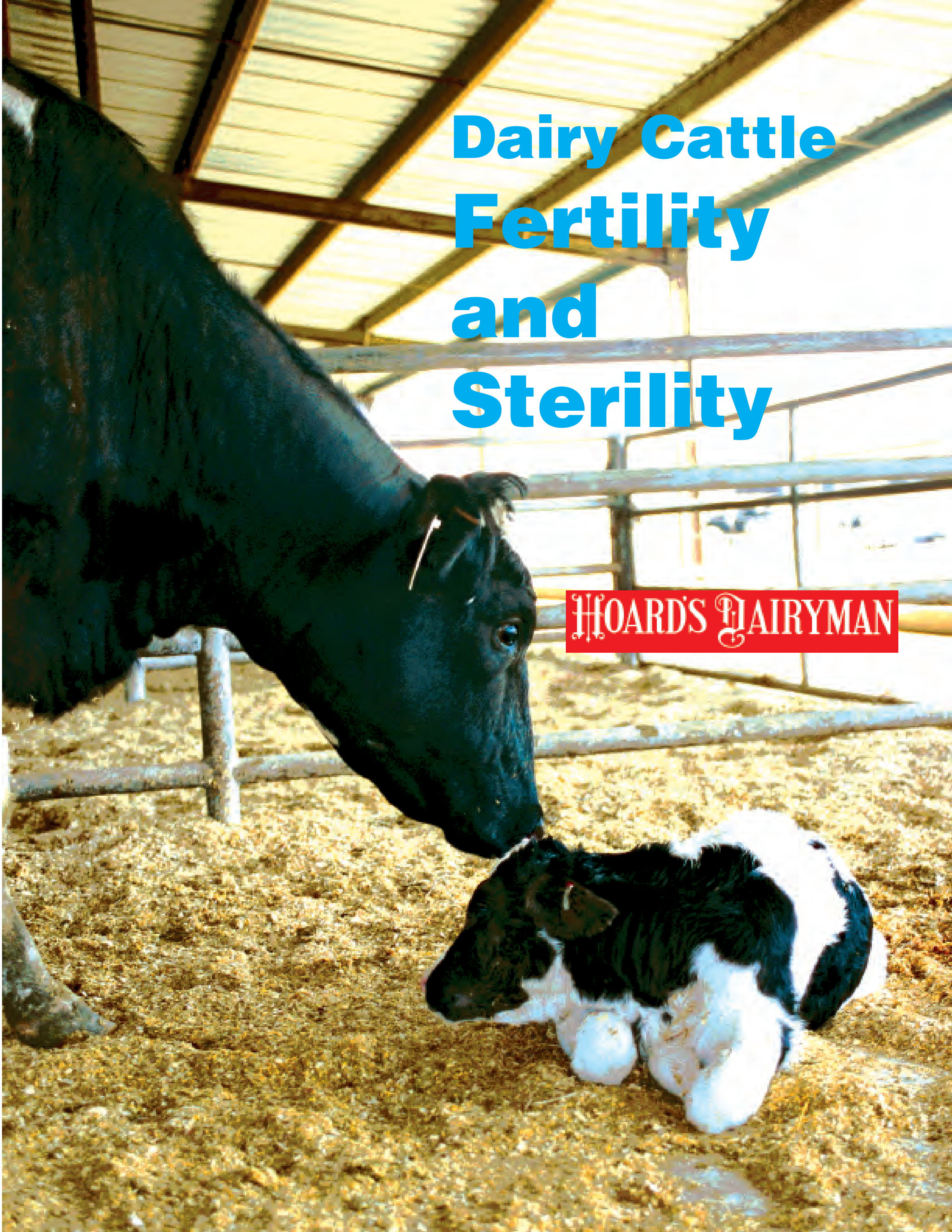
Dairy Cattle Fertility and Sterility



HOARD'S DAIRYMAN

Dairy Cattle

Fertility and Sterility

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Produced in cooperation with the
Dairy Cattle Reproduction Council

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ISBN 0-932147-51-8

Foreword

We are pleased to offer this newest edition of DAIRY CATTLE FERTILITY AND STERILITY. This is an important title in our dairy library, and we are fortunate to have had the talents of a number of authors in the writing and updating of several editions of this book over the past 40 years. In this time over 300,000 copies of this book have been sold.

The original writing of authors Harold D. Hafs and Louis J. Boyd provided the book's backbone. Ray L. Nebel, formerly associate professor of reproductive physiology and extension specialist in reproductive management in the department of dairy science, Virginia Tech at Blacksburg, and currently reproduction solution specialist with Select Sires, oversaw the book's revision in 1996 along with Jeffrey S. Stevenson, professor of reproductive physiology at Kansas State University; and W. S. Swecker, DVM, College of Veterinary Medicine, Virginia Tech at Blacksburg.

Ray Nebel and Ellen Jordan, professor and dairy extension specialist with Texas A & M University, have been instrumental in coordinating this new edition based on the first conference proceedings of the Dairy Cattle Reproduction Council (DCRC) in Denver, 2006. The authors and their papers are listed following the chapters, and Hoard's Dairyman is greatly indebted to the cooperation of these authors as well as the DCRC in making this update possible. Special thanks also goes to Dr. Rick Halvorson, a veterinary practitioner in Whitewater, WI, and Mike Hutjens, extension dairy specialist at University of Illinois, for their reviews.

We hope that everyone will find this newest edition full of valuable and practical information and that FERTILITY AND STERILITY will continue to have favorable influence on dairy cattle reproduction.

HOARD'S DAIRYMAN

Contents

Introduction

Of the 9 million milking dairy cows in the U.S., all have this important trait in common: they have calved one time. And to stay in their herds and continue to produce milk, they need to calve again.

Yet for all the progress in dairy cattle management, getting cows to complete the reproduction cycle is less successful today rather than more: there are many reasons, some less obvious than others. Some sobering statistics are that of each 100 inseminations, an average of only 28 calves will result. And each pregnancy that does not go to full term costs close to $1,000 in today's dollars, or even more, taking into account the high value of replacement heifers. Thus, it's a real struggle for an operation to be self-sufficient in providing its own replacements, much less try to expand without buying outside animals.

Here is a brief list of the basic reproductive challenges cows are up against today:

– Erratic cycling.
– Not showing heat.
– Not being caught in heat.
– Not being bred on time.
– Not being bred correctly.
– Fertilization failure.
– Early embryonic death.
– Abortions, seen or not.
– Calving problems.

Complicating matters are the often subtle effects of many other factors, including:

– Medical events at or near the previous calving.
– Herd disease status.
– Nutrition.
– Body condition score (BCS).
– BCS changes.
– Vaccination protocol.
– Mastitis.
– Weather.
– Housing.
– Crowding.
– Stress level, and essentially everything that contributes to it.

Ironically, while we've bred and managed for higher milk production, fertility is a victim of this success. There are no clear answers why fertility is reduced in high producing cows, but it's an accepted fact that today's high producing cows just do not breed back or carry a calf to term as easily.

So while there are no simple answers, there are many approaches that involve doing the little but important things to make cows comfortable, disease- and stress-free, on an ideal nutritional plane and of course, optimize response to the cow's reproductive cycle. Addressing fertility problems and approaches to improve dairy cow reproduction is the goal of this book.

Based on Hoard's Dairyman's Western Watch,
Dec. 2006, by Dennis Halladay

1 – Infertility and sterility: a huge loss

When a high producing cow has to be culled for failure to breed back, the dairyman not only loses a valuable member of the herd, but also loses the opportunity to cull a less valuable, lower-producing herdmate. Infertility continues to rank as one of the major reasons for involuntary culling in dairy herds. When too large a proportion of cows are culled for infertility, the average milk yield for the herd may decline. Even today with modern veterinary medicine, reproductive failures are all too common in most dairy herds.

There are many false ideas about infertility and sterility. First, sterility is not a disease in itself. Rather, it may be the result of several diseases or malfunctions working together or separately. As a result, each case must be diagnosed and treated individually according to its own symptoms.

The large number of causes complicates diagnosis and treatment, making sterility or infertility one of the most difficult problems for dairymen and veterinarians. Since sterility is not a disease caused by one specific agent, there is no universal cure-all.

The terms "sterility" and ''infertility" will be used frequently, so let's be perfectly clear.

Sterility describes the animal that cannot reproduce. Infertility, on the other hand, describes the animal that is neither normally fertile nor totally sterile.

A bull that produces no sperm cells is completely sterile. A "freemartin" heifer, because she was born twin to a bull, is usually sterile.

Animals such as these must be culled from the herd—a direct financial loss. But these are the easy cases. They are relatively easy to detect and can be culled before they become too costly.

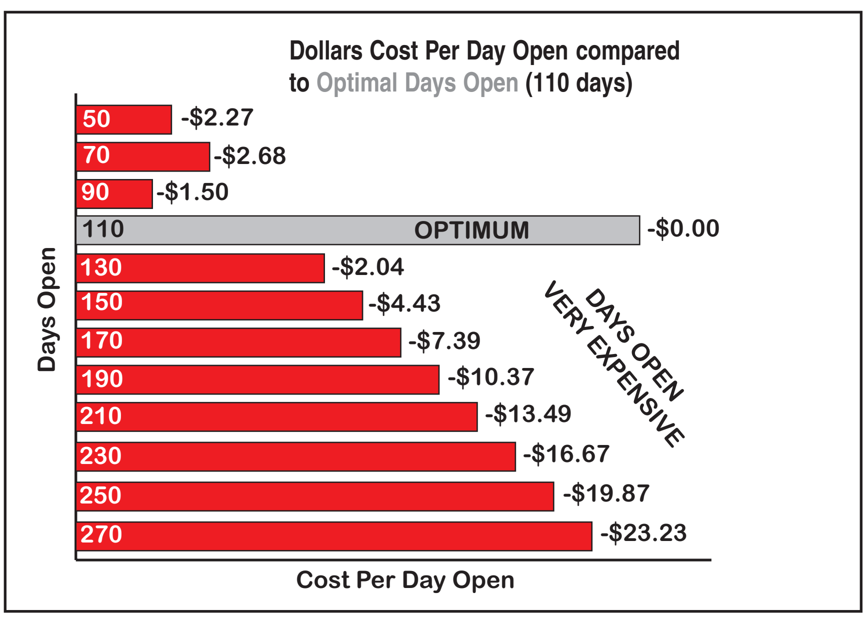
We usually think of a "normal" cow as one that conceives the first or second time she is bred. But more typically, we have cows that are somewhere between completely sterile and "normally" fertile.

These are the frustrating cows that may not be observed in estrus or must be bred several times before they settle, and consequently, do not freshen at the desired time.

Any time a cow fails to conceive from a single service or a series of services, or if she aborts or fails to produce a live, healthy calf every 12 to 13 months, she creates a loss. Dollar losses result from less milk per day of life, because more days are spent in late lactation when milk yield is low; from higher semen costs, because more units of semen must be used to obtain each pregnancy; from culling of infertile cows; from lack of herd replacements, because fewer calves are born; and from higher veterinary costs, because examinations and treatments increase in an effort to get cows to conceive.

Overall conception rates of lactating dairy cows in the U.S. have declined since the 1950's, while

THE COST PER DAY that a cow is open past the optimum becomes expensive quickly: multiply this in a herd that often falls short of this optimum and it can represent many thousands of dollars per year. Source: Milo Wiltbank, University of Wisconsin



annual milk yield per cow has increased 3.3 times from 2,410 to 8,061 kg (5,300 to 17,735 pounds). Given the inverse relationship between milk yield and fertility, it is no wonder that a genetic antagonism exists between some reproductive traits and milk yield; this is seen particularly in first-lactation cows. However, sound management practices can overcome this inverse relationship to achieve acceptable rates of reproductive efficiency.

Over 30 percent of our cows are culled each year. DHI records show that culling rates due to reproduction and mastitis are about equal and actually rank above milk production as reasons for cow removal. If the involuntary cow losses attributed to infertility could be reduced, dairymen could cull more strategically. Depending upon the herd goals, either the number of cows culled could be reduced or more emphasis could be placed on milk production.

Progress made. Tremendous progress has been made in understanding normal reproductive processes in cattle. This understanding resulted first in widespread use of artificial insemination, followed by development of procedures for embryo transfer, and most recently in programmed breeding through synchronization of estrus. New treatments for reproductive disorders have been discovered—many of which use naturally occurring compounds that are more desirable than some treatments used in the past.

However, automation and increased efficiency on dairy farms have resulted in larger herds with more cows in total or semi-confinement. This, along with the tremendous increase in milk production per cow, has created a situation where cows may now be more vulnerable to reproductive problems. Therefore it is essential to apply the latest information in herd management to maintain the herd's reproductive performance at optimum levels. Only through careful and skillful management can the dairy producer avoid the losses due to infertility and sterility that occur in many herds.

A LIVE CALF is the goal when combatting infertility in dairy cows.

2 – The bull’s role

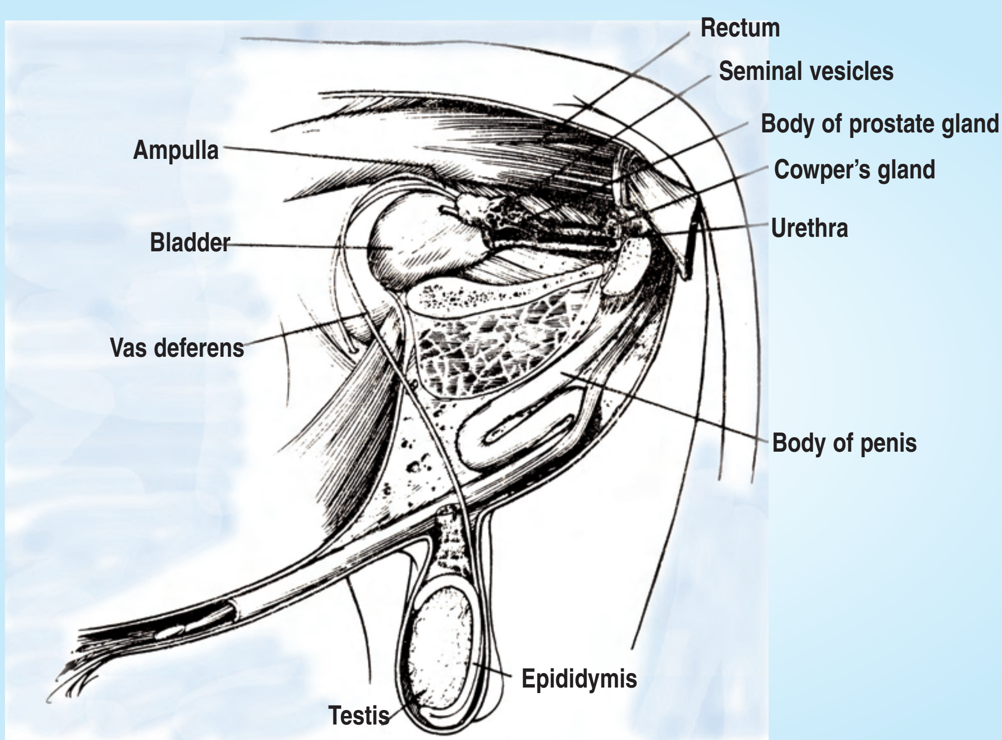
The bull’s role in reproduction in a dairy herd is often overlooked because many times he has been replaced by a liquid nitrogen tank containing frozen semen. However, many bulls are still used on dairy farms. Even if artificial insemination is used exclusively on a farm, the bull’s role is still essential.

The only reason we need a bull is for the sperm he produces. Sperm cells, which are necessary to fertilize the egg and produce a pregnancy in the cow, are manufactured in the two testes. Each testis is a completely separate unit, and is located in its own compartment within the scrotum.

In the scrotum, the testes are somewhat cooler than body temperature. Actually, the scrotum is a “temperature regulator.” By raising or lowering the testes, the scrotum provides a relatively constant temperature that is lower than body temperature. The lower temperature is essential for sperm production.

Before the bull calf is born, his testes are formed and located in the abdomen. Before birth the testes descend to their adult position in

ORGANS OF THE BULL. Sperm are formed in the testis and then move into the coiled epididymis surrounding the testis. When they reach the tail of the epididymis, they are ready for ejaculation. Total time from formation to ejaculation is 7 to 8 weeks. At ejaculation, sperm travel up through the vas deferens and then are mixed with fluids from the seminal vesicles and prostate glands.



the scrotum. Occasionally, one or both of a bull's testes remain in the abdomen. A bull with this condition is known as a "cryptorchid." If both testes remain in the abdomen, the bull is totally sterile. The testes will produce no sperm because of the high body temperature. Even though he is sterile, this condition may not affect the bull's libido (sex drive).

If only one testis descends into the scrotum, it is the only one that functions. The bull will produce about half as many sperm as would normally be expected.

Even with only one descended testis, a bull should produce sufficient sperm to provide for near normal fertility in natural mating. However, a bull with this condition **should never be used**, regardless of his genetic ability, because the condition is inherited.

Within a testis, sperm are produced in thousands of microscopic tubules (seminiferous tubules) which join larger tubules at the core of the testis. Over a period of several days, the cells lining the small tubules divide eight times to form immature sperm cells. Fluid produced in the tubules flushes the sperm along its length into larger tubules at the center of the testis.

The sperm next pass into a group of approximately 15 tubules which collect the sperm as they leave the testis near its top side and enter the head of the epididymis. An epididymis is located along the side of each testis and consists of three parts that are not clearly distinguished. They gradually form one highly coiled tube about 100 feet (30 m) long. As sperm reach the epididymis, they are immotile and cannot fertilize an egg. During passage through the epididymis, which takes about 2 weeks, sperm cells change both physically and chemically. During this time they become mobile and gain the capacity to fertilize an egg. Only sperm in the tail of the epididymis, located along the bottom of the testis, are available for ejaculation.

About 7 or 8 weeks are required from the time a sperm cell begins its formation in the testis until it is available for ejaculation in the tail of the epididymis. Consequently, if a bull is infertile today, we may have to search back two to three months to find the cause.

The photograph (lower right, this page) illustrates the complexity of the sperm-producing machinery. It is highly susceptible to a variety of injuries. An injury to the testis may result in the formation of an area of scar tissue destroying many sperm-producing tubules and blocking many others.

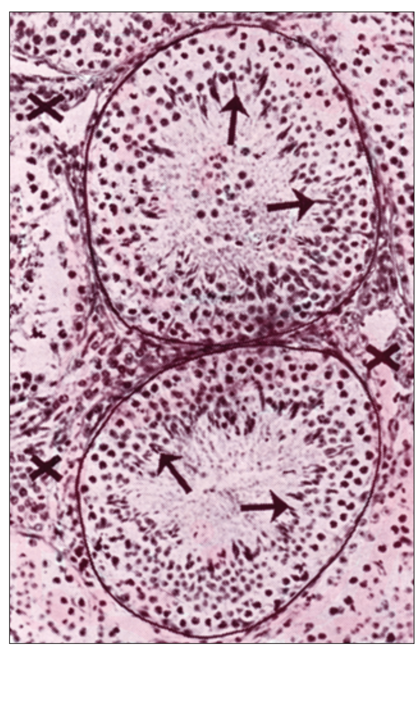
The tail of the epididymis joins the vas deferens (a 2- to 3-foot-long duct; 60 to 90 cm) which carries the sperm to the base of the penis near the urinary bladder. In the testis, epididymis, and vas deferens, sperm are not motile. Presumably, immobility conserves their energy until ejaculation, when they begin swimming vigorously.

In most bulls, sperm production goes on continuously from puberty until death. However, older bulls produce fewer sperm because of damage and degeneration of some of the spermatogenic tissue.

Ejaculation forms semen. At the moment of ejaculation, split-second muscular contractions of the vas deferens and epididymis propel sperm into the penis. At the same instant, contractions of the accessory glands force their fluid contents into the penis. The resulting mixture of sperm with fluid (semen) is instantly propelled through the penis to the outside.

BULL TESTIS has been dissected out of the scrotum. The epididymis is on the top and left side of the testis. Vas deferens exits from the bottom at right.

TESTIS AS SEEN THROUGH A MICROSCOPE. Two tubules, within which sperm are produced, are outlined. Elongated dark spots (arrows) are newly formed sperm heads. Testosterone, the male sex drive hormone, is produced by the cells (x) between tubules.



Sperm make up only about 20 percent of the total volume of semen. The rest of the ejaculate comes from the accessory sex glands located along the bull's reproductive tract.

The main accessory glands are the seminal vesicles, located at the base of the penis near the urinary bladder, as shown in the diagram (see diagram, page 9). Fluid from the seminal vesicles is rich in fructose, a sugar serving as an important nutrient for sperm.

The volume of fluid contributed by the prostate and Cowper's glands is small compared to that of the seminal vesicles. Fluids from the prostate and Cowper's glands flush out the penis, cleansing and lubricating the urethra and adding only a small volume to the semen. Fluid from the accessory sex glands functions as a media or carrier of sperm, providing energy for metabolism and proper pH and salt balance. However, these fluids only maintain sperm survival for a short period of time. Either the cow's fluid or chemically defined extenders are needed to prolong the life of sperm.

The testes are regulated by hormones from the pituitary gland. In turn, the testes produce the male sex hormone, testosterone, which controls the development and secretion of the secondary glands. Thus, the testes have a dual function; producing sperm and the male sex hormone.

Testosterone is manufactured by the cells that separate the small sperm-producing tubules in the testes. This hormone is responsible for the male sex drive (libido). Malfunction of the testosterone-producing cells of the testes also can cause infertility, usually because of a lack of libido.

At about 6 to 9 months of age, bulls reach puberty and start producing sperm cells. The onset of sperm production (spermatogenesis) is controlled by hormones produced by the anterior pituitary gland. The primary hormones from the pituitary that stimulate sperm production are luteinizing hormone (LH) and follicle stimulating hormone (FSH). However, other pituitary hormones such as prolactin may also be involved.

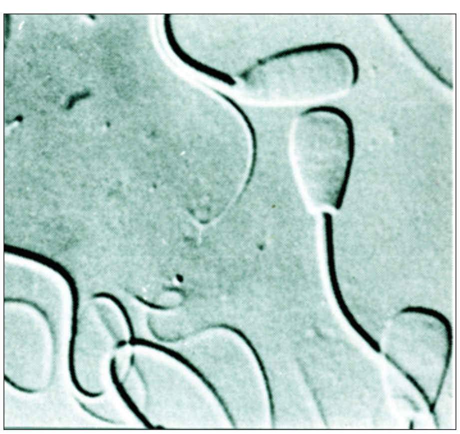
Bulls reach the adult rate of sperm production by about 12 to 18 months of age. But they produce only half as many sperm as a mature bull because their testes are only half as large. The amount of sperm produced is directly related to the size of the testes.

Mature bulls produce about 70 billion sperm cells each week. Nature has provided a great excess of sperm, so there is a good chance that at least one will find its way to the egg. A successful mating results in the union of one sperm and egg. This is one of the fundamental principles underlying artificial insemination. The excess sperm from any one ejaculation can be "harvested" and used to breed many more cows than would be possible with natural mating.

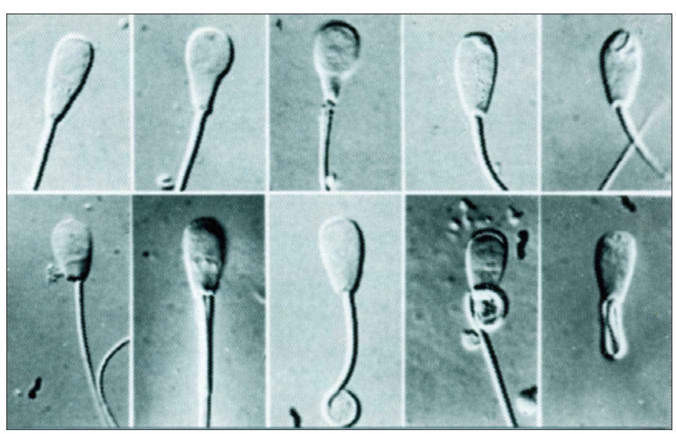
A bull in natural service might ejaculate from 7 to 10 billion sperm cells just to breed one cow. Most of these sperm are wasted. If this ejaculate with the same number of sperm were used in artificial insemination, the bull could breed about 300 cows. In fact, a single bull has been known to produce enough semen to breed more than 200,000 cows a year. Semen can be frozen and stored indefinitely in liquid nitrogen (at - 320 °F; -196°C). Thus a bull can be used to breed cows long after he is dead.

Even an artificial insemination stud rarely expects to obtain 70 billion sperm a week from a bull. The actual number of sperm obtained depends upon how the bull is prepared for ejaculation and how frequently he is ejaculated. When semen is collected twice a week with good preparation

NORMAL SPERM magnified 2000x.



ABNORMAL SPERM (magnified about 1500x). Head abnormalities appear on the upper row. Tail abnormalities appear on the lower row.



(sexual stimulation) of the bull, between 20 and 40 billion sperm usually are obtained each week.

Sperm head carries "payload". The head of the sperm is the "payload". Within the nucleus are the chromosomes, the genetic material that transfers hereditary information from the bull to the resulting calf. The tail of the sperm simply serves as a means to propel the sperm in its search for the egg.

A single sperm cell is extremely complex. All of its parts have to work properly to insure normal fertility. Many sperm abnormalities which can result in infertility may be detected with a microscope. Some of these abnormalities are illustrated in the photograph (lower right, page 11).

On the other hand, the number of cows that a bull can serve in a given period of time varies considerably among bulls. A rule of thumb is one bull per 25 to 30 open cows in a pen, or 50 mixed open and pregnant cows in a pen. If a bull is kept with a large pen of previously bred and still open cows, for example, it's very possible to overwork him, with disappointing results. In addition, disease can be spread, risk of injury is increased, and the loss of genetic advancement occurs by using bulls of usually unknown or inferior genetic merit.

Young bulls which have been fed adequately and have grown properly should produce fertile ejaculates by 6 to 9 months of age. However, fertility is lower in young bulls, thus the number of cows young bulls can service is lower than that for more mature individuals. Therefore young bulls in natural service should be used carefully to avoid overwork.

Actually, there may also be some danger of infertility when bulls are underused. It is common to find more dead sperm in ejaculates taken from bulls after several weeks of sexual rest than in ejaculates from bulls used more frequently. Sexual rest beyond three to four days does not increase the number of sperm harvested.

It is recommended that a bull pass a breeding soundness evaluation prior to service. This is especially important when the bull may be involved in an infertility situation. The breeding soundness examination should include a semen evaluation in addition to an internal and external examination.

The average volume of ejaculated semen collected with an artificial vagina is 5 to 15 ml. Color of the semen should be milky to creamy white. Occasionally, a yellow semen sample is obtained which is high in beta-carotene and is considered normal. When fresh semen is examined microscopically, at least 60 percent of the sperm should be swimming vigorously.

The average semen sample of a mature bull contains 800-million to 1.2 billion sperm per milliliter. The number of abnormal sperm in the semen sample should not exceed 20 percent. Abnormalities of the head of the sperm involve the DNA and are referred to as primary abnormalities. Abnormalities of the tail involve motility of the cell. Both of these abnormalities reflect malfunction of the testes. Droplets found on the sperm tail indicate immature sperm and reflect malfunction of the epididymis. Overuse of the bull cannot cause the release of immature sperm.

Whether a dairyman keeps a bull or uses artificial insemination, do not forget that the bull is half of the breeding herd. This is as true for fertility as it is for milk production. In fact, use of a low fertility bull is an easy way to reduce reproductive efficiency in the herd.

Bulls must be fertile. There is no evidence that a bull's fertility is affected by his Predicted Difference for genetic traits such as Milk (PDM), Type (PDT), Cheese Yield or Dollars (PD$). Thus, in selecting bulls to use, choose those that have a high PD for the traits important to you. Today there are enough genetically superior bulls in most bull studs so that bulls with low fertility are culled.

Sexed semen. The availability of sex-sorted semen has been eagerly anticipated for many years. However, expense and efficiency of the processing procedures, combined with compromised conception of the finished product, have stifled large-scale commercial implementation until recently. Numerous advances in the past 20 years have finally brought the technology to a point where commercial application can be economically justified. This is not to suggest that all issues have been resolved, but development of fluorescence-activated cell sorting has made this technology available to the dairy industry: sorting efficiencies have been increased so that sex-sorted semen can be offered at prices that allow for a return on investment, despite conception rates that are typically 70 to 75 percent of those obtained using conventional semen. To ensure the potential gain is realized, optimum reproductive management is essential. At this time, industry recommendations are to use sexed semen only in heifers, because of higher conception rates.

References cited: Nebel, R., And DeJarnette, J.M., Artificial Insemination Programs for Heifers, Dairy Cattle Reproduction Council, Nov. 7, 2006, Denver, CO.

3 – The cow's reproductive tract

ANIMALS such as fish and reptiles place their young mostly at the mercy of their environment. In contrast, mammals (animals which nurse their young) provide a sheltered environment for fertilization and for the developing young, at least until birth. This "shelter" in the female reproductive tract allows most offspring to survive the early stages of growth.

Nevertheless, we frequently find faults in the reproductive tract of the cow that cause pregnancy failures. Some of these faults originate with the cow herself, while others are caused by humans, reflecting poor management. Among these are unskilled artificial insemination or veterinary practices which damage the fragile parts of the reproductive tract. Sound dairy herd management minimizes most of these pregnancy losses and eliminates others.

Well protected. The reproductive tract of the cow is located just under the rectum, largely within the pelvic girdle. This bony channel protects the tract, at least until the middle of pregnancy. Actually, the uterus and ovaries are located ahead of the pelvic girdle, within the abdominal cavity just above and behind the intestines. They are held in that position by a tough sheet-like ligament (broad ligament). This ligament carries the weight of not only the reproductive tract, but also of the calf within it. The tract is richly supplied with blood vessels and nerve fibers.

Unfortunately, many of the vital organs of the reproductive tract are located so they cannot be seen. However, they are close enough to the rectum that they can be felt (palpated) through the rectum or visualized with ultrasound. Fortunately, skilled veterinarians, by rectal palpation or ultrasonography, can make many diagnoses that otherwise would not be possible. Additionally, convenient access to the cow's reproductive organs allows an unskilled person to cause considerable damage or even sterility. Some of the reproductive organs of the cow are very delicate. They must be handled only by a person who is aware of the danger of permanent damage. Ultrasound examination of the tract is becoming the "standard" of practice.

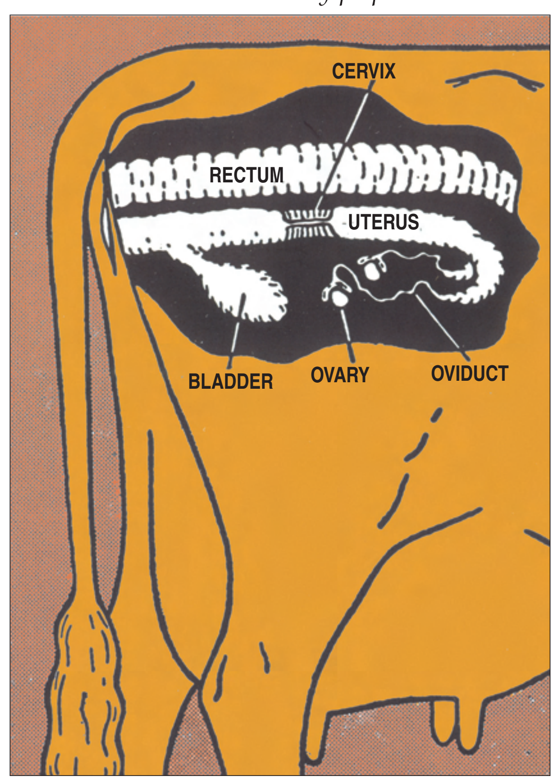
The vulva is the external genitalia and entrance to the vagina. The vulva and vagina are the only parts of the reproductive tract normally visible without surgery. The vagina serves not only as the birth canal but as a passageway for semen and the exit for urine.

In the cow, the vagina is a collapsed tube, normally about 12 inches (30 cm) long. The walls of the vagina are thin and elastic. Expansion is limited only by the walls of the pelvic girdle.

The vagina is lined by a membrane containing thousands of mucus-producing glands. These glands continually secrete a watery, clear mucus that bathes the vagina and flushes out any foreign material which may have gained entrance, especially during estrus (heat). Even with this defense mechanism, the vagina frequently is invaded by organisms, causing low-grade infections.

Cervix is tough. The inside end of the vagina joins the cervix, an

COW'S REPRODUCTIVE TRACT: Note how close organs are to the rectum, making possible a veterinarian's examination by palpation.



extremely tough and fibrous organ. The cervix, 4 to 5 inches (10 to 12.5 cm) long, has a narrow opening throughout its length. This opening or cervical canal is surrounded by heavy folds of tissue. These folds form 3 or 4 prominent ridges that encircle the interior. These ridges are commonly spoken of as the annular rings and act to prevent entrance of any foreign material. Consequently, **the cervix serves as a very effective door between the vagina and the uterus**. The cervix normally dilates (opens) only during estrus and at the time of calving.

The cervix also is lined with mucous glands that add their secretions to those of the vagina. The mucous glands of the cervix are most active during estrus. During pregnancy, the cervical mucus hardens and seals off the uterus by forming the cervical plug that dissolves before calving. At calving, the cervix dilates and allows the fetus and surrounding membranes to pass out.

The cervix is continuous with the body of the uterus, which is 5/8 to 1 inch (1.5 to 2.5 cm) long. As the uterus proceeds forward, it is divided into two horns, each 12 to 16 inches (30 to 40 cm) long, which are shaped similarly to the horns of a ram. As with a ram's horns, the uterine horns are larger at the body of the uterus and become smaller near the ends.

The wall of the uterus is made up of two layers of smooth muscle plus an inside lining, called the uterine mucosa. Contraction of the smooth muscles causes the expulsion of the fetus at calving time.

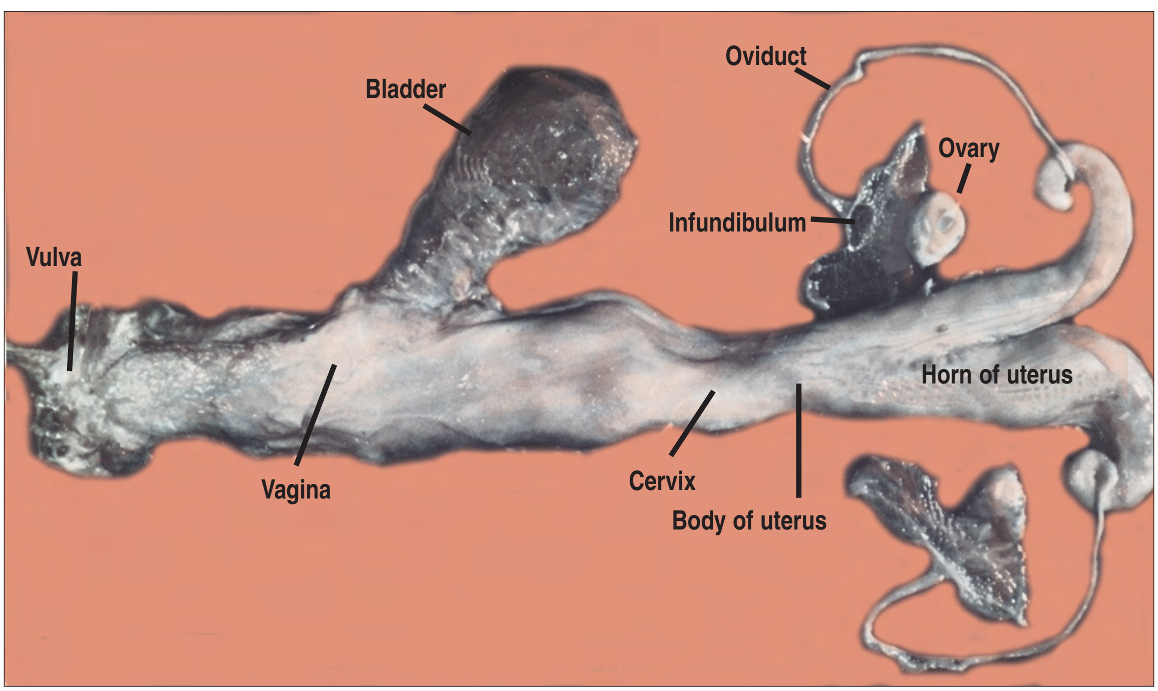
Similar contractions during and after breeding assist in transporting the sperm to the site of fertilization. The uterus is capable of undergoing great changes in size and position in order to accommodate the developing calf. Following calving, the uterus gradually regains its normal shape and size. This process is called involution. Rebreeding should be delayed until the reproductive tract has recovered from the previous pregnancy (see Chapter 13).

Uterine lining is very fragile. Superficially, the uterus appears quite tough. However, microscopic examination shows the inside lining is fragile and easily damaged.

Arranged in rows along the inside of the uterine horns are 80 to 120 "bumps" which range up to 0.5-inch (1.25 cm) in diameter. These are caruncles, the places where membranes of the developing calf attach to the uterus.

In the pregnant cow, the caruncles increase in size about 10 times. Nutrients from the cow's blood diffuse through the cell layers in the caruncles and enter the blood of the calf. Waste products from the calf's blood diffuse back

REPRODUCTIVE TRACT dissected from a cow. Notice blister-like follicle on ovary at top right. In the cow the bladder is located below the vagina. Oviducts are more coiled than shown here and the funnel-shaped infundibulum would partially surround the ovary.



into the cow's blood where they are eliminated. There is no mixing of the blood supply from the cow to the calf.

The area between the caruncles is lined with microscopic-sized glands that secrete fluids into the uterine lumen (center cavity). This fluid contains nutrients and other substances such as hormones that play important roles in the development of the embryo. The amount of fluid secreted is controlled by ovarian hormones carried through the bloodstream and by hormones produced by the developing embryo.

During estrus, there are phagocytes (white blood cells) in the uterus which rapidly engulf and destroy foreign organisms. However, phagocytes are not prevalent during the intervals between periods of estrus. As a result, if any infectious organisms survive estrus, they easily may start real trouble after estrus is over.

The uterus is the place where the calf develops, making it naturally a good environment for growing organisms. With this fact in mind, it is reasonable to expect bacteria might find the uterus to their liking, at least during the time between periods of estrus.

At the front end, each uterine horn narrows to a small opening and joins an oviduct. The two oviducts are fragile, highly coiled tubes. Each is 6 to 8 inches (15 to 20 cm) long and about 1/8 inch (3 mm) in diameter. The lining of the oviduct is very specialized and delicate. It also contains glands, but their secretions are watery. We believe this secretion usually flows away from the uterus toward the ovary.

