the original home of the crop, to search for greater variety.

Similar examples can be drawn from livestock monoculture and uniformity. They are less dramatic than the crop disasters described above, but they are significant. Scrapie, the ovine form of transmissible spongiform encephalopathy (TSE), has been known for 300 years with no evidence of any danger to humans but the British government panicked when BSE (bovine TSE) became an issue in Europe in the 1990s. The ancestral allele at the scrapie locus is ARQ. It mutated into ARR and VRQ, the former probably in response to a scrapie challenge and the latter because it might be associated with productive traits, so that breeds now differ in their commercial attributes and resistance to scrapie. ARQ is susceptible to the causal agent of the disease and sampling flocks in different clowgangs (groups hefted to an area of foreshore) on its native island confirmed its homozygosity in all purebred animals of the ancient seaweed-eating North Ronaldsay breed (Fig. 2.20). The threat of extinction hung over the breed when regulations were introduced to slaughter all animals tested as ARQ. Concerted action prevented such an extreme fate, but it was a prime example not only of non-governmental resistance saving a breed from a political knee-jerk reaction, but also of the danger inherent in homozygosity. There are records of earlier mass losses such as decimation by rinderpest (viral murrain) in the 18th century of Dutch native cattle which had been exported previously to England, where they became the Shorthorn. It is reasonable to believe that such plagues were accentuated by large concentrations of genetically similar animals.

The case against monoculture could rest there with some confidence but the malaise is deep and ongoing. Voices of protest have been raised for more than half a century (Carson, 1962; Harrison, 1964; Kensington Communications, 1986) and yet the damaging self-interest continues. Intervention by agribusiness has pushed production processes to a dangerously extreme level. Large multinational companies seek to maximize profit margins by higher yields to increase income, uniformity to facilitate easy management, and creation

Fig. 2.20. North Ronaldsay sheep beside the Atlantic (selenaarte).

of patents to protect genetic modifications. Inevitably there are trade-offs. Small growers and breeders, lured by the promise of higher yields, abandon their locally adapted crops and livestock and therewith their independence. They are unlikely to be aware that short-term gains will not compensate for longer-term lack of sustainability. Crop yield will increase but quality will fall. The value of higher lactation yields will be offset by costs of high-energy feed, shorter life and angular anatomy. Future security cannot be ensured by the much-vaunted power of technology, which is more likely to be a direct threat to enrichment of biodiversity.

The case for genetic diversity is rarely disputed. There may be some mild debate around methodology but the principle is firm. The dangers of uniformity have been exposed in a succession of genetics textbooks, although it is a characteristic highly prized by breeders of some pedigree livestock and pursued by those who adhere to a strict phenotypic breed standard. Nevertheless, as a general rule, extreme homozygosity is avoided. Logical progression of thought has led some elements of the scientific community to advocate vigorously that the highest priority is to reduce not only the inbreeding coefficient but particularly the rate of inbreeding (i.e. annual increase). Cyclic crossing (also known as rotational mating) (Alderson and Bodó, 1992) has been applied since the 1970s to restrict inbreeding in breeds such as Portland sheep, Caspian horses (Fig. 2.21) and Gloucestershire Old Spots pigs.

The ubiquitous Thoroughbred racehorse has a substantial global population, but it probably exhibits the dangers of inbreeding more vividly than many endangered breeds. It has experienced phases of inbreeding in the same tail

Fig. 2.21. Dun roan Caspian mare, Shirine, with foal.

male to Eclipse, St Simon and Northern Dancer, and has effectively only one extant sire line. When compounded by intense pursuit of a single major trait (speed), it has caused increased unsoundness and mortality in the modern population compared with the robustness of animals a century and more ago that competed in a series of 4-mile heats rather than a single sprint race. Up to the late 18th century in Britain, and later in North America, racehorses possessed both stamina and speed. They regularly raced in 4-mile matches several times at a single meet. Those champion 4-mile heat racers were genuine stayers, but they also had speed. The record time for a 4-mile (32-furlong) match, run over a less forgiving surface than a modern racetrack, was 7 minutes 32.5 seconds or an average of 14.14 seconds per furlong. Boston, born in 1833 in Virginia, was an outstanding racer and sire. He won 40 races from 45 starts, of which 30 were 4-mile heats and nine were 3-mile heats. He was linebred to Diomed, from the Byerley Turk sire line, and sired Lexington, which also was an outstanding 4-mile racer yet brought an injection of speed to racehorse breeding.

The last vestiges of stamina are now an insignificant part of the flat-racing calendar in the USA. Even in Britain 16–20-furlong races have merely a fringe interest, as only the Ascot Gold Cup and Goodwood Cup are classified as Group 1 races, and the Lonsdale Cup and Doncaster Cup as Group 2 races. In contrast,

if races for 2-year-olds are excluded, six races of 7 furlongs or less are classed as Group 1 and 11 as Group 2. The ratio is more extreme in Australia, where 69 sprint races are Group 1 (25) or Group 2 (44) and only three are stamina races: Melbourne Cup and Sydney Cup (Group 1) and Adelaide Cup (Group 2), all 16 furlongs. The Thoroughbred of the 21st century is a pale shadow of the champions of the past. The industry has discarded the robust dual-purpose traits of the Boston and Lexington era. It has glorified and rewarded the brilliance of specialist sprinting horses such as Mr Prospector and Danzig and ignored the fragility that they fix in the breed.

Comparisons of the Thoroughbred with White Park and Shetland cattle highlight the potential impact of population size. Shetland cattle (Fig. 2.22), an old crofting breed whose owners undertake an annual analysis of new registrations and have a conscientious responsibility to managed breeding programmes, indicate what is possible when effective genetic management is applied. In those circumstances even a small population is able to maintain its genetic diversity and functional viability more efficiently than a more popular breed. Shetland cattle and Thoroughbred horses have greater genetic diversity than White Park cattle as measured by the genetic conservation index (GCI) (effective founder number calculated by $1/\Sigma Pi^2$) (Alderson, 1992), and the pedigrees of Shetland cattle are not dominated by a single ancestor (Table 2.3). All the breeds have a similar number of female founders but the distinguishing factor is the paucity of White Park male founders, which clearly is a handicap compared with the Shetland and Thoroughbred. The total number of founders might appear to enable the latter breed to claim a superior genetic rating, but both its GCI (28.15) and highest founder contribution (0.14) are inferior to the Shetland, which takes the prime position because of the deliberate policy to conserve its diversity compared with close breeding and focus on speed in the Thoroughbred.

Numerically small breeds are more vulnerable to genetic drift and rapid genetic erosion but popular breeds are not immune from the damaging effects. Holstein cattle in the USA have an average coefficient of inbreeding (F) of ca. 0.08 (8%) and all bulls trace in tail male to only two extant sire lines. A study of the breed in the USA (Young and Seykora, 1996) revealed that the relationship to the breed of the dominant bull, Pawnee Farm Arlinda Chief (born 1962),

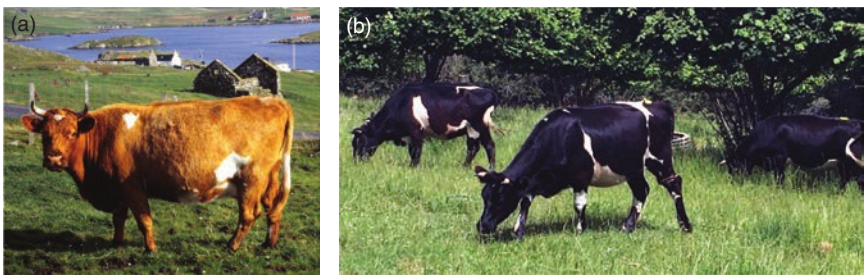

Fig. 2.22. **(a)** A red Shetland cow typical of the original type kept by crofters. **(b)** Zetralia herd of Shetland cattle in Australia (P. Zakaria).

Table 2.3. Measures of genetic diversity applied to three breeds.

	White Park	Shetland	Thoroughbred
Founders total	79	105	158
Founders male	7	30	85
Founders female	72	75	73
Main founder	0.27[a]	0.07[b]	0.14[c]
GCI	13.03	31.47	28.15

[a]Whipsnade 201; [b]Knocknagael A1; [c]Godolphin Arabian

had reached 0.123, a dangerous level that rang warning bells for some breeders and geneticists. But even they might not have been prepared for the scale of damage inflicted when subsequently in 2016 it was discovered that the bull transmitted a lethal gene that had caused spontaneous abortion in half-a-million female descendants (Adams *et al.*, 2016). Another analysis in 2009 of the popularity of Holstein bulls used by British breeders exposed a similar bottleneck with one bull, O-Bee Manfred Justice, and seven of his sons among the top ten bulls in the Profitable Lifetime Index (PLI) evaluation lists.

Other breeders, while aware of the nature of inbreeding, favour greater emphasis on the conservation of founder genetics by maximizing GCI and understand that control of inbreeding is simply one part of a conservation strategy. Greater importance is placed on concurrent selection for functional traits and linebreeding (a controlled form of inbreeding), a policy tested deliberately in some lines of White Park cattle where linebreeding exhibited no detrimental effects (Thwaites, 2019). A similar sense of balance must be maintained between the retention of more breeding males and maintaining a high standard of quality of those males.

Added-value

The term 'added-value' is usually applied in a genetic context with reference to purely commercial traits, but the value of some native breeds also accrues through their historical and heritage attributes. Even apart from new breeds created in the past 50 years, most established breeds have a relatively recent origin of 250 years but still may have historical value. They may have evolved from a local type that developed in a particular environment; they may have distinctively unusual traits; or they may have become an integral part of a community. All are valid qualifications for added-value, but some breeds have a longer history and a deeper heritage which gives them extra value. Captain James Cook, the intrepid sea-roaming son of a Yorkshire farmer in the mid-18th century, sent ashore animals that became feral populations such as those on Arapawa Island in the South Pacific. Several breeds in the Americas, such as Pantaneiro cattle, Ossabaw pigs and Navajo-Churro sheep, evolved from Iberian

animals introduced at the beginning of the 16th century. Soay sheep inhabited the island of the same name in the St Kilda archipelago before the Viking era. But probably White Park cattle hold the record, with Irish sagas tracing back their presence in the British Isles more than 2000 years ago and recent research revealing the inheritance of identified mitochondrial haplotypes from the cradle of civilization in the Middle East 10,000 years ago (Ludwig *et al*., 2013).

Failure to check the validity of sources of information can lead to erroneous conclusions. It is necessary to check not only references, but also their references back to the original document. Frequent assertions are made on behalf of many breeds that foundation stock supposedly swam ashore from the Spanish Armada. They are treated with due scepticism, but other statements require to be examined more seriously. The claim by Storer that Vaynol cattle descend from (West) Highland cattle was quoted by Wallace (1923), Whitehead (1953) and other commentators. However, reference to *Transactions of the Highland and Agricultural Society of Scotland* of 1878 (Clerk, 1878), which detailed the creation of the Kilmory herd (from which the Vaynol was founded), refutes the claim and demonstrates the foundation animals were 'white highland cattle' (Thwaites, 2019).

Many rare breeds NGOs would consider that heritage and historical significance constitutes added-value but others believe endangered status alone is the essential justification for conservation. Some of the early visionaries would have adhered to that philosophy, but gradually an additional dimension expanded the concept. It encapsulated the distinction between preservation and conservation. Preservation implies maintenance of the status quo so that saving an endangered breed demands only survival. On the other hand, conservation is a developing process incorporating preservation, characterization and utilization. Utilization might be realized at one extreme through craft groups, often seen as outlets for speciality coloured wool, to a complex structure at another extreme, but the principle being applied is that an endangered breed is more likely to survive if it can offer a product to give it added-value. In 1994 the Rare Breeds Meat Marketing scheme was established in Britain (see Chapter 3). It involved an infrastructure of producers, small local abattoirs to minimize 'food miles' and speciality butchers. It based its appeal on criteria that differed markedly from the mainstream market. Local provenance, verified origin, non-intensive management and quality of life for animals were strong marketing promotions. The popular fad for avoidance of fat was dismissed; fat is a culinary bonus and a vital component of flavour. Taste and texture were buzzwords. At an early launch we coined the pithy slogan 'Eat them to save them' with some trepidation. The apparent paradox was an illusion. Consumers welcomed the possibility to know which breed they were eating. The strongest endorsement of the scheme came at the height of the BSE crisis in Britain in the 1990s when, despite the burden of increased bureaucracy and biosecurity measures, sales of beef through the scheme doubled while mainstream beef lost 40% of its market. It was powerful proof that traditional methods and locally adapted breeds of livestock had an important role to play.

3

Building the Structure

Organization and development of the structure for action

A Basic Model

The visionaries enjoyed a special status as the inspiration for a remarkable initiative. Their concept was revered and they earned respect. But a concept is only the beginning. It is the core around which others may build. The philosophy derived from visionaries developed initially in Britain but organizations were soon created separately in each country, usually on the same basic model as RBST but with local modifications. Variations became more evident as some individuals made an especially significant contribution and influenced the development of their NGO. Michael Rosenberg, a major donor, built new offices for RBST in Warwickshire in 1983 adjacent to offices of other major livestock organizations (Thwaites, 2019), and Cary Fowler moved AMBC from New England to formal headquarters in Pittsboro, North Carolina, in 1985. Committed conservationists such as Juanvi Delgado in Spain, Fiona Chambers in Australia and Jy Chiperzak in Canada made their own mark, and most NGOs owe a great deal to one or two members who exerted a powerful influence at some stage of their development.

Management structures of national NGOs vary according to local circumstances and external influences. Administration and logistics present fewer obstacles in a small country, but require major adjustments in large countries such as the USA, Canada, Australia or South Africa. Even in the UK, a relatively small country, it is often difficult to organize either meetings of council in a location convenient for all directors, or gatherings of breeders at sales or field days for a widespread breed. It may result in a disproportionate number of officers from one region, or even a more centralized leadership. A council or committee structure theoretically provides a broader base of expertise and support, but lack of sufficient qualified and committed members may mean in practice that effective action relies on one or two drivers. Pam Heath in Canada has successfully filled several roles, which may not be a problem provided that retirement and succession planning have been carefully prepared. Anne Sim in Australia was both managing director and editor, but was able to find an

effective successor for the latter role. An undemocratic model is sure to lead to dissension at some stage, but strong leadership is often a vital factor in the success of an organization. Leadership may come from a President/Chair or Managing Director/Chief Executive Officer. The choice may excite conflict, but a good relationship is a bonus. The chair of RBST has been occupied by strong leaders, especially Ann Wheatley-Hubbard and Geoffrey Cloke, while in the USA Alison Martin has demonstrated how an innovative CEO is able to lead an NGO to commendable success by drawing a strong team around her. Each team member inevitably will have expertise in a specific department, especially practical animal breeding (sometimes one for each species), conservation genetics, information technology, communications and maybe regulations for charitable status.

In 2007 FAO conducted a survey of leading figures and experts in the world of rare breeds and genetic conservation to discover which events had made the greatest contribution to the movement. There was general agreement that the most important event was the creation in 1973 of RBST (see 'The Visionaries' in Chapter 2), confirming the opinion that inspirational impetus for many initiatives is a bottom-up process that benefits from fervour and passion generated at grassroots level. The second event was a major meeting in Rome in 1980 which brought governmental delegates and representatives of NGOs face to face with focused presentations and debate. The third event was the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992, which confirmed the importance of farm animal genetic resources in Agenda 21 of the Convention on Biological Diversity (CBD). It was convened and conducted at government level with little outside input, and demonstrated how governmental agencies gradually assumed greater control of the movement. It later settled into a more balanced structure which allowed all parties to operate, and cooperate, efficiently in their own sphere of expertise.

Emergency Action

The principles established by the visionaries had identified critically endangered breeds and revealed where urgent action was required. Thus development of the structure of the organization ran concurrently with emergency actions. Rescues of breeds in critical endangerment took precedence and conservation of a breed *in situ* was the first priority. Semi-feral Camargue horses and cattle are supremely adapted to the harsh conditions in the marshes of the Rhone delta. Iberic pigs produce their premium-priced acorn-flavoured ham in their native *dehesa* oak forests. Corkscrew-horned Racka sheep (Fig. 3.1) graze the steppes (*puszta*) in eastern Hungary alongside herds of Grey Steppe cattle, which were reduced from 99% of the local bovine population to less than 1% during the first half of the 20th century as they were displaced by

Fig. 3.1. Flock of black Racka sheep with corkscrew horns in Hungary in 1991.

imported Simmental cattle (Bodó, 2011). All are established ecotypes, and corkscrew-horned sheep have a long history as they were known in Egypt 4000 years ago.

