Kansas K-STATE Kansas State University
VETERINARY Quarterly
FOR THE PRACTICING VETERINARIAN
July–September 2000
Volume 3, Number 3

Vaccinations to Optimize Reproductive Efficiency

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Do current vaccines aid in reproductive performance? Can a vaccination program help prevent reproductive loss from diseases? During gestation, the bovine reproductive system, with its multilayered placenta, leaves the fetus in a naive environment susceptible to infection. Abortions may occur due to infection of the placenta, inflammation of the ovary, death of the fetus and/or disruption of the cervical plug. So reproductive disease is the hardest to protect against. Vaccination must minimize the amount/duration of the viremia/septicemia or prevent disease from moving through the cervix.

Reproductive diseases and protection against them through vaccination are areas of active research today. With current research, a vaccination program to aid in the control of reproductive diseases can be established. Unfortunately, there is little or no research regarding reproductive disease. Due to the numerous causes of reproductive failures (of which infectious agents are a small percentage), vaccination to prevent infectious reproductive losses may not appear to be effective. This is often because diagnostic testing has not been attempted or has not determined the cause of reproductive inefficiencies. A vaccination program may be inappropriately instituted when the cause is not infectious or the current program may be unfairly deemed ineffective.

Because there are many infectious and noninfections causes of bovine reproductive failure, only diseases for which there are currently licensed USDA vaccines will be discussed.

Reproductive Diseases

Bovine Viral Diarrhea Virus

The control of bovine viral diarrhea virus (BVDV) centers on the prevention and elimination of persistently infected cattle. The identification and removal of persistently infected animals and continued vaccination to prevent persistently infected animals are necessary for effective control measures. Persistent infections occur following in utero infection of the fetus (up to approximately 125 days of gestation) with a noncytopathic strain of BVDV. The mechanism of transplacental transfer of BVDV is unknown, but small amounts of virus in the bloodstream of the dam appear sufficient to cause the development of these immunotolerant cattle. Protection of the dam may or may not correlate with protection of the fetus from subsequent persistent infection if viremia of the dam occurs. In order to break the vicious cycle of utero infection and persistent infection, it is essential that vaccination provide fetal protection. BVD strains can also cause early embryonic deaths, early to midterm abortions, birth of weak, rutted calves and/or the birth of calves persistently infected with the BVD virus. Several studies have been performed to assess the ability of vaccines to protect the fetus against either a natural or artificial challenge. When analyzed, the majority of inactivated vaccines failed to provide much fetal protection with the exception of one experimental vaccine, which is reported to give a high level of fetal protection. With this experimental vaccine, the lack of virus isolation from offspring of vaccinated animals indicated good

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Thank you to the Pfizer Animal Health Group, Livestock Division, Cattle Products Group for financial assistance in publishing this newsletter.

Heat Stress in Feedlot Cattle

by Gerald L. Stokka, D.V.M., M.S., John Smith, Ph.D., Gerry Kuhl, Ph.D., Dave Nichols, Ph.D., & Travis Van Annex. Food Animal Medicine & Management: A Supplement to Compendium, October 1996.

Heat stress occurs when the heat load of feedlot cattle is greater than their ability to lose heat. A feedlot calf is a homeotherm, which means that it has an external comfort zone (thermoneutral zone) of around 16°C to 27°C (60°F to 80°F), while the internal environment (body temperature) of the calf remains relatively constant. A calf is most comfortable when the ambient temperature is in the thermoneutral zone. Health, weight gain, and feed efficiency are maximized and stress is minimized at these temperatures.

Temperature Regulation

Body temperature represents the integrated response of an animal to its internal and external environment. Stability of body temperature is an essential factor in production efficiency. Cattle confine body temperature to a narrow range and precisely regulate it through the interactions of peripheral and hypothalamic temperature-sensitive neurons.

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protection. But the challenge of controls only resulted in approximately a 50 percent rate of persistent infections. Other published reports have demonstrated that modified live BVDV vaccines were more effective at protecting the fetus. To date, vaccines licensed in the United States have not been required to provide fetal protection.