The junction between the uterus and the oviduct serves as a valve. It is tightly shut except for short times when it allows sperm and eggs through. At all other times, liquid can hardly be forced through the junction from the uterus into the oviduct or from the oviduct into the uterus. The opening and closing of this utero-tubal junction is controlled by hormones produced by the ovary. The rate of movement of the fertilized egg from the oviduct into the uterus is controlled by hormones (estrogen and progesterone) produced by the ovary.

Funnel for the egg. The other end of the oviduct, adjacent to the ovary, is shaped like a funnel and is known as the infundibulum. The large photograph on the bottom of page 14 illustrates how delicate the infundibulum is. It partially surrounds the ovary. The infundibulum is lined by tiny projections called cilia. These cilia beat in a regular rhythm to carry the egg into the oviduct. The two ovaries are oval-shaped, usually 1 to 2 inches (2.5 to 5 cm) long. They have two functions, producing ova (eggs) and hormones.

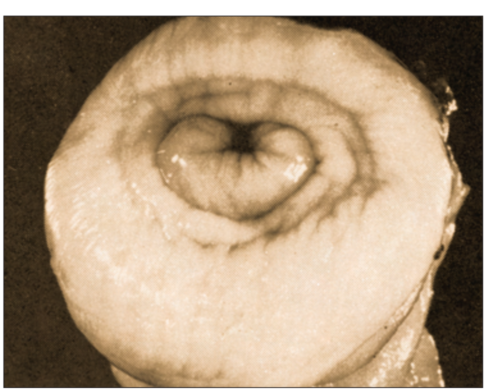
If we examine an ovary microscopically, we find hundreds of eggs, each egg at the center of a group of cells. The egg with its surrounding cells is known as a follicle. If we could watch a particular follicle, we would see the cells around the egg multiply. As a result, the follicle becomes large enough to be just visible.

Next, a fluid-filled cavity appears within the group of cells near the egg. This fluid-filled cavity enlarges, slowly at first, but very rapidly just before estrus.

The cells that surround the ovum (egg) and line the fluid-filled cavity of the follicle produce the female sex hormone, estrogen. As the follicle enlarges, it secretes more and more estrogen into the bloodstream of the cow. The high levels of estrogen bring on the estrus and sexual behavior (standing and mounting).

At this time, the follicle on the

OPENING OF THE CERVIX protrudes into the vagina. The vagina has been dissected off to show this view. Mucus from the cervix glistens around the opening.



INSIDE OF THE CERVIX cut open. Notice the heavy folds of tissue (annular rings). In the cow, the vagina would be at the left and uterus at the right of this cervix.

ovary may be half as large as the ovary itself and may be palpated through the rectum. It appears to be a very turgid blister. Then it bursts, releasing the fluid within it along with the ovum. The release of the ovum and fluid is known as ovulation, and occurs roughly 24 to 32 hours after onset of estrus.

About the time of ovulation, the infundibulum (funnel) of the oviduct becomes quite active. It "grasps" the ovary as if it were searching for the ovum. If all goes well, the ovum is directed into the oviduct. Occasionally, the ovum is not picked up by the infundibulum. As a result, it is lost among the intestines.

Hopefully, the ovum will be fertilized by a sperm cell waiting in or passing through the oviduct. The fertilized egg then passes into the uterus.

After ovulation, the old, collapsed follicle begins its "second life". Some of the cells that lined the cavity of the follicle suddenly begin to multiply. These cells secrete the hormone of pregnancy, progesterone. Within one day, these cells will grow to the point that they form a mass as much as 0.5-inch (1.25 cm) in diameter.

This new structure, which is yellow to red in color, is the corpus luteum, sometimes called "yellow body". It continues to grow for 10 or 12 days, secreting more and more progesterone into the bloodstream of the cow. At this point, the corpus luteum may be nearly as large as the ovary itself.

If the ovum is fertilized and the cow is pregnant, the corpus luteum continues to secrete progesterone throughout most of pregnancy. If the ovum is not fertilized, the corpus luteum starts to degenerate while, at the same time, another follicle begins to enlarge rapidly. The next chapter will describe the formation of the follicle and the corpus luteum.

Frequent defects. It is not at all unusual to find heifers with abnormalities of the reproductive tract. One of the most frequent abnormalities is a blind cervix. Such a heifer is totally sterile.

Other times we find a cervix with two channels into the uterus, or perhaps one open channel and one blind channel. Even when one pathway is blind, the heifer is usually fertile. However, the inseminator may have trouble finding the open channel.

Other parts of the reproductive tract also may be missing. Sometimes heifers have only one uterine horn or only one functional ovary.

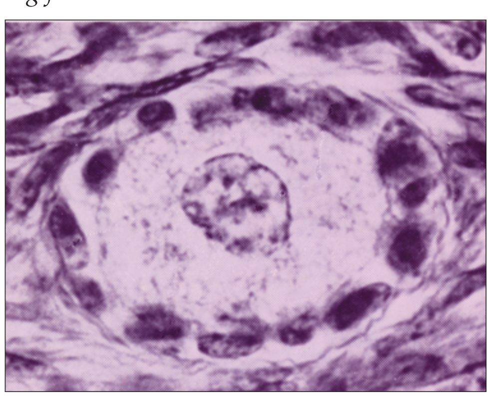
The freemartin condition is probably the most frequent abnormality involving the underdevelopment of the female reproductive tract. It occurs in over 95 percent of the heifers born twin to a bull.

Usually the tract of a freemartin is closed at the opening of the vagina, just in front of the opening of the bladder. Therefore, an ordinary test tube (6 inches long – 15 cm) can be inserted only 2 to 3 inches (5 to 7.5 cm) into the vagina. In the normal heifer the test tube can be inserted to its full length into the vagina.

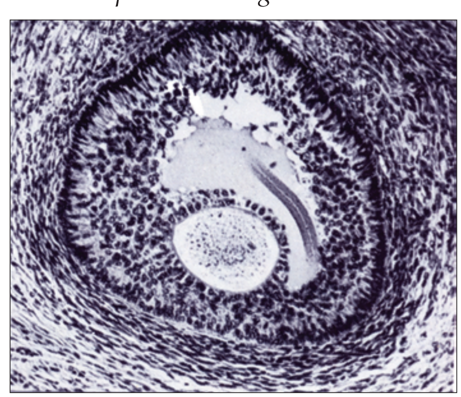
In some freemartins the tract is complete up to the cervix. In these cases, the freemartin condition can be detected by examining the chromosome makeup of a sample of white blood cells collected from the animal. In freemartins, some white blood cells contain the chromosome makeup of females (heifers); whereas other cells from the same sample contain the chromosome pattern of males (bulls).

Because the odds of a freemartin heifer being fertile are less than 1 in 10, it is recommended to feed her out for beef or sell her for the same purpose.

COW OVUM (EGG) IN OVARY (magnified 400x). Nucleus is in center, surrounded by cytoplasm and one layer of cells producing female sex hormone.



FOLLICLE IN COW'S OVARY (magnified 200x). Ovum (egg) is below fluid-filled cavity, which is, in turn, lined with cells that produce estrogen.



4 – Reproduction:
Full-time job for the dairy cow

THE FIRST THING WE demand of the dairy cow is that she produce 9 to 14 tons (10,000 kg) of milk a year. But let's not forget that, before we can get this milk, the cow must have a calf about once a year.

Ideally, we would like every dairy cow pregnant or recovering from pregnancy at all times. This is truly working her full time. It goes on continually. At least, it goes on until some part of the complicated process breaks down.

Among the causes of infertility, the body parts that control the functions of the reproductive tract are notorious. Many of these controlling centers are located far away from the reproductive tract. We now better understand how some of these glands affect reproduction and how aberrations of their functioning can cause infertility.

Chemical messengers. The most important controls of reproduction are the hormones that regulate the estrous cycle, estrus (heat), pregnancy, birth and even the secretion of milk.

Hormones are "chemical messengers". This means they are secreted by an endocrine gland at one location in the body and move into the bloodstream. The blood carries the hormone to an organ at another location where it delivers its message by affecting the target organ in some way. The hormones only act on or stimulate target glands or organs that contain specific receptor sites to which the hormone binds.

Specialized nerves located in a neuroendocrine center of the brain, called the hypothalamus, actually control reproduction and milk secretion by secreting hormones that control the pituitary gland.

Of all the endocrine glands, the pituitary gland occupies a position of primary importance. It secretes several hormones, many of which control the function of other endocrine glands. Because of its tremendous influence on other body glands, the pituitary gland is known as the master gland of the body. Now we know that the pituitary is controlled by the hypothalamus, which in turn is controlled by higher brain centers in the central nervous system.

The pituitary is located at the base of the brain, close to the hypothalamus. In the cow, it is only about 3/4 of an inch (2 cm) in diameter. Its location near the brain is essential to some of its functions, since the hypothalamus gives directions to the pituitary, telling it what to do and when to do it.

The hypothalamus controls the secretion of pituitary hormones by secreting other hormones into a specialized portal system that supplies blood to the pituitary. We now can control part of the reproductive process through synthesized hormones of the hypothalamus. The chemical structure of hypothalamic hormones is much simpler than that of pituitary hormones. Therefore they are less expensive to synthesize than the more complex protein hormones of the pituitary. Hypothalamic hormones are used to treat such abnormal conditions as cystic ovaries, and their uses in controlling reproduction are described in Chapters 18 and 19.

Among the hormones secreted by the pituitary gland are those that specifically control reproduction. These are known as gonadotropins, because they control the gonads (the ovaries of the cow and the testes of the bull). The gonadotropins all have long descriptive names. However, we will use the abbreviations commonly used by veterinarians.

Let's take a look at the body chemistry of the cow during the estrous cycle. The pituitary secretes the hormone known as "follicle stimulating hormone" (FSH). The blood carries FSH to the ovaries where, as its name implies, it stimulates the growth of follicles.

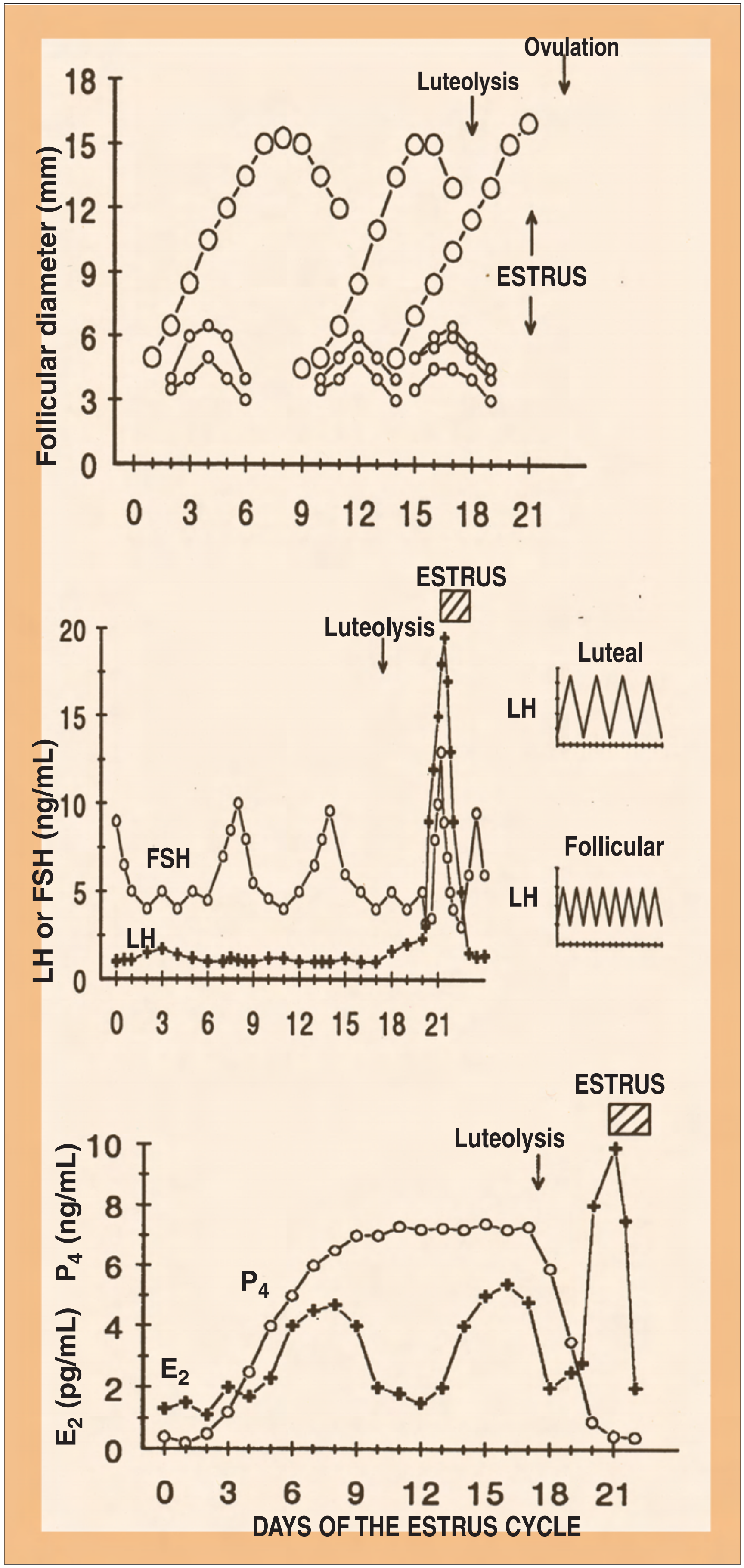
A group of follicles begins to grow in response to a transient increase in blood concentrations of FSH. This increase in FSH is observed one or two days before the appearance of several new follicles in both ovaries. Shown in the figure at the top of page 18 is the diameter of several follicles during the estrous cycle of a cow. This cow has three groups or "waves" of follicles that develop during the cycle. On days 1 and 2, three follicles were visualized, but only one grew (dominant) from this group (cohort) and "dominated" the other smaller (subordinate) follicles. The subordinate follicles undergo atresia (death) and are no longer useful as potential follicles.

The first dominant follicle

undergoes a growth phase (days 1 to 6), a static phase (days 7 to 9), and a regressing phase (days 11 to 12 or longer). The second wave of follicles visualized appeared around day 9 or 10 of the estrous cycle, one of which dominates the other follicles and becomes the second dominant follicle, which happened to regress before luteolysis (death of the corpus luteum). Therefore, a third wave of follicles, which began to grow about day 14 or 15, appeared with another dominant follicle emerging and eventually ovulating.

Although any number of follicles (beginning diameter of 0.1 inch, 2.5 mm) can make up a wave of follicles, usually only one to six develop per wave. The first wave and its dominant follicle always appear at the same time during the cycle in all cows. In the figure, a "three-wave" cow has an estrous cycle of 21 days. Two-, three- and four-wave cycles have been observed in cattle, with the beginning of the second, third or fourth wave during the cycle being more variable than the first. Estrous cycles are longer with increasing number of follicular waves. Two-wave cycles are shorter (19 to 20 days) and four-wave cycles tend to be longer (23 to 25 days) in duration.

What determines the number of follicular waves is not yet understood. However, if a prostaglandin injection is given on day 6 or 7, for example, when the first dominant follicle is growing, the corpus luteum will regress and the first dominant follicle can ovulate and be normally fertile when A.I. breeding is performed based on estrus. That would be true for any dominant follicle that is in its growing phase. It was recently demonstrated that any dominant follicle would ovulate (in the growth phase) during a normal estrous cycle if gonadotropin-releasing hormone (GnRH) is



injected, thus producing a secondary corpus luteum.

The female sex hormone (estrogen) also rises and falls with the growth and regression of a dominant follicle. The dominant follicle apparently dominates its subordinate peers by producing substances that inhibit their further growth. As it grows larger, the follicle (which is an endocrine gland itself) secretes more and more estrogen into the bloodstream. At this point, the mature follicle is about 0.75 inches (2 cm) in diameter. Estrogen in the blood is highest during the two days before estrus and starts to decline on the day of estrus.

Although we talk about high estrogen in blood near estrus, "high estrogen" is a bit misleading. It is high compared to other stages of the cycle. But the amount of estrogen in blood near estrus is extremely small, only about 10 parts per trillion parts of blood.

We have known about the existence of estrogen for half a century because it is such a potent chemical. However, the amount of estrogen in cows' blood is so small that it wasn't measured until 1971.

High estrogen in the blood has profound effects throughout the body. The most obvious effect of the estrogen is that it brings on the heat period (estrus). The behavior of the female (standing heat) is about the only reliable means we have to determine the optimum time for breeding. That people can detect estrus in cows is another factor which makes A.I. breeding possible. If the bull alone could detect cows in estrus, A.I. would not be practical.

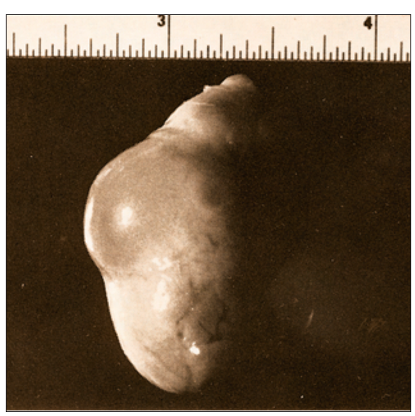
Yet, it is true that some cows do not show typical symptoms during the estrus period and, consequently, are less fertile simply because they are bred at the wrong time. Little is known about the manner in which estrogen brings on estrus, but this effect of estrogen acts on the brain.

About one day before onset of estrus, the high level of estrogen causes the pituitary to secrete more luteinizing hormone (LH). This LH causes the dominant follicle to reach its maximum size. Near the onset of estrus, LH surges to about 20 to 30 times its normal level, whereas FSH secretion reaches about twice its normal concentration. The blood carries both hormones to the ovary where they stimulate the follicle to undergo changes that lead to release of the egg from within (ovulation). Normally ovulation occurs about 25 to 32 hours after the onset of estrus.

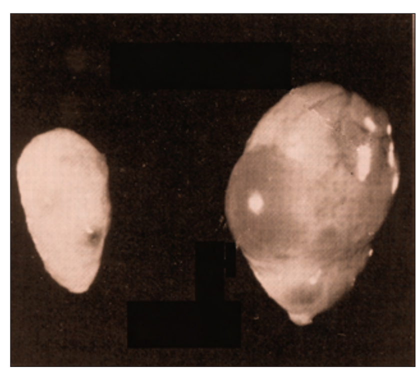
If all goes well, the egg is picked up by the funnel-shaped infundibulum and directed into the oviduct. The follicle, its job done, rapidly collapses at the time of ovulation. But LH does not let these old follicle cells rest. Instead, LH causes some of these cells to grow very rapidly. Within a few days, the follicle has been replaced

OPPOSITE: AN EXAMPLE OF CHANGES IN HORMONAL CONCENTRATIONS AND FOLLICULAR GROWTH that normally occur during a 21-day estrous cycle of a cow with three follicular waves. Abbreviations: E2 = estrogen; P4 = progesterone; LH = luteinizing hormone; FSH = follicle-stimulating hormone; luteolysis = time when the corpus luteum dies, progesterone decreases rapidly in blood; luteal = period of the cycle (days 4 to 18) when the corpus luteum is functional, progesterone is elevated, and the number of pulses of LH secretion in blood is about one per 4-6 hours; follicular = period of the cycle (days 19 to 21) when rapid follicular maturation occurs, estrogen is elevated, progesterone is low, and the number of pulses of LH secretion in blood is about one per hour.

LARGE DOMINANT FOLLICLE (blister at left) is shown on ovary. It grows in 5 to 8 days to an inch in diameter. The follicle contains the egg (ovum), that is released 10-16 hours after the end of estrus.



HEIFER OVARIES 8 days after the estrous period. Left ovary is presently inactive. Right ovary contains a corpus luteum (upper right) from the previous ovulation and a dominant follicle.



by a new structure, the corpus luteum (yellow body), which will be larger than the follicle (0.9 to 1.4 inches in diameter; 2 to 3.5 cm).

The corpus luteum is very different from the follicle. It is solid and dark red to yellow in color, and manufactures **progesterone**, the hormone of pregnancy (think of "pro-gestation"). Thus, the corpus luteum is also an endocrine gland. It continues to grow larger under the influence of LH. As it grows, it produces more and more progesterone.

The presence of estrogen and progesterone in the blood causes drastic changes in the reproductive organs, especially in the uterus. The inside lining of the uterus grows thicker and the uterine glands become more active as the uterus prepares to nourish a new fertilized egg and start a new pregnancy.

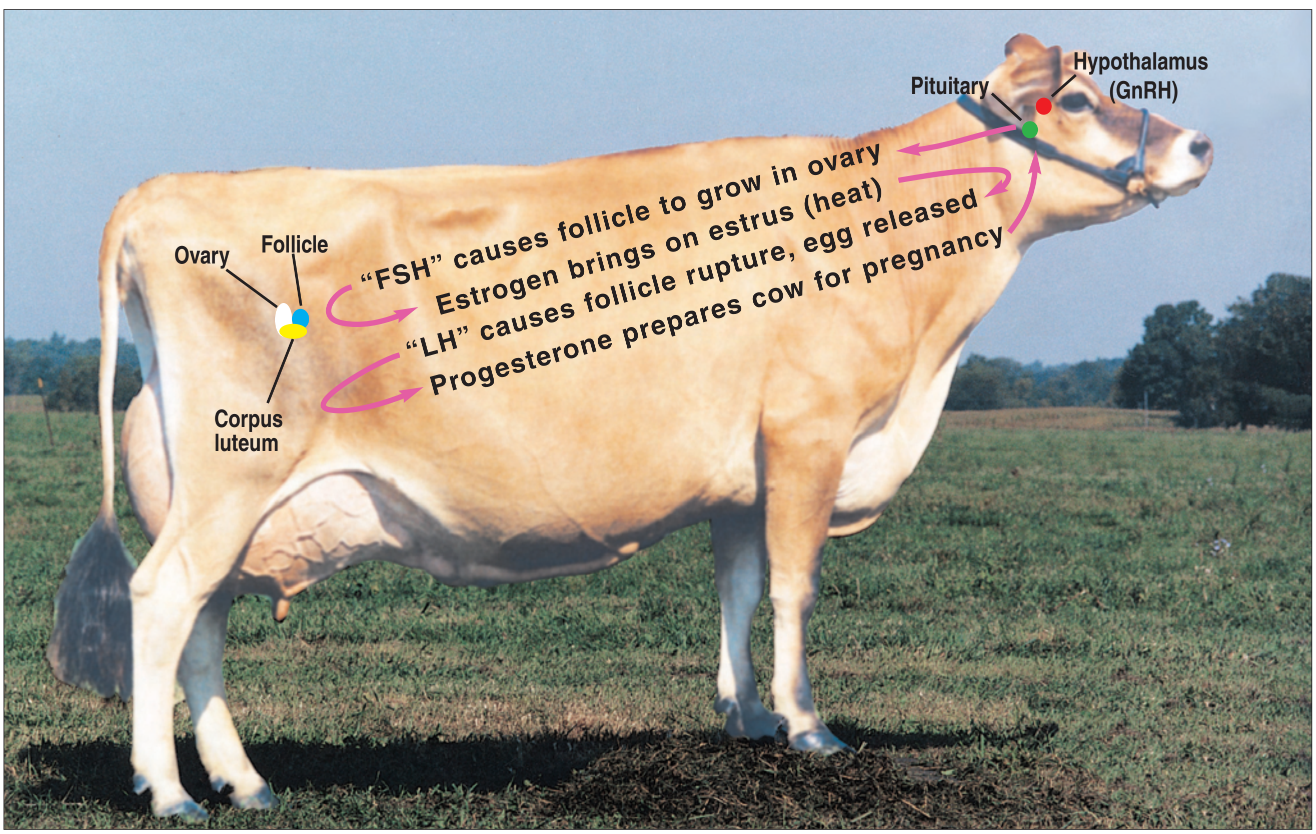
In about half of all cows, blood may be observed on the vulva about two days following estrus. This blood is believed to be caused by the breakdown of cells during rupture of the follicle.

The presence of blood following estrus has no relation to breeding, injury or whether or not the cow conceived. It simply indicates the cow was probably in estrus two or three days before.

If the egg is not fertilized, the corpus luteum grows for about 10 to 12 days and secretes high amounts of progesterone until about 16 to 18 days after estrus. High progesterone in the blood suppresses release of gonadotropins from the pituitary. During the period of luteal dominance (corpus luteum is functional and secreting elevated concentrations of progesterone), LH is secreted in pulses of one per 4 to 6 hours. This pulse frequency of LH, in combination with FSH, allows follicles to develop but not ovulate.

At about 16 to 18 days after

HORMONES secreted by the pituitary gland and the ovaries control the estrous cycle. About 1 day after estrus, the process starts with FSH (follicle stimulating hormone) from the pituitary. This starts growth of the first wave of egg-carrying follicles on the ovary. Then the follicle secretes the female sex hormone (estrogen). No estrus signs are observed because blood progesterone prevents estrus. Estrogen secreted by the follicle that matures in the absence of elevated progesterone (second-, third- or fourth-wave follicle) produces signs of estrus. Then the pituitary secretes LH (luteinizing hormone), which causes the follicle to rupture, releasing the egg about 10 to 16 hours after the end of estrus. Then LH also causes the corpus luteum (yellow body) to replace the follicle. It produces the pregnancy hormone, progesterone. If the egg is not fertilized, progesterone secretion is terminated about 16 to 18 days later, and the estrous cycle repeats.



estrus, if the cow is not pregnant, the uterus manufactures a luteolytic factor. This luteolytic factor is **prostaglandin F2-α (PGF)**, a 20-carbon fatty acid. Prostaglandin travels from the uterus through the uterine vein to a point just past where the uterine vein is fused with the ovarian vein to form the utero-ovarian vein. From this point in the utero-ovarian vein, prostaglandin passes through the wall of the vein and across into the ovarian artery. The ovarian artery carries the prostaglandin to the ovary. The luteolytic factor (prostaglandin) kills the corpus luteum and the corpus luteum degenerates rapidly. As a result, progesterone falls to very low levels within 24 hours. This leads to secretion of more estrogen and LH, and causes the dominant follicle to mature. This can occur because the pulse frequency of LH secretion increases to one pulse per hour.

If all goes well, the cycle repeats every 18 to 24 days until the cow becomes pregnant.

The discovery that prostaglandin stops progesterone secretion by the corpus luteum in the cow was made in 1972. Like the hypothalamic hormones, prostaglandin was a major discovery. Anytime between days 5 and 18 after estrus, a single injection of prostaglandin causes death of the corpus luteum. Estrus occurs between 40 and 80 hours later, with an average of 72 hours.

Prostaglandin can be used to control the time of estrus in a cow that has a corpus luteum. It also can be used to synchronize the time of estrus in a group of animals. This will be discussed in more detail in Chapter 18.

Maintain pregnancy. If the cow is bred and the egg fertilized, the corpus luteum continues to secrete progesterone. At first, the progesterone prepares the uterus for the developing calf. Later, it maintains the pregnancy, at least until the sixth or seventh month.

If the corpus luteum is removed from the ovary during the first two-thirds of pregnancy, the cow will abort. But abortion does not always occur if the corpus luteum is removed during the last third of pregnancy. The reason why cows do not always abort when the corpus luteum is removed during late pregnancy is that the placenta produces a large amount of progesterone during the last three months of gestation, thus taking over the role of the corpus luteum.

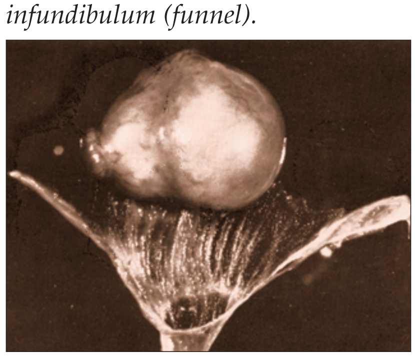
All during the estrous cycle, estrogen and progesterone have essential effects upon the udder, at least in the heifer. Progesterone causes the cells that secrete milk to multiply. Estrogen stimulates growth of the ducts that drain the milk to the teat.

These effects on the udder are very pronounced during the last few weeks of pregnancy. The placenta releases very large quantities of estrogen at this time, up to 30 times higher than the high level secreted by the follicle just before estrus. The combination of the large quantities of estrogen with some progesterone is responsible for the udder's tremendous growth in the few weeks before calving. In addition to the effects of estrogen and progesterone, mammary growth is stimulated by placental lactogen, a protein hormone produced by the placenta.

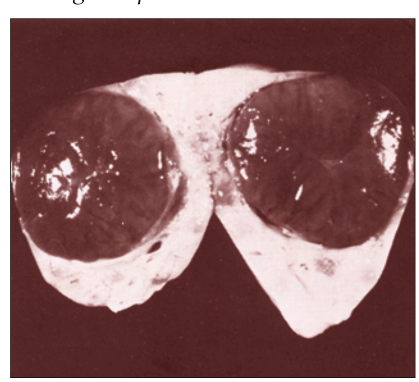
In these respects, milking is totally dependent upon reproduction. The two are inseparable. In fact, the mammary gland of the heifer will not develop appreciably until pregnancy is well under way. Milk secretion is a part of reproduction from an academic standpoint and from a practical standpoint.

There is still another hormone from the pituitary gland that affects reproduction. This hormone, oxytocin, is from the posterior part of the pituitary; the other pituitary hormones previously mentioned are from the anterior part of the pituitary. Because oxytocin was found in the posterior pituitary, it was thought for many years that the hormone was produced by that gland. However, now it is known that oxytocin is produced by the hypothalamus and is only stored in the posterior pituitary.

COW OVARY AND INFUNDIBULUM. Ovary has large corpus luteum (left) from previous ovulation and large follicle (right) for next ovulation. Ovary itself (top) is relatively small. Notice opening through the infundibulum (funnel).



CORPUS LUTEUM dissected open. Notice that squeezing ovary could dislodge corpus luteum.



Oxytocin is the hormone that causes milk let-down at milking time. It also causes contractions of the uterus. At the time of breeding, either naturally or by artificial insemination, oxytocin is released from the posterior pituitary. Experimental evidence indicates that contractions of the smooth muscles in the uterus aid the transportation of sperm through the female reproductive tract to the place where fertilization occurs.

When oxytocin is released from the pituitary, it travels through the bloodstream to all parts of the body, including the udder. It is not at all uncommon to see a cow leaking milk just after palpation of the reproductive organs or breeding as a result of oxytocin causing milk letdown.

As explained in Chapter 7, oxytocin also causes the uterine contractions that expel the calf at parturition. If you wonder why oxytocin does not expel the calf at milking time in pregnant cows, the reason is that the uterine muscle must be sensitized by the extremely high amounts of estrogen secreted by the placenta (up to 30 times higher than before estrus) during the two weeks before calving.

We have known for decades that it is important to be gentle with cows at milking time. The reason is that fright or stress causes the release of epinephrine from the adrenal glands. Epinephrine is a hormone that counteracts the milk letdown effect of oxytocin.

Presumably, epinephrine influences conception rate because most artificial inseminators agree that, to get highest fertility, they must treat a cow gently at time of insemination.

The two adrenal glands, one located next to each kidney, also secrete other important hormones. The chemical structures of these resemble estrogen and progesterone. Others control the rate and type of metabolism in the body. The adrenal glands of the fetus play an important role in its delivery. If the adrenal glands of the fetus are removed surgically, parturition fails to occur. The adrenal hormone responsible for this action is cortisol— a steroid hormone similar in structure to progesterone.

The nature and mode of action of hormones continue to baffle us. Our knowledge about them is very meager. In recent years we have learned how to use some of the reproductive hormones to regulate reproductive processes and reduce infertility. Some of the hormones now used to control reproduction or treat infertility problems include prostaglandin, LH, FSH, progesterone and gonadotropin-releasing hormone (GnRH) —one of the hormones produced in the hypothalamus.

5 – Union of sperm and egg

REPRODUCTIVE PROCESSES are difficult to study. Most processes take place inside the cow's body where it is very difficult to make measurements and observations. In recent years, procedures have been developed for growing and maintaining viable animal cells and tissues in the laboratory. Thus, it is now possible to study some of the early phases of development in greater detail under controlled conditions.

This chapter will describe the events leading up to the formation of a calf.

The story begins at the time of breeding, which normally should be from the middle to the end of estrus. In natural breeding, the bull deposits the sperm in the vagina next to the cervix.

In artificial insemination, the desired site of semen deposition is just through the cervix into the body of the uterus. Because 10 to 20 million sperm per insemination are used in artificial insemination versus 5 to 15 billion in natural breeding, it is necessary to deposit sperm in the uterus.

After natural insemination the sperm pass into the cervix by their own motility as they are oriented against the flow of mucus from the cervix. The cervix has a very complex network of folds that function as pathways for sperm as they travel to the uterus. Because of the discharge of mucus and structure of the cervix, most of the sperm cells inseminated remain in the cervix, with only a small proportion reaching the site of fertilization.

Once the sperm pass the cervix and enter the uterus, uterine contractions become the major factor in sperm transport. The sperm swim much too slowly to move so far so rapidly. Muscle contractions of the uterus, caused by the hormone oxytocin, are responsible for a rapid transport of sperm to the oviducts.

As mentioned in previous chapters, the ovum is released (ovulated) about 25 to 32 hours after the onset of estrus. It is picked up and directed almost immediately by the infundibulum (funnel) and enters the oviduct. The ovum then begins its journey toward the uterus. The first part of this journey is relatively fast. It probably passes to the middle of the oviduct within six hours.

After this time, the ovum rapidly loses its viability. Consequently, if the ovum is to be fertilized, it must be fertilized while it is in the upper half of the oviduct. Its fertile life is no longer than about 10 to 12 hours. Ova may be fertilized after this time, but evidence indicates such fertilizations are likely to result in early abortions or abnormal embryos.

Sperm are transported to the oviducts within minutes after insemination; however, these have been shown to be dead sperm. The greatest number of viable sperm are found in the oviducts 8 to 12 hours after insemination, with some decrease following. Acceptable fertility occurs when cows are inseminated about 12 to 16 hours after the beginning of standing estrus. The universally accepted time of insemination is a rule of thumb called the AM-PM guideline. Based on watching cows for estrus twice daily, those cows first detected in estrus in the morning are bred that same afternoon, and those found in the afternoon and night are bred the following morning. More exacting measures have been attempted, but the rule of thumb is as simple and successful as we have at the present time. Details regarding timed A. I. (TAI) follow in Chapter 18.

Sperm develop fertilizing capacity. Sperm apparently have to reside in the female reproductive tract for a period of time before they develop the capacity to fertilize an ovum. Changes in the sperm surface take place, making enzymes available that allow the sperm to penetrate the outer surface of the ovum. It may take the action of thousands of sperm cells to cause certain changes of the ovum and its surrounding cells before fertilization can occur.

Whether natural mating or artificial insemination is used, sperm live for only about 24 hours in the female reproductive tract. In normal cows, therefore, we can expect satisfactory fertility from matings made at any time from the middle of estrus to about 10 hours after the end of estrus.

Despite this apparent wide range of time during which satisfactory fertility results can be obtained, the highest fertility is obtained when cows are bred sometime during the latter part of standing estrus.

These are the reasons why A.I. technicians want to know when the cow came into estrus so they can breed her at the optimum time — before or just after she goes out of estrus. Best results seem to be obtained when cows are bred near the end of estrus. Breeding at this time enables the sperm to become "capacitated" (have the ability to fertilize the ovum) when the ovum is released from the ovary.

These time intervals represent averages, and many cows do not fit the pattern of the average cow. Some cows remain in standing estrus longer. Others will ovulate sooner or later after estrus than the average cow.

This is one reason why accurate breeding records on individual cows can be beneficial. For a particular cow, an abnormally long period of estrus might be "normal". Accurate records with this type of information provide valuable assistance for timing the insemination.

Our present understanding of the fertile life of the ovum and sperm, and the need for sperm capacitation explain why proper timing of the insemination is so important in obtaining optimal fertility. If cows are inseminated too early, the sperm may die before the ovum is released. If cows are inseminated too late (after ovulation), the ovum becomes infertile before the sperm gains the ability to fertilize the ovum.

Provided insemination was made at the right time, fertilization occurs within four to six hours after ovulation; that is, about 29 to 36 hours after the onset of estrus.

When sperm reach the upper half of the oviduct, the site of fertilization, they begin their search for the ovum. Motility of the sperm probably is important in this search, although contractions of the oviduct undoubtedly help the sperm.

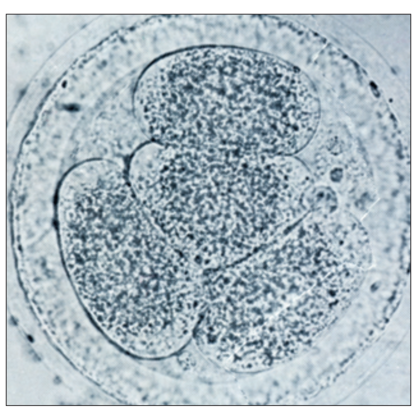
The sperm cell is much smaller than the ovum. Its length, including the tail, is about the same as the diameter of the ovum. The process of fertilization is not clearly understood. Several sperm cells may penetrate the outer layer of the ovum (zona pellucida). But under normal circumstances, only one sperm cell passes through the ovum membrane. This occurs because some change in the chemistry of the membrane blocks entry of any additional sperm after the first one has penetrated this layer. Exactly how this penetration occurs is still debated. But most evidence suggests that one membrane on the sperm fuses with the ovum membrane and the entire sperm is then engulfed into the cytoplasm of the ovum. The sperm nucleus is released and then unites with the ovum cell nucleus. Under some abnormal conditions, more than one sperm may fertilize the ovum. Apparently these genetic freaks are lost very early in pregnancy.

Speaking exactly, the union of the sperm nucleus and the ovum nucleus is fertilization. The nucleus of the sperm and ovum contains the hereditary information (chromosomes) that is passed on to the new offspring. These bits of hereditary information are contained in genes located on the chromosomes in the nucleus. The chromosomes become paired (one from each parent) as the two nuclei (of the sperm and ovum) join. The sex and inherited features of the new calf are determined at this time.