Although continued use of a breed in its native environment or ecosystem is an idealistic target it cannot always be realized. Some breeds have been culled almost to extinction by a policy to remove feral populations to protect botanical biodiversity, especially island populations in New Zealand. Michael Willis and others risked life and limb undertaking perilous expeditions to rescue the remaining descendants of feral pigs, put ashore on South Island in 1806, and two populations started in second half of the 19th century – sheep on Arapawa Island and cattle on Enderby Island, where the last cow was airlifted to safety before she was cloned in 1996 (the same year as Dolly the sheep was born) in a desperate attempt to save the breed. In those circumstances, *in situ* conservation was difficult or impossible. In other cases, it was an integral part of the planned action. A project in 1974 to create an island reserve for the population of seaweed-eating North Ronaldsay sheep (Box 3.1) (Fig. 3.2a) in the Orkney archipelago (see 'Major Players' in Chapter 4) also presented hazards. Even with the security of a local lobster boat, the crossing from Stronsay could be treacherous when western gales whipped the frenzied waves, but Linga Holm satisfied the criteria for a suitable alternative home and provided an accessible supply of the breed's preferred seaweed diet. On their native island the sheep follow a unique system of management controlled by a communal Sheep Court whereby they run on the foreshore for most of the year, excluded from the interior of the island by a drystone dyke (Fig. 3.2b). The dyke, which stretches continuously for 12 miles, is now recognized as a historic 'monument'. It was built in 1832 after the collapse of the kelp industry when the interior of the island was devoted to cattle grazing. It suffered extensive damage in winter storms in 2012–2013 but

Fig. 3.2. **(a)** North Ronaldsay sheep among seaweed (selenaarte). **(b)** North Ronaldsay sheep beside the iconic dyke in 2006 (selenaarte). **(c)** A group of volunteers repairing the dyke on North Ronaldsay (Kate Traill).

the formation in 2015 of the Orkney Sheep Foundation, with Peter Titley as Secretary and Trustee, attracts the support of many volunteers who help to rebuild the dyke (Fig. 3.2c).

Other projects were more cerebral than physical. Breeding-back programmes which saved Norfolk Horn sheep in England and Chato Murciano pigs in Spain were designed and monitored with computer assistance, combined with interaction between livestock owners and advisers. The Chato Murciano had fallen to a small inbred population and the infusion of outside genetics was measured to check the progress of the back-crossing programme by testing at 25 microsatellite markers, thereby permitting some comparison with the breed's genetic profile (Peinado *et al.*, 2003). The Norfolk Horn (Fig. 3.3) also remained only as a relic purebred population of three rams and three ewes in 1973 but had the benefit of a daughter breed, the popular Suffolk, which provided a related female base and enabled rapid recognition of the reinvigorated breed. Its natural environment was the Breckland, an area of heath in eastern England, but its flirtation with extinction and subsequent management placed many animals in different environments, which included amenity centres, farm parks and livestock museums. Conservation under those *ex situ in vivo* circumstances was not ideal but still provided a valuable insurance against a disaster in the *in situ* population and also brought the breed to the attention of a wider public.

Box 3.1. North Ronaldsay sheep

Country of origin: United Kingdom
Region: Orkney Islands
Species: Ovine
Type: Northern short-tailed (primitive)
Size: (M/F): 30/25 kg
Fleece: Double-coated; various colours; weight 1 kg; staple length 10 cm; wool quality 54–56 Bradford Count or 28 microns fibre diameter.
Horns: Rams horned; females horned or scurred or hornless
Diet: Seaweed (grass during lambing time) which lowers emissions of CH_4 from enteric fermentation.
Physiological adaptation: They have developed distinctive adaptations, especially regarding urea, copper and iodine, as a result of their diet of seaweed and seashore environment.
Population: More than 3000 breeding ewes and followers on their native island are governed by a Sheep Court in a communal system of farming. Since 1832 they have been restricted to the foreshore for most of the year by a large drystone dyke which encircles the island and incorporates punds to collect the sheep for specific tasks. The dyke has been damaged by winter storms, especially in 2012–2013, and repaired by volunteers. The breed is endangered because of geographical endemism as the purebred population is located on its native island.
Charitable status: The Orkney Sheep Foundation was created in 2015 to 'secure the future of the island flock on their native isle'.
Reserve population: A flock of 7 rams, 114 ewes and 57 lambs, managed by RBST, was created on the small isle of Linga Holm in 1974. It was dispersed in 1998.
Reserve population: Flocks were established on the UK mainland in 1974 and are registered in the Combined Flock Book with a current population of circa 500 ewes and followers. They are monitored by the North Ronaldsay Sheep Fellowship, but possess aberrant alleles.

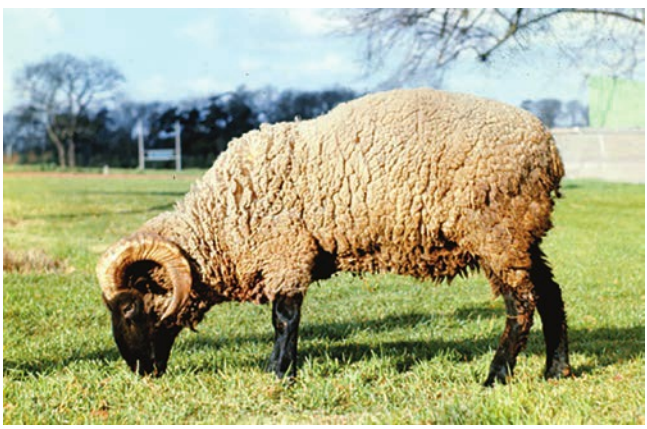

Fig. 3.3. The last purebred Norfolk Horn ram in 1973.

The range of resources available to reinforce efforts to save endangered breeds includes cryo-conservation as a major *ex situ* element of the arsenal employed by NGOs. Storage of genetic material as semen, embryos or oocytes in liquid nitrogen has given vital support and security to many programmes. The first attempt in England to save cryogenic stores of semen of traditional native breeds tested mental fortitude rather than physical stamina. It demanded emergency action in 1973 to prevent destruction by commercial organizations of 'obsolete' genetic material, but was only partially successful as some had been flushed away before intervention was possible. Thereafter in the latter part of the 20th century cryogenic storage of genetic material became an integral part of conservation policy, usually in the form of a 'Semen Bank'. It assisted the development of breeding programmes to maintain diversity rather than pursue high production at a time when many native breeds were threatened by substitution or introgression, especially dairy breeds by Holsteinization.

Longer-term Policy

The 1970s and early 1980s were a critical period for the conservation of threatened breeds. In the mid-1950s native breeds in Spain comprised three-quarters of the recorded cattle population but had fallen 30 years later to only 25%. In the same period Holsteinization in the Netherlands reduced local dairy breeds by 95%, and the number of Reggiana cows in Italy fell from 40,000 to 450. Effective programmes could not be implemented in a country until active conservation groups had been formed to scrutinize and evaluate the credentials of 'candidate' breeds, nor until the criteria of evaluation had been written and reviewed. Nevertheless, rapid progress could be achieved. In Britain a provisional list of breeds was completed in 1974, an 'acceptance procedure' was written and applied in 1975 and in that year a final list of approved endangered breeds was published in the September issue of *The Ark*, excluding those that failed to qualify as a result of detailed investigations during the previous 7 years. The organizational structures established during that period, which embodied the principles of the visionaries and were encapsulated in documented procedures, enabled the survival and subsequent recovery of breeds threatened with extinction. Its success in Britain was confirmed by breed surveys conducted from 1994 to 2007. The survey carried out by RBI in 2002 indicated that a resurgence of interest in some categories of native breeds with local adaptation had begun in the last year or two of the 20th century (Table 3.1), a pattern of success reflected in other countries and breeds.

It confirmed the peripheral role of native breeds in the dairy industry where the Holstein maintained a 95% stranglehold, although there was an upturn even there after 1998 due primarily to greater popularity of Jersey-type cattle. A comparable upturn was evident for native beef breeds as they

Table 3.1. Native cattle breed animals in UK as percentage of national population.

	1994	1998	2002	2007
Beef	56.03	48.51	49.30	56.47
Dairy	5.18	3.96	4.45	5.93

consolidated their position through increased interest in local adaptation, conservation grazing and speciality marketing. Ovine, porcine and equine breeds varied from the bovine pattern. Their fortunes were dictated more by the activity of their breed society and the particular function of each breed within the industry. Hebridean sheep were endangered when the Combined Flock Book was created in 1974 but had quadrupled their numbers by 1991 when a dedicated breed society was formed, and then further trebled them to 2000 annual registrations by 2005. It is a primitive breed but demonstrated its commercial attributes in productivity trials and in an environmental grazing project on Skipwith Common in Yorkshire. In contrast, several long-wool breeds lost their primary purpose with the collapse of the wool trade and the number of Leicester Longwool breeding ewes was no higher in 2002 than in 1982.

Although spontaneous activities erupted from time to time, sometimes with significantly beneficial effect, the organizational structure built to save rare breeds usually radiated from a central base where the national team of expertise was assembled. Nevertheless, within the coordinated framework there often existed opportunities for valuable volunteer support, either from an individual or from a member of an organized support group. Conservation centres where breeding groups of rare breeds were maintained, or amenity parks where animals were on public display, added a further element to the structure. Some national variations evolved, but the typical style and shape of the overall organization was recognizable in most cases. Other assets and activities were perceived widely as essential aids to success. Collection of genetic material for cryogenic storage was a priority. A Semen Bank is a vital asset which not only contributes constructively to current breeding programmes, but also is a last-ditch *ex situ* insurance against extinction in the event of the demise of the *in vivo* population. Northern Dairy Shorthorn cattle (Fig. 3.4) barely survived with only six pure cows at their nadir, but semen rescued four decades previously from six bulls facilitated a planned conservation policy which created a relatively large founder base and greater heterozygosity than might have been anticipated. It enabled the population to increase to almost 200 pure cows in 2019 with 53 stored embryos and 13,000 straws of semen from 18 bulls. More stores were extended later to include embryos, oocytes and other material. The use of cyclic crossing, developed in the 1960s and adopted to assist rare breeds, the creation of stud/herd/flock books to record parentage, workshops and seminars – these all added to the cumulative effect that prevented the extinction of any breed in Britain after 1972.

Fig. 3.4. Northern Dairy Shorthorn bull in 1950.

Marketing

Reliance on subsidy or hobby-farmer enthusiasm to save endangered breeds does not provide long-term security. It may be helpful as a short-term stopgap but eventually financial realism will assert itself. Products with value must be identified to develop opportunities for profitable (or at least break-even) outlets, and thus the added-value concept has become established in conservation vocabulary. Papers have been published in *Animal Genetic Resources Information* (*AGRI*, a series of bulletins published by the FAO) and proposals presented in proceedings of RBI meetings extolling such policies. They require an infrastructure of viable networks to supply marketable products, and teams of participants whose joint expertise and commitment will create profitable outlets. The products and outlets may range from food and craft goods to tourism and biodiversity.

Euskal txerria (the Basque name for Basque Black Pied pigs) originally come from the Bearn and Hautes Pyrénées regions of south-west France in the Basque country. In 1981 they were almost extinct and classified as an endangered breed when only 25 sows and 2 boars remained. In the 1980s Pierre Oteiza initiated a rescue project, which included exhibiting the pigs and their products at the Paris International Show (SIMA), and in 1990 he created *le Porc Basque en Vallée des Aldudes* with ten other breeders. The commitment of those people enabled the breed to survive and develop a deserved reputation for the quality of its products. By 2007 there were 70 breeders with 450 sows and 60 boars kept outdoors in natural woodland on hillsides with only wooden shelters. They graze on natural herbage and seasonal fruits

and nuts such as acorns, beechnuts and chestnuts. In winter they receive a supplement of cereals (free from genetic modification) to maintain a balanced diet.

The Rare Breeds Meat Marketing scheme established by Geoffrey Cloke and myself in 1994 for endangered native breeds in Britain, was based on two simple criteria: quality products and transparent traceability. It made a virtue of variability, compared with the uniformity demanded by the mass market, and valued quality of life for the animals. The factors determining product quality were breed, extensive management, slaughter and carcass management. Flavour, marbling, colour and texture were qualities associated with the meat of many locally adapted breeds which were enhanced by genetic/environment benefits of grass-fed stock and extensive systems of management. The infrastructure of specialist local networks of producers and abattoirs ensured minimum transport and minimum stress for the animals. Beef carcasses were hung for 3 weeks or more; bacon was dry cured; and marketing was through local specialist butchers throughout the country. Proof of origin relied primarily on a paper trail of pedigree certification, reinforced if necessary by DNA testing. The latter made it possible to detect introgression and even distinguish between the products of two red pig breeds: native Tamworth and imported Duroc. The sum of all these factors was a product of high quality, produced in low-input systems and retailed at premium prices.

Misinformation

It has amazed and saddened me to observe how swiftly history can be distorted. Many people are aware of high-profile examples and understand that artistic licence or other excuses may be to blame, but the same process is a regular feature of everyday life where character assassination is achieved or an enhanced reputation is established for spurious reasons. They encourage deviation from accurate evaluation and may even have an agenda of deliberate concealment of the truth. More than one biographer, when attempting to reconcile hearsay with factual evidence, has opted for the generous interpretation that 'memory does play false tricks' but this abnegation of opinion fails to focus attention on the harmful offence caused to others by falsehood. As myriad conglomerations of the written uncensored word pass into history it is inevitable that some uncorroborated and misleading statements and opinions will be repetitively copied until they become accepted as 'truth'.

The growing importance of the movement for the conservation of animal genetic resources proved to be a tempting target for anyone seeking to claim a position of prestige in history (see 'The Visionaries' in Chapter 2). As support for the movement widened there were inevitable personality clashes, often when desire to garner personal credit by some cut across altruistic motivation

of others. In 1993 Dudley Reeves, then chairman of RBST, found it necessary to send a formal letter of stern rebuke to one of his predecessors, Joe Henson, who had objected to the appointment of Bill Stanley, a father figure of RBST, as a vice-president. Henson claimed he had no knowledge of the man despite having sat on a committee chaired by Stanley. It was an indication of the kudos conferred by RBST and the burgeoning movement that such a risky gamble should be taken in pursuit of personal status despite the presence at head office of Dudley Reeves, Sir Richard Cooper Bt., Lord Barber of Tewkesbury and myself who were fully cognisant of the pivotal importance of Stanley in the creation of RBST. A similar incident at about the same time witnessed a Swiss attempt to hi-jack control of the fledgling RBI. There were implications of personal power-lust, or maybe even an anglophone aversion, but it was not entirely unexpected.

The generalization that any publicity is good publicity is not always correct. It can have a distinctly negative effect. BBC's farming programme, *Countryfile*, which also was broadcast overseas, theoretically had enviable opportunities to promote rare breeds. It fulfilled that role admirably, especially while Miriam O'Reilly presented the programme, but items of unfortunate misinformation and poor judgement jeopardized its credibility after her departure. Its new farming presenter, Henson's son, compromised the work of genuine supporters of endangered native breeds by lavishing praise on a herd of crossbred (Blended Red and White) cattle, and defined his reputation by declaring his ambition to save an extinct breed – a task which is impossible by definition. At the same time he sought to give the impression that RBST owed its existence and success in an overriding manner to his father, even claiming it 'was the brainchild of my dad'. That might be excused as filial sycophancy, but it was grossly misleading and discourteous as he failed to make any mention of those who in reality envisaged the RBST concept and played the major roles in its development.

Perhaps it was inevitable that a significant element of self-interest would pervade not only the media but also the chambers of authority where decisions affecting the recognition and status of endangered breeds were taken, although local knowledge was also a significant factor. John Cator, a member of RBST council, was a powerful advocate for British White cattle, and Robin Otter for Gloucester cattle, while Geoffrey Cloke's authoritative voice ensured that no pig breed was neglected. Other breeds suffered from vacillation. Northern Dairy Shorthorn cattle were moved on and off the priority lists in Britain depending on the balance of opinion on the RBST council. Such inconsistency is a damning indictment of the competence of an organization. Cambridge sheep, a relic breed created in the 1970s, are not recognized in lists of endangered breeds in Britain, presumably because they are classed as a modern (post-1950) composite breed. Yet both Oxford Sandy-and-Black pigs (Fig. 3.5) and Blue Albion cattle (Fig. 3.6) are listed although painstaking investigations showed they became extinct in the late 1960s. Both have been re-created and have assumed the same name as the original genuine population. The 'new'

Oxford Sandy-and-Black is a 1980s composite derived from a mixture of several breeds, and blue animals of unknown origin were the foundation for 'new' Blue Albion cattle. Its name now has been shortened to 'Albion' but the lack of genetic integrity remains. A recent publication, *Anarchy or Establishment* (Thwaites, 2019), sought to put the record straight by exposing inconsistencies and correcting the myriad items of misinformation, but it will take time for the truth to be understood by involved players and even longer to filter through to the media and general populace.