Bovine Herpesvirus Type-1

IBR (infectious bovine rhinotracheitis, rednose) can spread easily through respiratory, ocular and reproductive secretions from infected cattle. The virus remains in post infected animals via latent infections of the trigeminal ganglia. Infections with BHV-1 cause severe respiratory tract infections with a 5-10 percent death loss. Field exposure to BHV-1 can cause up to 25 percent of the cows to abort. The majority of BHV-1 abortions are seen in the last trimester of pregnancy, however, abortions can occur at any stage of pregnancy. Expulsion of the fetus may be delayed up to 100 days after exposure to the virus. Vaccination with a modified live BHV-1 or natural exposure to the virus can cause a temporary infertility due to follicular necrosis in BHV-1 seronegative cows. The decreased conception rate for the heat cycle following this occurrence has been estimated to be at 30 percent. It has also been shown that the effect on the ovary is not seen in seropositive heifers.

This virus can also cause conception failure as a venereal disease (infectious pustular vulvovaginitis). Pustular and necrotic lesions are seen on the vulva and vaginal tract and a balanoposthitis can be seen in bulls. A mucopurulent discharge may be seen during the infection in cows. The disease is spread primarily by infected breeding bulls and occasionally by the sniffing habits of cattle.

There are few published reports of BHV-1 vaccines' ability to protect against abortions and protection has been shown only with modified live BHV-1 vaccines.

Brucella abortus

Brucella vaccinations have been the most effective in controlling a reproductive disease. The successful control and eradication of Brucella abortus from many areas in North America are testaments that a program involving testing, culling, and vaccination can control a reproductive disease.

Abortions due to Brucella abortus are seen usually after five months of gestation. Retained placentas and subsequent metritis usually follows. The abortion is caused by severe placentitis. Brucella infections have also been associated with deceased conception rates and increased services per conception. Increased numbers of dead and weak calves have also been demonstrated in infected herds. Orchiditis and/or seminal vesiculitis may characterize infections in bulls.

Vaccination with either strain 19 or RB51 Brucella has been shown to be effective. Recently, many herds have stopped vaccinating against this disease as most states have been declared Brucellosis free.

Leptospira interrogans

Leptospira can cause severe liver and/or kidney disease and in some situations cause an outbreak of mastitis. Many different serovars of *Leptospira interrogans* have been shown to cause reproductive failure and abortions in cattle. *L. interrogans* serovar *hardjo* is the cattle maintained serovar and accounts for the majority of cattle infections. *L. interrogans* serovar *pomona* is maintained in pigs and other mammals and is the most common incidental Leptospira diagnosed in cattle.

These bacteria can cause abortion storms in which high numbers of cattle may abort within a short period of time. There may be increased numbers of stillbirths and births of premature and weak calves. While *serovar pomona* tends to cause abortions in the last trimester, *serovar hardjo* can cause abortions at any stage of pregnancy. Abortions are usually due to fetal infections and subsequent death of the fetus. Serovar hardjo can also colonize the oviducts, causing a decrease in fertility. After an initial Leptospira infection, cattle may remain infected and shed the spirochete for long periods of time. Leptospira vaccinations (initial and booster) help to prepare the heifer for entry into the breeding herd. There have been many debates about the ability of Leptospira vaccines to prevent abortions. This apparent lack of efficacy may be due to the antigenic difference between serovar hardjo types hardjo-bovis and hardjo-pratjino. However, infertility problems have been shown to decrease in herds after vaccination.

Bovine Genital Campylobacteriosis

Originally classified as *Vibrio*, *Campylobacter fetus subspecies venerialis* causes a venereal infection of cattle. The bacteria are introduced during natural breeding by infected bulls or by artificial insemination using infected semen. Bulls are usually infected by servicing infected cows but contact with infected bedding may also cause infection to occur. Older bulls (>4 years of age) are most likely to be infected. After being deposited in the vagina, the bacteria rapidly colonize the vagina and cervix. In 25 percent of the cows, bacteria will be found in the oviducts. It can persist for months after infection in these sites.

Early embryonic death and prolonged estrus cycles are the most common signs in Campylobacter infected cows. Early abortions may be seen as well. The signs are much higher in heifers, with immunity developing after a four-to six-month cycle with the infection. It has been shown that fertility will never return to normal in some infected animals. Some animals may be permanently sterile due to the damage after salpingitis.

Vaccination with Campylobacter vaccines has been shown to be effective in protecting heifers even when vaginal cultures are positive for the bacteria. This is attributed to the fact that the uterus is very resistant to the bacteria after vaccination. Studies have also demonstrated improved breeding efficiency in vaccinated herds. Furthermore, vaccination with 2X dose and/or two doses has been shown to be effective in clearing infections from carrier bulls.