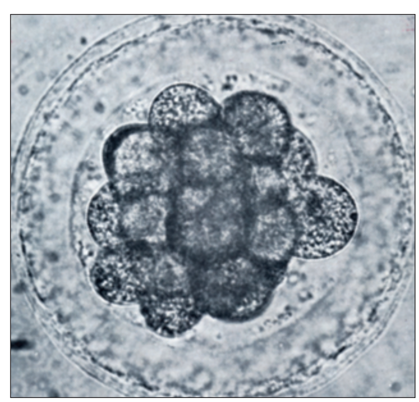
One-celled calf. The newly fertilized ovum is now a one-celled calf (or zygote). This one cell possesses the inherent ability to divide first into two cells, then into four cells, and so on until it reaches the countless numbers of cells that make up the various parts of a calf.

The cow has now completed only one phase of her task in reproduction. She has produced a viable ovum and provided the environment for fertilizing the ovum. Next, she must carry and nourish the developing calf during the nine months of its intrauterine life. Later she must give uncomplicated birth to the calf.

FERTILIZED OVUM has divided two times to form four cells. It now represents a newly formed animal.



DIVIDING CELLS of fertilized ovum total 16. All body parts of the mature animal originate from these cells. Both embryos are contained in a translucent membrane known as the zona pellucida, from which they will later "hatch" as the blastocyst develops and elongates to form the placenta and the new calf.



6 – Before birth

A calf begins to grow

THE REPRODUCTIVE PERFORMANCE of the cow has become so well accepted that we seldom give serious thought to what actually goes on inside her body. The cow is expected to produce a fertile ovum and provide a favorable environment for sperm cells to fertilize the ovum.

In addition, she must carry and nourish the developing fetus and then give birth to a normal, healthy calf. Meanwhile, she is expected to pay for her keep by producing tremendous quantities of milk.

The fertilized ovum divides the first time within about 20 hours. Each of the two resulting cells divides again to form four cells within another 30 to 40 hours. By this time, the developing embryo has descended into the lower half of the oviduct. The cells, still within the zona pellucida, continue to divide while the embryo stays in the lower half of the oviduct for about two additional days. At the end of this time, the embryo contains 8 to 16 cells.

Transport of the embryo down the oviduct is believed to be controlled by the hormones estrogen and progesterone. However, the exact mechanism is not known. If muscular contractions of the oviduct are responsible, we do not understand how similar contractions could transport sperm up the oviduct at one time and then propel the fertilized ovum down the oviduct just three days later.

At the end of these three days, the developing embryo is about the size of a pinhead.

The junction between the oviduct and the uterus is responsible for holding the embryo in the oviduct for as long as three days. During this time, the corpus luteum is growing and secreting more and more progesterone (the pregnancy hormone). When the progesterone balances the residual estrogen (female sex hormone) in the bloodstream, the tubo-uterine junction opens and allows the embryo to pass into the uterus.

The three-day stay of the embryo in the oviduct is important. It takes about this long for the progesterone to prepare the uterus so it can provide a suitable environment for the embryo.

Once the embryo enters the uterus, the cells within it divide rapidly and accumulate at increasing rates. The dividing cells remain within the zona pellucida for about 8 to 9 days. Then this outer membrane of the ovum breaks open and the cells begin to push outward (hatching). At first, layers of cells are formed. This is followed by the formation of the body organs and body parts. For example, the heart begins to beat as early as 22 days after fertilization.

For about 25 days, the developing embryo floats rather freely in the lumen of the uterus. During this time, it must absorb its nutrients largely from fluids (uterine milk) within the uterus.

While the embryo is floating freely in the uterus, membranes grow around it. When the embryo

EMBRYO IN PLACENTAL MEMBRANES at 45 days of gestation. The amnion is the spherical part around the fetus, shown at top center. The rest of the placenta extends the full length of both uterine horns.

is about 25 days old, the membranes from the embryo begin to unite with the caruncles (buttons) on the inside lining (endometrium) of the uterus. This forms the placenta.

The spaces between the membranes of the placenta become filled with fluid. Actually, the calf develops inside a fluid-filled sac called the amnion, which is enclosed by another fluid-filled sac, called the chorioallantois. The fluid distributes the force of any blow over the entire surface of the calf, thereby protecting it.

When the embryo is 35 to 45 days old, the head and legs are recognizable. Blood vessels begin to grow out from the heart of the fetus. A large artery and vein grow through the umbilical cord, pass through the placental membranes, and end in microscopic capillaries in the cotyledons on the placental surface.

Where the placenta contacts a uterine caruncle, a cotyledon (button) develops. The placenta is attached to the uterus by these caruncular-cotyledonary unions, known as placentomes. The caruncle and cotyledon attach together much like velcro. The cotyledons have microscopic-sized, finger-like projections which, by this time, have grown into the caruncles on the uterus. Blood vessels from the cow end in microscopic capillaries in the caruncles. The maternal capillaries in the caruncles lie very close to the fetal capillaries in the cotyledons.

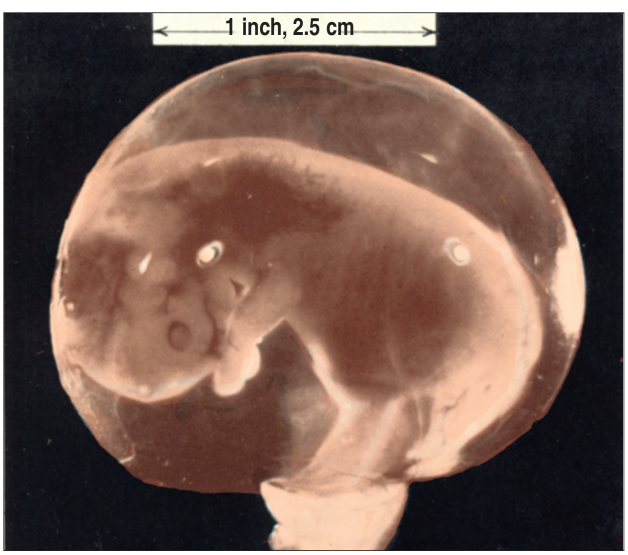
This intimate association between the fetal and maternal blood systems enables nutrients and gases to diffuse from the cow's blood into the bloodstream of the fetus. Waste products from the fetus diffuse into the bloodstream of the dam where they are eliminated. In this manner, the mother "feeds" the fetus and voids the waste products from it. There is no direct connection between the blood vessels of the cow and those of the calf. Nonetheless, if the pregnant cow consumes certain toxins, for example, or is infected by certain agents, the unborn calf can be affected. More detail on this in Chapter 8, 10 and 11.

By 60 days, most of its adult organs have been formed, although, by no means, are all of them functional. From this time on, the new calf is known as a fetus. By the time it is 90 days old, it may be clearly recognized as a calf.

Then comes the period of most rapid skeletal growth in the whole life of an animal. The fetus gains from about 2 pounds (1 kg) to a birth weight of 50 to 90 pounds (22 to 40 kg) during the last five months of pregnancy.

The birth weight of the calf largely is determined by the size of the cow and by heredity. The effect of heredity is evident in the average birth weights for the different breeds, which vary from 50 to 90 pounds (22 to 40 kg). It is interesting that all mammals, from the mouse to the elephant, are about the same size when life begins with the fertilized ovum.

EMBRYO IN THE AMNION, the membrane that immediately surrounds the developing calf. There is another outer membrane (chorioallantois) that has been dissected away. The two membranes and fluids inside them protect the calf in the uterus and form the placenta, or afterbirth.



THIS 60-DAY-OLD FETUS was removed from a cow. It measures about 3 inches (7.5 cm) long. A growing calf represents the successful conclusion of thousands of intricate events during normal reproduction.

Hormones necessary for birth. After the fetus is about 8 months old, drastic changes begin to occur in the cow. Progesterone secretion from the corpus luteum begins a gradual decline. At about this same time, the ovary begins to release another hormone, known as relaxin. Relaxin prepares the cow for calving by softening and relaxing the tissues that make up the birth canal. The cervix, for example, has been closed very tightly all during pregnancy to keep foreign material out of the uterus. But now the thick mucus making up the cervical plug liquifies, and relaxin softens (relaxes) the cervix so it can dilate and expand enough to allow the calf to pass through.

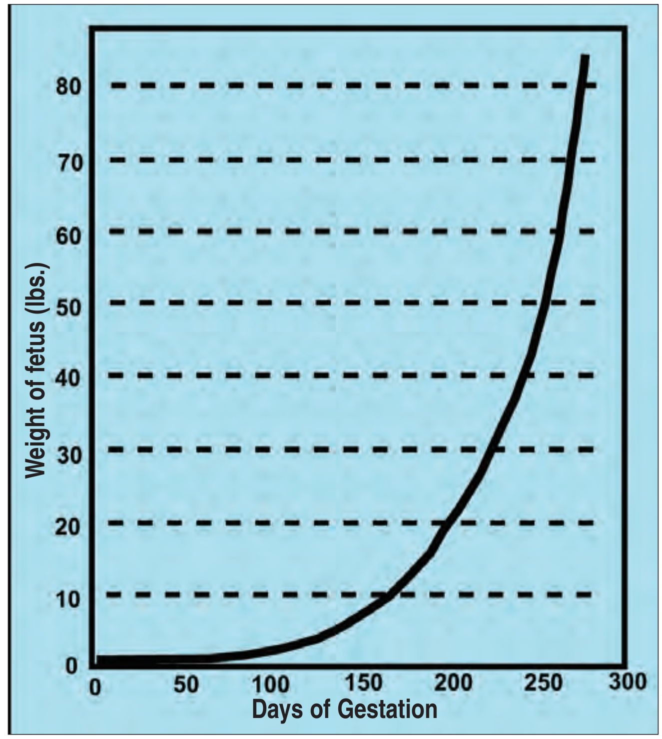
The calf plays the key role in its own delivery. Although the exact mechanism that starts the whole process is unknown, it is thought that maturation of the calf's hypothalamus is involved. Presumably the "matured" hypothalamus stimulates the pituitary to secrete adrenocorticotropic hormone (ACTH), which in turn stimulates the calf's adrenal glands to secrete more corticosteroids.

The corticosteroids from the adrenal glands stimulate the placenta to secrete large quantities of estrogen—much larger quantities than are secreted at estrus. The large amount of estrogen makes the uterus more sensitive to other hormones that stimulate contractions of the uterine muscles.

As the estrogen levels rise rapidly, they stimulate the uterus to secrete prostaglandin.

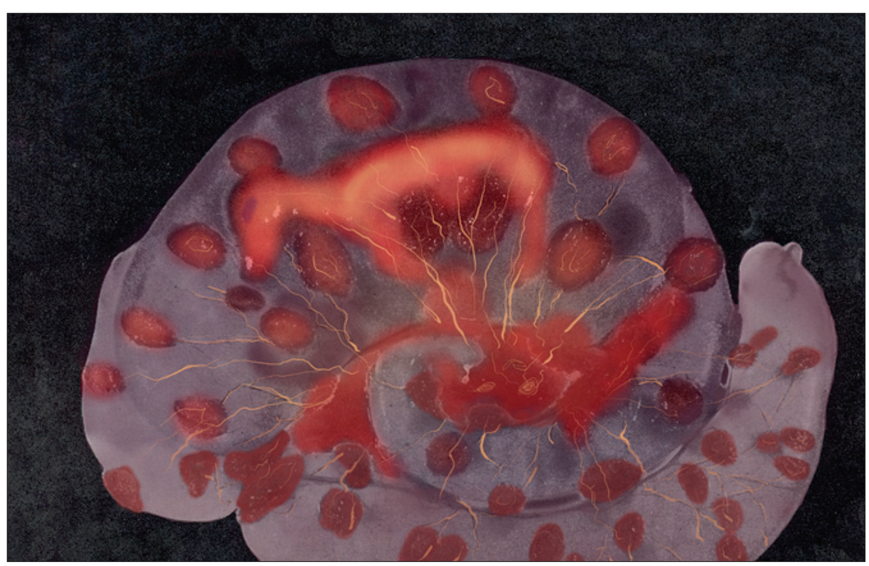
Prostaglandin plays two roles. It causes regression of the corpus luteum just as it does near the end of each estrous cycle, and it stimulates uterine contractions. At this same time, increased prostaglandin causes oxytocin release from the posterior pituitary. Together, prostaglandin and oxytocin cause uterine contractions leading to birth of the calf.

During the beginning stage of labor, the fully developed calf is pushed into the normal birth position. The forelegs are extended with the head lying on them ready to pass through the dilated cervix. In any other position, the calf is likely to cause difficulties for the cow. The calf is most often born free of its surrounding membranes. Because the umbilical cord is short, it



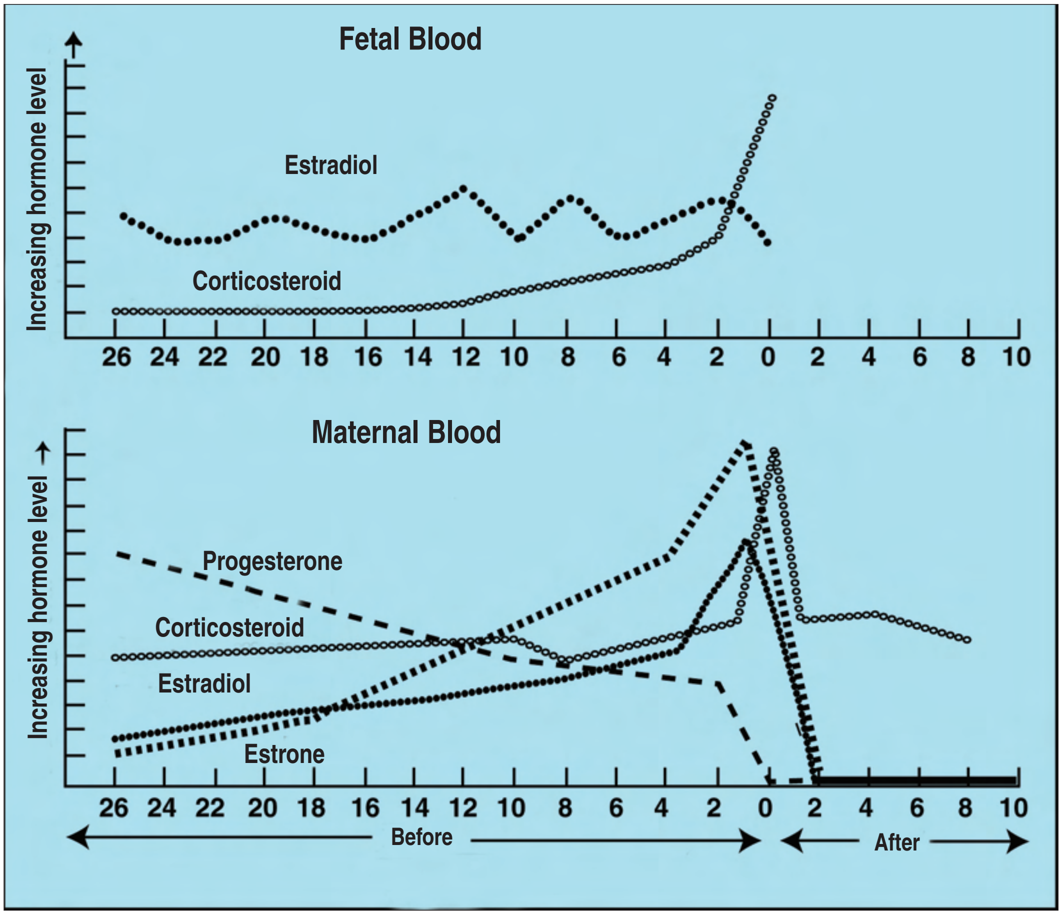
GROWTH OF THE FETUS is illustrated in this graph. The calf is still very small at 50 days. But the rate of growth increases rapidly as pregnancy progresses to the calving date.

FETUS IN PLACENTAL MEMBRANES at 4 months of gestation. The amnion (immediately surrounding the fetus) is bean-shaped and about 18 inches (45 cm) long. Blood vessels radiate from cotyledons on the surface of the placenta toward the umbilical cords of the fetus.



usually breaks as the calf is born. Thus, the calf must start breathing and begin its independent life in a new environment.

Infertility can originate at almost any point in the development of the calf. This infertility easily may result in the death of the calf. But in the long run, the possibility of permanent damage to the cow's reproductive tract may be even more serious.



CHANGES IN CONCENTRATION OF SELECTED HORMONES in the blood of the calf (top) and cow (bottom) around the time of calving. Each hormone is shown relative to the changes that occur for it alone. Actual levels may vary more than 100-fold for the hormones shown, so direct comparison should not be made among different hormones.

Beginning about 2 weeks before delivery, fetal corticosteroids increase, and this stimulates an increase in placental estrogens (estrone and estradiol) in the cow. Corticosteroids in the calf and cow, and estrogens in the cow peak around the time of delivery. In contrast, progesterone from the placenta and the cow's corpus luteum declines slowly until 1 to 2 days before delivery when it decreases rapidly. Not shown is an increase in prostaglandin F2-α in the cow's blood during 1 to 2 days before delivery and a simultaneous increase in prolactin from the pituitary gland that initiates milk secretion.

7 – Calving time

A FARMER may fertilize the soil, choose the best variety of seed corn, plant the seed at the appropriate depth in a properly prepared seedbed, and suitably cultivate the growing plants, but if the corn is not harvested properly, most everything that preceded the harvest is wasted.

Length of gestation. Gestation begins at fertilization and ends at birth. For practical purposes, however, the time of fertilization is difficult to measure. Consequently, most dairy producers use the time of insemination as the beginning of gestation.

The duration of gestation varies with age and breed of the cow, sex of the calf and number of calves carried. Probably the season of the year and inheritance also affect gestation length.

Surveys of all breeds of cattle generally show average gestation lengths of 276 to 292 days. While most dairy breeds have gestation lengths close to 280 days, that of Brown Swiss is about 10 days longer at 290 days. Bull calves are carried about one day longer than heifers. Twins usually are born about a week earlier than single calves.

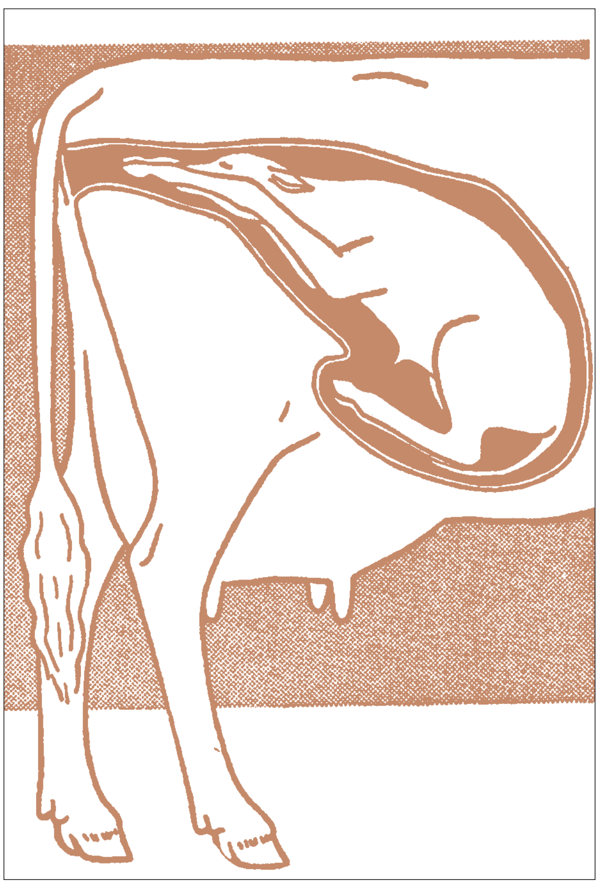
Events of a normal calving. Understanding the normal progression of events during calving and knowing when and how to assist an abnormal birth are essential to minimize calf deaths and cow losses. Cows undergo a series of hormonally-controlled changes that indicate the start of calving. Several weeks before freshening the udder fills with colostrum, and as calving approaches, the vulva becomes swollen. Pelvic ligaments relax, causing a sunken appearance around the tailhead. Mucus discharged from the vagina becomes flowing and clear, similar to the mucus observed during estrus. The actual birth process progresses through three continuous stages: preparation, delivery of the calf and passage of the fetal membranes.

During Stage 1, the cervix relaxes and dilates. The cow may act restless and seek solitude. She also may look at her flanks, stamp her feet, raise her tail, arch her back, and urinate or defecate frequently. Weak straining of the abdominal muscles can be seen as well. Stage 1 ends when the fetal membranes become visible. In cows this process may take 3 to 6 hours. Heifers may need 4 to 10 hours to prepare for delivery. During this time, observe animals hourly from a distance to monitor their progress.

Stage 2 begins when the "water bag" breaks. This is the chorioallantois, the outer membrane that surrounds the calf in the uterus. Once this membrane breaks, the legs and head of the calf begin to push through the cervix and into the vagina. The cow usually acts restless and repeatedly switches from standing to lying down. When the calf's feet enter the vagina, the inner membrane, called the amnion, breaks, releasing a thick, lubricating fluid. The time between the breaking of the first and second membranes is often about 1 hour. It is best to wait until the calf's feet are visible to move her to a maternity pen. Strong abdominal straining can be observed as uterine contractions become more frequent. Another delay occurs as the vulva is stretched by the head, which often slips in and out of sight. The cow continues to push until the head and shoulders are delivered, then typically rests for a few moments. Once straining resumes, the rest of the calf is usually delivered quickly. Most cows have their calves within 1 to 2 hours after the water breaks. Heifers may take 2 to 4 hours. During this stage, continue to observe the animal every 30 minutes, but do not disturb her.

The final stage, passage of the fetal membranes, is a continued series of uterine contractions and a rapid decrease in the size of the uterus, a process called involution. The attachment between the placenta and uterus relaxes, and the placenta separates from the uterus. Stage 3 ends with the passage of the fetal membranes, or afterbirth. Normally, the placenta is passed within 1 to 8 hours after birth of the calf. A placenta that is not expelled within 12 hours is considered a retained placenta. Do not attempt to remove a retained placenta manually or insert anything into the uterus. Work with your veterinarian to develop a treatment plan for such cows.

NORMAL BIRTH POSITION of the calf. The calf lies on its stomach with its forelegs extended and its head lying on them. In this way, the calf is presented at its smallest diameter.



Difficult and abnormal births. While the majority of cows and heifers calve normally with little assistance, roughly 6 percent of cows and 20 percent of heifers experience calving difficulty, or dystocia. Calving problems are a leading cause of death in cows. In addition, 7 percent of calves are born dead or die within 48 hours of birth. Stillborn births have actually increased somewhat in recent years, according to Iowa research. Dystocia is more common in heifers than cows because heifers are usually smaller and have not given birth before. When dystocia occurs in cows, the problem is likely to be more serious, often due to a large or poorly positioned calf. Milk fever may present additional complications. Observation of calving and assisting when needed can reduce the number of stillborn calves and increase survival rates.

As dystocia becomes more severe, calf deaths in the first 48 hours increase. Some causes of dystocia include age of the dam, large calves, small pelvic opening in the dam, weak contraction of the uterus (possibly linked to milk fever), abnormal position of the calf and twins. Pay attention to sire calving ease ratings, especially in small cows and first-calf heifers, and only use bulls with less than 10 percent calving difficulty on cows at high risk for dystocia. Besides heifers and small cows, those at high risk include cows with a history of reproductive problems (uterine torsion, prolapse or uterine tears) or metabolic disease (milk fever or ketosis). Fat animals also have increased dystocia risk, due to fatty deposits around the reproductive tract and pelvic area, and increased risk of metabolic disorders.

Examining the cow. During Stage 1, examine animals if no progress has been made after 4 hours. If progress seems to stop after the water bag appears, animals should be examined to see if assistance is needed. Examine cows if they have made no progress an hour after the water bag first appears. For first-calf heifers, wait 2 hours after the water bag first appears before examining the animal.

Animals also should be examined if progress has stopped for more than 30 minutes after active straining. Rest periods typically last only 5 to 10 minutes and a lack of progress may indicate the calf is too large or the cow is weak. In most cases, there is no need to rush and immediately pull the calf; it can live for 8 to 10 hours after the first water bag breaks. The exception is a calf presented backward. In this case pressure on the umbilical cord can cut off the oxygen supply. Quickly assist all calves presented backward.

Before you start the exam, restrain the animal and tie her tail to her neck with a piece of twine to keep it out of the way. Thoroughly wash the anus, vulva, and pin bones with soap and water. Wash your arms and hands with disinfectant soap. Using a clean, plastic, disposable sleeve is advised. Apply a generous amount of lubricant. Avoid using soap as a lubricant because it removes the natural lubrication of the birth canal and can irritate and inflame vaginal membranes. Commercially available obstetrical lubricants containing methylcellulose are recommended. Mineral oil also may be used for lubrication. Form a cone with your fingers and thumb and gently push a hand into the vulva. Once in the vagina, the hand can be flattened with the palm facing down and pushed along the roof of the vagina.

The first step is to determine the extent of cervical dilation. The calf's body will stimulate dilation as it is delivered, but early in delivery the cervical opening must be wide enough to allow the nose and feet to pass easily. Next, determine what body parts of the calf are presented. Front legs can be distinguished from back legs by the direction the joint above the fetlock bends. If it bends in the same direction as the fetlock, it is the knee and a front leg. If it bends in the opposite direction, it is the hock and a back leg. The soles of the feet indicate the position of the calf; in a normal delivery soles on the front feet face down, soles on the back feet face up. Since twinning rates of up to 10 percent occur in some herds, be sure to find two legs and determine that they belong to one calf before pulling the calf. To find out if a pair of legs belongs to one calf, follow one leg to the brisket and then trace down the other leg. Also, determine the position of the head. In a normal forward deliv-

ABNORMAL BIRTH POSITIONS

CALF UPSIDE DOWN. A veterinarian will usually turn the calf. Occasionally, such a calf must be delivered backward.

HEAD BENT BACK. If the veterinarian can push the calf back into the cow, the head can be brought into position.

FORELEG RETAINED. The retained leg must be brought forward, joint by joint, so the calf can be delivered.

BACKWARD & UPSIDE DOWN. The calf must be turned in the uterus to the normal position for delivery.

CALF BACKWARD. Veterinarians try to straighten the hindlegs and deliver the calf backward.

HINDLEGS FORWARD is serious if delivery is far along. Frequently the fetus must be dismembered.

ery, the chin rests just above the knees. In uncomplicated backward delivery, the head will not be presented; the tail should be down and between the thighs.

Finally, consider the stress level of the calf. Determine if the calf is alive by pinching between the toes. Live calves will reflexively draw the foot back. Calves presented backward can be tested by inserting a finger into the rectum. Live calves will squeeze your finger. The only time to pull a calf presented in a normal position is when it is distressed. The color of the tongue is one indicator of stress. Normally, tongue color darkens during hard contractions and lightens between contractions. If the tongue stays dark through the rest period, the calf is in distress. If blood or pieces of the placenta appear, the calf likely is bleeding and should be pulled.

Once you have examined the animal and assessed the situation, determine whether you can assist with the delivery or if extra help is needed. Three situations that call for help are: you cannot find the cause of the problem; you know the problem, but cannot solve it; or you have been trying to correct the problem for 30 minutes and have made no progress. If any of these situations occur, find a more experienced person to help or call the veterinarian.

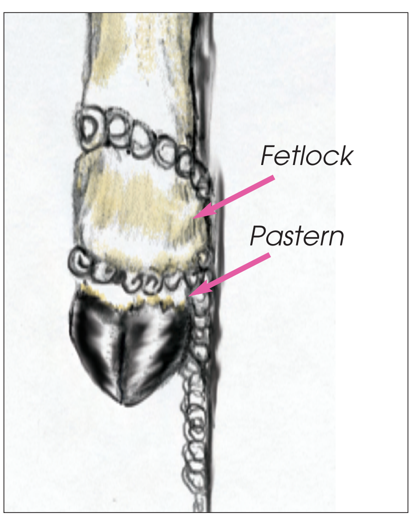
Abnormal birth positions. If examination of the cow reveals an abnormal presentation, the situation must be corrected before delivery can occur. If the calf cannot be quickly manipulated into a normal position, obtain veterinary assistance. Do not attempt to pull a calf in an abnormal position; this may injure the cow, kill the calf or both.

Calves presented backward can be delivered, as long as the legs are stretched out behind the calf. However, a backward calf must be delivered quickly because the umbilical cord is pinched between the calf and the pelvis early in delivery. Pinching the cord slows blood circulation and may cause death or brain damage. To correct abnormal positions, it is often necessary to push the calf back into the uterus where the cow's pelvis will not interfere with manipulation. Before moving the calf, attach obstetric chains to one leg to enable retrieval. Between straining episodes, firmly push the calf back and manipulate it into the correct position. When moving a foot, place your hand over the hoof to prevent tearing the birth canal. It is essential to determine the exact position before attempting to correct it. Correcting anything more than a turned leg or head usually requires veterinary assistance.

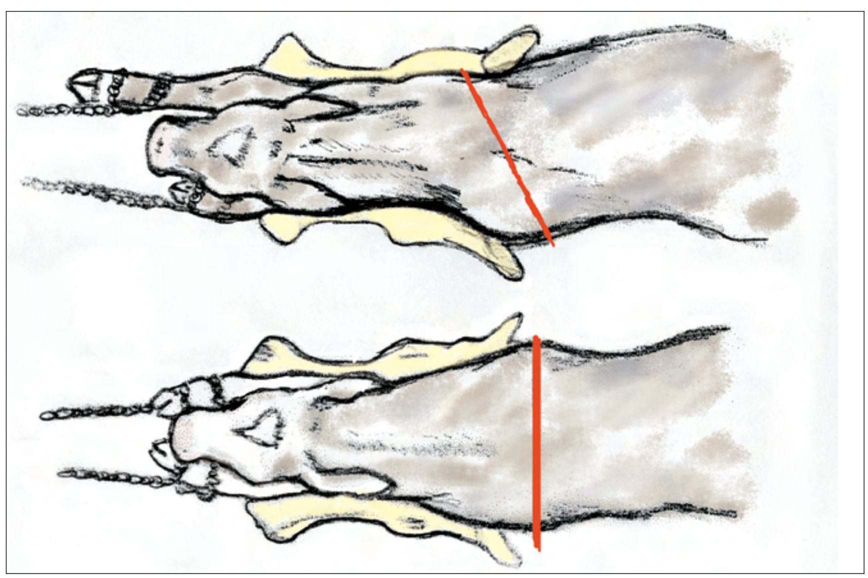
Assisting delivery. Most births do not require assistance. Rushing delivery can injure the cow and should be avoided. However, waiting too long after the water breaks to assist may deprive the calf of oxygen and cause death. When it is necessary to assist, use the following techniques to increase the number of live calves born and decrease injuries to cows.

First, remember to wash the external genitalia of the cow and wash and lubricate your hands and arms. Keep two buckets of warm water nearby, one to wash the cow and one to wash your hands and arms and store obstetri-

PLACEMENT OF LEG CHAINS for calving assistance.
Source: Whittier and Thorne, 1995.



CORRECT TECHNIQUE FOR PULLING A CALF: pull one leg at a time (top) to avoid wedging shoulders in the pelvis (bottom).
Source: Whittier and Thorne, 1995.



cal chains and handles. The birth canal may be dilated manually to assist delivery and minimize tearing injuries. To do this, insert both arms into the vulva and vagina, clasp your hands and bend your elbows outward to stretch the birth canal.

Attach obstetrical chains to both legs, making two loops, one above and one below the fetlock joint as shown on page 32. Position chains to pull from the underside of legs. Pull one leg out until the pastern is about four inches [10 cm] outside the vulva. While holding the leg in this position, pull the other leg out to the same distance. Use a back and forth motion between the two legs as pulling both legs at once may cause the calf's shoulders (or hips in a backwards delivery) to lodge in the pelvic opening as illustrated on page 32. If the shoulders lock in the pelvis, place a rope or chain around the calf's poll and through the mouth as shown below, left. Pulling on the calf's head in this manner reduces the size of the shoulders and chest and may loosen the calf.

Once the head and shoulders have been delivered, rotate the calf about half a turn. This allows the widest part of the calf's hips to pass through the widest part of the cow's pelvis as shown below. Without rotation, the calf's hips pass through the narrowest part of the cow's pelvis, which may result in hiplock. If pressure continues after hiplock, the cow can suffer nerve damage or tearing of the reproductive tract. If the calf is coming backward, rotation must be accomplished as soon as the legs are available, because the hips will come through the pelvis next. To be effective, rotation must occur before the hips enter the pelvic opening. If hiplock occurs, push the calf back and rotate it before pulling again.

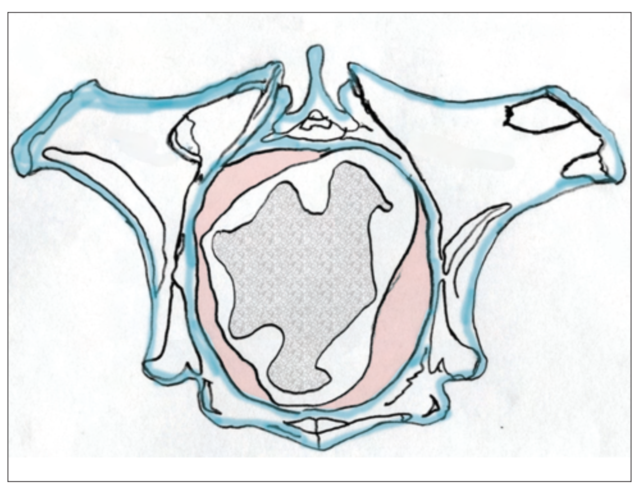
The direction and strength of extraction are also critical. Initially, pull straight back to move the calf into the pelvis. Once the head is delivered, pull downward in an arc toward the udder to slide the calf through the birth canal more easily. In a backward delivery, change the pulling direction once the base of the tail is delivered. Too much force can tear the birth canal or break the calf's legs or ribs; so no more than two people should pull on a calf. Extraction force should never exceed 400 pounds [180 kg]; a strong person can exert about 200 pounds [90 kg] of force. Calving gauges are available that measure the force exerted. To prevent injuries to the cow, pull on the calf only when the cow strains. Do not allow the calf to slip back into the cow in between straining, but do not exert force while the cow rests. Instead, use rest periods to reposition the calf if necessary.

Mechanical pullers or calf jacks are a last resort and should be used only by an experienced person. Applying excessive force is very easy when using a jack as many can exert 2,000 pounds [900 kg] or more. Pullers that work off of the cow, rather than a stationary object, are preferable. This allows movement with the cow and may change the pelvic angle and open the birth canal. Once the last rib is outside the vulva, stop pulling and allow the cow to finish the delivery.

Care of the newborn. The newborn calf represents the primary product, and prompt attention must be given to the calf at "harvest" time. Oxygen is the first requirement to

PULLING ON THE CALF'S HEAD as shown reduces the size of the calf's shoulders and chest.
Source: Practical Techniques for Dairy Farmers.

ALIGN THE WIDEST PART of the calf's hips with the widest part of the cow's pelvis.
Source: Practical Techniques for Dairy Farmers.



assure survival of the calf. Make certain that the nostrils are clear of membranes and fluids. Breathing may be stimulated by blowing into the nasal cavity or tickling the nasal cavity with a straw.

Undoubtedly, the most important factor in promoting calf survival is feeding four quarts/liters of colostrums (large breed calves) within one hour after birth, and another three quarts/liters 8 hours later. Colostrum is essential to get calves off to a good start. It provides a rich supply of nutrients; helps in activating the digestive system; and, most importantly, it provides protection against infection and disease.

In fact, colostrum provides the only source of protection (called passive immunity) for the calf against disease-producing organisms for about the first two months of life, while the calf's own immunological defense system (called active immunity) is developing.

Intact antibody proteins in colostrum can be absorbed through the intestine only for the first few hours of life. The ability to absorb antibodies diminishes after the calf is two hours old. Thus, it is extremely important to get colostrum into calves within an hour after birth and preferably within 15 minutes.

The first two weeks of life are the most critical period for calf losses. Certainly, prompt feeding of colostrum, sanitation, good housing and adequate nutrition will help get the calf off to a good start in its own environment.

Expulsion of the afterbirth. After the calf is born, uterine contractions continue, which expel the fetal membranes from the uterus. This is the afterbirth. It should be disposed of as soon as expelled. From natural instinct, cows will eat fresh membranes and may choke or have digestive disturbances.

If the afterbirth is not expelled within 12 hours, it is considered a retained placenta. The placenta usually dies whether or not it is expelled. The retained placenta will usually be shed within a few days. The lower portion of the retained placenta may be cut off, but some should be allowed to extend from the cow's vulva. This will help the placenta become detached. Do not tie weights to the afterbirth.

Physically removing the afterbirth from its attachments is no longer a recommended procedure. Usually, when forcefully removed, small fragments of afterbirth are left in the uterus where they decay and result in pus that may remain for weeks. Research has shown that even successful manual removal of the afterbirth prolonged the interval from calving to first appearance of a functional corpus luteum by 20 days, increased the interval to first service, increased the severity of uterine infection, and prolonged the presence of pathogenic bacteria in the uterus compared with allowing the retained afterbirth to expel spontaneously.

Currently, research does not support use of prostaglandins, estrogens nor manual removal of retained afterbirth. Accepted practices include 20 to 30 IU of oxytocin every 3 hours; systemic antibiotics; anti-inflammatory therapy; fluid therapy – and better yet, preventive strategies.

Recovery of the cow. Calving places a tremendous strain upon the well-being of the cow. On top of this, the sudden surge of milk secretion places another great stress on her. These factors make the cow easy prey for many infectious agents during the first days after calving.

It is essential that the cow be in a clean environment both before and immediately after calving. A clean, straw-bedded box stall or a small grassy pasture is ideal. Cows should not be allowed to calve in a box stall that is used continuously and seldom cleaned. A box stall bedded with sawdust is especially dangerous to both calf and dam. Such a site increases the chance that infection will be spread from one cow to the next and to the calves.

Provided there is no evidence of disease and the cow calved and cleaned normally, she should be returned to the milking herd as soon as her milk is legally saleable. Grouping fresh cows can be beneficial from the standpoint of easier monitoring for any health problems, as well as administering a fresh cow ration.

Following each use, the maternity stall should again be scraped free of manure and bedding, washed with soap and water, and allowed to dry for 24 hours. If there is evidence of disease, the stall also should be sprayed or rinsed with a disinfectant and allowed to dry for at least two or three days. The stall is then ready for the next occupant.

A temporary change in the calving facility is recommended when an infectious disease of the cows or calves is present.