The danger of false statements (whether deliberate or inadvertent) is that they are repeated or referenced by later authors and may become established as 'fact' by frequent repetition. It is a process of long standing. The statement that White Park cattle were introduced to Britain by the Romans (Wilson, 1909) is patently untrue as Pliny (AD 77) recorded white cattle as an important element of local culture before the Romans arrived, yet it has been repeated by many later authors such as Garner (1944), Whitehead (1953), French (1966) and others. Claims for any introduction of farm livestock by the Romans, apart from horses, must be viewed with due scepticism. The comprehensive agricultural treatise, *De Re Rustica* (Columella, AD 41–68), makes no mention of livestock exports. Similar unsubstantiated statements by various authors that Vaynol

Fig. 3.5. **(a)** Oxford Sandy & Black pigs a decade before they became extinct. **(b)** Crossbred pigs, with prick ears and white saddle, in re-creation project. **(c)** Crossbred pigs, with prick ears and dark colour, in re-creation project. **(d)** A medley of crossbreeding in re-creation project.

Fig. 3.6. Blue Albion bull with Warwick and Nelson Dennis in 1945.

cattle are descended from West Highland crosses, or that Soay sheep arrived in Britain before North Ronaldsay, or that the Spanish Armada disgorged various animals on to British shores, can all be seen to be false when recourse is had to original documents.

There is a tendency for rural programmes to be romanticized by the media, either in a hobby farming ethos or even as historical fantasy, but increasingly emphasis on authentic presentations is being pursued to portray native and rare breeds as natural ingredients in the mix of conventional livestock production. 'Our Yorkshire Farm' is an exemplar. The earthy wisdom of Clive and Amanda Owen on the British free-to-view terrestrial Channel 5 programme brings a refreshing realism to both the joys and the hardships of livestock farming. It highlights the interdependence of farmers and their animals, and, for both, the absolute necessity of local adaptation to their demanding environment in the Pennine moorlands.

Communications

Most rare breeds NGOs at one time or another published a magazine or journal to communicate with members and in some cases to open a promotional front to a wider readership. *The Ark* first appeared in May 1974 as a private venture by Rosenberg and myself, published monthly by Countrywide Livestock Ltd in an A5 format (Thwaites, 2019). It remained in private ownership for several years before being passed gratis to RBST as a functioning medium for transmitting essential information on livestock and as an opportunity for owners

of livestock to exchange ideas and advice. Letters to its 'Forum' were issues and opinions of readers and, within reason, were published without amendment, but other contributions and major features were subjected to editorial scrutiny to ensure that they did not disseminate misinformation. It remained in A5 format until 1996 when it became a quarterly A4 magazine. Similar magazines appeared in other countries and have developed into valuable and informative publications. *Genesis* is published twice each year by Heritage Livestock Canada and is a substantial journal of about 50 pages now produced by an editorial team of Pam Heath, Ruth Freeman and Debbie Hutchins. In the same vein, *Paddocks and Perches* is published by Rare Breeds Trust Australia and is produced by Jill Weaver, who recently succeeded Anne Sim as editor. Both publications are available to download as ebooks. *Rare Breeds News* is published quarterly in A5 format by Rare Breeds Conservation Society of New Zealand and produced by Marina Steinke as editor. The Livestock Conservancy (lineal descendant of AMBC) in the USA publishes its *News* quarterly but also makes effective use of electronic communication by the regular production of *eNews* to deal with thematic issues or to announce major events.

Advances in technology have allowed more rapid and direct communication, not only between members of a group but also between groups scattered around the globe. Skype, Facebook and other media opportunities are employed, and greater use is made of tele-conferences by RBI (based in Spain) and national rare breeds NGOs, particularly in the USA, Canada, Australia and New Zealand.

Books have played a significant role in both communicating the principles and practice of conservation of animal genetic resources to converted followers and bringing the message of saving rare breeds to the wider world. *The Chance to Survive* (Alderson, 1978) led the way, with later editions in 1989 and 1994. Several publications have come out of the USA, including *A Conservation Handbook* (1995), *A Rare Breeds Album of American Livestock* (1997) and *An Introduction to Heritage Breeds* (2014). Keith Ramsay and colleagues compiled and edited *Landrace Breeds: South Africa's Indigenous and Locally-developed Farm Animals*. Michael Willis has described his exploits in New Zealand and Michael Trotter and Beverley McCulloch authored *Rare Breeds of Heritage Livestock* in 2019. Proceedings of major RBI conferences in Warwick and Budapest are valuable works of reference. They were published by CABI in 1990 and 1992 as *Genetic Conservation of Domestic Livestock*. Proceedings of the third major conference in Kingston in Canada were published in 1995 by RBI as *Conservation of Animal Genetic Resources* before outside publishing procedures were used for later proceedings. Wider recognition was achieved when all breeds, extant and recently extinct, were included in the *World Encyclopedia of Livestock Breeds and Breeding* together with a section on genetics and conservation (Porter *et al.*, 2016).

4

Conservation in Action

Applying the principles of the visionaries within the structure of the organizers

Major Players

The interval of time following the NGO initiative in 1973 saw increasing governmental interest and involvement, evidenced by major events such as the FAO/UNEP (United Nations Environment Programme) conference in Rome in 1980 and the Convention on Biological Diversity (CBD) in Rio de Janeiro in 1992. John Hodges and Ricardo Cardellino, both Chief Livestock Officers of FAO, focused governmental attention more keenly on endangered breeds of livestock. Governmental agencies in some countries maintain a direct and watchful surveillance over native breeds. China possesses more than 80 native pig breeds which make a significant contribution to local economy and culture, and also to mainstream production through crossbreeding. More than half those breeds are each found only on one farm and were critically at risk in August 2018 when African swine fever broke out. It swept across the country, destroying about 40% of the population within 12 months. The proposed response by local authorities included both funding and biosecurity measures, but it omitted to include the fundamental priority of locating each breed at a minimum of two locations. That essential primary motivation lay behind the creation of a reserve population of North Ronaldsay sheep on Linga Holm in 1974, because the location of the entire population on its small native island, threatened by oil-spill contamination of its seaweed forage on the foreshore, rendered it acutely vulnerable. The same danger applies to genetic material in cryogenic storage. Entire semen stocks of some White Park bulls in Canada and some Longhorn bulls in England were lost when liquid nitrogen storage tanks failed.

In 2001 FAO appointed a network of National Coordinators, each with responsibility to report to it as a global governmental agency. Consequently much current activity is based on collaboration between governmental agencies and NGOs in countries where the latter exist. In other countries it was not uncommon for an actively influential worker to link governmental action with breeders and managers of native breeds. Laurent Avon was closely involved with livestock breeds in France and his reports exposed a trend of decreasing

diversity as the number of endangered native ruminant breeds had increased from 61 in 1974 to 70 (classified as 'at risk', 'critical' and 'under investigation') in 2001, and one of those (Bordelaise cattle) was a re-created breed. Raúl Perezgrovas and Chiapas sheep in Mexico, Elzbieta Martyniuk in Poland who always was fully informed on FAO and Conference of the Parties (COP) affairs, and Salah Galal in Egypt with academic and FAO links, deserve mention among many others. RBI as the 'umbrella' organization benefited particularly from the involvement of Jean Boyazoglu. During his lengthy tenure as a leading livestock authority in Europe, with prestigious appointments including Editor-in-Chief of *Livestock Science* and Secretary-General of EAAP (European Federation of Animal Science, formerly European Association for Animal Production), he served a term as Secretary of RBI and later as a Trustee. He was born in Egypt of Greek parents who came originally from Istanbul, and later he worked in South Africa before taking a professorial appointment at Thessaloniki University, where he worked with Andreas Georgoudis. He could realistically be described as a polymath with his expertise extending to ancient history, ceramics, wine and cheese, but without any doubt he was a polyglot and I sat in his office during EAAP conferences and listened in envious amazement as he slipped seamlessly through a dozen languages as delegates from different countries called for advice or instructions.

In most cases national NGOs have a salaried management structure but all rely heavily on unpaid volunteers. Many are indispensable general-purpose helpers, but others are linked to a specific breed or project. In Britain, Charles Castle undertook a massive programme to support Dairy Shorthorn and Northern Dairy Shorthorn cattle and Richard Allen organized an annual seminar in Edinburgh for a decade, while Sue Curliss championed carpet-wool sheep in Australasia. Individual key players in some countries operated on a wider front. Keith Ramsay was involved with all species in South Africa and Juanvi Delgado combined an academic position with practical breed programmes in Spain, but in other cases more emphasis was placed on teamwork and recruitment of outside expertise. Jack Howlett, of British Livestock Exports and an expert in pig breeds, was commissioned in 1976 by RBST to select and purchase rare pig breeds in Australia for export to England. The creation of reserve populations for North Ronaldsay sheep, championed most recently by Peter Titley through the Orkney Sheep Foundation, previously involved the coordinated input of Baxter Cooper (Fauna Preservation Society), Deryk Frazer (Nature Conservancy), Bill Carstairs (Orkney veterinary surgeon), Ken Briggs (management group leader), Howard Payton (photographic archive) and myself and Michael Rosenberg (Combined Flock Book).

The management structure of most national NGOs benefited from officers or staff with scientific expertise in applied genetics and experience of practical breeding programmes. Keith Ramsay was a governmental livestock officer in South Africa; Michael Willis in New Zealand was a hands-on breeder of several species; and Fiona Chambers filled the same role in Australia. All were closely

involved in RBI. Juanvi Delgado in Spain and Phil Sponenberg in the USA were geneticists with professorial status, while RBST secured the continuity of my experience for several decades working at first with Dr John Bowman of Reading University in the 1970s, later with Dr Ian Gill of Liverpool University and with Dr Rex Walters on porcine projects. Such scientific presence gave each organization an authority which facilitated cooperation with both political and industry colleagues.

The Dark Side

The commitment and expertise of all those people, and their colleagues in other countries, cannot be doubted. They have devoted themselves to a worthy cause unstintingly. Unfortunately, it is rarely possible to operate in a vacuum and even voluntary and charitable work must be planned within parameters defined elsewhere. The world around is swirling with intrigue and misinformation. The work they do and policies they attempt to promote can be negated by actions of others who do not have a comparable altruistic ethos. An article in *The New York Times* on 3 November 2019 reported a lengthy and detailed investigation into procedures in the EU that could impact severely on endangered local breeds. Since the earliest days of the EU, it has claimed that farm policy has had priority as an unshakeable system of public welfare with regulations designed to support animal genetic resources as shown in Council Regulation EEC 2078/92. However, the investigation discovered that although the equivalent of US$65 billion is distributed annually in subsidies intended to support farmers and keep rural communities viable, the beneficiaries of a great proportion of the funding are a relatively small number of well-connected and powerful recipients. It named a leading political figure in the Czech Republic, a billionaire agriculturalist, whose companies allegedly collected US$42 million in the previous year, and traced subsidies paid to Italian mobsters who have made 'Mafia-style land grabs in Slovakia and Bulgaria'. The overall effect is that ownership of land, and thus receipt of EU subsidies, is being concentrated in vast units appropriated by a new type of owner. Complaints of political and criminal intimidation were detailed and 'Small farmers have reported being beaten and extorted for land that is valuable for the subsidies it receives'.

There we have the kernel of concern in the specific context of this book. From an ethical point of view it is unacceptable if EU funds, to which all members contribute, are being used to amass political power. EU officials do not accept suggestions of fraud and in 2015 they dismissed recommendations to combat land-grabbing in Central and Eastern European countries. Meanwhile the European Parliament rejected a bill that would have prevented politicians benefiting from the subsidies they administer. Such political shenanigans may seem irrelevant in a review of the state of animal genetic resources, but they are not. The vast majority of local and endangered breeds are kept on small

farms where traditional systems of production are operated. As they are eliminated, either by force or by financial discrimination, the native breeds and local knowledge go with them. On the surface it may simply seem a serious human tragedy, but it has even greater significance. It undermines genetic biodiversity across a swathe of countries and therefore is a direct threat to long-term sustainability.

Maximizing Within-Breed Diversity

It is a humbling experience to understand that almost all biological research since the mid-20th century owes its origin to investigations at Cambridge University which defined the structure of DNA (Watson and Crick, 1953). DNA testing and analyses are now accepted automatically as an integral part of both livestock breeding and comprehension of biodiversity, so that recognition of the importance of within-breed diversity has developed in step with the movement for conservation of endangered populations. It is a valuable measure of the genetic health of a breed and is correlated closely with measurable factors such as allelic variation, heterozygosity, founder effect (GCI), population size (total and N_e), and male/female ratio in the breeding population which also is assisted by the creation of Gene Banks. A study of French dog breeds (Leroy *et al.*, 2006), elaborated in a later paper in 2009, detailed genetic variability in several breeds, including two that are endangered: Berger des Pyrenees (BRP) and Braque Saint-Germain (BQG). The BRP traced back to 317 founders and had a larger breeding population of 612 animals, compared with 49 founders and 62 breeding animals for the BQG. However, it had a poorer sex ratio of breeding animals (M/F: 0.56/0.72) and had experienced a recent genetic bottleneck, so that its coefficient of inbreeding was 7.2% compared with 6.0% for the BQG. The study concluded that both breeds were 'potentially endangered' but FAO criteria prioritized population size and classified BRP as 'endangered' and BQG as 'critical'. Measurement of relevant factors may be objective and accurate, but clearly interpretation and prioritization rely on subjective judgements. A similar project to analyse diversity in 68 European pig breeds (PigBioDiv) focused more on between-breed diversity, which measures the genetic health of a species. It demonstrated that local breeds contributed 55.9% of total diversity, compared with 28.7% from commercial lines and 15.2% from national breeds (Ollivier *et al.*, 2005). The marginal loss of diversity resulting from the extinction of a breed highlighted the particular importance of breeds such as Euskal txerria (Fig. 4.1), Tamworth (Fig. 4.2) and Negro Canario (Canary Black), which contributed heavily to between-breed diversity despite their small effective population size and limited allelic variation.

Within-breed diversity is decreased by inbreeding, and greater homozygosity may then expose an increasing number of inherited defects. These have been identified in dairy cattle, where female descendants of a popular Holstein

Fig. 4.1. Euskal txerria (Basque) sow and litter (SpiritProd33/shutterstock.com).

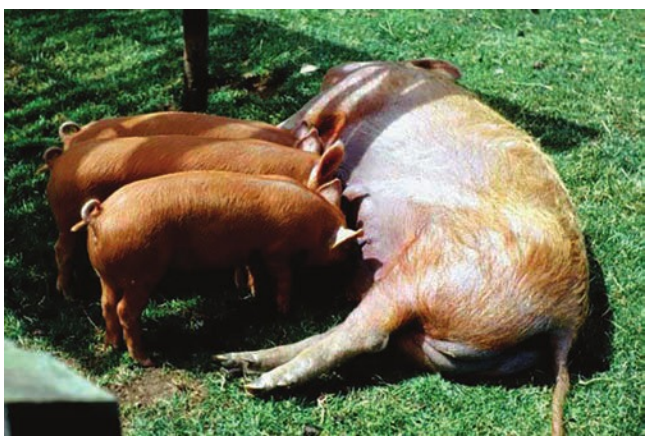

Fig. 4.2. Tamworth sow with small litter.

bull (Pawnee Farm Arlinda Chief) suffered from abortion, and in purebred dogs where overuse of show-ring champions for breeding is a causal factor. The problem is less severe in working breeds where functionality is the major priority in selection of breeding animals. Anatolian Karabash dogs (Fig. 4.3) prove themselves in testing conditions; and the Border Collie has instinctive traits for work. When a defect, such as progressive retinal atrophy (PRA), is identified it is controlled by a rigorous testing routine. Controls may not be applied where breed development is driven by the show-ring. In 2016 a 3-year-old German Shepherd bitch, Cruaghaire Catoria, won Cruft's 'Best of Breed' to the shock of welfare authorities. She had a sloping back with exaggerated angulation of the hind legs, a trait introduced and popularized by influential breed authorities for their own benefit. It is a trait which an impartial observer would

Fig. 4.3. Shepherd with Anatolian Karabash dogs, sheep flock and donkey in 1977 (N. Czartoryska).

view as a defect and which the Royal Veterinary College deemed was associated with osteoarthritis. Those views were valid, as the traditional German Shepherd was a working breed with a straight and powerful back.

Defects are not a beneficial contribution to within-breed diversity and should be eliminated, but care should be taken that desirable traits are not culled in the process. A weak topline and supernumerary teats are defects in cattle, but they did not prevent an 8-year-old Romagnola cow being paraded in the show-ring (Fig. 4.4). Some Zulu sheep are earless but are fat-tailed and locally adapted; and the excessively convex (Roman-nosed) facial profile of some Zakynthos rams leads to maladjustment of the jaw (prognathism) but nevertheless is a feature of the breed (Fig. 4.5). Dexter 'dwarf' cattle continue as a successful breed despite selection for small size, which is the heterozygous expression of a lethal recessive allele (Fig. 4.6). The split-eyelid defect in Hebridean sheep (Fig. 4.7), which prevents protection of the eye, is associated with their polycerate trait, which was known in the Middle East at least 3500 years ago. Linkage between the split-eyelid and polycerate traits may be modified by the inheritance pathway of the latter trait. It appears to be controlled at two loci and an animal will be polycerate if a recessive allele is homozygous at either locus. The linkage does not seem so close in other multi-horned breeds such as Jacob and Manx Loaghtan. Objective unbiased decisions may not be possible. Development of a breeding policy when there is close linkage of a defect and a desirable trait requires subjective evaluation.