Bovine Trichomoniasis

Bovine Trichomoniasis is a venereal infection of cattle caused by the protozoal agent, *Tritrichomonas fetus*. Early in an infection, abortions with pyometra may be seen in 5 percent of the pregnant cattle. These abortions occur early in gestation. However, infertility is the most common sign with long interservice intervals. Early embryonic death is followed by a period of conception failure. There is some natural resistant after infection but carrier cows may be an important component of the epidemiology of this disease. It is rare but a cow may become sterile following an infection due to uterine destruction. Efficacy of vaccines for Trichomoniasis is questionable and estimated to be at best 60 percent.

Hemophilus somnus

The effect of *Hemophilus somnus* on the reproductive tract is not clear. *Hemophilus somnus* has been associated with early embryonic deaths, abortions and conception failure. However, the bacteria is a normal inhabitant of the vaginal tract and can be cultured from both bred animals as well as animals that have aborted. Whether *Hemophilus somnus* truly causes reproductive disease or only sporadic uterine infections is now a source of debate. Recent textbooks only list *Hemophilus somnusas* as a potential finding of uterine cultures.

There is no evidence that *Hemophiluus somnus* vaccines are effective in impacting reproductive efficiency. Current vaccines are licensed on their effectiveness at stopping the Thomboembolic meningoencephalitis syndrome.

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Temperature, humidity, and solar radiation are the primary environmental factors that determine the animal's body temperature. Wind and precipitation are other environmental factors to consider.

Heat Gain

Body heat gain results from three kinds of sources: chemical, mechanical, and thermal. Chemical sources of body heat involve metabolism (e.g., digestion of feedstuffs). Mechanical sources relate to work, meaning exercise of any kind. Gains in body heat can be derived from a thermal source if the ambient (environmental) temperature is greater than the body temperature.

Heat Loss

The animal has four principal ways to dissipate heat: conduction, convection, radiation, and evaporation. Cattle might also release heat through elimination of urine and feces. During heat stress, evaporation is the most efficient means of heat loss.

Nonevaporative

When the ambient temperature for dairy cattle is below 10˚C (50˚F), non-evaporative methods account for 75 percent of the heat loss. For conduction, convection, or radiation to reduce body temperature, the animal's body temperature must be higher than the ambient temperature. Evaporation is the only one of the four that does not require the thermal gradient; however, it does use the vapor-pressure gradient.

Conduction is based on the principle that heat flows from warmer to cooler areas. Physical contact with a colder object (e.g., a calf wading in a pond) is needed for conductive cooling to take place. Convective cooling is possible when a cooler surface of air replaces a warmer one of the animal's body.

Radiation of body heat can decrease body temperature when the ambient temperature is lower than the calf's body temperature (surfaces of different temperatures radiate toward each other). Solar radiation can cause substantial increases in the body heat of cattle.

Evaporative

Evaporative cooling occurs when sweat or moisture evaporates away from the respiratory tract or skin. Evaporation is the primary means that dairy cattle have to cool themselves at temperatures over 21˚C (70˚F) because they are approaching the upper critical limit of 27˚C (80˚F). Maximizing the rate of heat transfer from the body core to the surface (skin) through blood is no longer effective in maintaining thermal balance. This is why cattle pant and sweat on hot days.

Panting aids cooling in two ways. First, it increases saliva secretion, which can increase evaporative cooling. Second, it cools by increasing evaporative cooling through the respiratory tract by increasing the frequency of breathing. Panting aids ruminants in another way through lowering the blood temperature going to the brain by maximizing air flow over the mucous membranes in the nasal passages. The problem with panting is that cattle do not ruminate and will wait until their respiration rate lowers before they start eating again. A respiration rate above 70 breaths/min may indicate that an animal is suffering some heat stress.

The skin, not the hair, is the site for evaporative cooling, which is why it is harder to observe perspiration on a cow than on a human. Unlike bovine hair follicles, human hair follicles are not associated with sweat glands. Humans have 2000 sweat glands per square centimeter of skin surface, whereas European cattle have 800 per square centimeter. Cattle are average sweaters; evaporation from the skin of cattle can be up to 150 $g/m^2/hr$.

Storage of heat with little heat loss is a problem in cattle. Consecutive hot days can cause health risks. High humidity reduces evaporation and makes hot days that much worse for cattle.