After calving, some bleeding may occur from the caruncles on the inside of the uterus. But the blood supply to these is normally quite limited by this time, causing them to gradually decrease in size.

At the time the afterbirth is expelled, the caruncles may be as much as 2 inches high and 2 inches (5 cm x 5 cm) in diameter. By three weeks after calving, they have decreased to about 1/4 inch (0.6 cm) high and 1 inch (2.5 cm) in diameter, dimensions still considerably greater than normal.

A few quarts of fluid, containing blood and bits of tissue (lochia) usually are found in the uterus during the first few days after calving. This fluid generally disappears during the first three weeks after calving. Normally, this is not an infection. However, uterine infections frequently occur, even in normal calvings.

A good indication of the beginning of an infection is the odor of the discharge. The bloody discharge, which is normal during the first two to three weeks after calving, should not have a strong odor. If the discharge shows pus or has a foul odor, the cow should be given prompt attention. More on this in Chapter 12.

The normal uterine defenses against bacteria are not as effective just after calving. This is one reason why a clean calving area is so important. It is also the reason why the average dairy producer is well-advised to call a veterinarian to assist abnormal births.

As pointed out in previous chapters, the cow should be in good physical condition at calving time. Good nutrition and proper care during the dry period are quite helpful in preventing calving complications. The cow alone cannot accomplish her important goal of carrying and delivering a normal, healthy calf. She is dependent upon the care and management given her by the dairy producer.

Prevention of difficult calving. Because about 50 percent of the herd calving difficulties occur at first calvings, efforts to prevent this problem are warranted. Most calving difficulties in heifers can be prevented by carefully selecting sires to which heifers are bred for the first time. Because heifers should enter the milking herd no later than 2 years of age to maximize lifetime performance and reduce their maintenance costs, inseminating growthy and well-developed heifers at younger ages offers the advantage of earlier recovery of their rearing costs. However, special attention must be paid to their nutrition program and growth (stature and weight).

There are two proofs for calving ease now: proofs for sires of calves to be born (Sire Calving Ease-SCE) and proofs for sires of daughters to give birth (Daughter Calving Ease-DCE). DCE is a fairly recent innovation that hasn't been around long enough yet to have much impact on the population.

Proven sires with known calving ease (less than 9 percent SCE – difficult first births in heifers) should be used as breeding sires to avoid extra large calves in heifers. It is not difficult to find excellent sires with acceptable levels of calving ease. An SCE of 8 for a sire means that only 8 of every 100 calves born to heifers that he sired will have a calving difficulty score of 4 or 5 (very difficult birth requiring assistance). There are good bulls for overall merit among the best bulls for SCE. It could be argued that bulls with higher SCE should be avoided, even among older cows, because the problem of difficult calving then becomes passed along. Still, heritability is rather low, 8.6 percent for SCE. Net Merit does take high SCE into account. But a high type proof bull might still be tempting, even if his SCE is high as well. In all cases, you should definitely use a low SCE proof bull when breeding heifers.

Use of sexed semen when used in breeding heifers has an added advantage in regard to calving ease in that heifer calves are usually smaller.

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8 – Can we feed for fertility?

Even though we have made tremendous progress in developing well-balanced rations for dairy cattle, during early lactation when dry matter intake is depressed it is difficult to meet the cow's nutritional needs; particularly when milk production exceeds 100 pounds (45 kg) per day. And in many herds, nearly every cow peaks at or above 100 pounds of milk per day. The nutritional demands of peak milk production usually occur just before rebreeding cows after calving. It becomes a real challenge to meet a cow's nutritional needs for both lactation and reproduction.

One of the major components of high reproductive efficiency is obtaining a successful pregnancy in the high-producing dairy cow by 100 days postpartum. Many studies have evaluated the effect of various nutrients on reproduction; however no one feed ingredient has been identified to insure reproductive efficiency.

Energy. One of the most common causes of nutritional infertility results from an insufficient supply of energy or negative energy balance. Many experiments have shown that underfeeding heifers seriously delays sexual maturity. Once the slightly underfed heifer reaches puberty, her fertility is apparently normal once fed a balanced diet.

Numerous reports have shown that stunted heifers or those in poor condition are likely to have infantile ovaries, irregular estrous cycles and decidedly lower fertility. In severe starvation, the estrous cycle ceases.

Some dairy producers pasture yearling heifers all summer. There is a tendency to forget those heifers until it comes time to breed them. Then heifers may look thin and do not come into standing estrus. The vast majority of these difficulties can be prevented or cured with an adequate grain ration combined with an effective parasite control program.

Studies have shown that heifers fed adequate forage with proper energy and protein supplementation will reach breeding size by 12 to 14 months of age. Holstein heifers gaining a minimum of 1.6 to 1.7 pounds (0.7 to 0.8 kg) daily from birth to calving can calve at 24 months of age weighing 1,200 pounds (540 kg) or more after calving.

A balance of protein and energy is required to insure heifers grow in height without getting fat. Often rapid growth is associated with fattening, but there is a distinct difference. However, many dairy producers still believe that overfeeding results in infertility. Excessively fat heifers are undesirable (body condition over 3.75), but not necessarily from the standpoint of infertility. Studies have shown that fat dairy heifers produce less milk after calving than heifers grown normally. In fact, excessively fat heifers are as likely to have reduced milk production as underfed heifers. In addition, overconditioned heifers experience more calving problems.

Meeting the energy requirements of a high-producing cow during peak lactation is much more difficult than meeting the needs of a growing heifer. Rations designed to promote maximum milk yield during lactation should also give the best reproductive performance.

Cows attain maximum dry matter intake at approximately 8 to 10 weeks into the lactation. Since peak production occurs earlier, at approximately 4 to 6 weeks, dairy cows are usually in a negative energy balance for 4 to 7 weeks after calving. During this period, the cow usually loses weight accumulated during the last lactation and

maintained during the dry period.

In high-producing cows, first breeding after calving may occur while the cow is still in a negative energy balance. This may result in a slightly lower conception rate than would be the case if the cow were gaining weight. The second service occurs during a period when the energy balance is positive. Proper energy balance is important to the resumption of ovarian cyclicity and the ability to obtain acceptable conception rates of 40 percent or greater.

High-energy rations formulated to provide adequate forage intake may benefit fertility. Adding 2 to 3 percent added fat or oil (from oilseeds such as fuzzy cottonseed) can increase ration energy concentration and increase dry matter intake. Added fat/oil can also increase ovarian structures and improve conception rate. In addition, rations containing buffering compounds (sodium bicarbonate) and microbials (yeast) may reduce "off-feed" problems and consequently result in more feed intake during peak lactation.

Many dairy producers accept that high-producing cows are more difficult to get pregnant. In one survey of high-producing herds, days open didn't suffer compared to average herds, but there were more services per conception.

The metabolic demand of high production can affect how soon a cow will ovulate. Cows experience negative energy balance during early lactation, because they can't consume enough energy to keep up with production. So a prolonged negative energy balance can mean delayed first ovulation and also lowered conception rates.

If a cow is carrying adequate body condition when she calves, she has body reserves to draw upon. This lessens the severity and duration of the negative energy balance, and will help her reproductive performance. However, you don't want cows too fat when they are dry, or they will experience a number of metabolic problems at calving and more calving difficulty.

Ideally, body condition scores (BCS), based on the 1 to 5 scale developed at Virginia Tech, are as follows: drying off and calving, 3.25 to 3.50; springing heifers, 3.0 to 3.25; prebreeding exam, 2.5 to 3.0; pregnancy exam, 3.0; late lactation, 3.0 to 3.5. A goal should be body condition score should not drop more than 1.0 unit between calving and breeding. Reproductive performance often will be impaired if cows lose more than 1.0 body score unit during the first 5 weeks after calving.

Generally, lower or average BCS in early lactation leads to poorer reproductive performance. One herd studied averaged 2.69 BCS at calving and 2.39 at 10 weeks postpartum. Cows with a BCS one point higher than this average at 10 weeks postpartum came into heat 5.4 days sooner, were bred 6.2 days sooner and had a 9 percent better conception rate.

It also is important that body condition is not lost during the dry period. During late lactation, the desired body condition should be obtained and maintained until calving. Cows that lose body condition during the dry period are prone to having more metabolic problems at calving, which have a negative relationship to subsequent fertility.

The body condition of dairy replacement heifers is also important. A heifer that grows too slowly will join the milking herd late. A thin heifer will not have the needed fat reserves for optimum milk production during her first lactation. During the first lactation, energy outflow is more critical because milk yield and growth demand more from a heifer. She quickly finds herself in a negative energy balance.

At 12 months of age, replacement heifers should average a condition score of 2.5. At 24 months of age, heifers in high-producing herds average a condition score of 3.0 to 3.25.

As a rule, cows should range from a 2.0 to a 3.5 score, depending on their stage of lactation.

Protein. One of the chief economic advantages of cattle over some other animals is their ability to synthesize amino acids in the rumen. This fact has complicated efforts to determine protein requirements for reproduction.

Initially researchers reported a negative effect of excess dietary crude protein on reproduction. However more recently it has been determined that rumen degraded protein (RDP) and rumen undegraded protein (RUP) – not crude protein – should be the types of dietary protein used to measure the impact on reproductive performance. High levels of rumen degradable protein have consistently shown a negative relationship with obtaining conception in dairy cattle.

The basis for an adverse effect on reproduction is an increase in ammonia and urea in blood and uterine secretions in cows fed high-protein diets. High protein also alters the amount of phosphorus, magnesium, potassium and zinc in uterine secretions or blood. Overall, it appears that RDP levels in the ration should be high enough to support maximum microbial growth, but not above that. Protein sources that are not degraded as rapidly in the rumen (RUP) may be beneficial in supporting high production without affecting reproduction.

There is no firm evidence that non-protein nitrogen (NPN) such as urea has an adverse effect on reproduction when added to the ration at recommended levels. Milk urea nitrogen (MUN) and blood urea nitrogen (BUN) levels have been used to monitor the effects of rumen degradable protein on nitrogen concentrations in an attempt to adjust rations and reduce negative effects on fertility. Although excessive NPN and rumen degradable protein adversely influence reproduction, they are not cause for concern if fed at or below recommended levels. MUN levels should range from 10 to 14 mg/DL.

Protein content normally is lower in heifer rations in comparison to lactating cow rations. Protein is usually adequate for reproduction in most heifer rations, and not normally considered as a factor affecting fertility in heifers.

Essential fatty acids. Essential fatty acids (EFA) provide energy from a cow's diet. The most important are omega-3 (linolenic) and omega-6 (linoleic). These are fatty acids that can't be synthesized in the cow's body in adequate amounts. At high production levels, cows use these fatty acids from body stores and cause a shortage for both milk fat and the other roles. EFAs serve as building blocks for several types of prostaglandins. One specific prostaglandin, PGF-2α, causes regression of the corpus luteum if a cow is not pregnant, allowing her to get ready for her next estrous cycle. Prostaglandin allows for better overall health of the reproductive tract and can lead to earlier cycles.

EFAs also are important in producing progesterone. Progesterone supports a pregnancy, if one occurs, until the placenta can sustain the pregnancy later in gestation. In two different studies, feeding EFAs improved pregnancy rates by 5 percent. Converting these acids into rumen inert fatty acids and feeding them as supplements ensures that more of the EFAs acids reach the intestine where they can be absorbed.

Vitamins. Ruminants, such as the cow, are fortunate from a standpoint of their vitamin supply. Generally the B vitamins, and vitamins C and K are manufactured in adequate quantities by the cow. Only vitamins A, D, and E need be considered here. All three of these fat soluble vitamins can be provided through supplements or by using certain feeds that contain adequate levels of each of them.

Vitamin A deficiency in cattle results in blindness (especially night blindness), edema, lower milk production and reproductive disturbances. In addition, vitamin A is required for spermatogenesis in bulls. Vitamin A deficient animals are likely to produce dead or weak calves. Some abortions may occur late in pregnancy, and retained placenta is common. The live calves born are usually weak, and their mortality rate is high. Eye abnormalities are common in these calves. These deficiency symptoms occur frequently on the range during and following a dry season.

Vitamin A deficiency is easily avoided under most dairying conditions. Good quality green chop or pasture should provide an adequate amount. All silages, including alfalfa, are low in carotene, the vitamin A precursor, due to fermentation losses. Although alfalfa hay may initially have adequate vitamin A levels, during storage it is lost. Consequently, most rations based on stored forage have supplemental vitamin A added.

Some recent work in Europe suggests that carotene, the plant precursor for vitamin A, is also required for normal reproduction. Cows fed rations devoid of carotene, but with adequate levels of vitamin A had irregular estrous cycles, more silent estruses and a higher rate of cystic ovaries.

We think of vitamin D relative to its importance in calcium and phosphorus homeostasis or in maintaining immune function. The need for vitamin D for reproduction has been demonstrated. The health of vitamin D deficient animals declines, and they do not show estrus. Calves from cows on rations deficient in vitamin D frequently are born with rickets, which is characterized by faulty bone development.

In the past this deficiency was easily avoided by allowing cows periodic exposure to sunlight and by feeding sun-cured hays; however as we have moved from pas-

Effect of vitamin E on mastitis cases

Vitamin E dose: During dry period	Vitamin E dose: During lactation	% mastitis
100 IU	100 IU	26
1000 IU	500 IU	17
4000 IU	2000 IU	3

*Diet selenium was 0.1 ppm

Source: Weiss et al, 1997

ture-based systems to total confinement, providing dietary supplementation of vitamin D is recommended.

Vitamin E is required to maintain cellular membranes, immunity and reproductive function. Vitamin E content is quite variable in fresh forages and declines rapidly after harvesting, particularly with increasing light exposure or heating. In general, concentrates have low levels of vitamin E.

Vitamin E has consistently improved cellular immune function which should improve cow health. In some clinical studies, vitamin E has helped reduce the incidence of retained placenta; however this has not been a consistent result, probably due to the interaction with selenium status.

Recently, vitamin E has been reported to reduce mastitis. Since mastitis has had a negative impact on fertility, a reduction in mastitis could indirectly improve reproduction. Recently recommended levels of vitamin E have been increased in rations. Since vitamin E levels decline in stored forages, it is usually supplemented to meet these higher requirements.

Minerals for reproduction. Mineral deficiencies may have marked effects upon reproduction. Generally, mineral deficiencies in the ration occur when the ingredients are grown on mineral-deficient soils.

Although phosphorus was once thought to be a common mineral deficiency affecting reproduction, recent research does not support that conclusion. In fact today's dairy rations frequently have more phosphorus than the cow requires. This is particularly true of rations with high levels of by-product ingredients. Adding phosphorus can result in environmental problems unless the excess nutrients are properly managed.

Calcium and phosphorus intakes should be maintained at recommended levels, because these two minerals are closely associated in many body functions.

Among other minerals essential to the general welfare of the cow, deficiencies of iodine, cobalt, copper, selenium, manganese and zinc have been implicated in reproductive disturbances. Deficiencies occur particularly in areas such as the Great Lakes region, which is known to be generally deficient in iodine. Goiter (enlarged neck) in calves is a common symptom of iodine deficiency.

Almost all of these trace mineral deficiencies can be avoided easily and inexpensively by providing trace minerals in the grain ration for cattle.

Excessive fluorine in the ration has been reported to cause lowered birth weights of calves and to delay the first heat after calving. Fortunately, such toxicity occurs only rarely.

Iron can cause problems if present in excess. It interferes with copper absorption and has other negative effects. Limit iron to less than 750 mg/kg DM in the diet, and less than 0.4 mg/L in water.

Various toxins. Occasionally, a feed constituent can block or modify reproduction. For example, under certain growing conditions, some of the subterranean clovers may contain abnormally high quantities of estrogen-like chemicals.

When fed to cows, these feeds may easily upset the estrous cycle or even pregnancy. However, this cause of infertility rarely occurs in the United States.

Mycotoxins – Molds also produce a metabolite or byproduct called mycotoxin that can affect animals consuming the contaminated concentrate or forage. Although there are hundreds of mycotoxins, the most common molds producing mycotoxins that affect cattle are: Aspergillus (aflatoxin, fumitoxins and ochratoxin), Fusarium (Deoxynivalenol [DON], Zearalenone and T-2), and Penicillium (Ochratoxin, PR Toxin, and Penicillic Acid).

Probably the most common mycotoxin is aflatoxin. Its metabolite, aflatoxin M1, is a potent carcinogen that is excreted in milk; consequently FDA regulates aflatoxin in milk (over 0.5 ppm) and feed (over 20 ppm). When aflatoxins are fed, cows frequently go off-feed, have reduced feed efficiency, decreased milk production and reproductive inefficiency.

Most of these mycotoxins cause decreased feed consumption and suppress the immune function. Zearalenone has a chemical structure similar to estrogen, which can negatively influence reproduction through increased abortions, increased vaginitis and general low fertility.

Although analytical methods for testing for mycotoxins have improved, cost of analysis can be prohibitive. In addition, collecting a representative sample is challenging since the mycotoxins level may be highly variable within a load of feed. Consequently, producers must focus on preventing mycotoxin contamination by minimizing drought and insect damage during the growing season, storing concentrates below 13 percent moisture, aerating grains during long term storage, protecting stored feeds from rain or other water sources, cleaning storage facilities to eliminate sources of inoculation and checking for heating and molding. Dry down hay to keep molds from growing during storage. When making silage, harvest at the proper moisture content, chop uniformly, fill the silo rapidly, add silage inoculants when appropriate, pack the silage continuously, cover immediately, and manage the face when feeding, including discarding moldy pockets. Mycotoxin binders also can be added to rations to reduce the absorption of mycotoxins by dairy cattle.

Gossypol – Whole cottonseed is increasingly being used in dairy rations to increase the energy concentration while simultaneously providing some fiber and protein. In addition, some areas are using cottonseed meal as a protein supplement. Unfortunately, cottonseed and cottonseed meal contain a compound called gossypol, which has been shown to cause infertility in males, reductions in embryo quality, decreased conception rates, and greater fetal losses. Gossypol is toxic to mammalian cells.

The gossypol content varies considerably depending upon type of cotton (Upland or Pima); growing, harvesting and storage conditions, and processing method. For example, six varieties of Pima cottonseed (also called black seed; usually cracked prior to feeding) had a total gossypol range from 0.95 to 1.58 percent of the meats (on a 100 percent DM basis). These varieties were all grown in test plots at three different locations. Based on the location, total gossypol ranged from 1.02 to 1.39 percent of the meats on a DM basis. The variation is just as evident in the Upland cotton varieties (also called white or fuzzy cottonseed). In one study with 24 varieties, the average total gossypol ranged from 1.01 to 1.95 percent of meats, DM basis.

Processing whole cottonseed reduces the total gossypol present. For example in one study the whole cottonseed averaged 0.61 percent total gossypol, DM basis. When the cottonseed was extruded the free gossypol fell to 0.26 percent and if it was extruded-expelled the free gossypol was reduced even further to 0.10 percent.

Unless a producer knows the variety of cottonseed grown and tests for gossypol levels, whole cottonseed should be limited to 6 to 8 pounds (2.7 to 3.6 kg) per cow per day. If cottonseed meal is fed in addition to whole cottonseed, the maximum amount of cottonseed products per day should not exceed 10 pounds (4.5 kg).

Dry cow feeding. A period not to overlook in feeding is the dry period. Care should be taken to avoid getting cows too fat when they are dry because this can cause problems at calving. Cows that are too fat or too thin at calving are more likely to have problems delivering the calf, and consequently are more likely to have postpartum problems (retained placentas, uterine infections and cystic ovaries).

You must focus particularly on calcium, potassium and phosphorus levels during the dry period to prevent milk fever and low blood calcium (called hypocalcemia), possibly feeding anionic (acidic)

Suggested nutrient levels for early lactation dairy cows

Nutrient	Holstein	Jersey
Body weight, lb (kg)	1500 (680)	1000 (454)
Dry matter intake, lb (kg)	66 (30)	52 (23.5)
Milk yield, lb (kg)	120 (55)	88 (40)
Crude protein, %	16.7	17.6
RDP, %	9.8	9.7
RUP,%	6.9	7.9
Metabolizable protein, %	11.6	12.6
Net energy-lact, Mcal/lb (Mcal.kg)	0.73 (1.61)	0.76 (1.68)
NDF, %	28	28
ADF, %	18	18
Non-fiber carbohydrate (NFC), %	38	38
Starch, %	24	24
Sugar, %	6	6
Fat/oil ,%	5.5	5.5
Calcium, %	0.70	0.73
Phosphorous, %	0.38	0.36
Magnesium, %	0.30	0.30
Chlorine, %	0.29	0.27
Sodium, %	0.25	0.25
Potassium, %	1.07	1.04
Sulfur, %	0.25	0.25
Vitamin A (IU added)	100,000	70,000
Vitamin D (IU added)	30,000	20,000
Vitamin E (IU added)	1000	1000

Trace mineral added to ration (expressed as ppm in the ration dry matter): cobalt 0.11 ppm; copper 10 ppm; iodine 0.4 ppm; iron 25 ppm; manganese 40 ppm; selenium 0.30 ppm; and zinc 40 ppm.

salts in the dry period to enhance calcium mobilization. Anionic salts are most easily managed in a dry cow total mixed ration (TMR). To verify that anionic products are working, urine pH for Holsteins should be between 6.0 and 6.5 and for Jerseys 5.8 to 6.2. Conversely, anionic salts can decrease feed intake if fed incorrectly, a disaster for dry cows. Although the anionic products are beneficial for cows, heifers do not require them.

Make sure that dry cows receive adequate trace minerals and vitamins. Dry cow rations can provide a good start for the fresh cow and her calf. For a detailed discussion, see the book Caring for Transition Cows, available from Hoard's Dairyman.

Remember, there are no nutrients specifically required for reproduction. Instead, reproduction requires most of the same nutrients that are required for other body processes. The protein, energy, vitamin and mineral requirements for reproduction (even for pregnancy) are small compared to the requirements for growth or for milk secretion.

For most practical circumstances, feed cattle for optimum growth and milk production.

Cows pregnant with twins. The current NRC model accurately predicted energy needs for a single pregnancy, but underestimated energy requirement for a twin pregnancy. You also can assume protein needs for the twin pregnant cow are underestimated. In the case of twins, the cow is attempting to support a total fetal mass that is at least 60 percent greater than a single fetus. So it is no surprise that a cow pregnant with twins has greater negative energy balance and resulting metabolic problems at calving.

An early diagnosis of twins can give an advantage. Twin pregnant cows need sufficient body condition coming into the dry period. Keep cows with twins on a higher plane of nutrition to build up nutrient reserves. You may wish to dry off pregnant cows carrying twins one to two weeks early, especially as these cows often calve five to eight days earlier than cows with a single pregnancy.

Once they're dry, feed twin pregnant cows a diet that is balanced to account for lower intake and higher energy and protein requirements. Those with a large enough herd might establish a separate, special needs dry group for the twin cows, or they could be moved directly onto the close-up dry diet for the entire dry period. This may not be feasible if you are feeding anionic products in your close-up diet.

Based on intake and estimated requirements, a suggested dry diet for cows with twins should contain 14 to 16 percent crude protein and have an energy density between 0.69 and 0.72 Mcal/lb.

Dry matter intake of pregnant cows (heifers and mature cows) in the close-up period

Days before calving	Mature cows	Springing heifers
	Lbs [kg] DM per day	
21 days before calving	28.2 [12.7]	22.4 [10]
1 day before calving	9.4 [8.7]	16.3 [7.3]
Average last 21 days	25.5 [11.5]	21.6 [9.7]

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9 – Genetic factors

It is well known that certain types of sterility may be inherited in dairy cattle. In other words, certain traits causing sterility are passed on from the parents to the offspring through the genes on the chromosomes in the egg and in the sperm. Some of these hereditary defects actually result in death of the offspring, sometimes before birth.

These hereditary defects are transmitted by recessive lethal genes that may have no measurable effect on the carrier bull or the carrier cow. Since these genes are not visible, the genetic defects or harmful traits may be transmitted in the genetic material along with the desirable traits.

When a carrier bull is mated to a carrier cow, about one-fourth of the offspring would not survive. About one-half of the offspring would be normal in appearance, but would be carriers of the lethal genes. About one-fourth of the offspring would be perfectly normal noncarriers. Identification and elimination of the carrier animals is the only way to eliminate the lethal genes.

If an animal is born dead because of a hereditary lethal defect, the bull is not entirely at fault. The cow is equally to blame because most lethal genes cause death only when they are passed on from both parents.

Usually, bulls used in A.I. are carefully selected to avoid the undesirable lethal genes. But it is possible that the dairy industry in this country has given too little attention to the harmful genetic defects in cattle. There are over 80 known inherited defects in cattle, and it has been well documented that systematic efforts can be successful in controlling and eliminating some of them.

Inherited abnormalities. It is not necessary for an inherited characteristic to be lethal to hamper the efficiency of reproduction. Fertility differences between breeds and between cow families within the various breeds provide general evidence that genetic factors are responsible for varying degrees of fertility.

Several of these inherited causes of infertility involve anatomical abnormalities. Most of these are the result of improper development of the reproductive tract. In severe cases, the heifer is completely sterile. Less severe abnormalities may permit conception and calving, but only with considerable difficulty.

These cows may require more services per conception, even though they appear to be essentially normal.

Inherited defects and disturbances of the body processes (physiological) probably cause considerable loss in reproductive efficiency. However, such defects are not recognized as easily as defects in body structure (anatomical), and there is not complete agreement as to the role that heredity plays in such conditions. Environmental effects complicate these defects so that losses due strictly to heredity are difficult to measure.

An example of this type of defect is provided by some cow families which show abnormal gestation lengths. In one report involving 27 closely related cows, the gestation period varied from 302 to 370 days. All of the calves were overweight at birth, averaging 146 pounds (66 kg).

Because of the size of the calves, there were serious calving difficulties. Most calves had to be dismembered to save the cows. Others were born dead or lived only for a short period of time after birth. Thus, it appears that the length of gestation may be inherited, at least in some cow families.

Many investigators have reported that cystic ovaries are usually an inherited trait transmitted by both the dam and the sire. In Sweden, the incidence of cystic ovaries has declined over 50 percent in less than 20 years by intense efforts in identifying and eliminating A.I. sires producing a higher-than-normal number of daughters with cystic ovaries.

Recessive hereditary disorders in cattle of importance in recent years include BLAD (Bovine Leukocyte Adhesion Deficiency), DUMPS (Deficiency of Uridine –5-Monophosphate Synthase), Bovine Citrullinaemia and, first identified in 2000, CVM (Complex Vertebral Malformation).

Most genetic disorders are recessive, meaning that both parents would have to carry the disorder and pass it on in a homozygous state to the calf for the disorder to appear. In years past, the only way to determine whether a sire or dam was a carrier for a genetic disorder was through the offspring, which took considerable time and expense. Now molecular technologies promise quick progress in identifying carriers.

When widely used elite sires produce large numbers of calves and then turn out to be carriers of a defective gene, the impact can be very negative, particularly when inbreeding also is involved. U.S. bulls born in 1998-99 were related to cow populations by 13:1 for Ayrshires and 10:1 for Holsteins. Five sires fathered 100 percent of Ayrshire bulls, and 42 percent of Holstein bulls in these breeds, respectively; similarly, five sires fathered 45 percent of Ayrshire cows, and 17 percent of Holstein cows, respectively, limiting maternal diversity as well.

As an example, the Brown Swiss breed became the most inbred of any major dairy breed during the period of approximately 1940 to 1960 due to the strong influence of the famed cow Jane of Vernon. A condition known as Weaver was detected in the late 1970s, along with two other undesirable recessives in Brown Swiss, spinal muscular atrophy (SMA) and arachnomelia and arthrogryposis (SAA), referred to as Spiderleg.

Weaver, a genetic recessive abnormality, caused gradual loss of control of the rear legs of affected animals, though they appeared normal at birth. When animals were six to 18 months of age, the first signs appeared: animals fell down easily and gradually lost all control of their rear legs, due to degeneration of the nerve passages in the spinal cord and the brain. Affected animals had to be slaughtered or they would die. The effect on the Brown Swiss sire proving program was devastating, because there was no way in those days to determine if a sire was a carrier of the Weaver gene except through one of his offspring. It was prohibitively expensive to progeny test sons of carrier bulls. In a small number breed such as Brown Swiss, this was doubly devastating when a high percentage of the top proven sires were discovered to be Weaver carriers.

A break came in 1991 when a reliable and affordable DNA test was developed to identify carriers of the Weaver abnormality.

In the U.S., the Holstein Assn. initiated a program in 1957 to identify carriers of undesirable recessives, and has retained records since then. At this time there are identification records for Bulldog calves (achondroplasia 1, 2, &3), Mulefoot (syndactylism), BLAD, CVM, Prolonged Gestation, Hairless, Dwarfism, Imperfect Skin, DUMPS and Pink Tooth (congenital porphyria). Mutated recessive genes are the reason for genetic disease in breeding animals most of the time.

BLAD. This is what happened with the genetic defect BLAD. This and other diseases caused by mutated recessive genes do not reveal themselves until descendants of the affected animal are mated. Calves born with BLAD have a greatly reduced ability to fight off diseases. Affected cattle have severe and recurrent mucosal infections such as pneumonia, ulcerative gingivitis, periodontitis (these two latter affecting the gums), loss of teeth, impaired ability to produce pus and delayed wound healing, stunted growth and other problems. Most calves die before they reach six months of age. Adult carriers have shown a poorer ability to utilize feed and grow more slowly.

The codes for BLAD carriers are BL and TL for animals found free of the BLAD allele.

DUMPS. An enzyme deficiency known as DUMPS (deficiency of the enzyme uridine monophosphate synthase) became a concern in the mid-1980s. The condition is believed to result in embryonic mortality during the first two months when the embryo carries a homozygous recessive for the trait. Without this enzyme, embryo growth ceases. Carriers (heterozygotes) appear to have normal growth. The practical affect of this disorder is that carrier cows show a higher rate of return to service because some of their pregnancies end in early natural abortion. Spread of the gene that caused the enzyme deficiency was limited by development of a biochemical test for the activity of the enzyme in the blood of potential carriers.

Bovine citrullinaemia. This is a recessive genetic error of urea metabolism characterized by high levels of citrulline, and more seriously, of ammonia in plasma. The disorder first was described in humans, then in dogs and was reported in Friesian calves. Affected homozygous calves are unable to excrete ammonia and display neurological symptoms that become progressively worse. They usually die within a week of birth. Though not as prevalent as BLAD, citrulllinemia can be costly. DNA testing is now performed easily with hair root or blood samples, with results available in a few days.

CVM. Complex Vertebral Malformation first was described in Denmark in October, 2000, in Holstein calves. Calves that have one defective gene will appear physically normal, and their performance will be unaffected, but they will be CVM carriers.

Typical signs of CVM are a shortened neck and forelimbs, severe scoliosis (curvature of the spine), malformed rear legs, and in half the cases, heart abnormalities. Many CVM fetuses are aborted at gestation day 159, while other CVM calves are born prematurely and usually stillborn. If the fetus is homozygous for CVM, almost 30 percent of the cows will abort before day 100; over three-quarters will abort by day 260. In 2003, 74 sires were confirmed as carriers of CVM malformations, with a prominent source being sire Carlin-M Ivanhoe Bell and his offspring. The method of detecting CVM carriers is based on molecular genetic detection methods. Most Holstein herds used some CVM carrier bulls before the abnormality was known. Those herds include carrier females that are in almost all cases unrecognized.

While A.I. studs no longer sample young sires that are positive for CVM, there still are carrier bulls listed as active sires. Some of these bulls offer a lot of good genetics along with the risk of passing along the CVM gene to a carrier female, resulting in an abortion; or to a non-carrier female, resulting in more carriers. When a carrier bull is bred to a carrier dam, it's like cutting pregnancy rate by 25 percent. Some feel that an aborted cow is a potentially infertile cow, and may have to be culled, not to mention loss of the calf. For this reason CVM may pose more potential economic loss to the industry than did DUMPs, BLAD and mule foot until the carrier bulls are inactivated, according to some specialists.

Animals found to be carriers will be identified with the code "CV" on all pedigrees and similar lineage statements, and those not found to be carriers will be identified with the code "TV".

Genetic potential for improved fertility. While genetic selection programs have led to rapid gains in milk yield and conformation traits, performance for female fertility, longevity and susceptibility to disease has declined. Geneticists have been focusing more on these latter traits in the past decade.

Some have suggested that increased milk production is related to subfertile – specifically anovulatory – cows. But recent studies (Lopez) found no relationship between the percentage of cows showing anovulatory condition and the daily milk yield level. Similarly, there was no significant link between milk yield and the rate of embryonic loss between 31 and 45 days post-breeding.

Rather, high milk yield is often associated with inadequate body condition, which is in turn linked to numerous metabolic disorders and impaired fertility. Cows with poor body condition in early lactation or significant loss of body condition during lactation tend to have impaired reproductive performance, including longer time from calving to first ovulation, lower conception rate, and increased days open.

More specifically, one study showed that among lactating Holsteins with a body condition score of 2.5 or less, over 80 percent were anovular. Of cows with a score of 3.5 or more, only 9 percent were anovular.

In short, selection for higher milk yield is not to blame for reduced fertility. Scandinavian countries have selected for health, fertility and longevity for over 20 years, and genetic evaluations for length of productive life (PL) in the U.S. was introduced over 10 years ago. PL is an indirect predictor of fertility.

A more direct selection for improved fertility is daughter pregnancy rate (DPR), introduced in 2003. Differences in sires rated for this trait are dramatic: the highest and lowest available Holstein sires differ by 7.2 percent in DPR. Because a 1 percent difference in pregnancy rate corresponds to approximately 4 days open, daughters of the highest and lowest sires differ by roughly 29 days open per lactation.

Breed differences also exist, as mean DPR for Jerseys is 4.5 percent higher than that of Holsteins or Brown Swiss.

There also is potential to further improve fertility through genetic selection for resistance to metabolic and infectious diseases. Health data collected from on-farm herd management software programs could be used effectively for genetic selection purposes. Considering the six problems of displaced abomasums, ketosis, mastitis, lameness, cystic ovaries and metritis/retained placenta, these usually occur during the first 60 days after calving. Heritability estimates are 0.14 for DA; 0.06 for ketosis; 0.09 for mastitis; 0.04 for lameness; 0.04 for cystic ovaries and 0.06 for metritis/retained placenta. Genetic selection for improved overall health is possible, as is genetic selection for resistance to specific diseases and disorders.

DAUGHTER PREGNANCY RATE (DPR)

$$\text{DPR} = \frac{\text{Number of cows that became pregnant during a given 21-day period}}{\text{Number of cows that were eligible for breeding}}$$

A 1% difference in herd pregnancy rate = ~4 days open

A bull at +3.4 DPR equals an advantage of about 13.6 days open

Combined with direct genetic selection for improved female fertility through DPR, fertility also could be improved indirectly through selection for longevity and resistance to common health disorders.

Multiple births. The most common abnormality characterized by underdevelopment of the female reproductive tract is found in the freemartin. The abnormal reproductive tract of the freemartin is not inherited. However, freemartins occur only among heifers born twins to bulls and the frequency of twinning seems to be inherited.

When heifer-bull twins occur in cattle, the male sex hormone (testosterone) from the bull calf enters the blood system of the heifer calf. In addition, there is usually an exchange of some blood cells between the two calves. This leads to sterility in over 95 percent of heifers born twin to bulls. Also this may cause an increase in sperm abnormalities and a decrease in semen quality in some of the bulls.

Male organs in female. In the freemartin, the heifer's reproductive tract does not develop normally. In fact, as shown in the photograph, the freemartin heifer's reproductive tract may actually develop parts (such as seminal vesicles) that belong to the bull.

Twins may be one of two types. The most frequent type occurs when two eggs are ovulated at one estrus. Each may be fertilized separately and develop into twins. These twins are no more related than any two calves born from the mating of the same bull and cow at two different times.

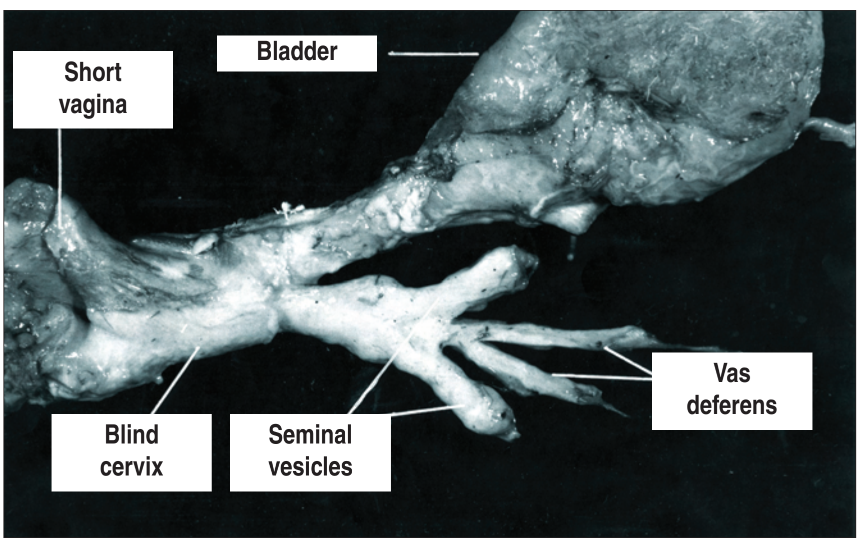
The other type of twins occurs less frequently when an egg splits, to form two eggs, shortly after fertilization. Both then may develop and result in twins. The result is identical twins since the two calves resulted from the union of one egg with one sperm. The freemartin condition never occurs in identical twins because they are the same sex.

On the average, twins occur about once in every 25 births, and triplets once in every 500 births. However, these frequencies are considerably higher in certain cow families. Genetics, cystic conditions, hormone treatments and high milk production all have been implicated as potential risk factors for twinning. Second-calf and older cows have a much higher twinning rate than heifers.

Total costs associated with a twin pregnancy may exceed $500 per lactation when accounting for greater disease risk, greater days open, premature culling and replacement costs. Cows with twins have more metabolic problems (total number of cases and prevalence rate) and are more difficult to get bred back.

A first concern is early diagnosis of twins. Ultrasound can help. Work with your veterinarian to improve early diagnosis of twin pregnancies. Cows with twins need a higher plane of nutrition to build up nutrient reserves. These cows also need special attention at calving. They are at greater risk for both calving difficulties and fresh cow problems.