Within-breed diversity is maintained and genetic exchange of cryogenic material is organized as part of the normal programme of national NGOs, but under appropriate circumstances effective cooperation between governmental agencies and NGOs provides an efficient structure to conduct major projects. PigBioDiv (Eur) was a prime example. It was organized and implemented by a consortium of four universities, three research institutes, two laboratories, two

Fig. 4.4. Romagnola 8-year-old cow with poor topline and supernumerary teats.

Fig. 4.5. Zakynthos ram with overshot lower jaw in 1975 (I. L. Mason).

NGOs for genetic conservation, a pig breeding company and a breed society, working with FAO. On the other hand, NGOs must be prepared to hold governmental agencies to account and challenge authoritarian edicts when they impose policies which damage endangered native breeds. When Defra applied a policy in the UK to eliminate scrapie-susceptible animals it triggered an urgent programme for cryogenic storage of genetic material, realized in 2002 by the

Fig. 4.6. Dexter cow being judged at Newport Show in 2011.

Ovine Semen Archive, which contained half a million straws of semen from 1329 rams of 73 breeds, all of which had risked severe loss of within-breed diversity. For some breeds, such as North Ronaldsay (Fig. 4.8), Castlemilk Moorit (Fig. 4.9) and Boreray, which have a high frequency of ARQ or VRQ alleles, it even spelled extinction.

An application to export North Ronaldsay sheep to the Netherlands in 2012 as a 'biodiversity conservation' project to reduce the risk of geographical endemism was blocked by the EU applying Regulation 999/2001, which limited trade to only ARR/ARR animals. Acting on behalf of RBI and working with Sipke Joost Heimstra, a prominent member of ERFP, I submitted a paper which concluded:

> Current policy conflicts with other EU regulations and international obligations which prioritise the conservation and sustainable use of animal genetic resources. A right of discretion should be observed whereby breeds at risk with an unknown or low frequency of ARR alleles should be permitted to trade in the absence of clinical scrapie.

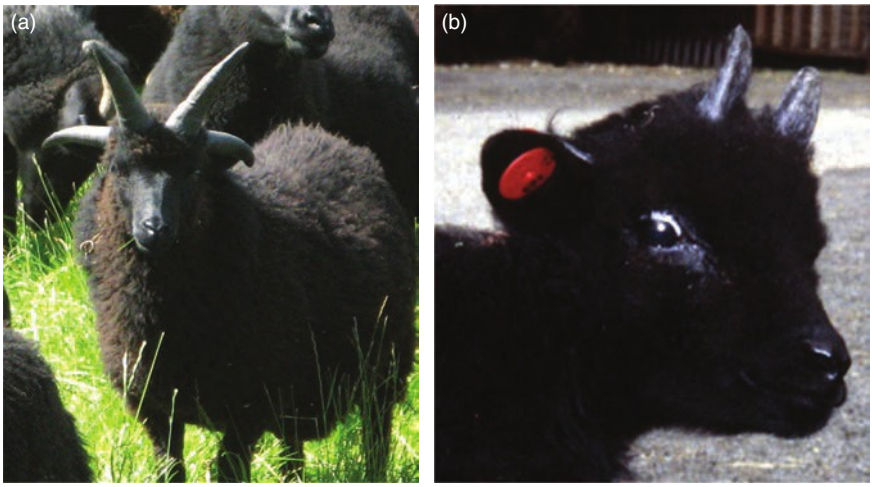

Fig. 4.7. **(a)** Polycerate Hebridean ram lamb at Whiddale in Yorkshire in 2011. **(b)** Split eyelid defect in a Hebridean lamb.

Fig. 4.8. North Ronaldsay sheep on the shore of their native island (selenaarte).

However, the unequivocal response that 'the designated problem of TSE regulations for small breeds, despite the arguments in this paper, will not be recognized' confirmed the inflexibility of dictatorial EU decrees which override biodiversity even though it is embodied in zootechnical legislation. The imposition of Defra's 'mathematical' policy to control the foot-and-mouth outbreak

Fig. 4.9. Castlemilk Moorit ram with flock in Cumbria in 2004.

in 2001 brought NGOs and government into direct confrontation yet again. The policy determined the slaughter of more than 10 million animals in the UK when only a small proportion of animals were infected and there were alternative methods of control. Once again I was embroiled in a highly emotional situation protecting treasured herds and flocks, but to no avail (Woods, 2004). In the end, despite vigorous opposition and exposure by RBI of the disproportionate and inappropriate solution to the outbreak, several breeds were left with little more than half their earlier population.

Breeding Policies

It might be expected that priorities for breeders of numerically small local breeds would differ from those applied to mainstream breeds. Their careful mating plans seek to prioritize robust rusticity, minimize loss of heterozygosity and avoid extinction of sire lines or female families. Such precautions may seem irrelevant for popular breeds, yet an elementary study of the Thoroughbred racehorse, which numbers more than 200,000 breeding mares, strikes an ominous warning note. Resounding publicity in the USA surrounded the dramatic termination of the racing career (and life) of outstanding racers such as Barbaro (2003) and Ruffian (1972), and a closer examination of their pedigree offers

some clues. Both combined influences of Native Dancer and the volatile unpredictable Nasrullah. Nasrullah died young through heart failure and Native Dancer was sire of the unsound Raise a Native. Barbaro further confirms the danger of such genetic links as his pedigree contains Native Dancer's grandson Mr Prospector. Mr Prospector was a brilliant 6-furlong sprinter but he was a fragile racer with a turned-out off-fore. He suffered from sore shins and chipped bones and retired at 4 years of age with a fractured sesamoid. His sire was Raise a Native and his dam was a grand-daughter of Nasrullah. Mr Prospector had six full-sibs, four of which were unsound and did not race, one was bad in its wind and won only once, and one broke down as a 2-year-old after one win. The powerful influence exerted by Mr Prospector as a sire of successful racers is concentrating unsoundness in the breed. The same criticism can be levelled at his sire: Raise a Native was very fast but broke down as a 2-year-old after three wins and then went to stud and transmitted speed and unsoundness. Now the Thoroughbred is being saturated by the blood of brilliant but seriously flawed superstars (Fig. 4.10a and b).

Darley/Godolphin is a powerful influence in the Thoroughbred breeding and racing world and an analysis of its stud stallions paraded at Newmarket in 2014 demonstrates a focus of attention on speed. Many of the stallions in the stud traced in tail male to Mr Prospector or Danzig (which retired with knee problems after only three races). Two-thirds of the stallions were bred and raced for speed, and 25% were pure sprinters. The danger of unsound breeding

Fig. 4.10. **(a)** Thoroughbred racehorse struggling under the whip (Lucas Gojda/shutterstock.com). **(b)** Racehorse with damaged front leg (Chelle129/shutterstock.com). **(c)** The starting gate at Santa Anita racecourse in California (Cheryl Ann Quigley/shutterstock.com).

was confirmed and emphasized in North America by a Sky News report on 30 September 2019 (Fig. 4.10c):

> California's embattled Santa Anita race track kicked off a new horse racing season over the weekend with a new horse death. A 3-year-old colt, Emtech, had to be euthanized on Saturday after suffering an injury during the second day of the opening 23-day Autumn Meet, raising the number of fatal injuries sustained at the Arcadia park to 32 since Dec. 26. … Emtech's death came 12 days after another horse, a 4-year-old gelding named Zeke, had to be euthanized after suffering a pelvic fracture during training on Sep. 16. California Gov. Gavin Newsom, responding to news of Zeke's death last week, warned that horse racing may not have a future in his state.

The death toll at Santa Anita rose further to 37 in the last meeting before Boxing Day in the Breeders' Cup Classic when Mongolian Groom was destroyed. Is it possible that the combination of inbreeding, intensive selection for speed and the influence of unsound stallions is rushing the breed towards a genetic cul-de-sac? In the desperate search for the elusive champion of champions, a 'diamond in the straw' or maybe more akin to a needle in a haystack, over-breeding annually produces thousands of foals which will be discarded as failures to end their short lives in an abattoir. Has the mesmerizing brilliance of a sprinting superstar blinded horse breeders to the obvious perils? The hazards of unsoundness, animal welfare, wastage and genetic decline must be listed in the debit column. Has money rather than morals become the driving force?

The Thoroughbred experience should urgently seize the attention of guardians of local endangered breeds. They are at greater risk and require even more careful management. Might avoidance of inbreeding be a helpful precaution? Maybe, but imaginative livestock breeding applied to genetic conservation should not be limited by blinkered minimization of inbreeding. That is equally simplistic and dangerous. A policy also may end in a cul-de-sac if it condones the use of a stallion or bull or any breeding male of poor quality because it has low inbreeding or a low relationship to the breed. The quality and soundness of breeding animals must come into the equation. Cyclic crossing efficiently limits inbreeding but is most efficient when it includes concurrent selection for linebreeding (a refined form of inbreeding) and functional efficiency. Males with poor locomotion, a twisted jaw, an undescended testicle, or any other defect, are not fit for breeding, although maybe the significant incidence of rigs in Chillingham males (Alderson, 2019) can be overlooked – even though it is foolish to ignore a defect – as their current management is deemed appropriate for a semi-feral group (Fig. 4.11).

The ability of a population to tolerate higher levels of inbreeding may depend on the number of deleterious alleles present in the founder population. If they are insignificant, or are eliminated in the early stages of a breeding programme, it may be possible to carry inbreeding to a higher level. On the other hand, if a breeding policy risks acceptance of unsoundness, it may be flirting with danger and a terminal cul-de-sac, literally a 'dead end'. In some circumstances, where a policy of linebreeding has purged deleterious alleles from a population, there is a danger that the introduction of an outside line might cause 'outbreeding depression' by introducing or re-introducing undesirable alleles. Successful breeding policies for small populations (i.e. rare breeds) demand an ability to tread a fine

Fig. 4.11. Chillingham bulls sparring in 2018.

line which avoids the extremes of both academic hypotheses and hobby farming and enables the blending of applied genetics with practical selection of functional breeding stock which minimizes the loss of founder influence.

Many software programmes (Structure, GeneClass, Genetix) are available to compute population genetics and assignment to a population. Bespoke programmes have been prepared for some individual breeds such as Shetland cattle, Shetland sheep and Cleveland Bay horses, but the Spanish programme Endog is designed specifically for the benefit of any small population as it includes calculations of GCI (to allow maximum retention of founder effect), co-ancestry, inbreeding and relationship to breed (theoretical homozygosity) and effective number of generations. Almost all breeding programmes now incorporate DNA testing as an invaluable component. Testing laboratories have amassed databases of microsatellite markers from which parentage can be verified and breed profiles developed, but now microsatellites are being superseded by the use of single nucleotide polymorphisms (SNPs). Laboratories and their clients face a dilemma. A change to SNPs has clear advantages of speed and efficiency, but years of accumulated data cannot be discarded with equanimity. Parentage verification can continue with little inconvenience, but breed profiles will need to be built again from scratch at significant expense and effort.

Genetic Exchange

Exchange of genetic material between countries and continents has proved a vital factor in the survival of some national populations, not least by widening geographical distribution. Rare breed pigs were exported from Australia to England in the 1970s (Tamworth and Berkshire) and 1990s (Wessex Saddleback (Fig. 4.12), Tamworth and Berkshire). Red Poll semen has been exported to England from the USA (Pinpur Intercontinental) and Australia (Yongerellen Power Mover and Eurimbla Gladstone), and Keith Ramsay and RBI

coordinated export to South Africa from England (Underhills Horatio). Most of the projects were facilitated, and some were organized, by national NGOs or by RBI. The account by Justin McKee in *Genesis*, the journal of Heritage Livestock Canada, of the generous and essential interaction between breeders of Suffolk Punch heavy horses in the USA, Canada, Australia, New Zealand and England verifies that the spirit of cooperation continues and provides a blueprint and the incentive for similar action with other critically threatened breeds (McKee, 2019). White Park cattle in particular (Fig. 4.13) have involved national NGOs in various methods of genetic exchange, including export of bulls to Germany to boost an existing population, semen sent to North America, from where semen went to Australia, while Churchill's export of cattle to Canada in Operation Fish in June 1940 was designed to save a precious treasure of national heritage.

Fig. 4.12. Wessex Saddleback sow in 1950.

Fig. 4.13. Embryo-transfer White Park calves with surrogate dams in Canada (E. Quinn).

Utilizing 'Old' Genetic Resources

Creation of a new breed provides an opportunity to recycle genetic material and reassemble genes to meet new environmental and market requirements. The Dorset Horn was an ancestral contributor to the British Milksheep where its fine wool, maternal traits and carcass qualities were blended with the prolificacy and milk yield of other contributing breeds. The Norfolk Horn was crossed with the Southdown to create the Suffolk; the Norfolk Red and Suffolk Dun combined to form the Red Poll; while the Blonde des Pyrénées, Quercy and Garonnaise were the ancestral breeds of the Blonde d'Aquitaine in southern France.

Unusual breeds or breeds with extreme traits also contribute to genetic diversity but a distinction should be drawn between established breeds with an unusual trait which has evolved naturally and is compatible with a sustainable system of production, and other breeds where an extreme trait can be sustained only with specialist management. Subjective opinion must again be applied to determine whether an extreme trait is a defect or a legitimate part of a breed standard. The distended appendages of Zulu sheep in South Africa, Kazakh fat-rumped sheep and Han fat-tailed Chinese sheep yield fat (Fig. 4.14) with medicinal and culinary value owing to its low melting point (Hanslow, 2012). The latter breeds are an integral part of their local culture and livestock industry which can be traced back to at least the first millennium BC when a 5th-century Greek historian noted that 'one kind had tails of three cubits in length which, if allowed to drag on the ground, would develop sores from the constant friction. To prevent that consequence the shepherds constructed small wooden carts and fixed one under the tail of each sheep' (Herodotus, 440 BC) (Fig. 4.15). Han sheep (Fig. 4.16) are kept in flocks close to the homestead, which is necessary for a prolific breed, but otherwise have evolved within an established and natural system of farming. In England, the prolificacy of Eastrip Prolific sheep was extremely high (Fig. 4.17). The average litter size of 3.42 lambs proved unsustainable without specialist management and the breed was discarded, although its prolificacy was captured at a more moderate level in the British Milksheep. Kari sheep, a newly discovered, small, fine-woolled, thin-tailed breed in the Chitral region in Pakistan, are claimed to have a remarkably short gestation period of 3 months. Gestation varies from 3 to 5 months and fetal growth in short-gestation ewes is more rapid than in ewes with a normal gestation. Under the environment of the North-West Frontier Province (now Khyber Pakhtunkhwa) it may be a useful trait but a variation of 40% from the usual gestation period for sheep is extreme.

Case Studies

The recovery of endangered breeds has not followed a standard pattern. The method chosen has varied according to the particular circumstances of the breed and the preferences of those devising the programme. The Euskal txerria

Fig. 4.14. Sheep carcasses and tail fat in a bazaar in Andijan, Uzbekistan, in 2018.

(Fig. 4.18) fell to dangerously low numbers in the late 1970s with only two boars and 25 breeding sows and its recovery can be credited primarily to Pierre Oteiza, who exhibited pigs at the Paris Show and exploited the special characteristics of the breed through an imaginative marketing strategy. He used traditional local methods to develop speciality products such as Kintoa ham, which is dry-cured for at least 17 months and derives its marbling and full flavour from the breed and the curing process. The case of White Park cattle (Fig. 4.19) is remarkably similar in some ways. The breed reached a nadir of only 65 cows in 1970 and survived partly on the strength of the quality of its products. Breeders have promoted commercial qualities such as well-flavoured marbled beef, adaptation to non-intensive systems of production, value in

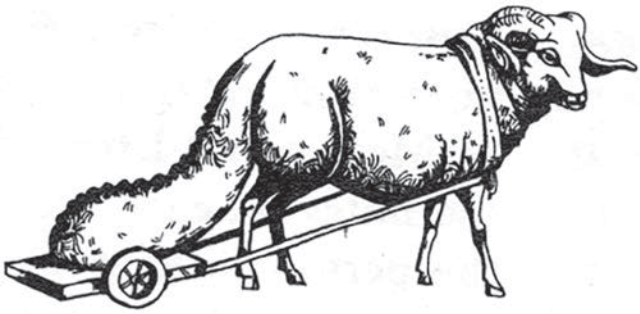

Fig. 4.15. A sheep (circa 440 BC) with its long tail carried on a cart (Rudolf the Elder 1682).

Fig. 4.16. Han fat-tailed sheep with long tail (Creative Commons).

conservation grazing and easy parturition, but in parallel have placed considerable emphasis on the unique historical and heritage status of the breed. Despite a high level of inbreeding, the result of dominant influences of Faygate Brace (born 1906) and Whipsnade 201 (born 1956), there have been no symptoms of inbreeding depression, which may imply that deleterious alleles had been purged. There has been selection for functional efficiency and exposure to robust environments, and progeny testing has been applied (Alderson, 2019; Thwaites, 2019).