Heat Stress

The effects of heat stress include decreased feed intake and slower rate of passage; decreased blood flow to the internal organs; increased water consumption; increased respiration rate; open-mouthed breathing (panting); discomfort; recumbency; and death. Diminished performance results from decreased dry-matter intake and the additional energy expenditures required to keep the animal cool. Early signs of heat stress may include restlessness and bunching of the cattle in the late afternoon and early evening.

Management factors can minimize the adverse effects of heat stress on cattle (see Managing Heat Stress, page 4). Heat stress could suppress the animal's immune system. So it is sometimes advisable to wait for a cooler time before working cattle.

Heat stress results from the combined effects of relative humidity and ambient temperature. The temperature-humidity index provides an effective way to predict the severity of heat stress. A temperature-humidity index above 72 (see Temperature-Humidity index below) is associated with heat stress in dairy cattle. A thermometer/hygrometer can be used to determine the level of heat stress associated with different feedlot locations. Measurements should be taken at water facilities, in feedbunks, in scale areas, and calf resting sites.

Reducing Heat Stress

Water

Providing adequate access to cool, clean water will help minimize heat stress. Cattle may require 1.2 to 2 times more water during periods of heat stress. In ambient temperatures of 25°C to 35°C (77°F to 95°F), cattle need up to 1.25 gallons of water for every pound of dry matter they eat. Above 35°C, cattle need 16 L of water for every kilogram of dry matter consumed (2 gal/lb).

Watering facilities available after feeding and during cooler periods of the day should provide enough space to prevent overcrowding and further elevation in body temperatures. Ideally, water would be available in more than one location between feeding and resting areas. Shade over water can lower water temperature 1˚C to 2˚C (2˚F to 3˚F) but should be made small enough that it does not encourage dominant cattle to loiter. Cooler drinking water has produced increased gains in *Bos taurus* cattle.

Dietary Adjustments

Dietary adjustments should be made to compensate for reduced feed intake. Reduced feed intake is a behavioral response to heat stress. Reducing feed intake decreased the heat produced by digestion. But this reduction in feed intake occurs when the animal is expending extra energy to cool itself.

In ambient temperatures between 25°C and 35°C (77°F and 95°F), cattle decrease their

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Temperature-Humidity Index

A temperature-humidity index over 72 leads to heat stress in dairy cattle. This value can represent the following conditions:

Temperature		Relative Humidity
Fahrenheit	Celsius	
75°	24°	80%
88°	31°	5%
82°	28°	20%

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feed intake by 3 percent to 10 percent In ambient temperatures above 90°F combined with high humidity and solar radiation, cattle on full feed reduce their feed intake by 10 percent to 35 percent.

Cattle will choose to eat during relatively cool periods (e.g., between 3 and 7 a.m.) if no shade is provided. Providing light at this time over feedbunks also may improve intake. Because dry-matter intake and water consumption are closely related, increasing the water content of the ration may increase the rate and amount of consumption by making the feed cooler and more palatable.

Intake does increase during the cooler parts of the day, and cattle may overfill on feed. An increased incidence of bloat or acidosis may result, especially if no shade is provided. A properly trained staff should be aware of these appetite changes.

Ration composition should be changed gradually, and more bunk space should be provided to prevent overcrowding when cattle do decide to eat. Roughage increases heat production or heat increment, which is associated with increased acetate levels. Roughage levels can be reduced while dietary fat with a low heat increment (i.e., digested with less effort) if increased, but any roughage that is fed should be of high quality. High-quality forages produce less heat and provide more nutrients for the animal as well as for ruminal microbes.

Cold weather creates a predictable, more stable need for energy to maintain body weight. In fact, there is a linear relationship between heat loss and temperature in cold weather. In contrast, hotter temperatures create a nonlinear relationship—each degree of temperature increase results in an additional adverse effect on cattle. Adding a pound of fat to the ration lessens the requirement for grain by about 2.25 pounds because of lipid's higher energy density. Tallow (saturated triglycerides) may be fed to help reduce losses in performance during periods of lower consumption by reducing heat production and lowering maintenance energy expenditure. If dry, rolled milo is the grain source, replacing it with corn will reduce total pounds of feed.

Adjusting protein levels to below-normal levels during periods of heat stress may also prove economically beneficial. Because cattle are not going to gain as well during periods of heat stress (because of increased maintenance requirements), cutting back on protein will cut costs without hurting performance.