A FREEMARTIN'S REPRODUCTIVE TRACT. It is badly underdeveloped. The vagina is only 4 inches (10 cm) long, the cervix is blind and the uterus is absent. Growth of some male parts in the freemartin heifer is due to testosterone (male sex hormone) from the bull twin. Note the male sex organs—the seminal vesicles and vas deferens.



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10 – Diseases of reproduction

REPRODUCTIVE DISEASES commonly cause serious economic losses in dairy herds. Disease may strike suddenly, as in abortion storms, or may be more difficult to notice as the cause of increased days open or services per conception. As discussed in Chapter 1, increased days open beyond the optimum 110 days or so become very costly to the producer. Many times this economic loss due to days open is not recognized; the economic losses due to reproductive diseases usually are easier to identify because of the finding of aborted calves and uterine infections. Reproductive inefficiency caused by infectious disease must be considered after eliminating problems with cyclicity, estrous detection, A.I. techniques, semen handling and nutrition.

On average, microbial diseases cause about 40 percent of all abortions. Noninfectious causes lead to about 9 percent of abortions, but there is no known cause for about half of all abortions, a sobering statistic. The issue of embryonic loss due to noninfectious causes will be dealt with in the next chapter.

The diseases that affect reproduction in dairy cows can be classified into four main categories:

1. Intrauterine infections which are associated with bacterial organisms. *Arcanobacterium pyogenes* and various anaerobes are the major bacteria that cause endometritis (infection of the uterine lining) or the less common metritis (infection of the uterine muscle wall).

2. Venereal diseases specifically and selectively attack the reproductive tract of the cow and are spread by natural or artificial breeding. Campylobacteriosis (vibriosis), trichomoniasis and ureaplasmosis are examples of these diseases. They are spread from infected animals to noninfected animals during breeding.

3. Infectious diseases that attack other organs of the cow's body and also affect the reproductive system. Leptospirosis, Infectious Bovine Rhinotracheitis (IBR), Bovine Viral Diarrhea (BVD) and Brucellosis are examples. These diseases are spread by several routes.

4. Other conditions affect reproduction by lowering the overall health status of the animal. Pneumonia and hardware disease are examples of individual animal conditions, while selenium deficiency and other nutritional disorders typify herd problems. Several studies have shown a strong relationship between mastitis and reproductive inefficiency from an increased risk for pregnancy loss and decreased conception.

Uterine infections usually prevent conception but are not always accompanied by outward signs such as an abnormal discharge or abortion. Many dairy producers fail to recognize their importance in causing reduced reproductive performance.

Aside from abortions, the venereal diseases present subtle symptoms that usually require laboratory tests to aid a veterinarian's diagnosis. Often these diseases are undetected until the cow aborts. By this time it already may be too late, and you must move fast to salvage the cow. Depending upon the stage of lactation when the abortion occurs, economics will require some cows to be culled following abortion.

The last two categories are easier to detect since they may also cause a sharp drop in milk production, poor appetite, rough hair coat or other externally visible changes.

MICROBIAL CAUSES OF BOVINE FETAL LOSS IN THE U.S.

• Viruses	• Bacteria	• Other
BVD	Leptospira spp.	Neospora
IBR	Listeria	Trichomonas
	A. pyogenes	Mycotic
	C. fetus	
	Salmonella spp.	
	Coliforms	
	Brucellosis	

Endometritis and metritis. While the uterus is normally a sterile environment, the vagina hosts a large number of microorganisms. Whether normal vaginal flora or pathogens from the environment, they most often invade the uterus at mating and at calving. Essentially, all cows have contamination of the uterus with bacteria in the first few weeks after calving. The healthy uterus easily rids itself of these invaders. Within days or weeks postpartum, the sterile uterine environment should return. When infection persists, chronic or subacute endometritis develops and negatively affects fertility.

Excessive stretching of the uterus – caused by twins, a difficult calving or improper calving assistance – interferes with uterine involution. Rapid involution is key to naturally expelling fluid, placental membranes and bacteria from the reproductive tract. Inadequate nutrition also can interfere with the uterus' ability to contract. Even if a cow expels her placenta, uterine contraction and involution still may be delayed.

Most cows have spontaneous resolution of endometritis by four weeks after calving. So there is no benefit in treating them before then. Use of intrauterine infusions of antibiotics before this time may give the producer a feeling of positive action, but may be not justified economically. Several studies indicate that routine postcalving use of prostaglandins (PGF2-α) was as effective as – or preferable to – intrauterine infusions for treatment of uterine discharges, especially endometritis, and an equal number find PGF2-α of no value in the first three weeks.

Endometritis must be distinguished from acute metritis that occurs within the first week after calving and often following a difficult birth. In this case the infection has entered the bloodstream, and the cow is outwardly sick. The cow is depressed, runs a fever and is off-feed. Milk production is down and the uterine discharge is watery and bad-smelling. This acute condition responds well to systemic antibiotics combined, if needed, with non-steroidal anti-inflammatory drugs and possibly fluid therapy.

Do twin births, retained placenta and endometritis necessarily impair fertility? The answer is no!

Exams for endometritis should start after approximately 28 days in milk and should include vaginoscopy. Two simple clinical findings by Guelph researchers identify cows at risk for reduced fertility: presence of a mixture of pus and mucus discharge (more than 50 percent pus) OR enlarged cervix (larger than 3 inches/7.5 cm).

Visual inspection of vaginal discharge will identify about half of those with clinical endometritis; the rest must be determined by using a vaginoscope: requiring only a few seconds per cow, researchers used a disposable, 20-inch, foil-lined cardboard tube that was inserted into the vagina up to the cervix. Gently inserting a sleeved hand (single-use gloves are required to prevent spreading disease) into the vagina to check for pus is an alternative.

An important finding of the research was that uterine palpation was pretty much worthless as a diagnostic tool to predict endometritis associated with reduced pregnancy rates.

The principle behind the beneficial effects of PGF2-α is to induce estrus and its associated normal uterine contractions that rid the uterus of unwanted pus, mucus, fluid and so forth, to assist the uterus in a healing process. These PGF2-α injections often are given during the voluntary waiting period before any A.I. breeding. The Presynch protocol (two injections of PGF2-α given 14 days apart) likely fulfills some of these positive effects by synchronizing the estrous cycle prior to using the Ovsynch protocol. More on this in Chapter 18.

On the other hand, intrauterine infusion or PGF2-α injection was more effective if the cow has a corpus luteum, and cows without a corpus luteum treated with PGF2-α actually had impaired subsequent fertility.

To summarize, cows should be selected for treatment of endometritis after four weeks postpartum. Visual inspection and vaginoscopy mandate action by the criteria described earlier. If you are using the presynch protocol (set-up injections of PGF2-α) before a timed A.I. breeding, cows with endometritis should not be given PGF2-α unless they have a corpus luteum. Delaying set-up injections to 40 or 50 days postpartum can assure that cows are more likely to be cycling and have a corpus luteum. Timed A.I. would then occur closer to 80 to 90 days in milk for these cows with abnormal uterine conditions, but would also more likely result in success.

BHV-4. Similar to the herpes virus in humans that causes cold sores and other maladies, cattle also harbor a variety of herpes viruses. Recently, a serious metritis associated with what appears to be a mutated strain of bovine herpes virus-4 (BHV-4) has been confirmed, more common regionally in the South and Midwest.

The infection occurs during the first month after calving, causing painful ulcers in the cow's uterus. Over the next weeks, the uterine ulcers enlarge and bacteria normally inhabiting the uterus after calving are able to invade the uterine wall.

The uterine discharge becomes dark and foul-smelling. Cows become depressed, go off-feed, become weak and eventually go down. They appear to be in pain. Herds affected by this strain of BHV-4 have experienced high rates of uterine infection and high death losses. While a similar syndrome attributed to BHV-4 occurred during the '80s in Europe, prior to 1999 it was not recognized in the U.S.. The U.S. strain of BHV-4 may have mutated to a strain that has the ability to attack the uterine wall and cause ulcers.

Blood titers taken on animals show that cows were infected with BHV-4 prior to calving, but the virus was not active. Then at calving, the virus became active and infected the uterus. BHV-4, like other herpes viruses, can be present but latent, and then appear later in association with nutritional or physiological stresses or both at calving. Metritis associated with BHV-4 also appears linked to fatty liver syndrome, which is itself related to poor immune function after calving.

Suspect a BHV-4 diagnosis when the herd experiences a rapid increase in severe, post-calving metritis that is not responsive to routine treatments. The disease can be fatal, and your veterinarian should perform a post-mortem on cows that die of acute uterine infection after calving.

Eliminating cow purchases from unknown sources might reduce chances for introducing the virus, though this is not known for certain at this time.

Venereal diseases. Presently, *Campylobacteriosis* (*vibriosis*) is a serious cause of infertility only in certain locales in the United States. Since it is transmitted mainly by natural mating, it is much more prevalent in beef herds than in dairy herds. But many dairy producers continue to keep and use bulls, thereby increasing the chances of introducing vibrio into their herds.

Repeat breeding problems or abortions between the fourth and seventh months of pregnancy are the first indications of vibrio infection. Most infected cows in the herd require several services before they settle. Estrous cycles are irregular and many cows will have uterine discharges.

For positive diagnosis, a veterinarian should culture the vaginal mucus from a cow, fluids from a freshly aborted fetus or mucus from the prepuce of the bull.

Cows develop an immunity a few months after infection with vibrio. Therefore, any new animals (fresh heifers or purchased additions) added to the breeding herd become infected from contact with bulls. Bulls of 4 or more years of age are true carriers of the disease. Younger bulls may transmit infection from cow to cow, but the organism only will "set-up housekeeping" in the prepuce of older bulls. This becomes an important control consideration. Following an infection, which may or may not cause abortion, some cows remain subfertile and a few become totally sterile.

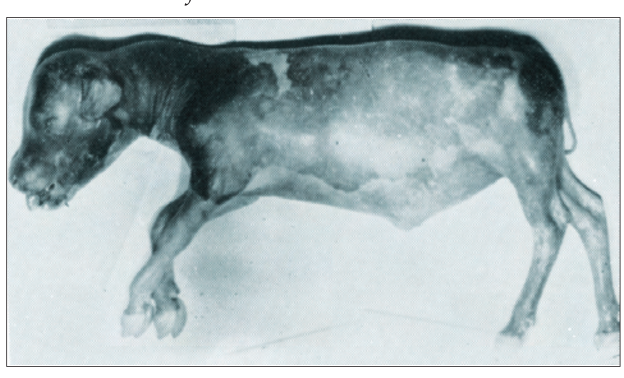
A vaccine is available to protect cows against vibriosis, but it requires cows to be vaccinated 30 to 60 days prior to exposure to the bull. For most dairy cattle, this would mean at calving or shortly thereafter.

Vibriosis also can be prevented by artificially breeding with semen from recognized bull studs. This method is nearly 100 percent effective in controlling the spread of the disease from the bull to the cow. All A.I. centers certified by the National Association of Animal Breeders (N.A.A.B.) regularly test their bulls for vibriosis and use only vibriosis-free bulls. Look for the letters CSS on the semen straw. These letters stand for Certified Semen Service and represent the N.A.A.B.'s health program.

Trichomoniasis, like vibriosis, became less prevalent with the use of artificial insemination, but with the continued use of bulls on dairy operations, the chance of trichomoniasis causing cattle infertility also continues.

Trichomoniasis is usually transmitted at the time of natural mating. Even though bulls never show external symptoms of the disease, they are usually the source of infection in a herd. Abortions usually occur during the first four months of pregnan-

CAMPYLOBACTERIOSIS caused this aborted fetus in the fifth month of pregnancy. Most vibrio abortions occur between months four and seven.



cy. Large quantities of greyish, abnormal fluid may be discharged during the first half of pregnancy as a result of uterine infection caused by trichomoniasis. The only signs a herd manager may notice, though, are irregular estrous cycles and increased services per conception.

Since trichomoniasis is caused by a protozoa, the organism must be identified microscopically for a positive diagnosis. Fluids from an aborted fetus, vaginal mucus from the cow or preputial smegma or semen from the bull are collected and examined for the organism. The trichomonas organism is very difficult to identify even by trained personnel, and more than one sample may need to be examined before a positive diagnosis is achieved.

There is no reliable treatment for trichomoniasis in the dairy cow. Cows that have aborted usually develop an immunity. If they subsequently have a normal calf, they may be regarded as uninfected. Once treated, bulls must be checked once weekly for 4 months to make sure that they no longer carry trichomoniasis. Because of a recent Food and Drug Administration ruling on available drugs, infected bulls are not as successfully treated. Consequently infected bulls are generally culled.

Prevention is now paramount. A vaccine is available which will decrease losses, but may not restore fertility to normal.

The best method of preventing trichomoniasis is by using semen from uninfected, tested bulls. A.I. organizations regularly test their bulls to guard against this disease. Again, check for the letters CSS on the semen straws.

Infectious diseases. *Brucellosis* is an old disease that has changed very little in the last few years, but the rules and regulations concerning its eradication have changed dramatically in some instances.

Brucellosis (Bang's disease) is caused by a bacterium and is easily transmitted from animal to animal. It is most often spread by:

1. An aborted fetus, afterbirth or fluids.
2. Feed or water contaminated with vaginal mucus from an infected cow.
3. Contact with an infected cow or bull.

People can contract the disease (called undulant fever) by drinking unpasteurized milk from infected cows, or by direct contact with vaginal discharges.

After the cow becomes pregnant, the brucella bacteria invade the junction of the cotyledons of fetal membranes and the caruncles of the uterus. In this way, they destroy the delicate transfer of nutrients to the fetus. As a result, the fetus may be aborted anytime, but usually abortion occurs after the fifth month of pregnancy.

After abortion occurs, retained afterbirth, infection of the uterus and infertility are common. These symptoms also may be due to many other causes. Therefore, specific diagnosis is required.

There is no cure for brucellosis, although some cows develop an immunity and subsequently carry a calf to term. Such cows usually continue to show a positive blood titer to brucellosis for life and may spread the disease for long periods of time. Slaughter of infected animals is the only effective way to eliminate the disease.

Calfhood vaccination of all potential breeding females provides adequate protection against the spread of brucellosis. Strain 19 was the standard vaccine until about 1995. It had the disadvantage of occasionally triggering a false positive for Bangs on the herd milk brucellosis ring test (BRT). From 1997 on, RB51 became the standard. Mandatory calfhood vaccination was dropped by most states, though in 2004, about 4 million calves still were vaccinated against brucellosis. Certain states in the western U.S. still require calfhood vaccination. The states of California, Washington, Idaho, Utah, Colorado, Oregon and Arizona do not permit entry of replacement animals that are not calfhood vaccinated.

Artificial insemination with semen from brucellosis-free bulls is an important weapon in preventing the spread of Bang's disease at breeding. All A.I. organizations in the United States routinely test for brucellosis and use only brucellosis-free bulls. Hopefully, brucellosis will be eradicated from the U.S. in the future.

Leptospirosis is an economically important disease of dairy cattle caused by a microorganism called a spirochete. It is presumed to be the most widespread disease caused by an organism in the world.

In some areas of the United States there has been a dramatic increase in the diagnosed cases of leptospirosis in dairy cattle. Leptospirosis causes severe economic losses due to its effects on milk production and reproduction.

Leptospirosis is most commonly contracted following exposure of an animal's skin and mucous membranes to urine from infected animals, or surface waters contaminated with urine from infected animals. Contamination can occur from domestic species or wildlife, and infection may persist for considerable lengths of time. Common hosts for the Lepto serovars (strains) bratislava, canicola and icterohaemorrhagiae are pigs, dogs and rats, respectively. Mating with infected animals can be a route of infection, but only in limited situations. The most common cause of lepto among cattle is infection with Leptospira belonging to the serovar hardjo. Cattle appear to be the primary host. The serovars pomona and grippotyphosa also cause lepto in cattle.

Symptoms of high fever, lack of appetite, bloody urine and generally poor health are evident in young animals (under 1 year) and are sometimes present in adults. But the clinical syndrome can vary from severe illness to mild signs that go unnoticed. Abortions, stillbirths and birth of weak calves are the most obvious signs most commonly associated with leptospirosis in cattle. Abortions usually occur in the last trimester of pregnancy, from one to many weeks after infection by the leptospira organism. Abortions due to the hardjo serovar tend to occur sporadically, compared to abortion "storms" which may occur as a result of infection with *Lepto pomona* or *grippotyphosa*.

Following the first invasion of the cow's bloodstream, the leptospira localize and persist primarily in the kidneys and the genital tract. Leptospira located in the kidneys are voided in the urine and serve as a source of infection for other animals. Persistent infection of male and female genital tracts is a feature of hardjo infections and may last longer than a year.

This persistent infection of the reproductive tract may be the most economically significant result of a hardjo infection. Infertility, which results in increased services per conception and prolonged calving intervals, results from this infection. It appears that presence of lepto in the uterus and oviducts of infected cows may interfere with implantation of the embryo or other early pregnancy events. The presence of mastitis that is unresponsive to treatment and blood in the milk of dairy cows should also alert you to the possibility of leptospirosis.

Diagnosis of leptospirosis infection is based on clinical signs, history of abortions, postmortems of stillborn and weak-at-birth calves, and serological testing of the herd. Because of variations in cows' responses to leptospirosis, it is suggested that at least 10 percent of the cow herd be sampled for serological testing to provide an adequate cross sampling of cows.

The best form of prevention and control is an adequate vaccination program against leptospirosis. Bacterins are available to immunize dairy cattle against the five major serotypes of lepto, although additional vaccination against hardjo is also sometimes recommended. Initial administration of the bacterins should be boostered within 2 to 4 weeks, with subsequent revaccination at 6-month intervals. Also consider management strategies that reduce exposure to wet areas (ponds, bogs, etc.).

Infectious bovine rhinotracheitis (IBR) is a viral disease that has widespread distribution throughout the United States. There are three forms of the disease seen in dairy cattle:

1. Upper respiratory form
2. Conjunctivitis
3. Infectious pustular vulvovaginitis (IPV)

Exposure to the IBR virus can cause a variety of clinical signs, including combinations of all three forms, or mild inapparent infection that may go unobserved. The upper respiratory form can be manifested in any age animal but is most likely to cause death in animals under 6 months of age. The signs of the upper respiratory form may include high temperature, labored breathing, snotty nose, sharp decline in milk production and lesions of the lining of the oral and nasal cavities.

Conjunctivitis may be the only form of IBR evidenced in a herd, and it is usually associated with increased tearing, reddening of the tissue surrounding the eye and corneal ulcers. IBR conjunctivitis may look similar to pinkeye and is very difficult to differentiate without close examination by a veterinarian.

IPV is first noticed when cows show evidence of pain in the rectovaginal area by raising of the tail and holding it up for abnormally long periods of time after urination or defecation. Examination of the vulva and vaginal canal reveals whitish ulcers and pus on the vaginal floor.

Abortion can occur after or at the same time as an undetected infection, respiratory disease, conjunctivitis or IPV. Abortion is most common in the last half of gestation. Fetuses are usually decomposed because expulsion occurs two or more days after death. Occasionally, fetuses are retained longer and show partial or total mummification at the time of abortion. Abortion and subsequent infertility are the major economic losses incurred in a dairy herd infected with IBR.

Diagnosis is very difficult in the case of IBR and requires the conscientious efforts of the dairy producer, veterinary practitioner and diagnostic lab. The entire fetus and placenta from an aborted cow should be refrigerated and submitted to the lab for full diagnostic workup. Paired blood samples can be submitted for serological testing, but always keep in mind that the cow may expel the fetus 2 to 3 months after IBR infection.

Vaccination is currently the

best means of controlling IBR. Since the virus is so widespread, isolation of a herd of dairy cattle from IBR is almost impossible. There are three basic forms of vaccine against IBR: intranasal (modified live virus—MLV), and intramuscular (both killed virus and MLV). Seek veterinary assistance to fit the various vaccine types into the herd vaccination program. Some MLV products are not recommended for use in pregnant animals. In using any IBR vaccine several important items should be kept in mind:

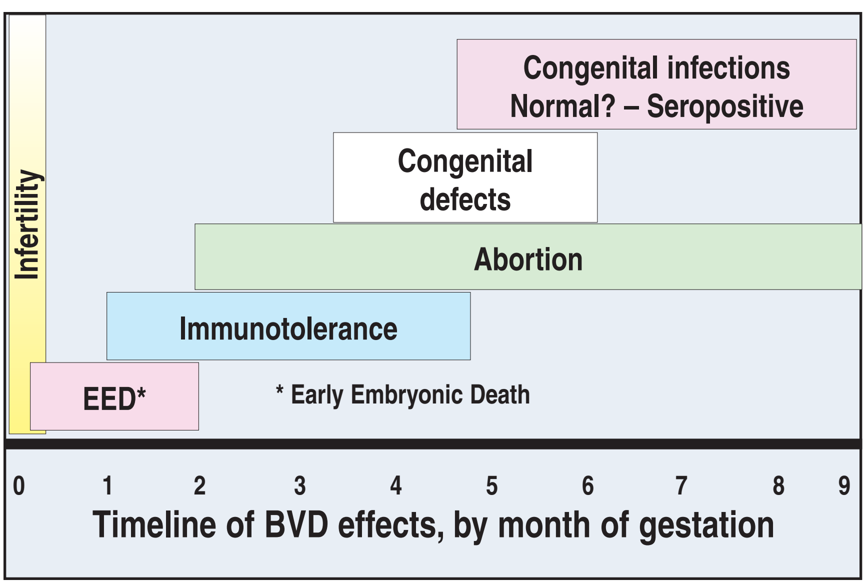
1. Label and package inserts should be read carefully and the instructions followed.
2. Vaccine should be used on healthy, well-fed cattle that have not been stressed by moving or exposed to other diseases.
3. It is best to vaccinate calves after 6 months of age and at least 1 month prior to breeding.
4. The protection induced by a vaccine should last for a lifetime in most cattle. Some feel that periodic vaccination may be necessary in adult cattle, so consult with your veterinarian for the best procedure for your herd.

Bovine virus diarrhea (BVD) is another viral disease that has widespread distribution in the dairy cattle population in the United States. It is commonly associated with respiratory, gastrointestinal and reproductive symptoms. Today, reproductive losses may be the most economically important consequence associated with BVD infection, and evidence suggests the incidence of BVD-related reproductive losses are increasing in the U.S.. These losses can range from an insidious reduction in reproductive performance at the herd level to devastating abortion storms.

As with the IBR, the BVD virus may cause a variety of signs in cattle from mild, inapparent infection to a severe gastrointestinal disorder resulting in death. If a cow is infected 9 days prior to breeding, there is a dramatic drop in her fertility. If infected after breeding up to about 45 days, BVD is believed to directly cause embryonic death. Abortion can be any time, though the first two-thirds of gestation are more common. Fetal expulsion can be delayed, and the virus then can be gone, making diagnosis difficult.

If the cow is infected between 100 and 150 days of gestation, the calf may be born with a variety of congenital defects. These include malformations of the eye and central nervous system. In addition to timing of infection, the strain of BVD also makes a difference in how the calf is affected. During a short period around day 150 of gestation, fetal abnormalities usually result with death at birth.

Some animals show no symptoms because of a complicated immune status commonly known as persistent infection (PI). Fetuses that survive infection with noncytopathic BVD between 18 and 125 days of gestation invariably develop immunotolerance to the virus and subsequently become persistently infected. Their immature immune system does not recognize the virus as foreign. Circulation of the virus during the period of gestation when immuno-competence is developing (90 to 120 days) is a prerequisite for persistence. If a PI animal is infected with a cytopathic BVD strain – possibly from internal mutations of the virus



Sources of BVD Exposure

- PI's or Transient infections
  - Replacements
  - Exhibition
  - Fenceline
  - Shared pastures
  - Semen
  - Embryos/Recipients
- Other species
  - Sheep/goats
  - Llamas, alpacas, etc.
  - Deer, elk, etc.
  - Insects
  - Humans
- Inanimate objects
  - Vehicles
  - Equipment

from external sources – it is highly fatal and known as mucosal disease.

Cattle persistently infected with BVD (PI's) are the major source of virus spread within and between farms: they shed incredible numbers of the virus and invariably give birth to persistently infected calves.

Calves infected in late gestation may be able to mount an effective immune response to BVD and effectively clear the virus. These calves are usually normal at birth, but may have higher risk for a serious postnatal illness of some kind. A study of these calves born with BVD neutralizing titers showed they were twice as likely to experience a severe illness during their first 10 months of life and were at increased risk for failing to conceive as breeding heifers.

As with IBR, abortion resulting from BVD infection may be delayed several months after initial exposure to BVD virus, making diagnosis difficult. Again, a concerted effort by dairy producer, veterinarian and pathologist is needed to establish a diagnosis of BVD.

The incorporation of BVD vaccines into the herd vaccination program should be done prebreeding under your local veterinarian's specific recommendations. Both killed and MLV preparations are available, usually in combination with IBR and other viral components. MLV products are not intended for use in pregnant animals. The accurate identification of persistent infection may alter vaccination schemes. A three-pronged approach to control BVD is biosecurity when introducing new animals; identify and destroy persistently infected animals; and vaccinate.

Confirming the presence of BVD in a herd. This is the first step in developing a control and eradication program. The "gold standard" diagnostic test is virus isolation on blood samples. It is relatively expensive, at $20 per sample. Other tests are available to determine persistently infected animals, and each has specific advantages and disadvantages; they again are generally limited by practical application and cost.

A simple and lower cost test recently available is the Antigen Capture ELISA skin test that is used on an ear notch from the animal. It is highly accurate, and the ear notch skin samples can be stored frozen in sterile saline for up to 6 months. Turnaround for results is within 48 hours.

Smaller dairies could use the approach of testing all cattle at once, taking blood or ear notch samples from all animals over 6 months of age and ear notch samples from animals less than 6 months of age for the skin test.

This approach may be economically impractical in larger herds. Here an alternative strategy is to test all calves at birth using the ear notch test. Calves testing positive should be retested before culling. The dam of a positive calf must also be tested, as she may be persistently infected as well. Dams of all negative calves can be considered negative.

Bulls and any nonbreeding cattle (steers, for example) also should be tested, as should aborted fetuses and their dams. Do not allow calves to commingle or be housed within 20 feet (7 meters) of breeding-age cattle until the calves are confirmed negative.

This strategy is continued until all animals on the farm have been tested or have had a calf that tested negative. PI's should be euthanized or sold directly to slaughter.

Polymerase Chain Reaction (PCR) tests on bulk milk can be used to determine if BVD is circulating in the milking string. The bulk milk PCR can detect a single PI animal within a group of 200 cows with a sensitivity of 98 percent and specificity of 99 percent. This test costs about $85 per sample. A positive test requires further testing to find the individual PI's.

Neospora caninum is a protozoal infection. Neospora infects many animals, including cattle, sheep, goats and horses. It also infects

EAR NOTCH SAMPLES to test for BVD can be obtained with a tool used for ear-notching hogs. Samples are taken along the lower edge of the ear.

dogs and coyotes, which appear to be definitive hosts for the species that infects cows.

There are two probable ways cattle become infected: first, eating or drinking material contaminated by dog feces. Second is from mother to calf through the placenta. It has not yet been proven whether the infection is transmitted through milk. About 80 percent of calves born to infected cows have this disease. Neospora typically causes abortions in the last two trimesters of gestation in cattle, either when introduced to a herd for the first time or when a cow is stressed by another disease (like shipping fever). The incidence of Neospora-related abortion varies by region, and has been estimated to be as high as 46 percent in California. Cows that are seropositive to *N. caninum* have a higher risk of aborting than seronegative herdmates.

A vaccine is available for this disease, and it seems effective. It is given to pregnant (and presumably infected) cows to prevent them from spreading the disease to their offspring. Neospora is a life-long infection, so the vaccine does NOT cure the adult cow being vaccinated.

Other diseases. Fungal and other sporadic infections of the placenta cause abortion by decreasing the placental functions of fetal nourishment and waste control.

A bacterial disease, ureaplasmosis, has been associated with a repeat breeding and occasional abortion syndrome. This agent causes an infectious, granular-appearing vaginitis and is subsequently inoculated into the uterus during artificial insemination by the insemination pipette. Diagnosis is difficult and may be confused with an IBR virus infection. Vaginal contamination of the A.I. pipette is prevented by covering the pipette with a plastic sheath.

A deficiency of the trace mineral selenium has been associated with abortion, retained placenta, endometritis and cystic ovaries. Feed analysis and serologic testing are aids in diagnosis. Short-term supplementation may be accomplished with injectable products, but a long-term solution involves ration supplementation.

Preventive measures. The dairy producer who is faced with an infertility problem in the herd should first eliminate disease as a cause before considering other causes. Rapid diagnoses are essential to minimize the extent of infection in the herd, and also to minimize the damage to each individual cow. Periodic veterinary examinations detect diseases early.

Diagnosis of abortion is frustrating to dairy producers and to veterinarians because many times the calf is too decomposed to make a diagnosis. Samples to submit include the fetus, placenta and blood from the cow. Keep these samples chilled until your veterinarian or diagnostic lab personnel evaluate them. Multiple fetuses often are needed to make a diagnosis.

Artificial insemination is another tool to help prevent disease. Bulls in most A.I. organizations are checked for diseases before they enter the stud. Thereafter, they are tested periodically. If the dairy producer employed similar preventive measures in herd management, most reproductive diseases could be reduced drastically

Isolation prevents spreading. In general, disease organisms (bacteria, viruses and protozoa) perish without host animals. This fact is the reason why isolation of diseased animals is so important.

The organisms responsible for most reproductive diseases die rapidly (or, at least, lose their potency) when they leave the animal's body and are exposed to dry air. However, survival outside the body is enhanced by filth, especially when moisture is present to provide a favorable environment.

Isolation pens should be far enough away from the main barns to prevent direct exposure of suspect animals to the rest of the herd. In addition, inadequate ventilation can result in aerosol contamination and therefore should be considered when locating isolation facilities.

The length of time an animal must be isolated to insure the safety of the rest of the herd depends upon the nature of the infection. There are no blanket recommendations. Instead, rely upon your veterinarian's recommendation for each case.

During isolation, utensils and tools used for infected animals should not be used for the rest of the herd. Wash your hands thoroughly with soap and water, and disinfect footwear before leaving the isolation area.

After a diseased animal is removed from isolation, the pen should be scraped and thoroughly washed with soap and water. The pen should then be sprayed or rinsed with a disinfectant and left vacant for at least two or three days. During this time, most remaining organisms will die because of dryness, provided no manure remains to protect them.

These recommendations are time-tested. But in view of the price squeeze on the dairy producer, they are at least as important today as they ever have been.

Vaccination plan. Because the cow's immune system is depressed around freshening, you should not vaccinate within 10 to 14 days of the calving date, either before or after. If using natural service in your herd, a Campylobacter (Vibrio) and trichomoniasis vaccine is warranted before breeding. If your herd has had issues with calf scours, vaccination against Rotavirus, Coronavirus and *E. coli* is recommended six and three weeks before calving.

Adult cows should be boostered annually with IBR, PI3, BRSV and BVD Strains 1 and 2 as well as the 5-way leptospirosis combination. The multivalent clostridial vaccines also should be boostered annually if given to the animal as a calf.

Bulls also should be up-to-date on their IBR, PI3 and BRSV and BVD Strains 1 and 2, and 5-way lepto vaccines (given annually).

Optional vaccines, depending on the individual herd status, include Pasteurella and Mannheimia, as needed; *H. somnus*, as needed; Neospora, if there are reproductive problems; and Brucellosis, if there are reproductive problems; Salmonella, if problems with scours; *Mycoplasma bovis*, as needed; *Moraxella bovis*, if problems with pinkeye; Fusobacterium and Treponema, as part of a foot problem management plan; *Staph aureus*, for problems with chronic mastitis; rabies, in endemic areas.

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11 – Embryo losses

A rather sobering statistic is that, of all ova ovulated by the cow, between fertilization and birth, some 60 percent of ova never result in a live calf. Reproductive failure in cattle costs the U.S. over $2 billion each year. An average cost of a lost pregnancy is $640, though this varies with stage of gestation and risk of culling post-partum. Of 100 inseminations, about 28 result in a calf. Two sources of pregnancy failure after A.I. are fertilization failure and pregnancy loss.

Numerous causes lead to pregnancy losses. Low concentrations of progesterone during the estrous cycle following A.I. may cause the formation of so-called persistent follicles. These persistent follicles produce ova that are less fertile and result in early embryonic death shortly after conception. Ova ovulated from smaller-size follicles in response to GnRH injections (in timed breeding protocols) also reduce conception rates.

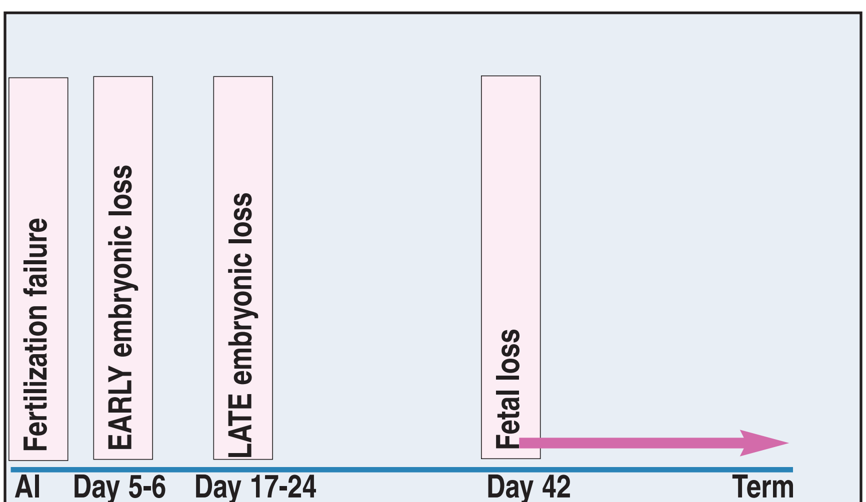
Most losses of pregnancy occur during the first 50 days of gestation. Cows with less than normal blood concentrations of progesterone are at risk for pregnancy loss. Progesterone secreted by the corpus luteum sustains the early embryo until attachment via the placenta after 18 to 22 days of gestation.

The developing embryo and primitive placenta must signal through chemical means that a pregnancy is underway. If this goes unrecognized, the corpus luteum regresses and results in embryo loss.

Heat stress plays a role. Cows exposed to heat stress before A.I. are only 33 percent as likely to conceive as those not exposed to heat stress. Efforts to reduce heat stress are well worth it for cows in confinement housing and holding pens before milking. Fans, sprinklers, plus plenty of cold water available in parlor exit lanes and confinement pens all are good strategies.

Cycling and noncycling. When noncycling cows conceive after ovulation synchronization and timed A.I., they are more likely to have late embryonic losses between the first and second pregnancy diagnosis (late embryonic or early fetal loss) than cycling cows. Studies comparing cows bred after estrous detection compared to cows bred by timed A.I. were not conclusive.

Other factors. Level of milk production in and of itself is not a factor in pregnancy loss. However, cows losing body condition during the first month in milk or losing body condition between 28 and 56 days of gestation had reduced pregnancy rates by two- to three-fold. We've already discussed how transition and calving-related problems that affect health of the cow and compromise uterine environment are detrimental to pregnancy. When too many cottonseed products are fed to cows, gossypol can negatively affect embryo quality as well as development and conception rates. A general guideline is not to exceed 10 pounds (4.5 kg) per cow per day of total cottonseed prod-

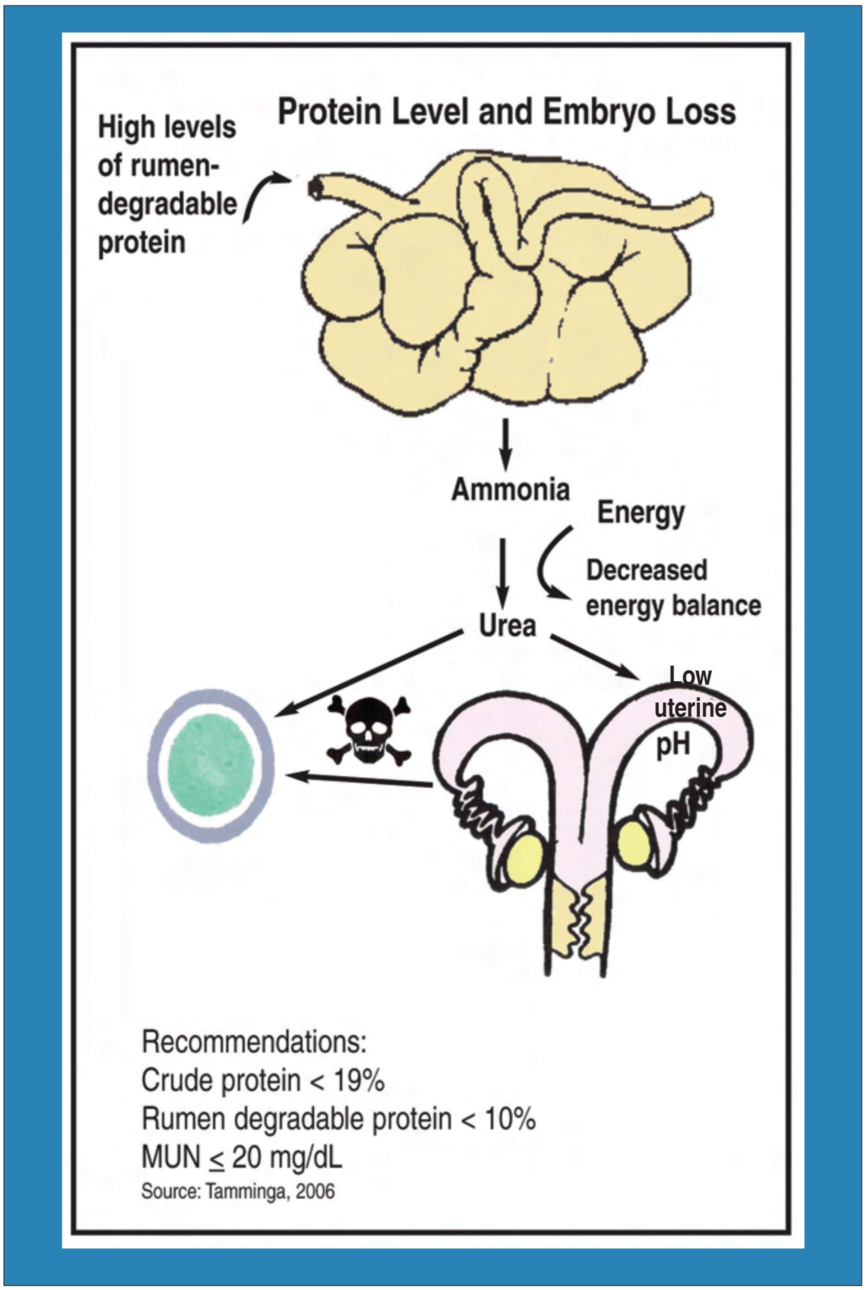


Characterization of reproductive failure in cows ucts, including whole cottonseed, hulls and cottonseed meal.