The survival of **Enderby cattle** (Box 4.1) (Fig. 4.20) is one of the most dramatic and remarkable in the history of rare breeds. The cull in 1991 by the New Zealand Department of Conservation of a feral population on the remote Enderby Island 320 km south of New Zealand with the intent to protect native flora raised a contentious question: should one element of biological

Fig. 4.17. Blossom, a very prolific Eastrip Prolific ewe in 1978.

Fig. 4.18. Euskal txerria (Basque) pigs in natural habitat (O Morand CC BY-CA 3.0 Creative Commons).

diversity be sacrificed in order to protect another? In the event, although 47 animals were destroyed, the cull was not total, as semen of very poor quality was harvested post mortem from several bulls while a black-and-white cow, Lady (Fig. 4.20a), and her calf escaped. In 1993 they were captured and airlifted by helicopter to a boat and thence to the mainland of New Zealand. Management problems at Massey University resulted in the death of the calf and almost the cow. She survived and was the dam of the only bull

Fig. 4.19. **(a)** Elite White Park bull, Dynevor Torpedo, with his herd on Salisbury Plain in 1993 (M. Mott). **(b)** White Park beef was the origin of 'Sir Loin'. **(c)** Dominant colour pattern. A calf sired by White Park bull out of Gloucester cow.

(Derby), eventually conceived after 35 *in vitro* fertilization attempts with the defective semen, before she was cloned under the supervision of Dr David Wells to produce two daughters in the first use of cloning to enable the survival of an endangered breed of domestic livestock. Despite the catalogue of disasters, the breed has survived although the number of animals remains small (Fig. 4.20b) and red animals (Fig. 4.20c) have been born as a result of the expression of a recessive allele. It has been an extraordinary outcome, involving Michael Willis (a dedicated individual who has been awarded MNZM for his services to conservation), Rare Breeds Conservation Society of New Zealand (a very active national rare breeds organization), the Agricultural Research Unit at Ruakura (an institute for pioneering work on cloning) and farmers such as Dave and Judi Matheson and Julian Twiss, who tend the nucleus population of the cattle.

Box 4.1. Enderby cattle

Country of origin: New Zealand
Region: Auckland Islands
Species: Bovine
Type: Feral
Size: Small and stocky
Coat: Predominantly black pied, but some are red pied or whole-coloured.
Horns: Short
Diet: Grass, browse and seaweed.
Population: The cattle originally were put ashore as a food source in the 19th century. The population was culled in 1991. Only one cow and her calf were rescued in 1993. All purebred animals are descended from that cow, Lady, by both cloning and embryo transfer. The current population remains critically endangered and is maintained on the mainland of New Zealand.
Cloning project: Carried out by the Agricultural Research Unit, Ruakura. It was the first cloning project designed to save a threatened breed.
Monitoring organization: Rare Breeds Conservation Society of New Zealand.

Fig. 4.20. **(a)** Enderby cow, Lady, in background, with clones and descendants (M. Trotter). **(b)** Embryo-transfer Enderby calves with surrogate dams (M. Trotter). **(c)** Enderby cattle showing colour variation (M. Steinke).

Reliability of information was taken for granted during the rescue projects for the breeds described above. Its absence throws doubt over decision making and thus inhibits decisive action on conservation programmes. Yet it permeates the most unexpected places. The case study of **Dairy Shorthorn cattle** (Box 4.2) (Fig. 4.21) is riddled with shocking revelations. The breed originated in the area

Box 4.2. Dairy Shorthorn

Country of origin: England
Region: Teesdale (North Yorkshire and South Durham)
Species: Bovine
Type: Dual-purpose. Population was founded on Teeswater, Durham and Holderness types. It was divided into dual-purpose and beef types in early 19th century; the former was developed by Bates and others in 19th century as the Dairy Shorthorn.
Size: Medium/large, M/F 970/650 kg
Coat: Red, white, red pied, roan
Horns: Short
Diet: Grass
Population: A census of 1908 described 4.5 million cattle (65% of total) as Shorthorn. In 1937 ten times more Shorthorn bulls were licensed than Friesian bulls, but by the 1960s the positions were reversed. In 1949 there were 25,800 registrations of female replacements but in 1970 a policy of crossbreeding by the breed society replaced purebred animals with crossbred animals, described as Blended Red and White, which reduced numbers to 3168 in 2003 (BCMS records). In 2017 (now described as OP Dairy Shorthorn) it was classified by RBI as critically endangered with only 342 breeding cows in its country of origin.
Breed organizations: Registered in Coates's Herd Book from 1822; Shorthorn Society of United Kingdom & Ireland formed 1874
Exports: Exports of breeding animals since the 19th century influenced breeding in many other countries, including France, Belgium, Germany and Scandinavia in Europe, and North America and Australasia.

around the River Tees in north-east England. At its zenith at the beginning of the 20th century it comprised about two-thirds of the national cattle population and remained the most numerous breed in Britain until the middle of the century. Pedigree records were entered in Coates's Herd Book from 1822 and exports distributed breeding stock around the world (Sinclair, 1907). In the second half of the 20th century it was first eclipsed by the Friesian (Fig. 4.22) and later virtually eliminated by the Holstein (Fig. 4.23). From the 1960s its history is an inventory of ludicrous fiascos. In 1969 the breed society, Shorthorn Society of United Kingdom & Ireland (SSUKI), initiated a programme of crossbreeding despite its constitution defining the maintenance of the purity of Dairy Shorthorn cattle as its primary objective. The resulting crossbreds, Blended Red and White (Fig. 4.24), were actively promoted by SSUKI and entered in the herd book (Thwaites, 2019). Official records maintained by British Cattle Movement Service (BCMS) included the crossbreds; and genuine Dairy Shorthorns declined to a critically endangered nucleus. Breeders in Ireland forced SSUKI to accept changes to its regulations but with negligible effect, as the crossbreeding policy was confirmed and extended in 2006. RBI intervened and advised Defra of the unacceptable situation in a detailed letter in 2012, again with no effect. A subsequent survey by RBI in 2017, which revealed a

Fig. 4.21. (**a**) Group of Dairy Shorthorn cattle in native Teesdale in 2008. **(b)** Traditional dual-purpose Dairy Shorthorn cow in Lancashire in 1950. **(c)** Group of Dairy Shorthorn cattle in Australia in 2011 (F. Chambers).

Fig. 4.22. Friesian cow at Peepy Farm, Northumberland, in 1965.

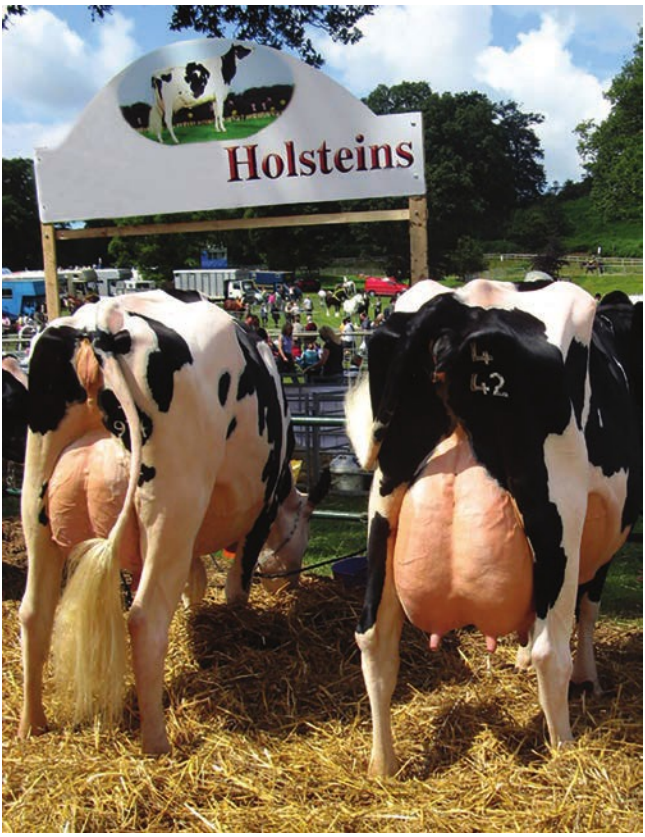

Fig. 4.23. Holstein cow with distended udder leaking milk.

global population of no more than 1500 breeding cows (pending proof of the purity of 3500 cows in New Zealand), could not be reconciled with data on FAO's Domestic Animal Diversity Information System (DAD-IS) site, which showed a global population of more than 20,000 breeding animals, including groups in countries such as Peru and even Sri Lanka, where the breed does not exist. In the UK the flow of information from SSUKI to FAO, passing through the hands of the FAnGR committee, the national coordinator and Defra, clearly had not been screened and verified at any stage and so DAD-IS showed a total of more than 9000, compared with the actual figure of 342 cows. The breed has now been rescued mainly by virtue of an embryo transfer project organized and funded privately by Charles Castle. The breed may be safer but can trust be placed in 'official' data, even when published by prominent and supposedly authoritative organizations? How many other native populations suffer from similar flawed misinformation which could deny essential support for them as an endangered breed?

Fig. 4.24. Blended Red-and-White cow at Newport Show in 2011.

Many horse and pony breeds are seriously endangered, their traditional functions superseded by machines, and they have resorted to diversification. Showing, riding, carriage driving and trekking are common targets, but some have entered the sport horse arena after judicious type 'adjustments' (Fig. 4.25). Exmoor ponies are valued in conservation grazing projects, but other breeds occasionally still find a use for their draught qualities. Percheron horses (heavy draught) are used in vineyards in France; forestry and farm work in northern England employs the Dales Pony (large pony) (Fitzgerald, 2000); and the Highland Pony (large pony) has long been used in deer stalking.

The development of special interest groups has added an extra dimension of safety in some countries. Breeds that previously were neglected have benefited from their support. The Combined Flock Book, created by Rosenberg and myself in 1974, offered registration facilities for primitive breeds of sheep in the UK that did not have access to flock book benefits, and some of those breeds also gained a political voice through the Northern Short-Tailed Sheep Group. A series of 'Coloured Sheep & Wool' conferences, held first in Adelaide in 1979 and thereafter at 5-year intervals, directed attention to wool colour variations of minor breeds such as Chiapas (Mexico), Shetland (UK), Damara (South Africa) and Pelibüey (Caribbean). The European Regional Cattle consortium (EURECA) carried out a case study of 16 local breeds of cattle in nine European

Fig. 4.25. Ms P.A. Fitzgerald and Mrs J.C. Ashby with Dales pony, Stainton Darkie, in Holker Hall driving trials marathon.

countries (Hiemstra *et al.*, 2010). RBI also operated through regional groups when appropriate, initially in Europe liaising with ERFP and EAAP and more recently through the Ibero-American group, CONDIBAND.

Added-value

Popular breeds and large organizations can mount effective promotion campaigns to appropriate an increasing share of a market for their products. Minority breeds lack the resources to advertise and access the benefit of scale to compete at that level, but they have ability to use alternative appeal: speciality, quality, health and even sentiment. A specific project was developed in the 1990s to add value to North Ronaldsay sheep. Note had been taken of the established success of Beaujolais Nouveau Day, when young wine was released for sale at 12.01 am on the third Thursday of November with a festival of pyrotechnics and music, and of the competition between grouse-shooting parties in northern England to rush the first birds to the market on the 'glorious 12th' in August. The objective of the 'Linga Holm Run' was to deliver North Ronaldsay carcasses, from sheep culled by Ken Briggs' working party and processed by Orkney Meat, to The Chop House near Tower Bridge in London with all speed possible. An application has been made by the Orkney Sheep Foundation under the Protected Geographical Indication (PGI) designation to recognize the

unique gamey quality of mutton from North Ronaldsay, where the seaweed diet preferred by the sheep depresses the production of methane (CH_4) in enteric fermentation.

The Rare Breeds Meat Marketing scheme, launched in 1994, was a wider and more comprehensive initiative working with a rural infrastructure of local producers, small abattoirs and speciality butchers. It was based on marketing quality products from a known source through local outlets. It involved celebrity chefs and gourmet commentators so that now rare breed meat products are found as specialities in upmarket restaurants. The fundamental principles were high quality and efficiency of production. Quality has been recognized for centuries. George III was enthusiastic about Portland mutton (Fig. 4.26) and a joint of White Park beef was dubbed 'Sir Loin' by James I in 1617 (see Fig. 4.19.b). Efficiency of production from breeds with local adaptation in low-input systems is more sustainable than inflexible pursuit of higher yields from intensive production. Now there is a trend in some classes of livestock away from specialist breeds towards others with 'old-fashioned' general-purpose traits. The Holstein remains a dominant dairy breed but at the fringes it is losing ground to dual-purpose breeds; and 'Original' Angus

Fig. 4.26. Lawrence Alderson judging Portland sheep at Singleton Show in 2019 (H. Payton).

beef cattle still retain their reputation in Argentina. Dual-purpose sheep are more suited to self-contained flocks, which avoid the danger of importing disease with purchased breeding stock, and some dairy sheep farmers look with greater favour on multi-purpose British Milksheep (Fig. 4.27) than very specialist Fries Melkschaap.

Adapting Policy Priorities

'Rare' and 'survival' are emotive words which proved effective to arouse the fervour necessary in the early decades of the movement, but gradually they were spurned by potential owners who prioritized a more commercial 'added-value' policy. In recognition of the changing interest of their potential constituency, several NGOs adjusted their name. The Rare Breeds Survival Trust opted for an acronym, 'RBST', and Rare Breeds Canada is now 'Heritage Livestock Canada'. A further step was taken in the USA, where the American Minor Breeds Conservancy (AMBC) became 'American Livestock Breeds Conservancy' and finally simply 'The Livestock Conservancy'. Has the change of name been reflected in change of objectives or policy? It was a more difficult transition for Old World countries which have many endangered native breeds on which to focus their attention, and where an entrenched pedigree ethos of some traditional breeds was offended by an admission that a breed deserved a 'rare breed' label.

Breeders in New World countries were less inhibited. Very few breeds could claim genuine native origin. They descended from stock imported in the 16th

Fig. 4.27. British Milksheep halfbred ewe with triplet lambs.

and later centuries. Therefore, they were more attuned to a philosophy of conservation of any breed that was endangered, whether native or exotic. In Brazil a major inflow of genetic resources from Iberia followed subjugation by the Conquistadores in 1492, but dual-purpose Kankrej (Guzerá) (Fig. 4.28), dairy Gir (Fig. 4.29) and beef Ongole (Nelore) cattle from India were introduced in a subsequent phase of importation in the late 19th century and exerted a more powerful influence on the livestock industry. In 2018 Heritage Livestock Canada listed 86 endangered breeds. The greatest number, 48.8%, were native breeds of the British Isles, while 19.8% came over the border from the USA and 12.8% from other countries. Only 18.6% were Canadian native breeds and one-third of those were relatively modern creations. The lack of native breeds does not in any way devalue the importance of the conservation work done in Canada. The number of breeds being conserved in that country is greater than the number being conserved in Old World countries such as Germany or the UK, and some native breeds of European countries, such as Jacob sheep (Fig. 4.30), have remained more true to their original type in the New World than in their country of origin.

Fig. 4.28. Guzerá (Kankrej) cows in Brazil in 2000.

Fig. 4.29. Gir cow in Brazil in 2000.

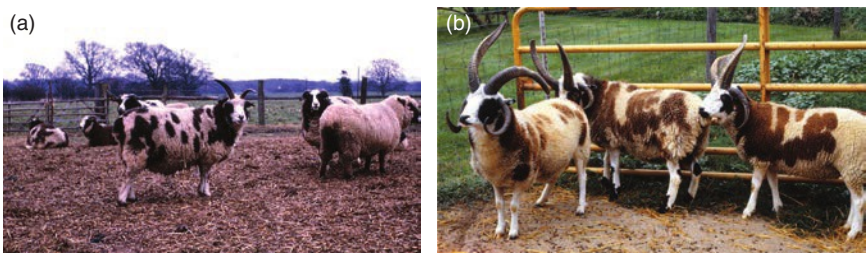

Fig. 4.30. **(a)** Evidence of introgressionn a Jacob flock at Knepp Estate in 1966. **(b)** Jacob rams in Norton flock in USA in 1994.