A great deal of potassium is lost in sweat; requirements during periods of heat stress can increase as much as 12 percent Increasing the potassium as well as the sodium content in the ration to compensate for both increased losses and decreased intake can improve performance in heat-stressed cattle. All ingredients formulated as a percentage of the diet should be recalculated when feed intake changes.

Managing Heat Stress

Take these measures to manage heat stress for feedlot cattle:

- Provide cool, clean water in the proper location with adequate spacing.
- Have a water wagon with a high-pressure nozzle ready if cattle must be cooled quickly.
- Adjust rations.
- Handle cattle correctly.
- Use shades and sprinkler systems.
- Choose cattle by type and origin.
- Enhance air flow (e.g., by providing mounds for cattle to stand on).

Handling

Cattle handling should be minimized during periods of heat stress because the animal is already trying to adapt to an unfavorable situation. If you must, do it during early morning or late evening hours. Do not crowd the animal—alleys and chutes are usually poorly ventilated.

During periods of heat stress, endogenous corticosteriods that inhibit normal functions of the immune system are released. These corticosteroids inhibit neutrophils by decreasing chemotaxis and receptor functions. Changes in the immune system coupled with increased stress of handling result in decreased response to vaccinations. Also, sick cattle do not respond as well to antibiotic therapy during heat stress.

All pens should have proper space for cooling—with mounds, if possible. Special care should be given to new arrivals, unhealthy calves, and market-weight cattle. Crowding of any kind—whether in a truck, at the feedbunk, or while standing for water—increases body temperature. Metabolic processes and exercise, including walking, produce heat through muscle activity.

Strange fat cattle should not be mixed 24 to 48 hours before slaughter because fighting will lead to heat stress and dark cutters. Flies also are a bother and increase energy expenditure in cattle. The increased activity due to flies increases heat stress, so care should be taken to minimize fly numbers.

Shade

Reducing heat stress by providing shade increases feed intake, weight gain, and performance of cattle. In addition, death losses may also be reduced. Shade reduces the heat gain resulting from solar radiation even when air temperature is not reduced. Trials in Kansas have shown a 6 percent increase in gain and a 3 percent increase in feed efficiency. These economic benefits are seen in *Bos indicus* (zebus) as well as *B. taurus* (European breeds).

Calves held under shade at temperatures up to 29°C (85°F) for six weeks recovered from weight losses after 2 weeks of cooler weather. But when shaded calves were subjected to temperatures of 35°C to 38°C (95°F to 100°F) for five weeks, cattle could not completely compensate for poor growth and required four more weeks on feed to reach the same weight as nonstressed animals.

Plasma triiodothyronine (T_3) and growth hormone are decreased during periods of increased body temperature, thus decreasing feed consumption and growth. After cattle are returned to cooler temperatures, compensatory changes can cause T_3, growth hormone, and growth to surpass levels that occurred when cattle were in their thermoneutral zone prior to heat exposure.

During periods of heat stress, cattle seek out the coolest spots and are unwilling to leave these areas. Place shades over feed and areas where you want the cattle to spend time. Shades (roofs) running east and west, parallel to and covering the feedlines, should be 3 to 4 m (10 to 12 ft) high and provide at least 2 m^2 (20 ft^2) for 270-kg (600-lb) cattle. For heavier cattle, provide 2.7 m^2 (30 ft^2) or more.

A north-south orientation of the shade will allow drying under the shades as the shaded area moves throughout the day. If metal is used for the roofing material, the top side should be left shiny or painted white, while the underside (facing the cattle) should be painted black. Solid shades are best, but cloth shades are inexpensive. Some fabrics provide up to 90 percent shade. Shades may prove most beneficial during periods of drastic temperature change because they help the cattle adapt.

Sprinklers

Sprinklers to apply water to cattle can help improve performance when the temperature rises above 27°C (80°F). During periods of heat stress, cattle sprinkled with water gain faster and more efficiently than do cattle that

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were not sprinkled with water. In the midwestern United States and Great Plains, where humidity can be high, a large water droplet is required to wet the skin; fine mists or fog systems are not as effective in these areas. Kansas State University has shown a 16 percent increase in daily weight gain along with a 17 percent improvement in feed efficiency when sprinklers were used. The system should include one nozzle for 8 to 10 head and have an output of 9.5 L/min (2.5 gal/min) at each nozzle site.