It's also now known that gossypol exists in higher concentrations and in more toxic form in Pima cotton compared to Upland varieties.

Cows fed diets high in ruminal degradable protein are reported to have reduced fertility. Feeding high levels of degradable protein may suppress fertility because urea causes lowered uterine pH and the urea and low pH is toxic to oocytes and to embryos, respectively. High amounts of protein also may worsen problems associated with energy balance, since energy is required to rid the body of the excess

Improving embryo survival. Cows receiving recombinant bovine somatotropin (rBST) concurrently with first insemination have better fertility, accelerated embryo development and improved embryo quality. Improvement in conception rates are the result of reduced embryonic death between days 31 and 45.



Pregnancy failure has been associated with low concentrations of progesterone as early as day 6 after A.I. As advised by your veterinarian, human chorionic gonadotropin, hCG (Chorulon from Intervet) on Day 5 after A.I. and use of an intravaginal, progesterone-containing device – CIDR – insert improved conception rates on Days 28, 42 and 90, but late embryonic and fetal losses were unaffected. Injection of hCG causes formation of extra luteal tissue and, in one study, made those cows 8 times less likely to have fetal loss than cows with a single CL. Both these uses are extra label, so your veterinarian's involvement is necessary.

As mentioned, low concentrations of progesterone in the blood are linked with poor fertility. Use of a CIDR is approved for use in dairy cows in the U.S.. In some studies insertion of a CIDR from 14 to 21 days after A.I. reduced pregnancy loss between day 31 and 60 of pregnancy.

Supplementing fat at 2 to 4 percent of the cow's diet, particularly fat rich in omega-3 fatty acids, might enhance embryo survival because of improved pregnancy recognition, as described earlier. Supplementing fat during the close-up dry period before calving improved pregnancy rates after calving.

Feeding a calcium salt of linoleic and monoenoic C-18 trans fatty acids increased conception rates in lactating cows, compared with calcium salts of palm oil. These cows have higher fertilization rates and higher-grade embryos.

Embryo transfer technologies in cattle have been developed primarily as a means for genetic improvement. In embryo transfer, defects in the oocyte, ovulation, fertilization and early embryonic development are not a factor, so in theory, pregnancy rates in embryo recipients should be superior. Generally, however, this is not the case, when comparing embryo recipients and cows pregnant following A.I.

Nonetheless, there is a case where embryo transfer has been shown to enhance fertility, and that is for lactating cows exposed to heat stress. During times of heat stress, pregnancy rates following embryo transfer in the summer were similar to rates in winter using A.I.

A potential problem to performing embryo transfer during heat stress is the difficulty in detecting estrus. Using timed A.I. protocols for ovulation synchronization can overcome this. For commercial producers, embryos produced in vitro with oocytes harvested from ovaries recovered at slaughter could be a major source of embryos for transfer in the summer, because embryos are less expensive to produce this way than embryos produced by superovulation. Moreover, use of sexed semen and/or from bulls of high genetic merit is inexpensive for this kind of application, since one straw can be used to inseminate dozens of oocytes.

A caveat with using embryos produced in vitro (fertilized outside the cow) as opposed to in vivo is that the in vitro embryos are associated with lower pregnancy rates, poor freezability and possible future abnormalities in the resulting calves.

Lactating cows seem to be most susceptible to reproductive failure in part due to poor fertilization rates (76 percent), and embryo viability during early pregnancy (50 percent), but also because of extensive embryonic and fetal death (60 percent). Research continues with the goal of improving the establishment and maintenance of pregnancy.

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12 – Health of fresh cows

Impact on reproduction

KEEPING cows healthy is one of the most important steps in maintaining good fertility and efficient milk production. Healthy cows produce more milk, rebreed sooner and have lower culling rates than their unthrifty herdmates. A recent study showed that, regardless of age, cows in sound health were in estrus earlier, were rebred by 70 days, had conception rates of more than 50 percent, bore a calf a year and experienced reproductive culling rates of less than 5 percent.

We cover uterine infections and other infections of the reproductive tract in Chapter 10, and cystic ovaries in Chapter 15. Several other disorders, including milk fever, retained placenta, displaced abomasum and ketosis add to the cow's risk of having uterine disorders and problems with fertility.

Watch problem calvers. Calving difficulty boosts the risk of retained placenta, uterine infections, culling, death, milk fever and cystic ovaries. Twinning increases risk for stillbirth, retained placenta, uterine infections, displaced abomasum and culling. Similarly, retained placenta makes uterine infections, ketosis, displaced abomasum and culling more likely. Therefore, all of these disorders are interrelated and reduce reproductive performance of cows.

Retained placenta. Retained placenta is failure to pass the placenta within 24 hours after calving, and it happens after about nine percent of calvings. The key element in retained placenta is failure of the placentomes (cotyledon and caruncle) to detach. Pre-calving suppression of the immune system is a big contributor. Contrary to previous belief, it is not lack of uterine contractions linked to hypocalcemia, though there is some association, and certainly contributors are abortion, twin birth, induced calving, difficult calving, caesarean section, stillborn calf and milk fever. Animals with elevated serum nonesterified fatty acids (NEFA), or fatty liver syndrome and/or low levels of vitamin E also are at higher risk.

Historically, manual removal of the retained placenta by manipulation and traction was practiced, and this is now strongly discouraged: it likely does more harm than good.

The impact of retained placenta ranges from none to impaired fertility, to severe metritis with loss of milk production. Like smoking cigarettes: a retained placenta is not bad in and of itself, but it can lead to bad things. The best estimate is that affected cows become pregnant about 15 percent more slowly than unaffected cows, and that this occurs only if metritis or clinical and/or subclinical endometritis result from the retained placenta. Loss of milk production appears to

ALL FARMS SHOULD HAVE A REGULAR PROTOCOL for examining fresh cows on a daily basis. It will pay off not only in getting cows rebred, but also in the following lactation.

be confined to those cows that progress to clinical metritis.

As discussed previously with endometritis, use of intrauterine antibiotics for retained placenta will increase the risk of antibiotics in milk and is not worth the expense in terms of getting the cow pregnant sooner. There also is no strong evidence that use of oxytocin or prostaglandin will hasten the expelling of the placenta. However, use of antibiotics is indicated should the cow become sickly, i.e. listless and not eating – many have fevers.

A reasonable protocol to treat retained placenta may be to treat cows that have at least two symptoms of metritis (fever, dullness or lack of appetite, bad-smelling discharge) with 3 to 5 days of antibiotic systemically, following drug withdrawal guidelines. Because many things can contribute to retained placenta, transition cow management must be optimal and include optimum feed intake, and a diet that includes 0.3 ppm selenium and 1000 to 2000 IU per cow per day of vitamin E.

Milk fever. Some level of milk fever exists in every dairy herd. A bottle of calcium gluconate administered intravenously usually gets most cows up, and many dairies have a person with the skill to administer this treatment.

The clinical term is parturient paresis, or paralysis following calving. There is a deficiency of blood calcium needed for muscle function. Mild clinical cases will exhibit some shakiness and stumbling. In the most extreme cases, the cow goes down and is unable to rise, and if left untreated, the cow will die. Although in general it may be treated easily, milk fever adds to the risk for calving difficulty, retained placenta, ketosis and possibly mastitis, even though it may not precede the clinical signs of these disorders.

Clinical cases mean that the cow has symptoms you can see. Many more subclinical milk fever (hypocalcemia) cases exist, often undetected.

Hypocalcemia can occur in over 60 percent of older cows in high producing herds, based on Colorado and Florida data. Blood calcium levels are below 8 mg per dl, but over 5 mg per dl (signs of milk fever can be observed at this lower level). Cows appear sluggish and dull. If you observe positive responses in fresh cows when fresh cows routinely receive calcium tubes or drenches, subcutaneous calcium and feeding DCAD (dietary cation-anion difference) products, you are treating hypocalcemia.

When anionic salts are fed, close-up dry cows experience a drop in urine pH when DCAD goals are achieved to acidify the blood and mobilize calcium. Normal urine pH is over 8. If an optimal DCAD is fed, urine pH should drop to 6.2 to 6.8 (Jersey cows need to be 5.5 to 6). Urine pH should not drop below 5.5, or kidney damage could occur. Commercial pH strips are available for checking urine pH.

Ketosis. Ketosis can occur a week before calving to 6 weeks after in high producing cows. Primary ketosis is related to an energy shortage caused by high milk yield, marginal dry matter intake or use of low quality ration ingredients. Diseases such as mastitis, metritis, or milk fever that reduce the cow's intake also can lead to ketosis.

In the days before calving, nutrient requirements are greater due to fetal growth, colostrum's synthesis, and the cow's udder is developing for lactation. At the same time, feed intake typically drops 15 to 30 percent. The amount of energy needed to maintain the cow and to support milk production in early lactation exceeds the amount consumed in feed. The cow enters a negative balance for energy and protein as well as calcium. Cows have some ability to draw upon body reserves. They typically draw energy from body fat mobilization. This is a normal process.

But if this process goes on too long and/or the deficiencies are too great, the cow loses too much body condition, and ketosis occurs. Ketotic cows are more susceptible to mastitis, metritis and other infections, and also have reduced fertility.

Monitoring ketone levels in a herd can help decide whether treatment is justified. Keto-Test strips are available through your veterinarian and are useful for monitoring sub-clinical ketosis in milk or urine. Urine is more sensitive and could be used before calving. For example, administering propylene glycol has a positive effect if the ration cannot support adequate levels of propionate or if the cow has sub-clinical ketosis. If incidence of ketosis is high in the herd, dry matter intake and feed quality also must be evaluated.

Fatty liver. This condition occurs within a few days before calving to several weeks afterward, most often among cows that approach calving with excess body condition (3.75 or more). These fatty liver cows act depressed, have lack of appetite, suppressed immune systems and general weakness. It is referred to as fatty liver syndrome because it almost always is associated with other problems, including ketosis, milk fever, displaced abomasums, retained placenta, metritis or mastitis. Fatty liver is almost always secondary to another problem.

The close-up dry cow and recently fresh cow mobilize fatty acids from body fat stores. The liver absorbs these fatty acids, and then manufactures another fat called triglyceride. Ideally, the cow should take up the triglycerides for milk fat synthesis. Fatty liver develops because the liver manufactures triglycerides faster than the triglycerides can be exported from the liver and moved to the udder. Once triglycerides accumulate in the liver, it is very difficult for them to be removed. They then interfere with important liver functions, and this leads to reduced immune function.

Prevention of this condition is the key, since treatments have limited success. The cow's body condition is best manipulated while she still is milking, not by restricting feed during the dry period.

DA's. Displaced abomasums (DA) occur when the cow's fourth or true stomach compartment is twisted to the left or right side from its normal position. About 9 out of 10 times, the abomasum moves upward on the left body wall. The abomasum is trapped and squeezed between the rumen and the left side of the cow. The entrance and exit of the abomasum are restricted, and the abomasum becomes filled with gas and bloats. The veterinarian taps the cow's left side and listens for the "ping" associated with this bloating.

Right side displacements may more commonly involve a twist and are more serious, as blood supply can be cut off, and recovery rate is much poorer compared to a left displacement if not diagnosed and treated promptly.

DA's cost an average of $340 per case due to treatment, lost milk production, longer interval from calving to conception, greater risk of severe ketosis and culling.

A common goal is no more than 3 percent of fresh cows have LDA's, and less than 1 percent is achievable. Managing the feeding program before and after calving is key. Feed the cow bulky feeds during the dry period to keep the rumen full and maintain dry matter intake. Avoid finely chopped silages. Sudden shifts from a dry-cow ration to a hot milking ration can contribute to DA's. Rumen acidosis can contribute to DA's; start feeding grain to close-up dry cows 10 days to two weeks before calving and increase it gradually. After calving, cows should be maintained on a higher forage ration for 10 to 30 days before switching to the hot milking cow ration.

In closing this chapter, one last, clear message is that measures taken to prevent one or more of these disorders probably will decrease the risk and incidence of other related problems, as well as improve fertility.

TIPS FOR VACCINATING DRY/FRESH COWS

- **Cow is immune-suppressed for up to 2 weeks pre- and post-calving; this reduces her response to vaccines administered during this time.**

- **Risk of disease is highest at calving, so administer vaccines well before the cow is at risk.**

- **For mastitis vaccines:**
  - **2 weeks before drying off**
  - **Boost at dry-off**
  - **Boost again 2 weeks before calving**

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13 – When should cows be bred?

BREEDING COWS AT THE WRONG TIME is one of the main causes of infertility. This statement is unanimously supported by those who work in reproduction.

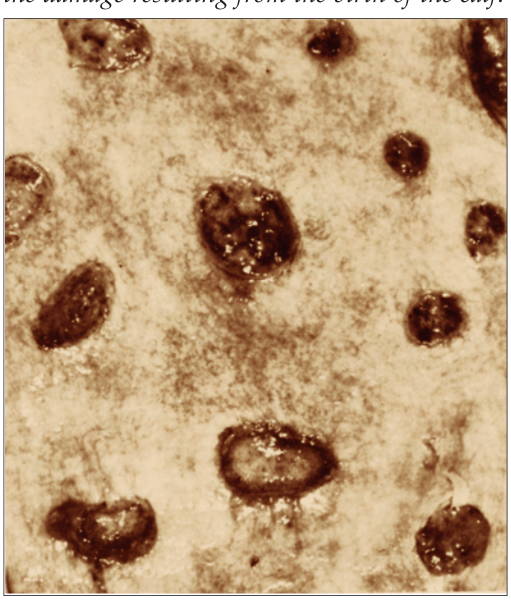
Infertility caused by breeding at the wrong time is a needless waste! Certainly, there are many causes of infertility that cannot be predicted and consequently, are very difficult to avoid. But timing of the insemination is one thing that we can control if a good job is done in the area of estrous detection.

Recovery after calving. Cows may show their first estrus any time from 2 to 10 weeks after calving. However, just because a cow shows estrus soon after calving does not mean that she is ready to breed. The uterus usually requires from 3 to 6 weeks to recover from the previous pregnancy. And fertility is appreciably lower until after this recovery is completed.

If you were to see the interior of a uterus within the first weeks following calving, you would quickly recognize that it has not yet recovered from the effects of calving. There are many blood clots and some inflammation of the uterine wall. Having seen it, you will not likely recommend breeding a cow too soon after calving.

By 45 to 60 days after normal calving, the uterus is usually back to normal, and at least 90 percent of the cows should show signs of standing estrus by this time. Experiments have shown that fertility of matings made at 45 to 60 days after calving is about 80 percent as high as fertility of matings made at 80 to 90 days after calving. However, not much increase in fertility is gained by delaying breedings beyond 80 days after calving.

INSIDE OF A UTERUS after calving shows the damage resulting from the birth of the calf.



Earlier breeding after calving is one means of shortening the average calving interval of the herd. Cows should not be rebred before 60 days unless palpation of the reproductive tract reveals that the cow is ready for rebreeding. Even 60 days may be insufficient recovery time for cows that had difficulty at calving.

Another way to ask this question is how long should you wait before initiation of breeding after calving? There should be a herd goal of when to start breeding or an established voluntary waiting period (VWP). This varies from 45 to 80 days—if your veterinarian has examined the cows and declared them OK to breed. With good estrous detection or an estrous synchronization program (Chapter 18), the average days to first breeding should be 70 to 75 days.

If the cow is bred successfully soon after calving, her production for the lactation will be somewhat lower. The first 5 months of pregnancy have no apparent effect upon lactation. Following 5 months, however, the effects of pregnancy become progressively greater. Thus breeding too soon after calving could have an adverse affect on economic returns from some cows.

Experiments have not shown consistent effects of stage of lactation on reproduction. High-producing cows will breed back on schedule if they are healthy and well fed. In some herds, high-producing cows are less fertile than lower producers. However, in other herds fertility is similar between high and low producers. Some of the differences in reproductive performance between high and low producers may be due to differences in how cows are managed rather than to differences in level of milk production.

Silent estrus (heat). Actually, most so-called silent estruses are simply missed estruses due to poor estrous detection techniques. About one quarter of estruses can be classified as low intensity and short duration, meaning that they were less than 1.5 standing events per hour and less than 7 hours in duration. Other studies find that high-producing dairy cows had shorter periods of estrus (6.2 hours compared to 10.9 hours) and fewer standing events (6.3 versus 8.8) compared to low-producing cows.

Estrus involves a series of changes affecting almost every part of the cow. The cow is usually more excitable, showing signs of restlessness. A clear mucous discharge from the vagina and reddening of the vulva are typical. Cows in estrus usually mount other cows. These are all important signs of estrus.

However, standing to be mounted by another cow is the best single characteristic of estrus. You cannot watch cows for standing estrus while they are confined. They must be free to move about plus have confidence of good footing. Dirt footing is preferred, but not always available. When cows are maintained on concrete, it should be grooved to improve estrous detection, as well as minimizing slipping at other times,

Estrous detection is one of the most important, yet most abused areas, of reproductive management. Missed estruses are not the only estrous detection problem. Studies from New York, Virginia and California have revealed that about 15 percent of all cows that were bred were misidentified as being in estrus and had no chance to conceive.

A good estrous detection program should give cows a place to exhibit estrus and should increase the chances that someone will be on hand to observe that behavior.

The following are management suggestions for an effective estrous detection program.

- Appoint specific people to be responsible for estrous detection, and allow time to do the job properly. This should be a clear part of their job description.
- Observe cows three or fours times daily; 50 percent of all cows are in estrus less than 8 hours.
- Spend at least 15 minutes during each observation period—mounts only last 2 to 3 seconds, and the cows must be given enough opportunity to interact.
- Avoid combining estrous detection with other chores.
- Record all estruses whether the cow is to be bred or not. Estrous detection will improve if future estruses can be anticipated.
- Pregnancy status should be a key criteria for grouping cows. Keep open cows together to stimulate more estrus activity. Cows that are approaching estrus, in estrus and going out of estrus form sexually active groups (SAGs). The size of the SAG can determine overall activity of the individual cow in estrus. Because of this, estrous synchronization can improve estrous detection, because more cows are in estrus at the same time.
- Provide an area where cows are free to interact and have good footing and few obstacles. Turn cows out on a dry, dirt surface for best results. Sore feet and legs can diminish overall activity, and the number of mounts received by lame cows was decreased by 70 percent in one study.
- When cows are lying down, check for mucus, rough tailheads, abnormal discharges or the bloody discharge that indicates a previous estrus (2 to 3 days prior). Then encourage cows to move around to increase interaction. At the same time, remember that conditions that distract or frighten cattle will decrease estrus expression.

SCORING SYSTEM FOR ESTRUS BEHAVIOR

SIGN	POINTS
Mucous vaginal discharge	3
Pestering other cows	3
Restlessness	5
Sniffing vagina of another cow	10
Mounted but not standing	10
Chin resting on another cow	15
Mount (or attempted) other cows	35
Mounting head side of other cows	45
Standing estrus	100

* based on proposal by Van Eerdenburg et al, 1996

Considerations for monitoring estrus. The increase of herd size in the U.S. has made the old recommendation for twice-daily estrous detection outdated. Even with three- or four-times-a-day monitoring with visual detection, larger pen size makes it impossible for one person to see the entire pen at one time.

Difficulties with visual detection are pushing large herds in one of two directions: either intensive use of timed A.I. (TAI) or toward using methods for estrous detection that supplement or replace visual detection. Many larger herds now use tail chalking to identify cows with rubbed tail-heads that have been ridden by herdmates.

These methods tend to be simple and efficient, but with potentially high error rates (once daily tail chalking and A.I. based on rubbed tailheads) or automated systems of estrous detection (mount detection or pedometers) that are more expensive but tend to be more accurate.

Timed A.I. We use signs of estrus because these help us to predict the time of ovulation: this is what really directs the timing of insemination. Ideally we would like to know the exact time of the LH surge, because ovulation occurs about 30 hours following the LH surge in a very predictable manner. If we knew the exact time of the LH surge, then we would not need to observe for estrus. That is the underlying beauty of TAI. The final GnRH injection of the Ovsynch protocol causes the LH surge. There is no need to detect estrus because the time of the LH surge is known, and cows can be inseminated at a set time after the GnRH injection.

Simple systems to detect cows in estrus. An ideal system for estrous detection would include these five features: 1) Continuous surveillance of the cow; 2) accurate and automatic cow identification; 3) operational for the cow's lifetime; 4) require minimal labor and 5) be accurate.

Devices to identify cows in standing estrus include tail chalk, tail paint, Kamar Heatmount detectors, Estrus Alerts, and other pressure-sensitive non-electronic devices. These all work on the principle that cows that stand when mounted by another cow received pressure and rubbing on the tail head. If chalk/paint is rubbed off, or the device is activated, this is an indication of estrus. These devices were traditionally viewed as aides to supplement visual observation, though large dairies may chalk tailheads once-daily and inseminate cows with rubbed tailheads. Of the five criteria, the above methods do allow continuous surveillance and require minimal labor. But they are not operational for the cow's lifetime and their accuracy may be low if used alone with no other information on the cow.

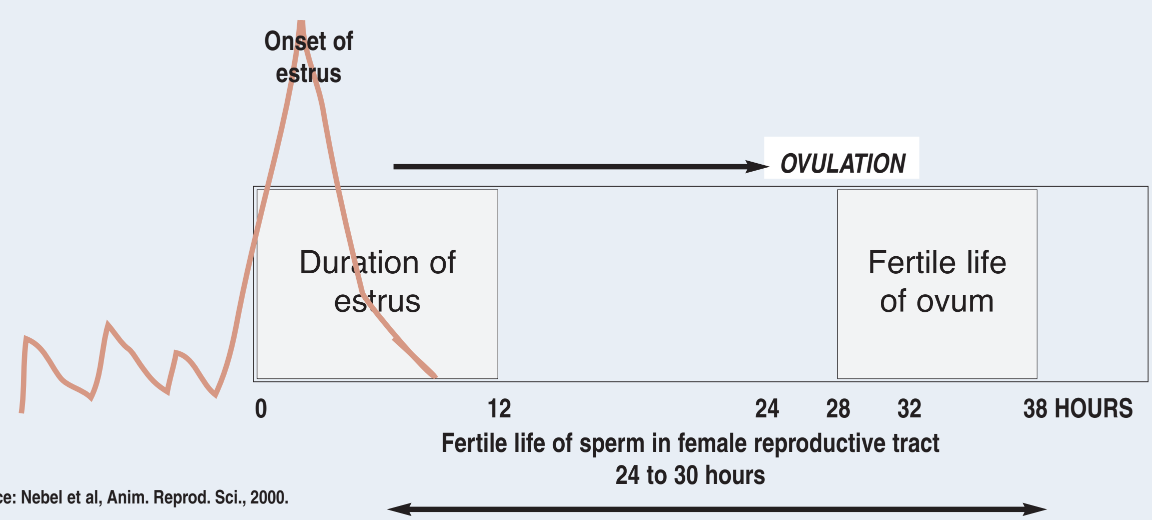
Electronic systems to detect cows in estrus. Systems such as HeatWatch will record the number and time of mounts through a transmitter located on the tailhead. Data can be transmitted to a computer on the farm, otherwise the devices themselves must be examined daily to retrieve information and determine which cows are in estrus. Limitations are their expense and the labor requirement to manage the system.

Activity monitors (pedometers or neck chain monitors) detect estrus using the principle that these cows are more active. A threshold is set and cows whose activity is above the threshold are considered in estrus. If the threshold is set too low, there are more false positives. Conversely, false negatives are higher if the threshold is set too high. The high rate of false positives tends to be the biggest drawback to these devices.

Integrating a variety of information on the individual cow may be the best: in other words, combining data from HeatWatch, activity and visual observation.

A sobering statistic that affects these systems that depend on the cow's behavior to detect estrus is that about half of cows in estrus

ESTRUS, THE LH SURGE AND OVULATION



Source: Nebel et al, Anim. Reprod. Sci., 2000.

do not show standing estrus, particularly high-producing cows: in other words, they have a silent estrus. At the present time, there is not a commercially available test to measure approaching ovulation or the LH surge in the cows' blood. This leaves TAI as an attractive alternative for handling these cows with silent estruses.

Fertility best toward end of standing estrus. If inseminations are not made at the correct time in relation to the time of ovulation, then fertility is reduced. Ovulation occurs about 25 to 30 hours after the onset of standing estrus. But under most conditions, we seldom know the exact time that standing estrus begins. Therefore, relying on visual observation alone, when a cow is first seen in standing estrus, she usually has already been in estrus for several hours. For example, if cows are observed at exactly 6 a.m. and 6 p.m. every day, a cow could have been in estrus for many hours before she was first observed to stand. Or she could be just beginning estrus. So, on the average, a cow observed in estrus under these conditions would have been in estrus about 5 to 6 hours when she was first observed standing.

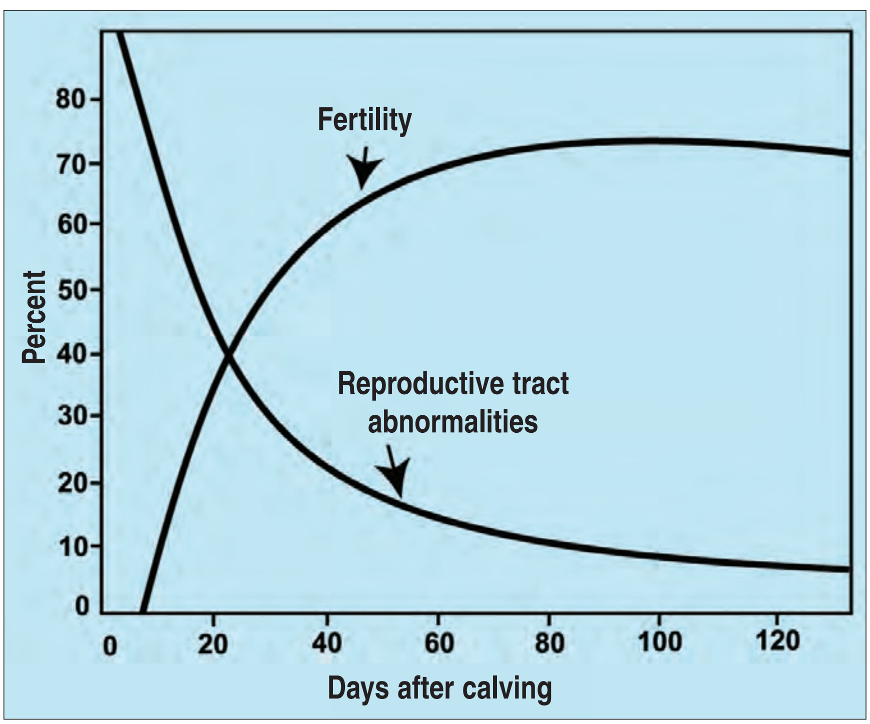
Sperm have to spend some time in the cow's reproductive tract before they develop the capacity to fertilize the egg. Therefore, inseminations should be made several hours before ovulation. To achieve highest fertility, a cow first observed in estrus before noon should be bred late in the afternoon that same day. Similarly, a cow first observed in estrus in the afternoon should be bred the following morning. This AM-PM system is easy to follow and under most conditions should result in good conception rates.

However, the AM-PM system works best with intense estrous detection programs. If cows are observed only twice a day, it is impossible to predict when onset of estrus occurred, thus timing of insemination is guesswork at best.

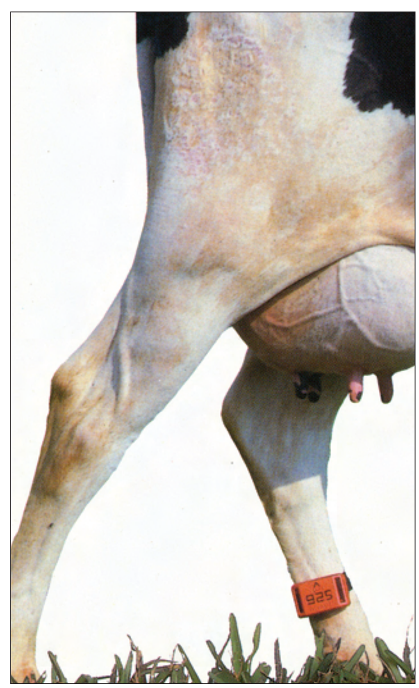
Based on life span of the ova and sperm, transport time of sperm to the site of fertilization and now accurately knowing that on average, cows ovulate 27.6 hours after the onset of standing estrus, **current recommendations are to inseminate about 8 hours after the best estimated time of peak estrus, with somewhat later than 8 hours being better than earlier.**

Some cows may deviate slightly from the herd average. For example, a cow may ovulate a few hours earlier or later than normal. But it is impossible, even for experienced veterinarians, to pinpoint the exact time of ovulation, even with ultrasound scanning of the ovaries. The same cow variation exists for other phases of reproduction, including the length of the estrous cycle and length of gestation, another reason why

REPRODUCTIVE TRACT ABNORMALITIES decrease with time after calving, while the expected fertility increases as the tract returns to normal.



A PEDOMETER alerts you to cows that are more active, a sign of estrus.



reproduction records on individual cows are so important.

Also, the discharge of blood following estrus provides a good clue as to whether the cows were bred at the proper time during estrus. Post-estrus bleeding usually appears (if observed at all) about 48 to 54 hours after the onset of standing estrus. The appearance of blood should follow breeding by about 30 hours.

If blood is observed consistently 40 to 48 hours after service, it indicates the cows were bred too soon after coming into estrus. If it is observed at or soon after breeding, then the cows were bred too late.

Management of anestrus and anovulatory cows. "Anovular" refers to cows that are not ovulating at or near the time that breeding of these cows should occur. While this can be confirmed by ultrasound or measurement of progesterone in the blood, cows that don't show estrus (anestrus) may be assumed to be anovular when this is not always the case. There are many physiological and environmental reasons why a cow may not display signs of estrus, even though the cow has an LH surge and ovulates.

A BLOODY DISCHARGE indicates that estrus occurred two to three days prior.

One example is high milk production: a study showed that cows with high milk production have a much shorter duration of standing estrus. A higher percentage of high producers also had silent ovulations: no standing estrus events, compared to lower producing cows. Regardless of the reason, higher producers are less likely to be found in estrus and might be misdiagnosed as anovular cows.

On the other hand, some cows may be detected in estrus, either inaccurately or due to expressing estrus but not actually ovulating. We'll be discussing anovular cows in the following paragraphs.

Incidence and causes of anovulation. Identification of anovular cows by testing for blood progesterone levels shows an incidence ranging from 15 to 54 percent by 49 to 71 days post-calving. In addition, first-calf heifers have a higher incidence than second or later lactation cows. On average, at 60 days in milk, some 25 percent of cows are anovular, and it often goes undiagnosed.

Presence of a persistent corpus luteum on the ovary is the most common condition preventing ovulation. This condition is present in pregnant cows, and in this case is not a problem. But some non-pregnant cows (1.5 to 6.4 percent) also may have a persistent corpus luteum that does not regress during a 25-day time period. The incidence of this condition increases dramatically in cows that ovulate during the first 25 days after calving (25 percent) compared to cows ovulating later. An effective treatment is using prostaglandin (PGF2-α) to cause the persistent CL to regress.

Three follicular growth patterns are observed in anovular cows. One is growth of relatively small follicles. This is associated with lower body condition score (2.5 or lower) and negative energy balance. These cows never have a follicle that reaches sufficient size or estradiol production to induce the cow to come into estrus and have an LH surge and ovulate.

The second follicular growth pattern readily identified by veterinarians is growth of follicular cysts. In most cases, these cows do not ovulate or show behavioral estrus, in spite of the presence of high concentrations of estradiol. The cystic cow's hypothalamus does not respond to the effects of estradiol, so she does not show estrus and does not have an LH surge or ovulate.

The third pattern of follicular growth in anovular cows is most prevalent and also the most difficult to diagnose on commercial dairies. The follicles grow to ovulatory size (16 to 24 mm) but do not ovulate. The ovary does not appear to have cysts but seems to be in a similar state as if it did. These cows also have high levels of circulating estradiol but do not show standing estrus or ovulation. Some secondary signs of estrus may be present (mucus, activity) but the cows do not ovulate.

On-farm factors associated with milk production. Although high levels of milk production do not cause anovular cows per se, in herds that are limited for energy or other nutrients, higher milk producers would logically have a much greater likelihood of being anovular than lower producers. In high-producing, well-fed herds, incidence of anovulation probably is related to factors other than level of milk production.

Body condition score (BCS) and incidence of anovulation at 60 days post-calving are strongly related. Yet 44 to 63 percent of anovular cows (two studies) were anovular yet had good BCS. So while cows with low BCS have a higher incidence of anovulation, many cows with anovulation do not have low BCS.

Most studies have shown greater incidence of anovular cows among first-calf heifers compared to cows with two or more calves. Yet this relationship is somewhat controversial and appears to vary by herd.

The rather frustrating fact is that in well-fed dairy cows with good BCS, there still is a surprisingly high incidence of anovulation.

Prevention through nonhormonal means. Improving nutrition is mentioned most often as a way to reduce the number of anovular cows. Another simple approach is to delay the time of first breeding, or increase the length of the VWP: over half those cows anovular at 71 days post-calving spontaneously recover by 100 days, according to one study.

A method currently under investigation is to shorten the dry period in 2nd+ lactation cows. One study showed that in cows where the dry period was shortened from 56 days to 34 days, the days to first ovulation was reduced from 43 to 35 days, and the percentage of cows that were anovular at 70 DIM declined from 18 percent to 8 percent. Note that cows with the reduced dry period received a steam-up, moderate energy diet at initial dry off and never received the typical low energy, dry-cow ration. Subsequent milk production did not appear to be affected.

Hormonal treatments of anovular cows. Hormonal protocols are needed to insure that anovular cows have every opportunity to become pregnant during their lactation. Most used in the U.S. is the Ovsynch protocol (illustrated on page 80). This protocol appears to induce ovulation in a high percentage of anovular dairy cows, but some of these cows have a subsequent short luteal phase. Nonetheless, while Ovsynch may induce ovulation in non-cycling cows, there is still likely to be a lower conception rate in these cows at the induced ovulation. The later the DIM at the start of Ovsynch, the more successful it will be in cycling or noncyling cows.

Use of a CIDR with the Ovsynch protocol is termed CIDR-Synch. Cows have the progesterone insert placed in the vagina at the same time as the first injection of GnRH in the Ovsynch protocol. The CIDR is removed at the time of PGF treatment. Study results have been variable, with no clear advantage as of this writing.

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Nebel, R. and DeJarnette, J. M., Artificial Insemination Programs for Heifers, Dairy Cattle Reproduction Council, Nov. 7, 2006 Denver conference.

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14 – Breeding heifers

Heifer rearing or replacement cost accounts for about 20 percent of the dairy's operational cost, often the dairy's second largest expense. Working to shorten the time between the heifer's birth and the birth of her first calf can do a lot to reduce this cost.

At the same time, A.I. is a powerful tool for genetic improvement that enhances the value of bred heifers. It's generally a more efficient process to get heifers bred using A.I. because they have a longer estrus. For example, while a study showed duration of estrus as 7.4 hours for Holstein cows and 8.9 hours for Jersey cows, heifers exhibit estrus for a 40-percent longer period: 10.8 hours for Holstein heifers and 12.7 hours for Jersey heifers. Heifers also show more mounting activity than cows, and while there is no "best" time to observe heifers for standing activity, movement of heifers prior to observing for estrus seems to increase standing activity.

Age of heifer. Well-fed heifers normally show their first estrus (puberty) at 9 to 11 months of age, though they may ovulate even earlier. Poorly fed heifers, however, may not come into estrus until they are 20 months or more of age. Puberty appears to occur when heifers achieve about two-thirds of adult size, rather than at a constant age.

Nevertheless, once heifers reach puberty (start coming into estrus), age and size have comparatively little effect on the percentage that become pregnant. This is true for heifers bred at 14 to 16 months of age, and for older animals bred for the first time at 2 to 3 years.

After that age, there is a tendency toward poorer reproductive performance. Females not mated before 4 years of age may tend to develop irregular estrous cycles, cystic ovaries and other reproductive disturbances.

There is a popular opinion that breeding heifers while they are too young will retard their ultimate size. Experiments have shown that the age of breeding has little, if any, effect upon the ultimate body size, provided the animals are well fed during pregnancy and during the first lactation.

Another popular opinion maintains that breeding heifers when they are too young may shorten their life expectancy. This idea is largely unfounded. Little or no indication of shorter productive life exists due to earlier calving. Actually, heifers calving at about 2 years of age have a higher lifetime production total than if they calve for the first time at 3 years.

It is true that older heifers yield more milk in their first lactations than do younger heifers. However, after the first lactation, age at first calving has only a small effect on milk yield. Early-calving heifers start paying for their keep sooner and maintain a higher cumulative milk yield all their lives.

Recommended body weight for first service is when heifers reach approximately 65 percent of their expected mature body weight, or 750 to 800 pounds (340 to 363 kg) for Holsteins and 550 to 600 pounds (250 to 272 kg) for Jersey heifers. An adequate nutrition and development program is critical for success in a heifer A.I. program.

Perhaps the most important consideration in determining when to breed heifers is the ability of the heifer to deliver a calf. Small heifers may have severe calving difficulties. Such difficulties can cause permanent infertility or even death of the cow. They may also lower the expected milk production in the next lactation. Thus, ease of calving is much more dependent upon size than upon age.

In order to assure safe calving size, the postcalving weight of heifers should be at least 1,200 pounds (545 kg) for Holsteins, 850 pounds (386 kg) for Jerseys, 1,000 pounds (454 kg) for Guernseys, about 950 pounds (430 kg) for Ayrshires and about 1,100 pounds (500 kg) for Brown Swiss.

Breeding dairy heifers to beef bulls, in an effort to produce a smaller calf that might result in less calving difficulties, is a questionable procedure. In the first place, if the heifers are grown out well at the time of calving, there is no need for this practice. In the second place, experiments have shown that the size of the dam is the primary factor in determining the birth weight of the calf. Third, within beef breeds, some bulls have larger calves than others, so unless you have selected the bull based on calf size you may be better off with a calving ease dairy bull. Finally, you are losing the genetic merit and production in this generation of cross-bred calves.