The programme of events advertised by The Livestock Conservancy includes several that focus on grazing livestock. A significant feature of conservation policy in the 21st century is the symbiotic relationship which developed in the 1990s between support for endangered native breeds and wider botanical and faunal biodiversity. Its effect has been widespread and is evident across much of Europe. Endangered breeds showed signs of accelerating recovery as national allocations from the EU Rural Development Programme, although at times misappropriated, were applied in some countries for the intended purpose. Grazing native endangered breeds in the UK on a specified area attracted an increased subsidy from the Rural Payments Agency under the Environmental Stewardship (Higher Level) scheme. The outcome was positive until 2005 when a change in subsidy payments reversed the effect. Whereas many local breeds declined significantly in the first eight

Fig. 4.31. Aure et Saint-Girons (also known as Casta) herd near Foix in southern France.

decades of the 20th century, they benefited from a combination of favourable opportunities in the 1990s. They were underpinned, especially for cattle, by an increasing appreciation of 'local food' and extra subsidy from environment grazing. Reggiana numbers fell from 41,000 cows in 1950 to 450 cows in 1980s but recovered thereafter through the special status of Parmigiano cheese. In France, Villard de Lans numbers fell from 16,000 cows in 1900 to a nadir of 100 cows in the 1980s before rising to 500 cows in 2010; and Aure et Saint-Girons (Fig. 4.31) (also called 'Casta' because chestnut is a common colour) fell from 30,000 animals in 1930 to fewer than 400 in 2014, but there had been fewer than 100 in the 1980s.

The trend was less obvious for other species and not relevant in the UK, where an active NGO genetic conservation policy since 1973 enabled most endangered breeds to achieve a steady improvement in their security, although conservation grazing accelerated the trend. The Agriculture Bill 2020 in the UK was an even greater step forward. The proposed 'new financial assistance powers' pointedly included conserving native livestock and recognized uplands as an important part of cultural and natural heritage. The EU 'Direct Payments' subsidy system, which has skewed payments away from small farmers by granting exorbitant payments to the largest landowners (see 'The Dark Side' above), will be discontinued and instead payments will reward farmers and land managers for 'public goods' that enhance biodiversity and the environment.

5

The Way Ahead

How animal genetic resources may contribute to a sustainable future

The previous four chapters have been a factual review of the emergence and development of a significant and valuable movement which has had a beneficial impact on genetic diversity and quality of life. The character of this final chapter is in marked contrast. It is a speculative view of the future – evidence-based and formulated from careful consideration of available options, but speculative nevertheless. It should be read in that context.

Formidable Challenges

Climate change

The challenge to supply sufficient wholesome and nutritious food for a burgeoning global population is threatened by current climatic unpredictability, and the impact of global warming seems set to dominate scientific, political and public debate for the foreseeable future. *Homo sapiens* cannot escape censure. Humans have invited self-inflicted catastrophe as ruthless corporations use their power and influence to manipulate policy and regulation (Albrecht, 2015). Faltering democracy is dominated and corrupted by powerful vested interests so that the greed of totalitarianism and oligarchism prospers, destroying the environment and allowing global warming to escalate. It is becoming a frontline battleground as evidence of climate change becomes more dramatic and opposing factions grasp an opportunity to occupy egocentric and increasingly polarized positions. The primary purpose of the militant vegan annual demonstration organized by Surge in London in August 2019 was not to promote a dietary preference, which might have been a legitimate objective, but rather to use vulgar clichés as a direct attack on livestock farming and on the lifestyle of others in the community. Its extremism against both beef and dairy cattle was heralded by lurid placards declaring 'meat is murder' and 'leave my tits alone', with an extra agenda of disrupting life in the capital city. Intolerant or bigoted behaviour is an affront to other citizens wishing to pursue

their life in peace. It could have been dismissed as rather unpleasant anti-social extremism, except for a few quotes from a contribution to 'Comment' in *The Times* in October 2019. It stated:

> Eating animals is bad for the environment. Most rearing practices involve stress and harm … Industrial meat production making the products cheaper involves horrible trade-offs involving cruelty, abuse of antibiotics and pollution … The conclusion is inescapable, food technology will do for cows (soon) and other animals (later) what the mechanisation of transport did for horses … By 2030 the number of cows will be halved; the dairy industry will be bankrupt; the value of agricultural land will plummet … doom for farm animals and the industry that depends on them.

The overstated melodrama and gloating extremism is ominous but self-defeating. The ruse of wrapping an argument around a potent criticism, such as overuse of antibiotics, cannot conceal the fiction and half-truths, the generalizations which lack evidence, and the fundamentally unbalanced tone of the piece. Yet it was not unexpected. Perhaps surprising to see it in *The Times* rather than *The Guardian*'s slanted columns, but maybe that indicates how far misleading opinions can penetrate if they are not challenged. The issue is too critically important to be treated with such flippancy. The measures necessary to deal with the problem deserve serious and considered discussion and action.

Ruminant livestock, and cattle in particular, have come under increasingly ferocious attack from various quarters since the turn of the millennium. Historically, when mass hysteria builds, victims that are perceived as weak and incapable of strong response have been targeted. Thus cattle have become whipping boys, blamed as accelerators of global warming as it moves into the realms of mass hysteria. They are easy targets made even more vulnerable when attacked from an unexpected quarter, especially one from which they might have expected support. A report by staff at FAO's Livestock Information and Policy Branch titled 'Livestock's long shadow' (Steinfeld *et al.*, 2006) was brutally direct: 'Livestock are one of the most significant contributors to today's most serious environmental problems. Urgent action is required to remedy the situation.' But it was naïve and dangerously misleading. It was disowned by other colleagues (Mottet *et al.*, 2017) and disproved by several (Alderson, 2008; Allen *et al.*, 2018; Costain, 2019 a,b; Fairlie, 2019). There is a responsibility on authors, journalists and the international media to evaluate any major issue with impartiality and rigour to prevent a political knee-jerk reaction to emotive prejudiced opinions.

The Industrial Revolution lies at the core of the problem. Before 1800 all greenhouse gases remained in balance in a natural cycle. Atmospheric carbon (in the form of carbon dioxide, CO_2) was absorbed by plants, eaten by grazing animals, emitted after enteric fermentation as methane (CH_4) and oxidized back to CO_2. No carbon was added and there was no climate warming. In 1800

global fossil fuel consumption was less than 100 terawatt-hours (TWh); by 1950 it had risen to 20,139 and now is 1350 times greater than in 1800. The 'carbon crisis' leading to global warming is a post-industrial phenomenon and that should be the focus of attention. It grew with mechanization and industrial sources are responsible for the greatest carbon pollution. Burning fossil fuels accounts for 87% of CO_2 emissions, the primary pollutant, and 33% of CH_4 emissions when natural sources are excluded. Destruction of tropical rainforest or stripping of Irish peat bogs deservedly attract severe criticism, but they continue unchecked as political scrutiny is conveniently redirected and global industrial giants, who wield more political clout than livestock farmers, are able to divert blame elsewhere. The powerful fuel lobby, aided by vocal militant vegans, has skewed the debate to such a degree that both politicians and public have succumbed to high-decibel opinion.

The apparent inability of some commentators to understand that the answer must take carbon sequestration into account, rather than simply measuring emissions, inevitably leads to erroneous and damaging conclusions. It is almost criminal when a purveyor of such conclusions held important political office. Prof Sir Ian Boyd, Chief Scientific Adviser to Defra 2012–2019, clearly is unaware that upland pastures sequester carbon more reliably than woodland as he advocates transforming them into nature parks and woodland. Even with the prospect of having to feed an escalating population, he is happy to see 90% of our cattle and sheep discarded, but maybe that only underlines his vegetarian conversion. He attempts to argue that extensive pasture-based systems of livestock production are less carbon efficient than intensive systems. His willingness to ignore facts and brush aside reality is staggering. He should have the courage to plead guilty and admit the suspect prejudice of his seemingly confused opinions.

Analysis within the agricultural industry in temperate ecosystems allocates responsibility overwhelmingly to intensive arable systems, where heavily fertilized soils are disturbed and cultivated, and to intensively managed livestock that are pushed to high yields with high-energy rations in winter housing with slurry pits. According to the Intergovernmental Panel on Climate Change (IPCC) and other sources, slurry and fertilizer account for two-thirds of all anthropogenic emissions of nitrous oxide (N_2O), which is a potent pollutant.

Methane is a short-life greenhouse gas (GHG) which degrades rapidly, but is used as the stick with which to beat cows. Apart from natural sources, which account for 36% of CH_4 production, other sources are landfill and miscellaneous waste 26%, burning fossil fuels 21% and agriculture (including enteric fermentation) 17%. In contrast, long-life GHGs accumulate and are the primary fuel of climate change. Every emission of CO_2 will add to global warming during its residence of hundreds of years in the atmosphere. N_2O also accumulates during a life of 114 years, and its potency is 300 times greater than that of CO_2. Although that information is readily available, it rarely is granted any worthwhile publicity. Prejudiced heavy guns are trained on CH_4, conveniently

ignoring the greater damage inflicted by CO_2 and N_2O. Flawed evidence presented previously was based on GWP_{100}, an outdated measure of global warming potential. Conclusions may have been accurate for the effects of CO_2 and N_2O but they hugely overestimated – by 50% in 2050 and 150% at the end of the century – the effect of CH_4 (Allen *et al.*, 2018; Mayhew, 2019). The agricultural culprits are intensive production systems of high yield and high input based on cereals, soy and maize.

Locally adapted native breeds, which include endangered breeds, do not fall into the global warming categories, but attacks on livestock have failed to distinguish between intensive systems of production and non-intensive carbon-sequestering systems where local breeds are found. Generalization is misleading. Generic criticism masks the significant variation which exists between various groups of animals and systems of production. Breeders or keepers of non-intensive livestock would not condone stress, harm, cruelty and pollution (as printed in *The Times*), but would resent the inability or unwillingness of many commentators to recognize the tangible benefits which their animals bring.

Biological diversity

Biological diversity is an essential ingredient as we face an uncertain future. It acts as an insurance against changes in the environment and the market place. It is eroded by both the extinction of a breed and the loss of founder effect within a breed. The Holstein, which is not adapted to low-input extensive grazing, is focused on high lactation yield and has pushed many local breeds to the brink of extinction. It now comprises more than 90% of dairy cattle in the USA and has infiltrated many other dairy breeds, including heritage breeds such as the Dairy Shorthorn globally and the Normande (Fig. 5.1) in France. Intensive selection for a single major trait, such as lactation yield, annual egg yield or galloping speed, should carry a 'genetic health' warning.

Diversity in the global livestock industry can be described and interpreted in many ways. Within-breed diversity will be eroded by loss of founder influence as measured by GCI or by increasing homozygosity caused by genetic drift or inbreeding. Between-breed diversity can be calculated simply from the variation between breeds. The loss of local and endangered breeds, which make a major contribution to diversity, restricts future options. Domestication of new species could increase diversity incrementally, but opportunities probably are limited as candidate species must exhibit particular traits of social structure and productive potential. Bison (Fig. 5.2) have been farmed in North America but cannot be described as domesticated, as their temperament requires management appropriate for a wild animal.

Diversity in its widest context might seem to give the green light to several species that have become 'pests', such as deer, badgers and foxes. They have no predator and have run out of control. Deer damage upland environments and

Fig. 5.1. A Normande heifer (CC BY-SA 3.0 Creative Commons).

encroach on productive farmland. Badgers transmit tuberculosis to cattle and decimate populations of hedgehogs, bumble bees and ground-nesting birds. Foxes are predators of lambs and even calves since their behaviour changed as a result of urban foxes being dumped in rural areas. Controls which should be applied are resisted either by vested interests (e.g. deer-stalking industry and fox-hunting fraternity) or by vociferous groups motivated more by emotion (or maybe even rancour) than by reason. Sheep flocks in the Picos de Europa, which sustained local cheese-producing communities in Spain, have been removed as a result of predation by recent introduction of legally protected wolves. It might be argued that exotic (alien) species add to diversity but the damage inflicted by grey squirrels, signal crayfish and mink (all native to North America) destroy that argument. Local authorities in Italy and France have prudently taken action to eliminate pockets of invasive grey squirrels before they spread out of control.

Sustainability

Human error, often prompted by a personal agenda, must bear much responsibility for the current predicament of the planet. Human-induced soil degradation has resulted in a decreased capacity of soil to support life (Oldeman *et al.*, 1991). Unprecedented land use change, driven by ever-increasing demands

Fig. 5.2. Bison herd on National Bison Range in Montana in 2011 (US Fish and Wildlife Service Headquarters. Public domain 5447888883).

from economic development, has caused land degradation and soil erosion with associated problems of nutrient depletion and loss of biodiversity. The Global Environment Facility (GEF) estimates that 25% of land has been degraded globally, 24 billion tonnes of fertile soil are lost annually, and reduced biodiversity has rendered agricultural production systems less resilient. There is an annual wastage of more than 400 million hectares of agricultural land globally through soil loss and degradation. A justification claimed for the accelerating trends towards monoculture, in both crop and livestock production, is the need to produce an increasing volume of food from a decreasing area of land as the global human population grows towards a predicted 9.8 billion people by 2050 and developing countries acquire a more sophisticated palate. That is not a valid claim. High-input specialized systems, including monoculture, are not sustainable and therefore the premise must be rejected. It has been shown that diversity is a fundamental requirement for sustainability and there is evidence of declining diversity in production systems in many parts of the world. Vast fields of crops are cultivated with the aid of pesticides, mineral fertilizers and fossil fuels, while expanding units of intensively housed livestock are maintained by heavy doses of drugs, by feeding stuffs from distant origins and still by antibiotics in many places (Bélanger and Pilling, 2019). To feed intensive livestock, Britain annually imports 2.5 million tonnes of soya, much grown on land where biodiverse primary rainforest has been destroyed.

Holsteinization has popularized a breed with extreme characteristics. The Holstein cow's high lactation yield depends on high-energy feed, often with

animals housed much of the year zero-grazing speciality crops plus concentrates, but its short productive life and specialist inflexibility do not inspire confidence in its future. The intense selection necessary to continue the breeding policy renders genetic material from previous generations obsolete, and produced a 'double whammy' in a period when developed countries dumped 'waste' genetics on the developing world under the guise of philanthropy. Locally adapted breeds in those countries were pushed to (or towards) extinction as they were substituted by exotic genetics, which then often failed within one or two generations.

The equine industry presents a similar scenario. Arabian infusion historically changed the type of many local breeds. The relatively recent interest in the development of a sport horse 'breed' continued that process, reducing many native breeds to a relic population as a consequence. National stud books for several breeds are affiliated to the World Breeding Federation of Sport Horses with a registration system embracing animals from local types. Yet a 'mongrelization' breeding system, whereby stallions of varying type and origin are used, has not established a recognizable and stable population. Sir Shutterfly, a dark bay stallion born in 2002, is classified as 'Hanoverian' like his dam, but his sire is 'Oldenberg' by a 'Holstein' and his dam's sire is 'Thoroughbred', giving him grandparents from four different types.

On the race track the Thoroughbred may be in danger of terminal decline even though it is a major established breed. The demise of human civilizations resulting from decadence and dissipation is well documented, and a parallel may be found in the apparent disregard for dysfunction in the Thoroughbred. Selection for a major performance trait, speed, has been pursued regardless of the threat posed by associated defects. The unsoundness and fragility of popular stallions, such as Danzig and Mr Prospector and Raise a Native, is not a safe foundation on which to build the future of a breed (see 'Breeding Policies' in Chapter 4). That fragility and unsoundness were confirmed and emphasized by the summary in the report from Sky News on 30 September 2019 which included a disturbing revelation: 'Last year, nearly 10 horses died a week on average at US racetracks, The New York Times reported, citing the Jockey Club's Equine Injury Database.' Questions on the use of banned substances, lax medication regulations, and even dirt tracks, also were raised as possible contributing factors in the death of horses. The horseracing industry appears besieged on all sides.

Threats to sustainability seem impervious to an effective solution. If the horse racing and bovine dairy industries are used as examples, both are entrenched in the grip of big business, which has little inclination to yield its privileged position. Pessimism may be justified. Many who wield crushing power are reluctant to prioritize public interest above self-interest (see 'The Dark Side' in Chapter 4) and have created an aura of despair in other strata of society, leaving the latter resigned to a feeling that change is not possible. The rate of dispersal of dairy herds in Wisconsin is accelerating: 37% were lost in the decade 2008–2018, but 8% were lost in 2018 alone, although the number

of cows was static. A similar pattern emerges elsewhere. In the UK, 22.6% of herds were lost in the past decade as the national herd became concentrated in fewer and larger herds. Small herds are unable to compete with the economy of scale enjoyed by larger enterprises and suffer unsustainable financial deficits resulting from pressures exerted by wholesalers and supermarkets. The trend accentuates the process of Holsteinization, as other breeds tend to be found in smaller herds. Yet maybe there is a logical solution as far as the future of the dairy industry is concerned. The era of high yields, fuelled by high energy inputs, will come under increasing pressure from a combination of animal welfare concerns, a requirement for more cultivated land to be devoted directly to production of food for the growing human population, and the damaging effect of intensive systems on global warming.

There may be light at the end of the tunnel for endangered breeds of dairy cattle, but it is a long tunnel and the light is dim. The prospect for racehorses is even less reassuring. The Thoroughbred racing industry still has the opportunity to draw back from obvious dangers of unsoundness and obsession with speed, but is unlikely to do so while it is controlled by a 'money is no object' or 'never count the cost' philosophy. Small breeders and stud owners will disappear even faster than dairy herds. If so, the following discussion may be academic but nevertheless is worth pursuing in the hope of discovering answers. Negative arguments are legion but three items in particular can serve to illustrate relevant issues, namely loss of founder lines, the effect of the 'speed gene', and evaluation of outstanding racehorses.