Sprinklers reduce heat stress and are beneficial in three ways: by increasing evaporative losses, by reducing ground temperature and reducing radiant heat gain, and by reducing dust and illnesses related to dust. Ensure proper air flow by removing barriers (e.g., windbreaks designed to protect against cold stress) or by installing fans. Mounds in the center of pens also help air flow. Air movement and low humidity enhance the effectiveness of sprinklers.

Sprinkling should be intermittent, otherwise high humidity may result and there may be little drying. Cattle should have sufficient dry-off time between showers—20 to 30 minutes is common after a 1- to 2-minute shower.

Cattle Type and Origin

Bos indicus breeds (Brahman and others) handle the heat better than do *B. taurus* (European) breeds. *B. indicus* cattle have more sweat glands, the glands are more widely spaced, and a slightly larger surface area created by the skinfolds allows better heat dissipation. The faster metabolic rate of European breeds makes them less heat tolerant, but overall, they are faster growing and more productive.

Color also plays a big role in heat stress. Black cattle are the worst and white cattle the best for warm conditions.

Cattle brought in from the Southeast may have eaten endophyte-infested tall fescue grass. These cattle may be unthrifty and have increased body temperatures and may therefore be predisposed to heat stress. Cattle brought in from colder climates also are at a greater risk of heat stress. All cattle need time to acclimate, and the quicker the temperature change the bigger the problem.

Cattle also need time to cool down from extreme temperatures, at least at night. Extended periods of relentless heat create many problems because cattle never get time to "reset their thermostat" by eliminating excess heat.

Heat exhaustion, heat stroke, and death are all possible because of compromises in thermoregulation as a result of extreme temperatures. Fever and collapse are signs of heat strokes, and hyperpyrexia (fever) directly causes tissue damage. Circulatory shock due to vasodilatation without increased blood flow can occur in cattle suffering from heat stress. In cattle with heat stroke, circulatory shock is compounded with loss of fluid and electrolytes.

The best treatment for heat-stressed cattle is to place them in a shaded area and apply ample amounts of cool water as soon as possible. Water baths, if available, also may be used for quick cool-down. Teaching personnel to identify signs of heat stress early will decrease mortality rates, but these are management-by-crisis techniques. If economically feasible, microenvironment adjustments (e.g., shade and sprinklers) are easy to install and are relatively inexpensive.

Summary

Heat stress is caused by a combination of environmental and animal factors that result in reduced performance as the animal attempts to cool itself. The main objective during periods of heat stress is to keep the cattle's body temperature and respiration rates from climbing to the critical stage. Feedlot performance of cattle is reduced during periods of heat stress because maintenance requirements increase while the animal's appetite is lessened. Aggressive management of heat stress may prove economically beneficial by increasing efficiency of weight gain. Success in managing heat stress may help the veterinarian attract new feedlot business.

Recognizing these changes is critical. Be prepared if you have a group of high-risk cattle and live in an area with high humidity. If the temperature-humidity index reaches a high enough level, the problem may no longer be keeping cattle cool but keeping them alive.

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Results of Water Testing on U.S. Beef Cow-calf Operations

Veterinary Services, United States Department of Agriculture, Animal and Plant Health Inspection Service

A quality water supply is essential to the production of healthy cattle. Unsatisfactory water can result in poor production performance, sickness, or even death. Overall, drinking water from subsurface sources on U.S. beef cow-calf operations is of high quality. Nearly all (99.4 percent) of the water sources tested in 1997 were within Federal guidelines for acceptable nitrate levels in drinking water for livestock.

To evaluate the quality of the subsurface water available to the nation's cow-calf operations, the USDA's National Animal Health Monitoring System (NAHMS) conducted a study involving cow-calf states. Of those producers participating in the NAHMS Beef '97 Study, 498 had a subsurface water source for their cattle and submitted a single water sample for evaluation. Overall 2,713 producers with one or more beef cows participated in the NAHMS Beef '97 Study.

For this study, producers were questioned about the source of the water provided for their cattle. Wells were reported as the primary source of water on 82.9 percent of the operations, with springs (15.3 percent) and other sources (1.8 percent) making up the remainder. This distribution varied considerably by region of the country, with wells cited as the primary source in 94.0 percent of Northcentral operations and only 64.1 percent of those in the Southeast.