The sire also affects a calf's birth weight. There is almost as much difference in birth weight of offspring between bulls within a breed as there is between bulls of different breeds. This means that certain Holstein sires may be just as effective as some beef bulls in siring small offspring from first-calf Holstein heifers. These "smaller" offspring from Holstein matings do not necessarily remain smaller all their lives. See the discussion in Chapter 7 on using SCE scores of sires to avoid calving difficulty in first-calf heifers.

First-calf heifers make up about 30 percent of the herd. This means that 30 percent of the heifer calves born are from first-calf heifers.

If 30 percent of the heifer calves born each year are sired by beef bulls, nearly all of the other heifer calves (from the older cows in the herd) must be kept for herd replacements, eliminating selection of heifers as a tool in herd improvement. It is highly recommended that heifers be bred A.I. to a good dairy bull.

Estrus detection in heifers. In general, A.I. after detected estrus usually is associated with higher conception rates compared to timed A.I. (TAI) following synchronization of estrus or of ovulation in heifers. One study showed the proportion of heifers pregnant was nearly equal using four protocols that ranged from A. I. following detected estrus to three popular synchronization programs. The conception rate was highest in the groups that relied on tail paint combined with visual detection of estrus.

Tail-chalking is performed by applying a stripe of chalk or paint down the tailhead from the hooks to where the tail slopes off the topline of the heifer. All heifers in a breeding group or pen must have a stripe applied because during daily observation, the absence of the stripe indicates that the heifer possibly stood to be mounted by herdmates. However, the absence of the stripe should be only an alert: the observer should look for other secondary signs such as swollen and red vulva, mucous discharge either on the rump, tail or suspended from the genital tract and muddy flanks. The tail stripe is freshened up on a daily basis as needed. Referencing prior breeding dates is also helpful to determine if this suspected estrus is within a normal estrous cycle interval of 18 to 24 days. With training and experience, you can determine which rubbed-off stripe markings are results of legitimate estrous activity and which were licked or worn off naturally.

The major reasons for not using A.I. for heifers are perceptions of lowered conception rates compared to natural service, time commitment for detection of estrus, heifers kept at an inconvenient location, and lack of restraint facilities. When the onset of estrus cannot be accurately determined, producers should consider estrus synchronization and a concentrated A.I. breeding program for selected months during the year.

Sex sorted-semen. As noted in chapter 2, the dairy industry recommends use of sex-sorted semen primarily in dairy heifers. Field trials show conception rates with sex-sorted semen to be 70 to 73 percent of those obtained with conventional semen.

Taking this reduced conception rate into account, a proposal for the best use of sex-sorted semen would be a strategy of earlier breeding of heifers with sex-sorted semen followed by use of conventional semen for repeat services.

A three-week earlier A.I. scheme would provide 62 to 66 percent female offspring at first calving with no detrimental effects on average age at calving or difficult calving (dystocia). Efficient application of sex-sorted semen use in heifers would be further enhanced with recent advances in estrus synchronization technology.

At present, sex-sorted semen is only recommended in highly fertile virgin heifers detected in standing estrus. Also, sex-sorted semen is NOT recommended in conjunction with either timed A.I. (TAI) protocols or in lactating cows. Producers should be aware that the flow cytometric technology developed by USDA, sublicensed to XY, Inc., and presently commercialized in the U.S. by Sexing Technologies of Navosota, TX, is the only validated sex-sorting technology in the market place.

References cited: Nebel, R. and De Jarnette, J.M., Artificial Insemination Programs for Heifers, Dairy Cattle Reproduction Council, Nov. 7, 2006, Denver.

Stevenson, J. Synchronization Strategies to Facilitate Artificial Insemination in Lactating Dairy Cows, Dairy Cattle Reproduction Council, Nov. 7, 2006, Denver.

15 – Pregnancy diagnosis

Remember that the most important information from pregnancy testing is identifying open cows; identifying pregnant cows is secondary. Non-pregnancy diagnosis then requires rapidly returning the cow to A.I. service to improve reproductive efficiency.

Palpation, ultrasound and blood tests. Veterinary palpation through the rectal wall used to be the only option for early detection of a cow's pregnancy status. The use of ultrasound has grown, particularly since portable, battery-operated units improved in quality and could be used in larger herds.

Dairy producers can purchase their own ultrasound, but veterinary-grade machines are expensive, $8,000 to $16,000. Possibly more daunting is the training and experience needed to use the machines and obtain accurate results.

In addition, new tests are just becoming available that test for unique components in the cow's blood if she is pregnant. One test confirms the presence of a protein secreted by a type of cell that is part of the placenta. The protein is known as pregnancy-specific protein B, also known as pregnancy-associated glycoprotein (PAG). It becomes detectable in the bloodstream in about 28 days in pregnant heifers and 30 days in pregnant cows.

This test for PAG is most accurate for blood samples collected on or after Day 30 post-A.I. Lactating cows should be at least 90 days in milk when the test is performed to ensure the protein from the previous pregnancy has been eliminated from the bloodstream. This isn't a problem for cows inseminated on or after Day 60 postpartum, and blood is collected 30 days after A.I. (at least Day 90 postpartum).

An average minimum of days by which veterinarians can confidently predict a pregnancy through trans-rectal palpation of the uterus could be set at 35 days. For ultrasound, assuming some of the newer, more sensitive equipment is being used, 28 days could be the minimum (you could find those who would argue several days earlier or later for either of these figures). The bottom line is that ultrasound has at least a seven-day advantage over palpation. Nonetheless, since the embryo loss following successful A.I. tends to occur early, some of these cows diagnosed pregnant at 28 days may be open a few days later. Depending on the routine and strategies to get open cows rebred, those seven days may or may not have an advantage over palpation. Yet knowing that cow is definitely open at 28 days lets you restart the cow that much sooner in an estrus induction program. Ultrasound also has a definite advantage in diagnosing other details that palpation cannot, and these are discussed below.

ULTRASOUND has at least a seven-day advantage over rectal palpation in diagnosing pregnancy, and in determining cows that are open.

Estrous detection still valuable. Regardless of when and how often pregnancy diagnosis is carried out, the best way to reduce inter-insemination intervals is to rebreed the cow at her first eligible estrus after the last A.I. breeding. Good estrous detection for cows that have been inseminated 19 to 25 days previously lets you rebreed more cows sooner.

Using various heat-mount detectors, activity monitors, electronic devices, pressure-sensitive tailhead patches, and tail paint or tail chalk may all be helpful. But nothing can surpass visually watching cows for signs of mounting and standing activity.

Rebreeding options. How often do you have your cows preg checked? Frequency of checks may be monthly in smaller herds. Others have their cows checked every two weeks (biweekly) or weekly.

Weekly or bi-weekly checks allow earlier determination of open cows, fewer missed estruses, and potentially shorter inter-insemination intervals. Monthly checks could mean potentially missing up to three estruses or three opportunities to re-inseminate your open cows.

Various synchronization protocols will be described in Chapter 18. In brief, if you find that following pregnancy checks, more than 70 percent of your cows are pregnant, on average, you may not choose to use an aggressive approach of starting all cows on a synchronization protocol seven days before pregnancy check: you would be wasting 70 percent of the GnRH injections on pregnant cows.

On the other hand, if less than 50 percent of your cows are averaging pregnant, you may want to choose this option. Then all cows determined not pregnant at pregnancy check could receive a first injection of GnRH seven days prior to pregnancy check: all cows not pregnant on that day receive prostaglandin, followed by GnRH again in two days, followed by TAI. This protocol then ensures that all nonpregnant cows are re-inseminated within three days. If you wait to give the first GnRH injection, all open cows won't be re-inseminated until 10 days after pregnancy check, costing you an additional seven days open.

Consider doing more frequent pregnancy checks in your herd, to optimize the number of cows presented for insemination.

Other uses for ultrasound. *Cystic ovaries.* When the veterinarian palpates a cystic ovary, usually a large blister-like structure is detected which is two or three times the size of a normal mature follicle. For the most accurate diagnosis, a second palpation 10 to 14 days later was required to verify that the cyst was still present. Frequently this didn't occur. Furthermore, the vast majority of cystic ovaries diagnosed in the first 60 days in milk recover spontaneously, so could be considered a normal part of the return to cyclicity. Twelve to 14 percent of all problem breeders have cystic ovaries. Furthermore, between 10 to 40 percent of all dairy cows develop cystic ovaries during their lifetimes, and 35 to 45 percent of all dairy cows with ovarian cysts are repeat offenders.

There are three types of conditions that usually fall within the cystic ovary category—follicular, luteal, and those involving the corpus luteum. Follicular cysts are thin-walled, anovulatory (not ovulating) cysts that may occur singly or in multiples. Some cows with this type of cyst will be in estrus every three to five days and may be known as "chronic bullers." However, cows with cystic ovaries more frequently fail to show any signs of estrus and are termed anestrus. Follicular cysts secrete variable amounts of the hormone estrogen, which induces estrus.

Luteal cysts are also formed from follicles that did not ovulate properly. However, luteal cysts are thick-walled cysts, which secrete low levels of progesterone. Cows with this type of cyst almost always will be anestrus. Many researchers now believe that most luteal cysts were once follicular cysts that were not detected and progressed from an estrogen- to a progesterone-producing structure. Ultrasound is very useful in detecting which type of cyst exists, or whether what would be palpated as a possible cyst is a large and otherwise normal CL.

Treatment. Frequently a combination of GnRH and prostaglandins are used to treat the cystic cow. When GnRH is given to a cystic cow, it causes the release of large amounts of LH from the pituitary. The LH, in turn, causes the follicular cyst to luteinize or ovulate and then produce progesterone in a pattern much like a corpus luteum. However, luteal cysts are nonresponsive to GnRH. The second segment of this treatment is the administration of prostaglandin, usually 11 days later, which now can regress both cystic types. When this occurs, the cow responds by showing a normal estrus within two to five days. Improper hormones and improper amounts injected into cows can cause more problems than they cure. Hormones should be administered only upon the advice of a veterinarian.

Years ago, a recommended treatment (no longer recommended) for some cows with cystic ovaries was to squeeze the persistent cyst by rectal palpation until it burst or popped off from the ovary. This procedure may result in some bleeding. This forms a blood clot around the oviduct and the fragile infundibulum. The clot frequently causes adhesions that may prevent an egg from entering the oviduct. Such a cow would not become pregnant at the time an egg was ovulated from this ovary. Hormone injections, which have fewer known complications, have replaced the old method of treating cystic ovaries.

Presence or absence of a corpus luteum helps determine pregnancy status, especially when conducting pregnancy exams early post-A.I. When present, the size and location (left or right ovary) of the corpus luteum indicates the location of the embryo within the uterus if the cow is pregnant.

Diagnosing twins. The presence of multiple corpora lutea is one indicator of twins. By 40 to 55 days post-A.I., twins can be accurately identified, by scanning the entire length of both uterine horns. Most twins are due to double ovulations, and not the splitting of an embryo. So these twins resulting from two eggs would most likely occupy separate uterine horns. Nonetheless, it can be tricky to scan both horns carefully to identify with certainty two embryos. At times the same fetus shows up at different angles and would appear to be twins. In addition, twins resulting from splitting of one fertilized egg (homozygous, identical twins) would not have multiple corpora lutea and would both occupy one horn. Again, care must be taken for accurate diagnosis of twins.

Although multiple births are sought in some animals, they are considered a liability in dairy cattle. Upon identifying twins, some have considered aborting the twin pregnancy with intention of rebreeding the cow. However, induced abortions tend to greatly lengthen the time required for successfully rebreeding the cow. In theory it also should be possible to abort one of the twins at 30 days, if they are in different uterine horns. Letting the cow calve carries a greater risk for future twinning in subsequent pregnancies, as this trend tends to increase as production increases with advancing age. On top of that, a heifer calf born twin to a bull (close to half of all twin births) is most likely a freemartin and sterile. Finally, cows calving with twins have more likelihood of problems at calving time as well as greater likelihood of retaining their placenta.

Knowing ahead of time which cows carry twins can be useful, because depending on the value of the dam and calf, culling might be a better alternative. Or should you decide to let the cow carry the twins to term, you can manage her better by drying her off a little earlier and moving her into the close-up pen 10 days sooner. This will allow cows to still have two to three weeks in the transition pen despite having a shorter gestation length.

Fetal sexing. Beginning on Day 55 to 60 of gestation, ultrasound can quite accurately detect the sex of bovine fetuses. Day 60 also is a good time for reconfirming pregnancy. After this time, it becomes more difficult to view the fetus and make an accurate diagnosis. Though not economical as a routine test, filling a sales contract for a calf of one sex or the other could justify this expense. In addition, this information could help determine the decision whether or not to cull the cow.

Pyometra or pregnancy? When manually palpating the uterus, it sometimes is hard to determine whether an enlargement is a pregnancy or a pyometra. Pregnancy fluid as viewed in an ultrasound is completely black in appearance with membranes and/or embryonic tissues clearly visible. In contrast, ultrasound shows pus as gray with floating flecks of white-appearing debris.

In addition, other signs of trouble include lack of a heartbeat (visible as early as 30 days) and disruption of the membranes and the fetus itself can be detected with ultrasound. When these signs are recorded, the cow can be rechecked in a week or given prostaglandin.

How early is too early? Following conception, a 13.5 percent rate of embryonic death is common in the industry. There are factors that can help you minimize this, but embryonic death most commonly occurs between conception and 60 to 70 days gestation.

So while it's very useful to detect pregnancy early (28 to 35 days of gestation), it's also very wise to follow up four to five weeks later on a cow diagnosed pregnant early in gestation to reconfirm the pregnancy. Otherwise, if a cow loses the embryo and it goes undetected, considerable time will be lost before this open cow is identified as open and rebred.

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Fricke, P., Synch Programs and Ultrasound: Are We Getting in There Too Early? AABP, St. Paul, September 2006

Stevenson, J., One- and Two-Week Herd Checks Pay, Hoard's Dairyman, June, 2006.

16 – How do we achieve reproductive efficiency?

Artificial insemination (A.I.) is one of the most important agricultural technologies of the century, and most dairy producers use A.I. to some degree. However, reproductive inefficiency in lactating dairy cows substantially reduces the impact and advantage of A.I. in dairy operations.

A calving interval of 13 months has long been an ideal. With approval and use of recombinant bovine somatotropin (rbST), some researchers wanted to reconsider this ideal and suggested extended calving intervals. But regardless of rbST use, extending calving interval beyond 13 months results in a decrease in annual revenue per cow. One study showed an annual return of $813.19 per cow when the calving interval was 18 months (76 weeks), compared to $959.18 per cow with a calving interval of 13 months (56 weeks).

The time after calving until the cow is eligible to receive her first A.I. service is called the Voluntary Waiting Period (VWP). "Voluntary" implies that it is a management decision on the dairy, and it usually varies from 40 to 70 days. Since the VWP includes the time immediately after calving, it includes part of the transition period, when the cow is at great risk for numerous disorders related to the stress of calving and start of a new lactation. Naturally these disorders would have an impact on how fast the uterus returns to normal (involutes), the first postpartum ovulation and the start of reproductive cycling for the cow.

Once a cow passes the VWP, she is eligible for breeding. For dairies relying on visual estrous detection, the time following the VWP before the cow is bred depends greatly on how efficiently estrous detection is carried out on a farm; to a lesser extent, the cow's physiological status also affects the length of this time period.

The ideal would be that 1) all cows are cycling by the end of the VWP, 2) the estrous cycle is 21 days, and 3) estrous detection is 100 percent: in this ideal scenario, time between end of VWP and breeding would average 10.5 days.

Sadly, field research paints a bleaker picture: over a quarter of fresh cows were anovulatory at 60 days in milk (DIM); this means they would not express estrus at the end of the VWP. Second, estrous cycle length varies widely among lactating cows; in this study, the average was 24 days. Finally, estrous detection efficiency is estimated to be less than 50 percent on most dairy farms in the U.S. This latter increases the interval to first A.I. and also increases the average time between services to 40 to 50 days.

Some definitions. *Pregnancy versus conception rate:* Conception rate is the number of cows that become pregnant after one insemination divided by the total number of cows inseminated during some defined period of time.

Let's say we give prostaglandin to 10 cows on Monday morning, check for estrus, and inseminate those detected in estrus during the next 21-day period (an average cycle length).

A = the 10 cows.

B = cows detected in estrus and inseminated, 8 in this example.

C = cows diagnosed pregnant, 4 in this example.

<u>Heat detection rate</u>, or A.I. submission rate is B ÷ A, or 8÷ 10, 80 percent

<u>Conception rate</u> is C÷B, or 4 ÷ 8, 50 percent. (Half of the cows inseminated conceived)

<u>Pregnancy rate</u> (sometimes called 21-day pregnancy rate) for this cycle of 21 days is the number of cows diagnosed pregnant divided by the number eligible to be bred by A.I., or C ÷ A, 4 ÷ 10 or 40 percent. The difference is those two cows that were never detected in estrus and were not bred.

An unfortunate trend is illustrated by the overall average pregnancy rate in 1951 of 61 percent declining to an estimated 40 percent in 1997 for lactating cows. On the other hand, pregnancy rate in heifers has remained steady at 70 percent during this same period.

Since less that 50 percent of all estruses are accurately detected, this means that fewer than 50 percent of eligible cows are being presented for A.I. breeding. A key to improve poor reproductive efficiency, then, is to improve the A.I. submission rate.

Let's look at a second example where we take our cows and apply the Ovsynch protocol. We will inseminate all the cows whether or not they show estrus. So the A.I.

submission rate is 100 percent.

Of the 10 cows bred, 4 conceive: C÷ B is 4 ÷ 10, or 40 percent Conception Rate

Since all 10 cows were bred, Pregnancy Rate also is 40 percent: C ÷ A is 4 ÷ 10, 40 percent. When timed A.I. is used and all cows are bred A.I., conception rate is identical to pregnancy rate.

When people refer to pregnancy rates of 13 to 14 percent, they are referring to a continuous pregnancy rate that is similar to a rolling herd average. An open cow has a pregnancy rate of 0 until she becomes pregnant. Poor rates of estrous detection reduce pregnancy rate because of missed opportunities to inseminate each cow when not detected in heat every 21 days.

When estrous detection and conception rate are quite low, pregnancy rate is low because it is the product of these two processes.

Large dairies always have had difficulty performing visual estrous detection. Instead they often have relied on secondary signs of estrus, using tail chalk, for example. Relying on secondary signs can often be inaccurate, and studies have shown that almost one-fifth of inseminations were performed on cows not in estrus or in the early stages of pregnancy. Insemination of pregnant cows led to 17 percent embryo loss.

By using a synchronized breeding and pregnancy diagnosis program as described (Chapters 15, 18), you can improve overall pregnancy rate. One study using this protocol showed a pregnancy rate of over 20 percent, compared to the national pregnancy rate of around 14 percent.

Reduce days open. How early is too early for pregnancy diagnosis? Rectal palpation traditionally starts at 35 to 40 days post-A.I. Anything less than 30 days is unreliable. Use of ultrasound shrinks the days for accurate pregnancy diagnosis into the mid-20s. Emerging technologies might allow diagnosis even earlier, perhaps the low 20s or high teens in the future. Why is earlier better?

Use of synchronization programs and not relying on estrous detection can be efficient when there is timely rebreeding of open cows. While there is a high A.I. submission rate to first Timed Artificial Insemination (TAI), you lose this advantage if 60 days or more go by before cows failing to conceive are inseminated again. Assuming about 60 percent of cows that first receive TAI fail to conceive, these cows need an aggressive resynchronization strategy to rebreed them and reduce days open.

When the veterinarian comes every two weeks and if the pregnancy check limit was set at 35 days, the range of examination would be from 35 days to 49 days, averaging 42 days. Recently, various studies have been evaluating different strategies to reduce the days until cows can be identified as not pregnant and re-inseminated in TAI programs. Although weekly ultrasound pregnancy diagnosis could occur as early as 26 days, recent work indicates this is not the best choice.

In traditional palpation programs, the open cow is then reenrolled for estrous detection. Depending on how good your estrous detection is, the cow may not be rebred for 1 to 30 days. Even if the cow is reenrolled in the traditional program within two days, the difference between palpation and early ultrasound still is 14 to 16 days. This reduces the days open by two weeks or more. Still, there are some drawbacks.

Pregnancy loss in early gestation. We've talked about embryo losses, which do tend to occur earlier in gestation rather than later. If this loss occurs from about Day 25 to Day 60 during gestation, doing preg checks at Day 26 will give a false sense of higher pregnancy rates than preg checks at Day 42. This may not actually be the case. The reality is that the examiner will declare the cow open, but will not know whether it was due to failure to conceive or pregnancy loss.

Studies seem to indicate that the rate of pregnancy losses slow around 60 to 70 days postbreeding. Therefore, in any program, it would be wise to confirm the pregnancy at 60 to 70 days postbreeding, regardless of when the initial preg check was performed.

IT'S WISE TO CONFIRM PREGNANCIES at 60 to 70 days postbreeding in any breeding program to catch early embryo losses, regardless of when the initial preg check was performed.

If very early diagnosis (mid 20s or early 30s) is performed, an additional confirmation around day 40 may be useful to detect open cows and minimize days to re-insemination. Finally, while losses diminish in mid- to later gestation, confirmations of pregnancies at later stages are in order.

Conception rates lower. The most aggressive resynchronization strategy, where GnRH is given at day 19 after A.I. with re-insemination on Day 28 following preg check on Day 26 also results in an unacceptably low conception rate compared to waiting 7 to 14 days. For better conception, here are two ways for a Day 42 rebreeding:

1. Preg check at Day 33, followed by giving the first GnRH at time of open diagnosis.
2. Inject GnRH at Day 33 without examination, followed by preg check at Day 40. A plus to this approach is better accuracy in diagnosing pregnancy at Day 40 versus Day 33.

Remember that GnRH used in the ways described above is considered extra label use, and you must work with your veterinarian in setting up a program.

The use of GnRH at 7 days prior to pregnancy check on all cows lets you give the prostaglandin in an Ovsynch program at the time a cow is identified as not pregnant. The second GnRH is given two days later with TAI 16 hours later, saving at least a week in rebreeding open cows. Of course, the GnRH at 7 days prior to pregnancy check is wasted on cows that are pregnant at the diagnosis. In a herd with 100 pregnancies a year, this would be around $250 to $300 in GnRH costs.

Comparing costs. If we can assume that using synchronized estrus and timed A.I. improves reproductive performance, how does it measure up when it comes to cost and extra labor? A German study did a comparison and found that Ovsynch cows had a somewhat lower conception rate compared to cows bred by estrous detection, but that more cows got pregnant sooner with Ovsynch. This is because the A.I. submission rate is 100 percent with an Ovsynch program.

The costs of a pregnancy were: costs of hormones (purchase and labor to inject); all costs associated with each A.I.; the costs of all palpations; the costs of days open; and the culling costs (difference between cull cow sale and cost of a pregnant replacement heifer).

Culling (replacement cost) and the cost of days open were the most costly items, representing 68 to 83 percent of the value of a pregnancy. The study showed that the benefit from using the Ovsynch protocol is far more pronounced in herds with poor estrous detection efficiency. In herds with acceptable estrous detection, use of Ovsynch may be of limited value, even if it increases reproductive performance to some extent.

If you feel your estrous detection is efficient, consider an alternative use of the Ovsynch protocol. Begin estrous detection and A.I. breeding after a 60-day VWP. All cows not inseminated by 80 days in milk receive the Ovsynch protocol. So if you inseminate about 40 percent of your cows after estrous detection, you only need to apply Ovsynch to the remaining 60 percent. But if you only inseminate 22 percent by 80 days, then Ovsynch may be the most economical approach for all cows before first service. Regardless, don't forget the value of Ovsynch for all cows not found pregnant, since it does offer a speedy re-insemination.

References cited: Fricke, P., Aggressive Management Strategies for Improving Reproductive Efficiency, Dept. of Dairy Science, UW-Madison

Fricke, P., Resynchronization Strategies for Dairy Cows, Dairy Cattle Reproduction Council, Nov. 7, 2006 Denver conference.

17 – Inseminating your own cows

While many farms use the services of a professional A.I. technician, a large portion of cows in the U.S. are inseminated by a farm employee, the owner or a family member. This allows dairy producers to purchase semen from bulls in different A.I. organizations. The main disadvantage of direct service A.I. is that some producers or herd managers do not develop sufficient skill in A.I. techniques to maintain acceptable conception rates in their herds. Along with the technique of cervical penetration, the importance of sanitation must be emphasized and skills perfected to consistently obtain acceptable conception rates.

The producer assumes the full responsibility of record-keeping required for registration/identification of animals, keeping up-to-date on new recommendations on semen handling and insemination techniques, and keeping current on bull proofs. He or she must become a purchasing agent to maintain their supply of semen, liquid nitrogen and other insemination equipment.

The quality of frozen semen when it arrives at the farm is determined by the bull and by the A.I. organization that processed the semen. Semen obtained from reputable A.I. organizations has been processed under standard controlled conditions and is routinely subjected to stringent quality control tests. However, high quality, highly fertile semen can deteriorate rapidly if it is handled or stored carelessly.

Handling semen before thawing. In the farm semen tank, dangerously high temperatures for frozen semen exist in the upper half of the neck tube. Semen is exposed to these temperatures when you try to locate and thaw a specific unit of semen or when you transfer semen from tank to tank. Thermal injury to sperm should be minimized, because it is permanent and cannot be corrected by returning semen to liquid nitrogen.

Although sperm cells, when processed properly, can withstand the rigors of long-term storage at 320 °F below zero (-196°C), they are very delicate and must be handled with extreme care during thawing and insemination. There are rules that must be followed completely in handling frozen semen to minimize thermal damage.

1. Establish a semen inventory that keeps track of the location of each bull, preventing unnecessary searching that increases semen exposure.

2. Wash your hands. Inseminating cows is equivalent to a surgeon performing an operation. Bacteria on your hands would likely be transferred to your insemination gun during the loading procedure. If carried into the uterus during insemination, these organisms could thrive and grow rapidly, resulting in metritis and infertility.

3. Keep unused straws cold. Raise the canister just high enough in the neck region to grasp the desired cane of semen, keeping the canister top below the frost line. Any time it takes more than 8 to 10 seconds to locate a particular cane, the canister should be lowered into the tank to cool completely.

4. Use forceps to remove straws. This allows you to keep the canister and semen further down in the neck of the tank during straw retrieval. Immediately after the semen is removed from the cane, return the cane to the canister, immerse the straw in the warm water bath, and return the canister to its storage.

5. Thaw only as many straws as can be used in 15 minutes. Once thawed, sperm cells begin to burn up their limited energy reserves.

6. Regularly calibrate your thaw bath thermometer, at least every six months. Improper thermometer calibration results in improper thaw rates and damaged sperm cells.

Never return a unit of semen to the tank once it has been removed from the cane.

7. Protect semen after thawing. Cold shock occurs when thawed semen is subjected to sudden temperature declines. While we think of cold shock as only being a factor during the cooler months of the year, this is not the case. 70°F (25°C) on a warm summer morning feels very comfortable to you and me. But it represents a sudden 25°F (10°C) change in temperature for a sperm cell taken from 95°F (35°C) thaw water.

The recommendation for thawing of semen frozen in straws is not the same for all A.I. organizations. For optimum results, the recommendations of the semen processor should be followed. The problem is that most dairy producers use semen from numerous A.I. organizations, and only one thawing procedure is practiced. The National Association of Animal Breeders (NAAB) has recommended that when in doubt, 90 to 95 °F (32 to 35°C) water for a minimum of 40 seconds should be followed for those who buy semen from several sources.

Correct thawing procedures are critical for the retrieval of the highest quality semen from the frozen state. Always use a thermometer to check thaw water temperature. After thawing for the required time, dry the straw thoroughly with a paper towel and protect it from rapid cooling.

While the semen is thawing, warm the insemination rod by rubbing it briskly with a paper towel. In cold weather, place the warm rod within clothing so it will be close to the body and maintain warmth. After assembly of the insemination rod, tuck it within your clothing for transport to the cow.

The cow should be inseminated within minutes after the semen has been thawed. The period of time between removing the semen from the tank and depositing the semen in the cow should not exceed 15 minutes.

When breeding a number of animals due to large herd size or timed A.I., it may be necessary to thaw multiple straws of semen at one time. Several studies have shown no reduced conception if these rules are followed: careful inseminators may thaw four straws simultaneously provided insemination is done in a timely fashion (within 15 minutes after thawing). Prevent direct straw-to-straw contact during thawing to avoid decreased post-thaw sperm viability. Maintain straws at a constant temperature and avoid thermal shock between thawing and transport to the cow.

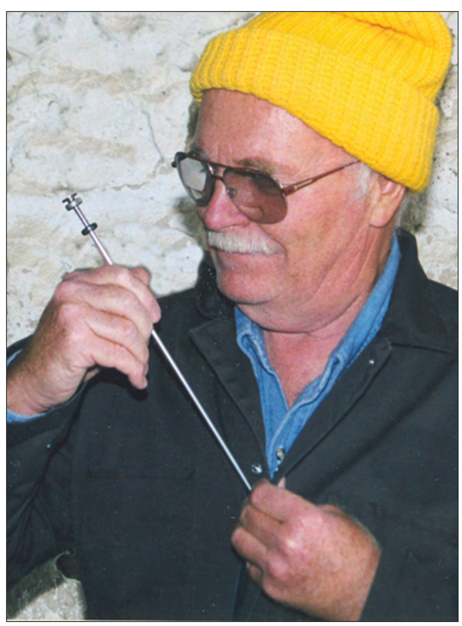
Semen packaging. When semen was first packaged in straws, U.S. A.I. companies chose the 1/2-cc straw, while European and Canadian companies marketed semen in 1/4–cc straws. One U.S. A.I. marketing organization began a transition to 1/2-cc straws, leading to the question, what's the difference? Because of its smaller diameter, the 1/4-cc straw lends itself to slightly faster freezing rates and the potential for slightly improved post-thaw sperm survival, provided glycerol levels and freezing rates are adjusted appropriately to accommodate the alternative packaging system.

However, the smaller diameter 1/4-cc straw also was found to be more sensitive to heat and cold shock after thawing. Inseminators must exercise a greater degree of both pre- and post-thaw thermal protection during straw retrieval, gun assembly and A.I. when using 1/4-cc straws to get optimum results.

These facts were major reasons for the U.S. A.I. industry's decision to use the 1/2-cc straw. Greater sensitivity of the 1/4-cc straw to thermal insult and inseminator competence are of little significance in Canada and Europe, where more than 95 percent of all inseminations are performed by professional technicians whose conception rates can be monitored routinely. However, in the U.S., where many inseminations are performed by the herd owner or an on-farm inseminator, variation in inseminator skills and level of training may interact with straw type to affect conception rates. Back in the late 1970s, the variation in A.I. technician proficiency in the United States and its potential impact on semen quality and fertility was recognized as a strike against the smaller-diameter, more thermally sensitive 1/4-cc straws. This is still of great concern today.

ALWAYS USE A THERMOMETER to check thaw water temperature, and thaw for the required time.

PROTECT SEMEN after thawing by placing the assembled insemination rod inside your clothing for transporting it to the cow.



Inseminator training. Whoever breeds the cows on the farm must be adequately trained. The skill required for successful artificial insemination is not learned quickly. An organized training course is necessary, and frequent refresher courses are beneficial.

Considerable experience is needed before a person gains confidence in his ability to inseminate cows. Poor results are almost a certainty unless you master the technique and know where you are placing the semen.

Site of semen deposition. The bull, of course, normally deposits the semen in the vagina next to the cervix. This location is satisfactory because he ejaculates about 10 billion sperm. With artificial insemination, only about 15 to 20 million live sperm are used and semen must be deposited in the uterus. When using A.I., do not deposit the semen in the vagina or cervix.

The uterine body is the accepted site for depositing semen when cows are bred artificially.

On repeat services, the recommendation also is to deposit semen in the uterine body. Approximately 5 percent of all pregnant cows show standing estrus. If you suspect the cow is pregnant by a sticky feeling when passing the insemination rod, stop and deposit the semen about halfway through the cervix. However, cervical deposition increases semen loss and lowers conception rates by about 25 percent.

When inseminating, guard against contamination of the catheter (inseminating tube) as it passes through the vulva. Clean the vulva with a paper towel. Use the gloved hand inside the rectum to spread the vulva lips so the catheter end will remain clean.

Insert the catheter gently along the top of the vagina, guiding it with the hand in the rectum. Grasp the cervix firmly with the gloved hand and guide the catheter through it. With the forefinger, make sure the end of the catheter is through the cervix into the uterine body. Expel the semen slowly.

Ideally, deposit semen in the uterine body to allow sperm transport up both uterine horns. Misplacement of semen decreases sperm numbers in one or both uterine horns, reducing the odds of fertilization and subsequent pregnancy rates.

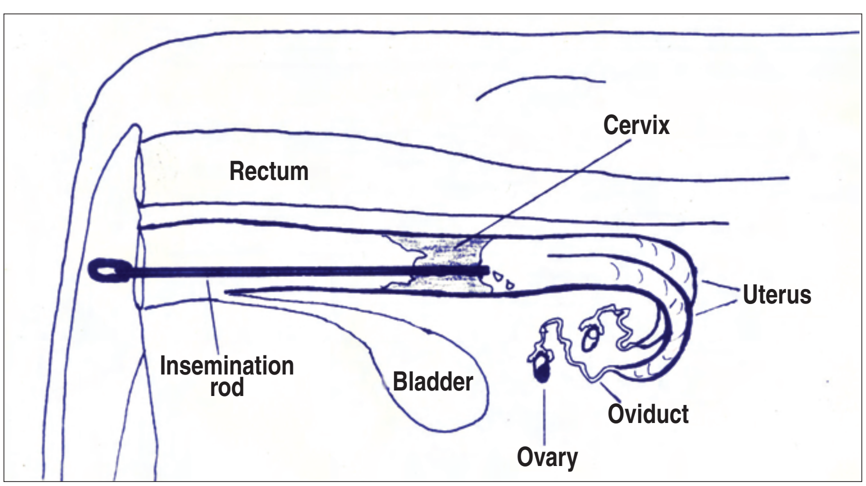
Research using dye deposition has shown error rates for deposition of semen in the uterine body to be quite high (50 to 60 percent). Cervical errors are common and they may account for over 20 percent of attempted uterine body depositions.

Make sure to push in with the plunger and do not pull back on the gun. Pulling back may result in much of the semen dose being deposited in the cervix and vagina instead of the uterine body. Although the recommended site of semen deposition is in the uterine body, research suggests that when exact gun tip placement is in doubt, depositing semen slightly into one uterine horn is less likely to compromise fertility than depositing it in the cervix.

Good housekeeping. Prevent contamination of the insemination equipment with manure, water or soap. Even a small amount of sanitizing solution on the inseminating tube is sufficient to kill the sperm. Do not store inseminating tubes where they will collect dust, or leave the A.I. kit where it will become contaminated.

Regardless of who inseminates the cow, the objectives of A.I. are: 1) Settle the cow; 2) Obtain calves from the best bulls; 3) Use disease-free semen; 4) Obtain the first three at a reasonable cost.

UTERINE BODY BREEDING: Semen is placed just past the cervix into the uterine body.



References cited: DeJarnette, J. M, Select Sires

Dalton, J., and Ahmadzadeh, A., Does Batch Thawing of Semen Affect Conception?, Hoard's Dairyman, June 2004

18 – Synchronization strategies

As dairy herds have become larger, it has become more difficult to identify when cows need to be bred. Consequently, strategies have been developed to allow dairymen to "tell" the cow when she's to be bred, instead of waiting for the cow to tell us she's ready. Advantages of programmed breeding (Timed A.I., or TAI) include: 1) convenience of scheduling labor and tasks; 2) controlling the occurrence of estrus, ovulation or both and 3) knowing the stage of the estrous cycle and reproductive status of all cows in the herd.

These reproductive statuses include: 1) open cows scheduled for first A.I.; 2) bred cows awaiting pregnancy diagnosis; 3) open cows scheduled for re-insemination; 4) open cows designated as culls (do not breed list); and 5) cows confirmed pregnant.

The two groups eligible for programmed breeding are 1) open cows scheduled for first A.I. and 3) open cows scheduled for rebreeding.

VWP a factor. When cows calve without complication, the healing process requires no more than 40 days, so the voluntary waiting period varies from 45 days to 80 days on most farms. Using TAI on lactating cows appears to have greater success when the VWP is delayed beyond 60 days.

If a cow is detected in estrus and then inseminated, or inseminated as part of a TAI program, the pregnancy rate is similar. Conception rates are actually somewhat higher if cows are bred following detected estrus. The key difference is that because cows in estrus are not all detected, more cows are presented for A.I. when using TAI.

Prostaglandin F2-α programs. A simple approach is to inject all non-inseminated, breeding-eligible cows with PGF2-α, detect estrus and A.I. Cows not detected in estrus are re-injected in 7 days (the "Monday morning program"). Those cows not observed in estrus during the 7 days after injection will be those that 1) displayed estrus but were not detected and 2) did not respond to PGF2-α because they were still not cycling or they have a new CL that was unresponsive to PGF2-α. A downside to this program is that some weekly injections of PGF2-α are wasted in animals that can't respond.

A partial solution is a program of biweekly injections of PGF2-α to make estrous detection easier and then A.I.. After the third biweekly injection, you could use timed A.I. at 72 to 80 hours after the injection, in place of trying to detect estrus OR, after failing to detect estrus, apply the Ovsynch protocol 10 to 14 days after the last PGF2-α injection (see figures on pages 80, 81).

Select Synch. This program combines control of follicular development (GnRH) and the lifespan of the CL (PGF2-α). An injection of GnRH is followed in 7 days by an injection of PGF2-α and then cows are inseminated after detected estrus. The GnRH causes release of FSH (follicle stimulating hormone) and LH (luteinizing hormone) from the pituitary. The LH stimulates ovulation of any dominant follicle that is present on the ovary at the time of treatment. In addition, FSH stimulates a new follicular wave to develop. One of the follicles from this wave then becomes dominant,

PRESYNCHRONIZATION TREATMENTS

- **1x PGF2-α 10 d before Ovsynch**
- **1x PGF2-α 10 d and GnRH 7 d before Ovsynch**
- **1x PGF2-α 8 d and GnRH 6 d before Ovsynch**
- **Ovsynch initiated on day 7 of cycle**
- **Presynch-12[1]**
- **Presynch-14[1]**

1 - Two injections of PGF2-α 14 days apart. Presynch-12 or Presynch-14 indicated that Ovsynch was initiated either 12 or 14 days after the second Presynch injection, respectively.