Traits associated with mitochondrial DNA are transmitted directly down a female family, while traits associated with the Y-chromosome are passed down a sire line. There are only three male lines in the Thoroughbred breed and 95% of current stallions are descended in tail male from Darley Arabian. If it proves impossible to find direct tail male descendants of the other two founder lines, there inevitably will be diminished variation (diversity) from the loss of the Y-chromosome of Godolphin Arabian and Byerley Turk lines. The loss is imminent and will cause further erosion of within-breed diversity.

It has not yet been agreed whether discovery of the speed gene (Hill *et al.*, 2010) was a blessing or a curse. The speed gene was not present in oriental founders of the breed and thus it is a legacy of native British racing mares; and probably the extinct Galloway played a role of some importance, or maybe the Spanish Barb via the Irish Hobby. The Quarter Horse in the USA (Fig. 5.3), the ultimate equine 'speed machine', was developed from a mixture of native horses descended from the 16th century Spanish Barb and English animals imported from the early 17th century. Whatever its origin, the discovery of the speed gene made it too easy to test the DNA of a foal at birth and declare an opinion whether it would be best suited to sprints or long distance. As a result, there is a temptation to pay insufficient attention to other important factors such as temperament, robustness and conformation. Equally salient, there may be other genes that determine speed and stamina through different genetic pathways that could lead to alternative hypotheses (Fig. 5.4).

Fig. 5.3. Quarter Horse mare with foal and colt on Purdy Ranch in Wyoming, 1965.

Fig. 5.4. Thoroughbred racehorses at full gallop (Lucas Gojda/shutterstock.com).

Frankel (born 2008) enjoyed a spectacular racing career and inevitably his retirement to stud precipitated a flood of demand for his services. Yearling progeny changed hands for more than 1 million guineas each at Tattersall's Sales in 2019. He was essentially an 8-furlong horse and was unbeaten in 14 starts with a best time of 97.30 seconds (12.16 seconds per furlong). He was retired early, a practice often employed when high stakes are involved, to

avoid the possibility that his huge reputation and 147 Timeform rating might be devalued by a poor race. He had demonstrated undoubted ability, and there is a chance that he inherited some constitutional robustness from his grandsire, Sadlers Wells. By the same logic he may have inherited unsoundness from Mr Prospector and Danzig, as both lurk further back in his pedigree, and it would have facilitated a surer evaluation of his apparent soundness if it had been tested more severely.

It is more difficult to present positive arguments, but evaluation of another high-profile stallion may provide some helpful pointers. Secretariat (born 1970) was an outstanding racer and caught the imagination of most racegoers (Fig. 5.5). His performance in the 12-furlong Belmont Stakes, where he completed his Triple Crown triumph, was an awesome and unforgettable revelation. He won by 31 lengths at an average speed of 12.00 seconds per furlong, and even then his jockey could hardly stop him. His speed almost matched that of sprinters over short distances and yet he did not have an explosive start. He was not a speed horse. Momentum generated by his relentless 7.75 m stride even suggested he might possess a stamina gene. In the 10-furlong Kentucky Derby he simply accelerated throughout the race covering each quarter-mile faster than the one before to create a record which still stands. He was an impressive physical specimen with an unusually large heart (diagnosed post mortem),

Fig. 5.5. Statue of Secretariat at Lexington (Shutterstock.com).

a trait which he likely inherited from his maternal grandsire, Princequillo, and which it is claimed can be traced back through the famous mare, Pocahontas, to the dam of Hautboy, a foundation stallion born in 1690. If the large heart hypothesis withstands critical scrutiny, and if other speed and stamina genes may have contributed to Secretariat's success, it confirms the merit in seeking to encourage a more comprehensive and enlightened approach to breeding the Thoroughbred racehorse. Otherwise, we must assume Secretariat was simply a spectacular one-off racer, unlikely to be repeated.

Other species may not be threatened so severely. The lessons drawn from the examples above may point to sensible policies which could restore a sustainable future, but there are too many 'ifs' and 'buts' to feel great confidence in a positive outcome. Dairy cattle and racing horses both perform in industries motivated by intensive selection for a single major production trait. The acute dangers, and remote opportunities for escape from them, have been detailed above, but are they typical of the problems facing other species? Maybe not so severely, but they are following the same path and will reach the same destination unless appropriate action is taken. The iconic agrosilvopastoral *dehesa* in Spain, covering almost 4 million hectares of oak woodland and grassland and grazed by several species, including the black Iberic pig, is being eroded and degraded by ploughing driven by EU subsidies. More pigs are being housed intensively and crossed, especially with the imported Duroc, which precludes production of the famed *jabugo* ham.

Feeding the world

Discussions on biodiversity and the importance of domestic animal genetic resources often end with the same question: will it be possible to feed 10 billion people in 2050? Should attention be focused on high-yielding, but unsustainable, breeds and varieties in intensive systems? Their production will be greater, at least in the short term, but biodiversity would be compromised, and in Europe imported feed plus 60–70% of cereals and oilseeds are used to feed animals. Or is efficient sustainability of more moderate production a safer and more prudent choice? It would be largely self-sufficient with minimum food miles, and its use of extensive grasslands would not damage biodiversity, which independently is a major factor of sustainability. Simple logic indicates that the latter option is the answer, especially if waste can be eliminated. Waste produces greenhouse gases, and prevention of waste at every stage – production, storage, processing, distribution, retailing and consumption – will be essential. It is tempting and easy to be snared by eye-catching headlines. Annual food waste in the UK is 13.6 million tonnes. North American consumers throw away 110 kg of food per person each year, and the value of the combined waste by retailers and consumers is £133 billion, but it is clear that waste occurs in every country, with the least loss from milk and meat and most from fruit and vegetables. Although producers and consumers are the worst offenders,

the confusion in retailing (supermarkets) caused by 'sell by', 'best before' and 'use by' labelling results in a horrifying statistic that 40% of discarded food is fit to eat.

Our priorities demand that efficiency of production and processing must improve, novel methods of food production must be developed, and especially more cultivatable land must be devoted to the direct production of food for humans rather than animals. The latter point is often conveniently ignored by groups pursuing specialist agendas. An activist campaigning organization, 'Rewilding Britain', advocates abandoning large tracts of farmland and diverting subsidies from direct payments for land ownership (as applied by the EU) to encourage tree planting subsidized at more than £500 per hectare per annum. Restoration of heathland and grassland are given much lower priority at £300 and less than £150, respectively – yet another example of grassland being undervalued. Conservation websites now are peppered with a plethora of new groups lobbying with such expressions as 'holistic management', 'rewilding' and 'regenerative farming'. They may have good motivation or they may simply be jumping on board a bandwagon. More critical scrutiny of their objectives and programmes is necessary before judgement can be passed. 'Impossible Foods', a California-based purveyor of plant-based meat analogues, found it impossible to resist taking a swipe at 'supposed negative health and certain environmental impacts associated with livestock products' when attempting to divert suspicion and criticism from its own genetically modified organism (GMO) soy-based (and other) products. 'Vertical farms' and hydroponics are catchy concepts. The idea of having absolute control over growing plants in high-rise production units (without soil), using mineral nutrient solutions (fertilizer) in a water solvent, has a novel appeal but technology can only take the world so far, and over-reliance brings its own threats and problems. 'Factory meat', hydroponics and other fashionable suggestions are likely to be part of an ongoing discussion and may prove to have a role to play in a future solution, but prudence dictates that we should seek and evolve a wider answer that includes a combination of desirable factors: food production, the environment, quality of life, sustainability. All are relevant.

Blueprint for the Future

Climate change

The debate swirling around climate change has been dominated by 'prophets of doom' with a pack instinct seeking vulnerable targets and howling for the blood of the weakest. The 'pack' includes former government advisers, columnists in *The Guardian*, various fanatics and many others who may have fallen into the trap with the best intentions. There are elements of truth in some of their tirades which, although compromised by a strong whiff of zealotry, must be given due consideration. They aggressively sweep aside any contrary

opinion, but it is there that the kernel of positive and helpful developments may be sought and found.

Before any realistic plan for future development can be instigated it is necessary to determine the truth about GHGs. CO_2 is the major culprit and therefore must be the primary target when seeking to control global warming, to which it contributes 53.8% of anthropogenic emissions, compared with 15.8% by CH_4 and 5.3% by N_2O, with the balance coming from halogenated compounds and tropospheric ozone (Sustainability For All, 2018). Burning fossil fuels stands at the head of the queue, as it accounts for 87% of CO_2 and 33% of CH_4 anthropogenic emissions. In comparison, enteric fermentation of domestic ruminants is a negligible irritant as it only produces 17% of CH_4 emissions and therefore has a trivial effect on global warming. That truth may be able to emerge only when and if the hysteria has subsided. By then it may be too late for cattle. Cattle have borne the brunt of unfairly targeted criticism; and no doubt destruction of the Brazilian rainforest by commercial interests, including beef farmers and soya growers, has swayed emotions and opinions. A balanced evaluation reveals a very different picture. CH_4 degrades rapidly and has a short life of about 10 years, compared with 200 years for 80% of CO_2 (and < 3000 years for the remainder) and 114 years for N_2O, and remains in a relatively stable balance. It fluctuates when a source (fossil fuels, landfill and waste, livestock, etc.) changes. When the number of cattle declined, as it did by 8.1% in Britain between 2005 and 2018 (Defra statistics), there was a reduction in CH_4 production but the correlation is difficult to interpret as it coincided with a reduction of 50% in burning fossil fuels in the same period (Ritchie and Roses, 2020).

However, reduction from other sources of all GHGs offers much greater opportunity to control global warming. There was a significant scaling down in fossil fuel consumption by Britain of 13% between 1965 and 2015. During the same period the global increase was 300%, but the increase in China was more than 2000% (Ritchie and Roses, 2020). Any positive blueprint for the future depends on China, and the USA to a lesser degree, adopting policies which will enable them to match the efforts of European countries and reduce consumption of fossil fuels. That would be a huge step for mankind. It requires governance by national leaders who not only understand and empathize but also apply full and harmonious integration of industry and technology with living systems – symbiosis at a global level (Albrecht, 2015).

Grassland or trees

Another recurring theme in the global warming debate is the insistent demand to plant more trees. Trees certainly have a role to play, but not at the expense of grassland, especially long-term or permanent grassland. Recent research at the University of California at Davis has highlighted the risk of relying on trees as a safe carbon sink and demonstrated that grassland environments, including tree-sparse rangelands, will be more effective carbon sinks in the 21st century

(Dass *et al.*, 2018). Superiority of grassland will become even more evident as global temperatures increase. Already 40% of our planet is a semi-arid environment ravaged by wild fires, not only in the tropics and California or Australia but also Europe (temperate forest) and Canada (boreal forest). Grass in the form of permanent pasture and heath, or even long-term leys, has a significant capacity for carbon sequestration, and stocks of carbon in soil and roots are 150% higher per km^2 than those in temperate forest. It stores 97% carbon underground, which is more reliable and efficient than storage by trees in woody biomass and leaves from which carbon (including CH_4) is released directly into the atmosphere as a result of the annual loss of almost 50 million hectares of forest harvested, or destroyed as in a forest fire or by insect damage. Conversion of grassland to tree plantation monoculture depletes soil carbon stocks by 10% (Ostle *et al.*, 2009), and managed moorland prevents flooding and sequesters carbon more effectively than gloomy subsidized coniferous Sitka plantations where drainage ditches are cut deep into the peat. That research should warn policy makers to beware of those who advance dangerously extreme opinions or use prestigious titles to wield seemingly authoritative theories. Boyd (see 'Industrial Revolution' above) attacks extensive grazing systems and advocates wholesale tree-planting with associated removal of livestock, which would be mainly native breeds (Fig. 5.6). It must be hoped that other and more reliable sources of opinion are consulted by those responsible for policy decisions.

Extensive or intensive

Although evidence is irrefutable that agriculture's contribution to global warming is small in comparison with the industrial contribution, it is necessary to determine which elements of agriculture have the greatest effect. With specific regard to CH_4, burning fossil fuels, waste and landfill, biomass burning and biofuels together total 64% emissions (excluding natural sources). Agriculture

Fig. 5.6. Ustaness heifers on hill grazing in their native Shetland Islands in 2000.

(including rice) contributes 36% with livestock a significant factor. Further analysis within the agricultural industry in temperate ecosystems shows that conversion of grassland to crop land decreases carbon stocks held in the soil by 59% (Ostle *et al.*, 2009) and that intensive (high-yield) systems of production not only are a source of CH_4 and primary source of CO_2 and N_2O, but also favour monoculture, damage biodiversity and are fundamentally unsustainable. Ongoing production of more food from fewer acres is a superficially attractive concept, but it relies inherently on incrementally higher yields and that scenario may be unsustainable (see 'Genetic Plateaux' in Chapter 1).

The relationship of non-intensive grazing systems to carbon emissions was summarized in my paper (Alderson, 2008) written in response to the irresponsible 'Livestock's long shadow' paper. It concluded:

> The contribution of non-intensive grazing livestock to GHG emissions is small, and they utilise land which sequesters carbon, so that overall they are net contributors to carbon sequestration. The negative light in which they have been shown results from lack of evidence or from misinterpretation in some quarters of an FAO report.

Other authoritative voices supported that evaluation by confirming that CH_4, the supposed culprit from livestock enteric emissions, is a powerful but short-lived greenhouse gas which does not accumulate and therefore does not contribute to long-term global warming (Costain, 2019a; Fairlie, 2019). A dedicated blog (Costain, 2019b) addressed the misconceptions and problems of misinformation that have fuelled the attacks on grazing ruminant livestock. It noted that the

> ... current focus on agricultural emissions, centred on biological methane, is likely to drive dangerously unsustainable land use and the further intensification of animal and arable agriculture. Instead farmers [with grazing ruminant livestock] can produce nutritious, affordable, quality food, while sequestering carbon, restoring nature, delivering mitigation against extreme weather, and establishing rural economic resilience.

The revised measure of global warming potential (GWP*) confirms that methane from Britain's ruminants is not causing global warming (Allen *et al.*, 2018). On the contrary, grazing cattle and sheep are combating climate change in temperate ecosystems (Allard *et al.*, 2007).

Global grasslands

At face value, the argument is simple with a glimmer of optimism. Upland pastures sequester carbon efficiently and reliably; cattle and sheep on those pastures are a food source; grazing uncultivatable grassland is carbon efficient, productive (food and other products) and a desirable element of quality of life. Deeper examination reveals that those benefits may be conferred by several variations, including mob grazing, conservation grazing and wood pasture.

Such systems merit greater political recognition and support and should be promoted for their beneficial effect. Wood-pasture (*silva pastilis* in the Doomsday Book) offers a combination of the benefits of trees and grassland, which is the most efficient system of carbon sequestration and a sensible balance in contrast to extreme suggestions of wall-to-wall tree planting. Grassland or heath hosts a scattering of trees, pollarded just above cattle browsing height. Cattle are an essential component of the habitat as their grazing prevents the mass regeneration of trees. They perform a similar function in forest glading. My own herd of ancient White Park cattle evolved in wood-pasture and were used to restore forest glading in Savernake Forest. It seems very positive, but do not let optimism become complacency.

The massive global loss and degradation of soils described above puts an urgent and more sombre aspect of any assessment of future sustainability. At the same time it focuses attention more acutely on the requirement for remaining areas, which are found especially in temperate regions, to maintain food production. Locally adapted livestock on upland grazing are a vital part of the equation. Yet in Europe the acreage payment of EU subsidy after 2005, de-coupled from production of livestock or crops, led to a significant decline in the upland sheep population (SAC, 2008) which was compounded by attempts of some conservation bodies in the UK to remove sheep from their natural upland and moorland grazing environment (Fig. 5.7). It was counter-productive as reduced grazing, or lack of grazing, permitted invasion by worthless bracken and scrub, with an adverse impact on biodiversity.

Fig. 5.7. A Swaledale ewe on Pennine moorland (Shutterstock.com).

Almost all heather moorland, extending to more than 1 million hectares, is found in the British Isles, where it enjoys cultural and iconic status. When managed by a combination of controlled grazing by sheep, predator culling to protect native birds, and regulated burning, it increases biodiversity, stores carbon underground, reduces the risk of flooding, and is a beautiful landscape. Yet a shameful problem was created. To aggravate the problem further, some environmentalists continued their short-sighted and ill-advised urging of government to remove cattle and sheep. They have tipped the scales far beyond sensible balanced policies. Wildlife Trusts and similar organizations should reflect and consider that production of healthy food from otherwise unproductive land will become an increasingly valuable and essential long-term contribution to nutrition in the UK and elsewhere.