The majority (76.1 percent) of the 498 water samples analyzed were obtained from a running water source such as a faucet, hose, or pipe. The remainder were collected from tanks (16.9 percent) and other sources (7.0 percent).

Some factors that affect water quality include levels of nitrite, nitrate, sulfate, and total dissolved solids. Levels of these components considered safe for livestock and the percentages of operations where water supplies were at or under safe levels are shown in Table 1.

Nitrite

Nitrite is occasionally found in water, but rarely at levels dangerous to livestock. When nitrite reaches the bloodstream, it can adversely affect the oxygen-carrying ability of the blood. A similar process causes "blue baby" syndrome in humans. In cattle, large amounts of nitrite in the blood can cause death if untreated. Sublethal amounts can cause abortions. None of the Beef '97 water samples contained detectable levels (10 or more parts per million ppm) of nitrite.

Nitrate

Nitrate can be converted to nitrite in the rumen of cattle. Effects of high nitrate consumption would be similar to nitrite toxicity, although a higher level of nitrate is required to induce toxicity. Nitrite is about ten times more toxic to ruminants than nitrate.

Sources of nitrate in water include fertilizers, manure, crop residues, human wastes, and industrial wastes. Older, shallow wells with damaged casings are at greater risk of contamination. Cattle may also be exposed to high concentrations of nitrate in forage material as some plants accumulate nitrate from fertilizers and in specific soil or environmental conditions. For example, acid soils and drought conditions can enhance nitrate accumulation in plants, as can cold temperatures and certain mineral deficiencies.

Crop plants that are known to accumulate nitrate include alfalfa, Sudan grass, and oats. A variety of weeds accumulate nitrate as well (Osweiler et al.). Producers may wish to have forage samples tested for nitrate content. Water, feed, and other sources of nitrate are additive. All sources must be considered when determining whether there is a nitrate problem. Table 2 provides guidelines of factors to consider in determining safe levels of nitrate in drinking water for livestock. While 3.2 percent of Beef '97 samples fell in the 221-660 ppm range, a small percentage (0.6 percent) exceeded safe levels for cattle (less than 440 ppm). Twenty percent of the samples tested exceeded the safe level for human infants, which is much lower (less than 45 ppm) than for cattle.

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Table 1. Percentage of Water Samples at or Under Maximum Safe Levels for Nitrate, Nitrite, Sulfate, and Total Dissolved Solids

Water Quality Factor	Nitrite	Nitrate	Sulfate	Total Dissolved Solids
Level generally considered safe for most livestock	Less than 33 ppm*	Less than 440 ppm*	Less than 300 ppm*	Less than 0.3%* (3000 ppm)
Percentage of operations at or under maximum safe levels	100.0%	99.4%	78.9%	96.2%

* Source: National Academy of Sciences.
ppm = parts per million.

Table 2. Concentration Levels and Effects of Nitrate in Water for Livestock and Percent of Beef '97 Samples by Concentration Level

Nitrate Concentration Levels	Effects	Percent Samples
<10 ppm - 44 ppm	No harmful effects	80.1
45-132 ppm	Safe if diet is nutritionally balanced and low in nitrates	16.7
133-220 ppm	Could be harmful if consumed over a long period of time	0.0
221-660 ppm	Dairy cattle at risk; possible death losses	3.2
661-800 ppm	High probability of death losses; unsafe	0.0
Over 800 ppm	Do not use; unsafe	0.0
	Total	100.0

WATER TESTING continued from page 6

Shallow wells have a higher risk of nitrate contamination. In the Beef '97 samples, nitrate level was generally lower in deeper wells. Of wells less than or equal to 100 feet in depth, 93.8 percent had a nitrate level less than 133 ppm. Approximately 42 percent had a non-detectable level (less than 10 ppm). The 0.6 percent of samples noted in Table 1 as having nitrate levels greater than or equal to 440 ppm (n=3) were wells no more than 100 feet in depth, 98.0 percent had a nitrate level less than 133 ppm and 63.7 percent had a non-detectable level.

Water from well sources generally had a higher nitrate level than did water from spring sources. Of all Beef '97 samples from wells, 55.4 percent had a non-detectable level. Of all samples from springs, 69.7 percent had a non-detectable level.

Age of wells varied significantly by region. But well age alone was not related to nitrate levels in these samples. Wells identified as being more than 25 years old were slightly more likely to be shallow than newer wells.