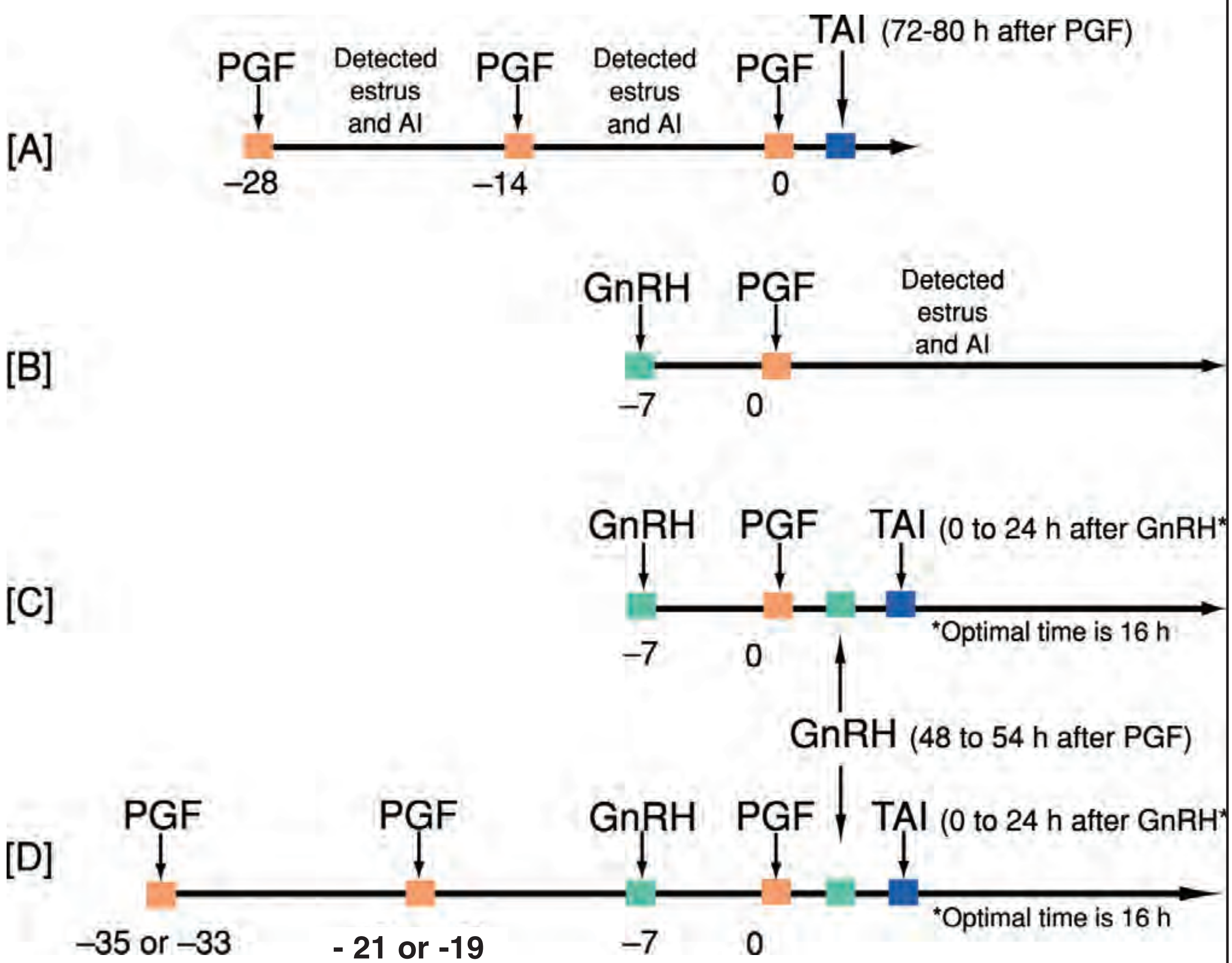
SYNCHRONIZATION PROGRAMS

A = Prostaglandin program

B = Select Synch

C = Ovsynch

D = Presynch + Ovsynch



Injection Schedule for Presynch + Ovsynch Program

Week	M	T	W	Th	F	S	S
1			PGF		Estrus		
2							
3			PGF		Estrus		
4		12 days					
5	GnRH						
6	PGF		GnRH	TAI			

growing larger than other follicles on the ovary. The prostaglandin causes the corpus luteum to regress. Progesterone levels fall so the developing follicle can continue maturing, becoming a pre-ovulatory follicle.

Ovsynch. Similar to Select Synch, but it does not require watching for estrus. It is probably the most popular protocol in the industry. Following the first GnRH injection, PGF2-α is injected 7 days later. Then 48 hours to 54 hours after the PGF2-α, a second GnRH injection is administered. TAI follows, optimally at 16 hours after the second GnRH and before 24 hours after. The first GnRH injection causes ovulation in 60 percent of the cows in preparation for PGF2-α-induced luteal regression. The second GnRH injection induces the pre-ovulatory LH surge to time ovulation 24 to 34 hours later, with TAI optimally occurring at 16 hours. If cows are detected in estrus at any time during this program, they should be inseminated according to the AM-PM rule to maximize conception, and the injection of PGF2-α, GnRH or both should be eliminated. In this case, TAI is used more as a "clean-up" for those cows not detected in estrus, and cost of hormone injections were reduced.

Presynch + Ovsynch. Research has shown improved fertility in cows when estrous cycles are pre-synchronized before applying the Ovsynch protocol. There are a number of methods which can be used; however the most common method includes two injections of prostaglandins given 14 days apart with the second injection occurring 12 or 14 days prior to the initiation of the Ovsynch protocol. See the figure on page 79 and at left.

Intravaginal Progesterone-Releasing Insert (CIDR). Studies of combined use of the CIDR insert with either Ovsynch or Presynch + Ovsynch protocol in lactating dairy cows have shown varied results. In one study (Stevenson), cows treated with a CIDR that did not have a functional CL at the time the PGF2-α injection of the Ovsynch was given (cows having premature luteolysis and those that were anestrus) had improved pregnancy rates compared to controls, showing some benefit of the CIDR in these problem cows. Theoretically, the CIDR should prevent premature events associated with estrus and ovulation while it is in place from the time of the GnRH (-7) until the PGF2-α injection of Ovsynch is administered. Use of CIDRs in heifers is discussed on page 84.

Proper timing of GnRH and A.I. One of the initial studies on Ovsynch evaluated inseminating cows at 0, 8, 16, 24 and 32 hours after the second dose of GnRH. The highest conception rate occurred at 16 hours, thus that is the recommended interval to insemination. There are slight reductions in conception rates when insemination occurs at 0, 8 or 24 hours after the second GnRH. (Note that 0 hours indicates that the second GnRH injection and A.I. are performed at the same time: also known as Cosynch, the practice eliminates an added handling of animals for follow-up A.I.) Because there is only a slight reduction in fertility, some producers may elect to inseminate at one of these times to avoid the hottest part of the day or for another management reason. For example, in large herds, either the injection of the GnRH or the TAI must be adjusted to accommodate an injection routine when cows are locked up only once daily at the feedline.

Under no circumstances should the timing of the inseminations be delayed to 32 hours as conception rates are lower and pregnancy loss is increased (figure, page 82). The increase in pregnancy loss in cows inseminated at 32 hours means even fewer cows calve.

When the second GnRH injection of the Ovsynch protocol was given at 48 hours after PGF2-α, the optimal time to A.I. was 16 hours after GnRH. For large herds, either the injection of the GnRH or the TAI must be adjusted to accommodate an injection routine when cows are locked up only once daily at the feedline.

A different, recent study showed the best pregnancy rates occurred when GnRH was administered at 56 hours after PGF2-α and cows were inseminated about 16 hours later. To accommodate that schedule, all cows were injected once daily during lockup, but the second GnRH injection was given at 56 hours (afternoon) after PGF2-α. This protocol probably best mimics what spontaneously occurs in cows during estrus. The second GnRH injection initiates the preovulatory LH surge to accommodate ovulation 24 to 34 hours later. When live sperm are inseminated 16 hours after GnRH, capacitated sperm should arrive at the utero-tubal junction or in the lower oviducts about the time the first cows ovulate after GnRH. This should maximize conception.

Advantages of the various programs. The best program should be simple and easy to manage. Simplicity could be defined as handling cows the fewest times during a protocol.

As a result of less efficient estrous detection or the lack of expressed estrus by cows in environments with poor footing or greater milk yield, TAI programs have become very popular because of their predictability and likelihood of producing the greatest proportion of total pregnancies in the herd. Still, the multiple injections and handling of animals can be complex with the overlapping nature of breeding cluster groups.

For example, if the Presynch + Ovsynch protocol is followed where a new cluster is initiated every week, injections must be given concurrently to three different cluster groups during any given work week. Further, if pregnancy is diagnosed once weekly and open cows are started in their own separate cluster group, the complexity of more cluster groups increases. It can be a challenge for personnel to make these programs work in a disciplined and detailed manner: protocol compliance must approach 100 percent. Fortunately, computer programs can create lists of cows which need treatments and electronic ID is being used to locate the correct cows. More on this in Chapter 19.

The table on page 83 presents some costs and comparisons of breeding by detected estrus only and various synchronization programs. Most of the reduced cost per pregnancy achieved by the TAI programs was lost if visual detection of estrus was not used between synchronization cycles to detect the first eligible estrus 20 to 22 days after TAI and before pregnancy diagnosis occurred.

At the same time, A.I. programs that depend solely on estrous detection must exceed 70 percent detection of all cows in estrus for their cost to be less than a hormonal protocol. And what was not assessed was the value of the reduced "hassle factor" in being able to program inseminations and exercise some control over the breeding program, including management of the required skilled labor.

Comparison of cows conceiving and calving when A.I. occurs at varying intervals after the second GnRH in Ovsynch

	Time after 2nd GnRH until A.I.				
	0 hr	8 hr	16 hr	24 hr	32 hr
% conceiving	37	41	45	41	32
% calving	31	31	33	29	20

Systems for managing A.I. programs for heifers. *Estrous synchronization using PGF2-α.* A study compared A.I. using a tail chalking program compared to a modified Ovsynch protocol. Days to pregnancy across the 42-day breeding period were about the same. Note that PGF2-α programs depend upon regression of a spontaneously induced CL; they are therefore not effective on heifers before puberty.

A two-injection PGF2-α program uses an 11-day interval between injections so that a high percentage of heifers possess a functional CL at the time of the second PGF2-α injection. All heifers detected in estrus after the initial PGF2-α injection are inseminated, and only those not detected in estrus are re-injected 11 days later and inseminated following detected estrus. Some modifications to this 11-day program are:

(1) no estrous detection or A.I. after the initial PGF2-α, eliminating the need for two detection periods;

(2) exclusively appointment A.I. at a specified time after the second PGF2-α injection, the time usually varies between 72 and 80 hours after injection and may incorporate a double insemination at 72 and 96 hours;

(3) a combination of A.I. fol-

Inputs for spreadsheet calculations of cost per day open and costs of various ovulation synchronization programs compared with visual detection of estrus before A.I.[1]

Mailbox milk price	13.23	$/cwt	
Feed cost	0.07	$/lb DM	$0.15/kg DM
Milk price:feed cost	1.89	Range of 1.0 to 2.5	
Replacement cost	1200	$/heifer	
Cull price	0.39	$/lb	$0.86/kg
Replacement cost:cull price	2.20	Range of 1.5 to 3.0	
Milk yield	65.0	lb/cow/d	29.5 kg/cow/d
Cull yield	40.0	lb/cow/d	18.1 kg/cow/d
Days open	160		
Do not breed, DIM	300		
Reproductive losses	2.99	$/cow/d	

		PROGRAM	
	Detected estrus only[2]	Ovsynch[3]	Presynch[4] + Ovsynch
Annual cost, $	11,801	17,221	18,507
Unadjusted cost per pregnancy, $	55.40	73.66	78.59
No. of reproductive culls	37	16	15
Average days open	162	122	116
Cost per day open beyond 85 DIM	3.16	1.16	1.02
Adjusted cost per pregnancy, $	298.35	115.39	110.49

[1] Adapted from Nebel et al. (2003). Calculations are based on a herd size of 250 cows using costs per day open as the descriptive variable (see text) and detection of estrus before resynchronization (maximum twice) with TAI (43 d after a previous service). Drug costs: $2.50 for PGF2-$\alpha$ and $2.25 for GnRH. Labor cost was $10/h with 60 min of labor required for detection of estrus per day. Inputs utilized were a maximum of three synchronization cycles followed by detection of estrus, average of 75 d to first service, 300 DIM (do not breed limit), and $15 per straw of semen.

[2] A VWP of 60 d, 40 % rate of detected estrus, conception rate of 40 % (16 % pregnancy rate).

[3] Ovsynch = injections of GnRH 7 d before and 48 h after PGF2-α· with TAI 16 to 20 h after the second GnRH injection. Average days to first service of 75, 300 DIM (do not breed limit), 33 % conception rate for first and subsequent synchronization cycles.

[4] Presynch = two injections of PGF2-α 14 d apart. Ovsynch was initiated 14 d after the second Presynch injection. Assumed 40 % conception rate after the first synchronization and 33 % conception rate for subsequent synchronization cycles.

lowing detected estrus and by appointment, with heifers not receiving A.I. by 72 hours being inseminated by appointment;

(4) a single PGF2-α injection with estrous detection 6 days prior to and 5 days after the injection. Usually, heifers are observed twice daily and AI occurs using the AM-PM guideline. After the initial 6 days, heifers not inseminated receive PGF2-α and are observed for the next 5 days;

(5) usually with larger groups of heifers or where visual observation is not practical, combining any of the above programs with tail chalk/paint and daily or twice daily inspection for rubbed tail heads has resulted in acceptable pregnancy rates; and

(6) varying the time between injections from 11 to 14 days so scheduling can be on the same day.

The table below shows results of a large field trial, with heifers not inseminated after the first PGF2-α injection receiving a second injection 11 days later. Estrous detection rate was higher for heifers that received two injections of PGF2-α a compared to one: almost 73 percent compared to 53.4 percent. But conception rates were higher for heifers receiving A.I. after the first injection (65.4 percent) compared to those bred after the second (60.9 percent). Lower still was conception rate for heifers not detected in estrus after the second injection and receiving TAI at 80 hours (40.6 percent conception rate).

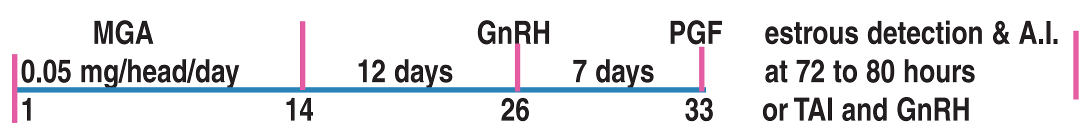
Synchronization with progestin. There are two progesterone products on the market that can be used in heifers to synchronize estrus. CIDR inserts or the progesterone-like compound melengesterol acetate (MGA) both suppress estrous expression and ovulation. Use of MGA fed to heifers followed by a PGF2-α injection is highly effective in synchronizing estrus. Most research was conducted in beef heifers, where it is still widely used, but it also is effective in dairy heifers with the following protocol:

- MGA is fed at a rate of 0.5 mg per head per day for 14 days.
- There is a waiting period of 17 to 19 days after MGA feeding followed by a PGF2-α injection.
- Heifers are bred upon detection of estrus during the following week.

This figure below shows a modified protocol, in which GnRH is used at day 26. Studies in beef cattle have shown pregnancy rates ranging from 55 to 65 percent. MGA is very economical and lends itself well to use in a feedlot. However, it is not readily available in all areas, and you must have adequate bunkspace and thorough mixing of the ration to ensure that heifers consume the prescribed dosage on a daily basis for the 14 days. Remember, MGA is not labeled for lactating dairy cows.

The CIDR + PGF2-α program. Like MGA, the CIDR insert elevates progesterone levels, gener-

Sequence of events for heifers on the MGA Select system.



Estrous detection rate and conception rate of dairy heifers after injection of PGF2-α (PGF).

	Estrous detection rate[1]		Conception rate[2]	
Time of A.I.	No.	%	No.	%
After first PGF	1435	53.4^{b}	766	65.4^{a}
After second PGF	1409	72.7^{a}	1025	60.9^{b}
A.I. at 80h after second PGF	–	–	561	40.6^{c}

[a,b,c] Values within a column with different superscripts differ ($P < 0.05$)

[1] Estrous detection rate is number of heifers that were detected in estrus divided by total number of heifers observed.

[2] Conception rate is number of heifers that conceived to A.I. divided by total number of heifers receiving A.I.

ally more effectively than MGA. The CIDR is inserted into the vagina for 7 days to deliver progestin, and upon removal after 7 days, heifers receive an injection of PGF2-α and are inseminated on detected estrus during the next 72 hours. Heifers not inseminated by day 10 receive TAI along with GnRH. The pregnancy rate in one study was 53.6 percent.

This protocol and others were compared for conception rates, pregnancy rates and program cost. Pregnancy rates overall were quite similar, including a control group that received no treatment and was bred strictly on detection of estrus. The biggest difference among the protocols was the cost, and based upon this, either breeding heifers detected after spontaneous estrus or a PGF2-α program (insemination following detected estrus following a first injection, with heifers not inseminated after 14 days receiving a second injection and again bred by estrous detection). Program costs ranged from under $33 per heifer for these two groups, compared to $43.86 and $53.87 for the CIDR protocol and modified CIDR using GnRH and PGF2-α, respectively.

FEEDING MGA to heifers is an effective way to synchronize estrus, but you must have adequate bunk space and thorough mixing of the ration.

References cited: Nebel, R. and DeJarnette, J. M., Artificial Insemination Programs for Heifers, Dairy Cattle Reproduction Council, Nov. 7, 2006 Denver conference.

Stevenson, J., Synchronization Strategies to Facilitate Artificial Insemination in Lactating Dairy Cows, Dairy Cattle Reproduction Council, Nov. 7, 2006 Denver conference.

19 – Fine-tuning your reproductive program

As with a successful milking routine protocol, there can be different choices and approaches to developing a reproductive program for your farm, but most important is consistency: you select a protocol, employees know and understand the steps, and there is consistency in following the protocol among all people involved.

An example that lends itself to numerical illustration is following a Presynch + Ovsynch protocol for submitting cows for first A.I. service. Each individual cow receives 5 consecutive injections at the appropriate time and in the correct sequence. Failure to administer any one of these five injections or administering one in the wrong order will reduce the conception rate to TAI and delay pregnancy. For a farm that achieves an injection protocol accuracy of 95 percent on any given injection day (that is, 95 percent of the cows that should get an injection actually get the correct one), on average nearly one in four cows will not successfully complete the five injections of the Presynch + Ovsynch protocol: $0.95 \times 0.95 \times 0.95 \times 0.95 \times 0.95 = 0.77$.

Farms that cannot achieve acceptable protocol compliance should consider focusing on other methods than those requiring multiple injection protocols to improve their reproductive program.

How do you monitor whether protocol is being adequately carried out? Compliance to protocol can be monitored through a number of record management systems. Most reproductive monitoring is performed by measuring the days in milk at first breeding, serum progesterone levels at time of insemination and ultimately pregnancy rates in the following 21-day cycles. In evaluating data, you must ask:

- What pregnancy rates are being achieved? Are they meeting your goals?
- What may contribute to performance that is less than expected? In addition to protocol compliance, you must consider insemination technique, anestrous cows, quality of estrous detection, poor transition cow care, to name a few.
- Are there differences between lactation groups?

If you are using a synchronization program that relies upon detected estrus followed by TAI as a final effort, you should note:

- Are any cows bred earlier than mandated by the on-farm program and for what reasons? Other than aborts and purchased cows with unknown freshening dates, there should be very few.
- Are any cows bred later than the TAI program? If there are, the program is "leaky", indicating poor compliance in carrying out the protocol.

Hormone evaluation. In addition to using a dairy management record system to evaluate reproductive performance of the herd, serum samples from individual cows can be used to measure compliance with a synchronization program. Evaluation of serum progesterone concentrations helps determine the accuracy of estrous detection, incidence of anestrus, and accuracy of synchronization for the time of breeding. A recommended procedure is to sample 20 cows at the time of breeding (first sample) and then to resample the same cows 7 to 14 days later (second sample). Here are possible outcomes:

- The first sample has low progesterone and the second is high: the cow is in estrus and has been properly synchronized.
- The first sample is high in progesterone while the second is low: the cow was NOT synchronized properly.
- Both first and second samples are low: the cow is not cycling.

If a herd is following a presynchronization strategy, in which cows receive two PGF injections 12 to 14 days apart, 90 percent or more should have an active CL at the time of the first GnRH injection of this program. The veterinarian could choose to sample for progesterone at this point in the cow's estrous cycle. The percent of cows with low progesterone at this time may indicate the prevalence of anestrus animals; it also could indicate problems with injection protocol compliance.

Those persons responsible for carrying out the synchronization program may check off all cows on the list, though not all are injected. Sometimes this may be an honest mistake, but if you think it indicates a pattern, you could include sham cow IDs into the list and see if they are also checked off.

More and more herds are voluntarily moving toward Radio Frequency ID (RFID) for individual cows, although eventually it may be a mandated program of the federal government. Besides providing government disease monitoring, RFID can provide benefits in that major recordkeeping packages have integrated the ability to read the RFID tags using a Bluetooth wand that transmits to a Pocket PC. This device has the entire herd database in its memory, can access individual cow records, and provides an audible command for the next action step through headphones, such as Pass, Prostaglandin, GnRH, BST and Wrong Pen as examples. Commands can be recorded in English or Spanish.

One person in front can use this equipment while a second follows through to administer injections, etc. Data entry also is more efficient, as is transfer of the accumulated action information to the host computer. It's no longer necessary to transcribe from paper records. Compliance also should improve. "Reading" a pen is easy for the user of this device. Every action is announced and must be acted upon. At the end of the procedure the Pocket PC can produce a list of cows that were acted upon and more importantly a list of cows that were not found.

Recipe for success. The 21-day pregnancy rate in the U.S. averages 13 to 14 percent. Yet some farms do far better than this. What practices or characteristics do they share?

A survey of eight herds in various parts of the U.S. gave some common as well as some unique traits. The following table shows a summary of their reproductive performance and a summary of their management techniques.

Seven of the eight reduced reliance on humans to detect estrus. These seven used a presynchronization + synchronization program. Pedometry without a synchronization program was used by the eighth herd. By 100 DIM, 19 percent of all animals had not been inseminated in this last herd for the first time.

Common to all herds was recognizing that key employees were a crucial element of their dairy's success. Either long-term, trusted employees or family members were the A.I. technicians. Training involved A.I. training courses, working with the head herdsman and/or veterinarian, and some used regular refresher training courses for employees.

To ensure compliance with each farm's reproduction protocol, methods varied, but each herd had a system. In those using synchronization programs, there was extra effort to ensure cows received scheduled treatment. One herd gave most treatments during the weekly veterinary exam, treatments or insemination.

In terms of cow care, all farms had cow cooling. All herds also had close-up dry cow groups as well as a super fresh group, where cows stayed from 14 to 30 days, depending on the herd. All herds worked with a nutritionist. There were no magic ingredients, but rather a silage-based TMR. Different types of fats were included in the ration, and over half manipulated dietary cation-anion difference (DCAD) in the close-up dry cow group.

In the health program, all herds developed a vaccination schedule customized to their herd situation. All used an IBR-BVD-PI3 vaccine in their lactating animals, and five-way lepto vaccines were used in all eight herds.

In summary, each farm's representative offered tips for success, which included emphasizing compliance with reproductive program protocol; good employee communications with willingness to take suggestions and change; cow care and comfort, and attention to detail throughout every aspect of the dairy, from nutrition to health to employee management. Shared factors included:

- Technology adopted to overcome estrus-detection challenges;
- Trusted long-term employees or family members were A.I. technicians;

COLORED EAR CLIPS can help keep a synchronization program on track.

Reproductive performance and management in top performing herds

Item	Herd A	Herd B	Herd C	Herd D	Herd E	Herd F	Herd G	Herd H
Location	CA	CA	VA	NC	WI	WI	TX	NM
No. of Cows	5000	3000	2300	900	1400	1650	2500	1500
% Herd AI	97	99+	100	100	100	100	100	95
Breed	Holstein	Jersey	Holstein	Holstein	Holstein	Holstein	Holstein	Holstein
Housing	Freestall	Drylot	Freestall	Freestall	Freestall	Freestall	1° Freestall	Drylot
VWP, d	50	50	60	72	74	78	80h, 50c[1]	65 (45)[2]
Ave. DIMFS, d	64	62	87	75	76	80	75	61
% w DIMFS>100d	<1	<1	19	0	0	0	<1	<1
1st Serv. CR, %	48h, 39c[1]	39	31	31	35	40	35	33
Annual CR, %	40	32	26	25	30	35	28	30
EDR/AI SR[3]	63	69	60	58	69	51	63	69
% Preg-150 DIM	60	88	48	53	50	43	47	77
21d PR, %	25	24	19-20	19	22	17	19	18
Preg Check Freq	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Monthly
Type Preg. Diagnosis, DCC[4]	Palp-35	Palp-36	Palp-30	Palp-36	US-28	US-31	Palp-39	Palp-36
Embryonic Loss, %	10	NA	NA	4.5	10	7	NA	NA
% Abortions (>42 DCC)	10	10	7.5	7.5	5	7.3	15.6	5
ED Program	Chalk	Chalk	Pedometer	Chalk	Visual – 6X/d	Synch Program	Chalk	Chalk
Presynch program *cherry-pick	PGF 14-14*	PGF 14-14*	No	PGF 14-14	PGF 14-14	PGF14-12	PGF14*-14*	PGF 14-14
Synch Program	Ovsynch	Cosynch-72[5]	No	Cosynch-72	Ovsynch 48G-16TAI	Ovsynch 56G-18TAI	CIDRsynch -48G-24TAI	Ovsynch -48G-24TAI
Resynch Program	Ovsynch	Cosynch-72	No	Cosynch-72	Resynch-(-7) -Ovsynch[6]	PGF12- Ovsynch	PGF7- CIDR-Synch	Ovsynch- 48G-24TAI

1 The values for heifers (h) and cows (c) differed.
2 The voluntary wait period was 45 d until they started the synchronization program in March and moved to 65 d.
3 EDR/AI SR= Estrus-detection rate/Artificial insemination Submission Rate
4 The type of pregnancy diagnosis was either by palpation (Palp) or ultrasound (US) with the shortest interval possible for days carried calf.
5 Cosynch-72 refers to a modified Ovsynch protocol in which cows receive both the last GnRH injection and are A.I.'d at 72 hours after PGF to save handling them an additional time.
6 Resynch-(-7) means the resynchronization program began seven days prior to pregnancy diagnosis.

• Most scheduled routine A.I. refresher courses;

• System in place to insure compliance with the reproductive program;

• Cooling, sand bedding, overall cow comfort was stressed;

• Close-up dry cow and super fresh groups for cows;

• Over half manipulated DCAD in the close-up dry cow group;

• All had vaccination programs customized to their herd situation, with half having a program to identify BVD-persistently infected animals;

• Silage-based TMR rations;

• Personnel are recognized as key to success.

References cited: Fricke, P., Resynchronization Strategies for Dairy Cows, Dairy Cattle Reproduction Council, Nov. 7, 2006 Denver conference.

Jordan, E., Tips for Reproductive Success, Dairy Cattle Reproduction Council, Nov. 7, 2006 Denver conference.

Kirkpatrick, M. and Olson, J., Monitoring Compliance, Dairy Cattle Reproduction Council, Nov. 7, 2006 Denver conference.

20 – Using bulls on the farm

Adoption of A.I. breeding was nearly universal on dairy farms after its introduction to the U.S. in the late 1930s. Only the milking machine and refrigerated bulk milk cooling exceeded its adoption rate. Before that time and since, some dairymen have chosen to use natural service sires, either wholly or in part. Some choose to have pens of cows that are all A.I. and some that are all bull breeding.

Various reasons for use. A recent survey showed that almost 90 percent of California dairies used bulls to some degree. Those surveyed cited a number of reasons, including problem/hard breeders (over 50 percent), as well as clean-up following A.I., heifer breeding, "no heat" cows, reduced labor – more than one reason was given on some farms.

Bulls used on the farm should have outstanding pedigrees for production traits. Pedigrees can be evaluated by use of a simple index called "Parent Average", or "Estimated Transmitting Ability". A dairy producer needs the most recent Predicted Transmitting Ability (PTA) values from USDA on the sire and dam of a prospective herd bull to calculate parent average. Parent average for a single trait like milk production would be calculated by averaging PTA for milk from the sire and the dam of the bull.

Standards for acceptable value for a herd bull should increase through the years due to genetic trend. Holstein and Jersey breeds currently are improving by at least 150 pounds per year in PTA. Sires of herd bulls should be among the very best A.I. sires available, with a Rank Percentile at least above 80 and preferably above 90.

Dams of herd bulls should qualify or be very close to qualifying for USDA "Elite Cow" status. Breed organizations can provide you with current Elite Cow standards of PTA MFP$.

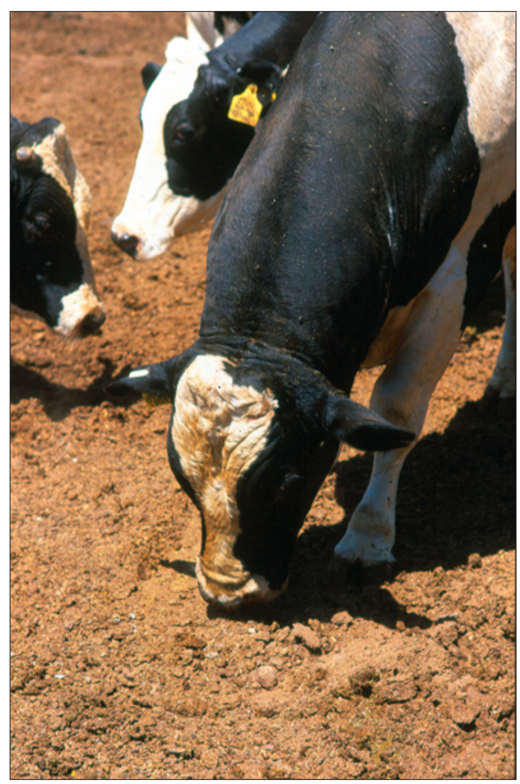
Remember that the herd bull can quickly become the most influential sire used in a herd breeding program. His pedigree is extremely important, but his best role for genetic improvement would be the smallest possible role compared to good A.I. sires.

Growing the bull. Bull calves can be fed and housed with heifers when they are young. But it is a good practice to provide separate housing for bulls over 6 months of age. Feed the bull to keep him growing steadily without fattening. The nutrient requirements for bull calves are similar to those for heifers. Provide bull calves with a well-balanced ration that contains appropriate amounts of minerals and vitamins.

Make sure that the bull has plenty of opportunity for exercise. Don't put the bull in a small, poorly bedded stall in the corner of a barn and forget about him. Pay close attention to the bull's feet. If the feet become overgrown, have them trimmed properly. Poor development of feet and legs can cause problems later on. Also, make sure that any parasites that might affect his performance are controlled.

Most bulls reach puberty and are able to breed heifers by 12 to 15 months of age. However, bulls should be older than this before regular use on mature cows.

Younger bulls (2 to 2.5 years of age) are preferable to older bulls because they pose less danger to humans and can be used in multi-sire groups with less social dominance problems (fighting, broken fences, etc). Still, their size differ-



ence should not be greatly different than females. For young Holstein bulls used with mature cows, this would preclude bulls less than about 1,000 pounds (450 kg) body weight.

Health exam. Before a bull is put into use, he should have a breeding soundness exam conducted by a veterinarian. Take particular care with bulls from sale barns or from contract raisers where biosecurity protocol is unknown. This exam should include health tests for any diseases that he may transmit to cows. Reports of trichomoniasis being picked up and then spread widely by herd bulls emphasizes the need for adequate testing and care in introducing animals into the herd. The bull also needs thorough examination of his reproductive system. A semen sample should be collected and evaluated. The bull should be allowed to breed a cow in heat and observed to make sure that he performs correctly.

The breeding soundness exam will help identify bulls that may be poor breeders or that may have some anatomical defect in the reproductive system. The exam will not indicate whether the bull will have high, normal or low fertility. All bulls should have a physical exam every 6 months and a full breeding soundness exam annually.

Using the bull. Once the bull is ready for use in breeding, he can be used in two ways. He may be run with a group of animals or he may be housed individually and used to breed selected cows put into his pen. The first method reduces the amount of time required for heat detection. However, when a bull runs with a group of animals, he still needs to be observed regularly.

When a bull is to be used to breed both heifers and cows, it is best to use him on the heifers first and then use him on the cows. This practice will prevent the spread of reproductive diseases or infections from the cows to the heifers. In addition, if the bull is young when he is first put into use, he will do a better job of breeding and will compete for feed better if he is with a group of heifers. Make sure that a young bull is not overworked. If there are several heifers in heat at the same time, he may miss some of them.

One way of identifying which heifers the bull has bred is to fit him with a halter-mounted marking device. These devices have an ink reservoir and a "ball-point" type valve which leaves a streak of ink on the cow's loin or rump when the bull dismounts. The reservoir has to be filled periodically, so some method must be available for catching and restraining the bull. Regular filling of the ink reservoir provides a good schedule for checking the bull's condition.

If a young bull is to be run with a group of animals, it is important that all fences and gates be constructed to keep him confined to the designated area. A poorly constructed gate or fence is not much of an obstacle to a bull interested in a cow in heat in the adjacent pasture. Feeding facilities should also have ample space so that the bull does not prevent heifers from getting their share of feed.

If the bull is to be run with a group of lactating cows, he should be introduced into the group carefully. One way to do this is to move the bull into the group at the time a few other cows are added to the group.

When a new animal is put into a group, some fighting occurs until a new "pecking order" is established. If several cows and the bull are added at once, the fighting is spread among several animals so that no single individual is involved in all the encounters. This should reduce the amount of stress on the bull as well as the cows.

When a bull is to be run with the milking herd, the herd should be split into at least two groups. Fresh cows should go into a group (high producers) that does not have a bull running with them. Cows should stay in this high producing group until they are past the peak in lactation—usually 4 to 5 months after calving. Any cow to be bred in this group should be bred by A.I. Once cows from this high producing group are moved to the second (lower producing) group, most of them should already be pregnant to A.I. So the bull's role in the second group is to breed those cows that failed to conceive to A.I. and are open too long. Sometimes he is referred to as a "clean-up" bull.

If a bull is run with milking cows, facilities should be designed to prevent him from gaining access to other groups. Also, some convenient arrangement is needed to separate the bull from the group; for example, separating the bull while the herd is being milked. Some smaller bulls may actually go through the milking parlor with the cows, but this practice should be discouraged.

A bull running with the milking herd may fatten quickly if given free access to the herd's ration. Consequently it is wise to have him a bit on the thin side before putting him with the herd. Make sure that the bull is watched carefully so that he doesn't get too fat. Also, special attention needs to be given to the bull's feet if he is on concrete. The feet should be trimmed regularly and the bull should have access to a dirt lot if possible.

Hand mating. Sometimes bulls are used to breed individual cows that have been detected in heat rather than running with open cows. If the bull is to be used in this manner, he should be confined to a sturdy pen that has ample room for him to breed a cow put into the pen. The pen should be designed so that the cow can enter and be removed from the pen without the bull being in the way. Care should be taken when separating the cow from the bull since this act may antagonize him. The cow should not be left with the bull for an extended period but rather should be removed after she has been bred once or twice.

Conception rates. Conception rates from natural service will be no higher than those obtained with a good A.I. program. But if heat detection in the herd is not good and if improper semen handling techniques and insemination procedures are used, then higher conception rates may be obtained from the use of natural service. However, poor conception rates may occur from natural service if the bull has low fertility, if reproductive diseases are spread from cow to cow, or if some other factor (i.e. nutritional deficiency) affects the fertility of the herd.

Recent studies comparing calving to conception intervals for cows in A.I. pens with cows exposed to natural service bulls have shown an actual advantage to the A.I.–exposed cows: comparing seven large western dairies, the A.I.-exposed cows were 1.3 to 1.9 times more likely to have fewer days to conception compared with bull-exposed cows. This study's authors concluded that keeping cows in the A.I. pens longer before exposing them to clean-up bulls may improve pregnancy rates despite the potential decline in expected conception rates. Another study showed a pregnancy rate of only 8 percent, mostly due to the bull being overworked. If pregnancy rate for A.I. is 15 percent, then natural service at 8 percent obviously is not showing an advantage. Clean-up bulls may be better used as a last resort for cows 200 DIM, rather than 150 DIM, as you may get more pregnancies by using A.I. longer into the lactation.

At what cost? Looking at all costs when comparing natural service versus A.I. breeding, you should include the milk return from marginal cows that take the housing space opened up by not keeping bulls as well as the greater genetic merit of A.I. sires. Use of A.I. sires results in a gain of $89 to $101 in value of milk production per year of life by resulting offspring compared with natural service sires. One study showed a net cost per cow of $10.27 more for natural service compared to A.I.

Safety first. Bulls can be dangerous! All personnel working with the herd should be aware of the bull's presence. Whenever the bull is to be handled, at least two persons should be present. Never try to physically overpower a bull. Bulls have been known to attack workers operating tractors on loaders in the alleys, so always use caution in the presence of the bull. Indeed, safety is a cost that can't be estimated, but really must be considered when comparing natural service compared to A.I.

Custom freezing. If a dairyman wishes to use a herd bull through A.I., it is possible to have semen collected from the bull and then processed and frozen. Some bull studs provide this service. This eliminates some of the hazards of using natural service. It also provides a way of getting daughters from the bull into several herds if the objective is to obtain a multi-herd proof on the bull. Bulls that are to be used in A.I. should be blood-typed and their semen processed by an organization that is approved by Certified Semen Services.

References cited: Smith, J., et al, Managing Herd Bulls on Large Dairies, Proceedings of 6th Western Dairy Management Conference, March, 2003, Reno.

Stevenson, J., There Is A Money Winner in the Bull Breeding Versus A.I. Game, Hoard's Dairyman, May 10, 2007.