Grasslands in the widest definition occupy about 35-40% of the world's terrestrial area excluding Antarctica, equivalent to approximately 50 million square kilometres (Box 5.1). They vary in type and nutritive value from upland grazing on land unsuitable for cultivation in temperate climates to Himalayan mountain grazing. The largest area is the Nagqu Grasslands in Tibet inhabited by nomads with very little cultivatable opportunity and no industrial development. Other significant areas are the prairies of Canada and the Great Plains of the USA, the belt of Sahelian acacia savanna across Africa, and the Australian savanna, which experiences extreme temperatures and wildfires. The Llanos grasslands in northern South America and the Pampas in southern parts both allow limited cultivation (Fig. 5.8), but the Andean Altiplano with an average elevation 3660 m above sea level is largely covered by the puna grassland ecosystem with herding of camelids (Fig. 5.9). The Kazakh steppes experience intensely cold winters (Fig. 5.10), but the Manchurian Plain, Huben Buir Grassland (Mongolia), Great Hungarian Plain (which includes the puszta) (Fig. 5.11) and similar ecosystems have sufficient fertility and climatic benevolence to allow small-scale farming.

A more detailed analysis identifies 2 billion hectares of permanent grassland not suitable for cultivation of crops (which support active populations of maybe 2 million nomads and transhumant populations), plus 2 billion hectares of barren land. Grazing more of these vast areas of uncultivated grassland, upland heath and rough pasture around the world would not only augment food supplies for the increasing human population, but also contribute significantly to the control of global warming. Livestock additionally contribute a dimension of aesthetic pleasure to enhance quality of life, a factor that should not be ignored. It is an uplifting experience to see traditional Tudanca cattle on their upland grazing in the Picos de Europa above their native Nansa valley in Cantabria (Fig. 5.12), or to walk in the hills following the melodious sound of sheep bells first used 5000 years ago in China, or to recall the memory of ruminating camels resting under the shade of a tree in Wadi Rum (Fig. 5.13). It is yet another scenario which justifies the conservation of locally adapted breeds of livestock.

Box 5.1. Grasslands

Total global land area: 149 million sq km
Forests: 39 million sq km
Barren land: 28 million sq km
Large areas of barren land may have limited potential for maintaining any viable system of livestock production.
Grasslands: 24 million sq km
The major areas of extensive grasslands are the African savanna, Russian/Siberian steppes, South American Pampas/Campos/Llanos, North American prairies and plains, Mongolian and Chinese plains, with smaller areas in Australasia and Europe.
Individual locations:
Peruvian Altiplano: an area in the central Andes, occupying parts of Chile, Argentina, Bolivia and Peru; average elevation (3660 m) is only slightly lower than that of the Tibetan Plateau; grazed by herds of camelids which usually are housed at night as protection from predators.
Pennine moorland in northern England: blanket bog on deep peat soils over limestone; elevation c. 550 m (max < 900 m); vegetation is heather, purple moor-grass and bilberry; grazed by black-faced horned sheep; livestock use limited by environmental restrictions and grouse shooting.
Hungarian puszta: alkaline steppe which is part of the Eurasian Steppe; partially cultivated but noted for the conservation of native breeds of grazing livestock such as Racka sheep and Grey Steppe cattle on alluvial sands with elevation < 100 m in Hortobágy National Park.
Note: areas of land type may vary according to different systems of classification.

Fig. 5.8. Pantaneiro horses on Pantanal in Brazil in 2000.

Biological diversity

Cary Fowler summarized the significance of diversity concisely in an interview with Rachel Nuwer for BBC Future in 2014: 'Diversity is the most effective, easiest, cheapest and most sustainable way to help agriculture adapt to change' and local adaptation in domestic livestock is an important ingredient

Fig. 5.9. Farmed llama on Altiplano in Peru in 2016.

Fig. 5.10. Sheep flock on upland pasture in Uzbekistan in 2018.

Fig. 5.11. Grey Steppe herd on puszta with a red calf in 1991.

Fig. 5.12. Tudanca cattle changing pasture in Picos de Europa in Spain in 2015.

Fig. 5.13. Camels resting in Wadi Rum in 2018.

for sustainability. A significant recommendation of the PigBioDiv project was 'to define marginal breed contributions to both within- and between-breed diversity, and to combine those contributions according to the objective of diversity pursued' and noted that 'more than half the total European breed

diversity of the pig could be assigned to local breeds' (Ollivier *et al.*, 2005). It reinforced the opinion that local breeds such as the Tamworth and Euskal txerria, as distinct from mainstream and industrial breeds, embody valuable resources that should not be neglected or discarded. The publication in the UK of the Agriculture Bill (2020) not only confirmed the continuation of financial incentives to support native breeds but also demonstrated a welcome understanding by government of the importance of genetic resources. The measures proposed could be used

> ... to incentivise farmers to invest in rearing rare and native breeds or species, because these genetic resources may offer a way to sustainably increase food production and/or improve our capacity to adapt to climate change or the emergence of new animal or plant diseases by providing a breadth of genetic traits

and also

> ... to incentivise existing gene banks to safeguard UK native and rare breed genetics or to provide on-farm measures to manage disease risks amongst populations of rare breed livestock.

It gives reason for optimism and provides a blueprint for similar policies in countries which have not yet espoused biodiversity through the support of native breeds.

Further development of domesticated species for new purposes might offer more possibilities to maintain and reinforce biodiversity. Camels have been regarded historically as beasts of burden with extreme adaptation to desert conditions. Climate change may allow expansion into new regions such as Australia, where currently feral camels are culled as pests. Already selection is leading to development of types more suited to the dairy and clothing industries. Camel hair is a recognized raw material for fabric production. Bactrian camels (Fig. 5.14) produce the best fibre and the insulating short undercoat

Fig. 5.14. Bactrian camels in Uzbekistan in 2018.

of fine fibres (diameter 5–40 microns) is used in the manufacture of warm, comfortable fabrics ranging from knitwear to rugs. The coarse fibres of the outer coat are used more in industrial fabrics, but camel hair carpets are reputed to have additional properties which cure rheumatism and repel insects and snakes. Camel milk is seeking to gain a foothold in the food industry and world production in 2017 was already almost 3 million tonnes, with Somalia and Kenya the leading countries. It is easily made into yogurt, but cheese manufacture has proved difficult and the content of both fat and lactose is lower in camel milk than cow's milk (Yagil *et al*., 1994). Further work in research and breeding may overcome the problems and the camel may then increase diversity in domestic livestock.

Sustainability

There are signs that the dairy cattle industry may achieve sustainability. Traits of local adaptation, robustness and thrifty utilization of uncultivated grassland, along with products of high quality, are increasingly being appreciated. The Northern Dairy Shorthorn, a critically endangered breed with fewer than 200 cows (93–100% pure), continues to graze the low-quality herbage of its native upland pastures on the Pennine hills in northern England (Fig. 5.15), while small breeding units of its close relatives in the Shorthorn group

Fig. 5.15. Northern Dairy Shorthorn heifers on rough grazing in Derbyshire in 2006 (W. Grayson).

persist in North America and Australasia. The Tarentaise (France), Évolène (Switzerland), Angeln (Germany) and other minority breeds have followed a similar pattern, but other breeds have abandoned milk production and survived only by reinventing themselves as a beef breed. At present those issues are not properly appreciated by policy makers or by the media. It is a challenge to ensure that their lack of understanding is remedied before currently endangered but potentially valuable breeds become extinct.

In the racehorse breeding industry there may be a possible, but remote, chance that other genes which determine speed and stamina through different genetic pathways could offer a route to diversity and sustainability. Sadlers Wells (born 1981) was linebred (4×5) to Hyperion (Fig. 5.16), a tough pony-sized stallion which did not possess the speed gene but nevertheless won the Derby in record time in 1933 and was champion sire for 6 years. Sadlers Wells was subjected to a testing campaign as a 3-year-old and was awarded a 132 Timeform rating. He started in nine races and demonstrated a combination of soundness and temperament to complement his obvious talent. He also passed the ultimate test by transmitting his quality to his progeny, not only classic winners but also Istabraq, which won the 16½-furlong Champion Hurdle three times. His son, Montjeu (1996), was a 12-furlong racer and won 11 races from 16 starts, including the prestigious l'Arc de Triomphe. He continued racing as a 4-year-old before retiring to stud where he sired Authorized, who in turn sired Tiger Roll, which was only 15.2 hands high but twice won the Grand National 4¼-mile steeplechase handicap, a formidable test of athleticism and

Fig. 5.16. Statue of Hyperion, champion Thoroughbred sire, at Newmarket.

stamina. It is likely that Authorized will be sidelined in the blinkered search for sprint horses, but he should be prized as a beacon of hope for the future. As big money drives the race industry it is noteworthy that Grand National prizemoney in 2019 was £1m spread over the first ten horses to finish, with £561,000 to the winner. That is dwarfed by the US$6 million prizemoney paid in 2019 to the first three to finish in the Breeders' Cup Classic (the race in which Mongolian Groom was destroyed), and does not quite compare with the Epsom Derby where £1.625 million also was shared among fewer animals. Nevertheless, it is enough to suggest that racing should not be focused exclusively on a single objective of speed over short distances. Even if that does not prove possible, there may be opportunities to learn lessons from the mistakes of horseracing.

The pessimistic evaluation of the horseracing industry, and qualified ambivalence regarding the dairy cattle industry, does not necessarily extend to other species. Pigs are beset by similar problems in the mass market, but *jabugo* ham from black Iberic pigs provides a blueprint for exploitation of a premium market. Pierre Oteiza demonstrated the potential of specialist markets with an endangered traditional breed of pig, and pig meat probably benefited most in the Rare Breeds Meat Marketing scheme in the UK in the 1990s. Camels have not yet realized their full potential but are making dramatic progress. Breeds of native beef cattle and sheep have been accused of lagging behind the progress made by other livestock, but that may prove to be a boon. They have avoided the straightjacket of intensive farming and have placed higher priority on local adaptation and ability to thrive in sustainable non-intensive systems of farming. They are more likely to find opportunities on the vast areas of grassland around the world, although they will need to refute those unfounded opinions which fail to recognize obvious distinctions between different farming systems and associate all cattle, and sheep to some extent, with destruction of the Brazilian rainforest for logging, growing soya and beef cattle. Adaptation will be an increasingly coveted quality as both climate and market place shift unpredictably. Local adaptation, which often is associated with geographical endemism and endangered status, underlies the efficiency of Rough Fell sheep on the Howgill fells of Cumbria in northern England, Herdwick sheep in the Lake District and colourful Damara sheep in southern Africa adapted to an unforgiving environment by natural selection.

It may seem incongruous to return to dairy farming at this juncture but on upland Pennine pastures in the Yorkshire Dales, home to curlew and lapwing and cheek by jowl with iconic heather moorland and grouse-shooting syndicates, two farmers are exploring a significant alternative strategy. Northern Dairy Shorthorn cattle (Fig. 5.17), the hardy locally adapted dual-purpose breed, are being milked to produce specialist cheeses from herb-rich grazing on low-input systems. Much is owed to such people who are prepared to demonstrate their belief in local breeds and self-contained traditional systems. The superiority of health-giving polyunsaturated fatty acids (PUFA) in pasture-fed beef and mutton, and the quality of eggs from hens on genuine free-range systems, fall

Fig. 5.17. Northern Dairy Shorthorn cows in snow on Pennine pastures in 2019 (A. Hatton).

into the same category. They are part of a new and thoughtful philosophy that places biodiversity high on their agenda, alongside associated benefits of quality of life for humans and animals, products of high quality, combating climate change and releasing fertile land to grow crops for human consumption.

Feeding the world

Providing sufficient food for 10 billion people by 2050 is a daunting challenge, but the task is even greater. People will not stop eating in 2050 and thus sustainability must be an integral part of the equation. Measures put in place must be capable of ongoing application and production. Earlier discussion indicates clearly that efficient sustainability of more moderate production must take precedence over intensive systems. The lack of sustainability of the latter has been described in the preceding pages and chapters, but less intensive production will demand that more land must be devoted to the direct production of food for humans rather than animals, novel methods (or maybe traditional practices) must be applied, efficiency of production and processing must be improved, and finally waste must be eliminated or at least reduced.

Locally adapted and endangered breeds have the credentials to meet those requirements. Livestock is a major resource in developing countries where the

majority of poverty is found, and rural populations depend on them as a vital component of their livelihood (Hoffmann and Scherf, 2005). They provide a wide range of valuable products, extending beyond the staples of milk, meat, eggs and wool to draught power (Fig. 5.18), fertilizer, heating fuel and cultural value such as ceremonial functions and dowries. Vast areas of uncultivated grassland and heath provide an environment to which native breeds are finely adapted. Pelts of lambs of locally adapted fat-tailed Karakul sheep from Central Asia are used to make haute-couture Astrakhan hats, while the Red Maasai (also fat-tailed) in Kenya has strong resistance to gastrointestinal nematode parasites. The aptly named Vietnamese Pot-Bellied pig, once dubbed a 'pet pig', can be reared in extensive systems and has good resistance to pests and diseases, while the flexible skin of purebred N'guni cattle (Fig. 5.19) is resistant to ectoparasites on the South African Highveld and the crosses with Jersey cattle thrive in more benevolent conditions.

The future of livestock in the developed world is more precarious, but gradually there is an increasing body of opinion defining the benefits of new policies. Intensive farming is the major agricultural contributor to global warming. Refocusing livestock production on extensive (permanent) grasslands, with high carbon sequestration and storage capacity, would not only combat climate change but also confer a range of other benefits. Locally adapted upland breeds of sheep have retained some hold on their native territory but it is essential that policies to remove them must be reversed. Replacing long-legged angular Holstein cattle with functional thrifty dairy breeds, and using natural breeding herds of animals of robust rusticity and good locomotion, instead of bulky muscle-bound beef breeds, would be an immense aid to biodiversity, would remove the need to import feeding-stuffs such as soy and maize,

Fig. 5.18. Draught oxen drawing water from a well in Rajasthan in 2016.

Fig. 5.19. N'guni herd at Makatini, with colour variation, in 1994.

would minimize food miles, would improve the quality of livestock products and would release fertile land for the growth of crops for direct human consumption (Alderson, 2008; Poux and Aubert, 2018). Intensively farmed pig and poultry populations in Europe consume 80% of livestock concentrate feed (Poux and Aubert, 2018) and inevitably would be reduced drastically. They could find a role as outdoor scavengers of arable areas under revised methods of cultivation. Ruminants consume the remainder of concentrates but two-thirds of their diet is grass. The proportion of forage is even higher in the diet of traditional breeds of cattle and sheep with local adaptation and should ensure that they are an essential component of a sustainable future.

Conclusion

Thus a coherent process of philosophical enquiry and rigorous evaluation, without diversions of misinformation or misconceptions, indicates a possible route from the current state of uncertainty that besets the world to a future that embodies sustainability and embraces quality of life in an environment of fulfilling biodiversity. Farm animal genetic resources are an integral and essential part of that diversity.

1. Prevent global warming by reducing emissions of GHGs. The primary target is reduction of burning fossil fuels. International governmental action is an essential prerequisite.

2. Prevent soil degradation and loss by changing agricultural systems of intensive production. International governmental intervention may be necessary.
3. Recognize and prioritize the value of sustainable non-intensive systems of agricultural production. Most intensive systems reduce biodiversity and are not sustainable.
4. Recognize and prioritize the value of long-term grassland, not only because it covers a vast area of our planet but also because it has a dual purpose of reliable carbon sequestration and providing grazing for food-producing animals.
5. Utilize the special value of native breeds with local adaptation and functional efficiency, which yield healthy food from carbon-sequestering grassland and increase genetic diversity by avoiding selection for a single major trait.

The outcome will depend on the successful negotiation of obstacles in steps 1–5 within a short time frame. Among many other benefits it would celebrate the successful conservation of farm animal genetic resources (saving rare breeds) and I may have the pleasure again of seeing Northern Dairy Shorthorn cattle, Dales ponies and Teeswater sheep fulfilling their traditional functions of yesteryear. The alternative, in the worst scenario, is shrouded in pessimistic prognoses of global warming, land degradation and loss of biodiversity which will ensure catastrophic failure of the human 'experiment' and loss of life as we know it.

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The Quest to Conserve Rare Breeds

Setting the Record Straight

Lawrence Alderson

Since the middle of the twentieth century the world has witnessed a succession of political and social disruptions. Globalisation, technological advancement, climate change, human migration, war and conflict – all have caused major worldwide upheavals.

In this light, it's unsurprising that conservation of rare breed animals has been neglected. Yet the preservation of these genetic resources – this biological diversity – is an essential ingredient of sustainable life on Earth, and not something we can afford to lose.

This book challenges often repeated 'facts' about livestock farming, straight from the horse's mouth. In it, rare breeds expert Lawrence Alderson CBE argues for a reasoned and evidence-based approach from political and public circles. Correcting misconceptions as he goes, he recounts the creation and development of the rare breed conservation movement, addresses extinctions and genetic safe-guarding measures, and considers where we go from here. Challenged as we are by climate change, sustainability and feeding the world, perhaps it is these endangered animals that hold the answer – perhaps with them, we can adapt to our changing environment and see a way forward to a more certain future.