The U.S. Geological Survey has determined that the areas most at risk for nitrate contamination of groundwater are located primarily in the western, midwestern, and southeastern United States. In this study, nitrate levels appeared to vary regionally, but these differences were attributable to regional variation in water source. Regions in which a high proportion of the water sources were wells had higher nitrate levels than those regions relying more on springs for water.

Sulfate

Dissolved salts from rock and soil are the naturally occurring sources for sulfate in water. While adult cattle may be able to tolerate higher concentrations, levels of 500 ppm or greater may result in weight loss due to decreased feed and water intake (NAS 1974).

Twenty-one (21.1) percent of the Beef '97 samples tested exceeded the sulfate levels considered safe for all livestock. Water from tank sources generally had a higher sulfate level than water from faucet or other running water sources. Of the samples from water tanks, 32.1 percent had a sulfate level of 500 ppm or greater, and 59.5 percent had a level below 200 ppm. Of the samples from running water sources, 19.8 percent had a sulfate level of 500 ppm or greater, and 72.6 percent had a level below 200 ppm.

Total Dissolved Solids

Total dissolved solids (salinity) is measure of the total amount of dissolved minerals in the water, including calcium and magnesium, which are largely responsible for water hardness. Moderate (0.3 to 0.5 percent) levels of solids may cause problems such as diarrhea or initial water refusal. High (0.5 to 1.0 percent) concentrations should be avoided for pregnant or lactating cattle. Very high concentrations (greater than 1.0 percent) are not suitable under any conditions. Few Beef '97 samples (4.2 percent) exceeded total solid concentrations safe for all livestock of less than 3000 ppm.

Summary

Overall, quality of subsurface water on cow-calf operations participating in the Beef '97 Study was high. However, since water quality is such a key factor in animal health, periodic water testing is recommended to all livestock producers. Those operations relying on shallow wells for water and those operations located in heavy agricultural regions should concentrate testing at times when shallow wells are more likely to be contaminated by fertilizer runoff or other sources of nitrate. To decrease the chances of well contamination, producers should slope the area around the well to keep surface runoff away. Exposed parts of wells should be inspected periodically for damaged well surface seals, caps, aor casings.

Interpretation of water analysis is extremely complex and is best accomplished with the assistance of a veterinarian or other professional with expertise in water quality.

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[1]The Beef '97 study collected management and health data on a stratified random sample of producers in 23 states: Alabama, Arkansas, California, Colorado, Florida, Georgia, Illinois, Iowa, Kansas, Kentucky, Mississippi, Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Tennessee, Texas, Wyoming, and Virginia.

VACCINATIONS continued from page 2

Vaccination Programs

Vaccination programs in the herd need to be custom designed for the particular needs of the herd. Vaccination programs in the replacement stock have two specific goals. The first is to prepare the calf against any pathogens that are causing disease problems in calves. The second is to prepare the calf for entry into the adult herd with a good foundation of protection from which to build herd immunity. Immunization of the replacement heifer can have dramatic impacts on the health of the adult herd. A program that entails both an effective vaccination program and management is mandatory in order to control reproductive diseases and improve reproductive efficiency.

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The Real Cost of Johne's Disease

Much more is known about Johne's disease now than was 20 years ago, but experts still struggle to determine the costs of the disease. A 1999 study by H. Groenendaal and D.T. Galligan at the University of Pennsylvania School of Veterinary Medicine determined that the price of Johne's disease in an infected herd of 100 cows is $35 per cow per year. While lowered milk production is frequently viewed by dairy producers as the major cost of the disease, lost milk alone only amounts to 10 percent to 15 percent of total costs; whereas, premature culling of cows and the lost milk production of these cows accounts for 77 percent of the cost. Johne's disease not only decreases milk production and premature culling of cows but also decreases breeding efficiency and slaughter weight and increases death loss and susceptibility to other diseases.

Maintaining a clean calving area and feeding milk replacer rather than colostrum, which can transmit Johne's, can prevent the spread of the disease. Raising replacement heifers separate from cows also inhibits Johne's disease as the calves are removed from the premises and not allowed contact with shedding cows until they join the milking herd and can no longer contract the disease.

Dairy Today, July 2000
www.oznet.ksu.edu/library/lvstk2/samplers/ep52.htm

The Kansas State University Diagnostic Laboratory and Department of Animal Sciences and Industry at Kansas State University greatly appreciates the sponsor(s) of the Kansas Veterinary Quarterly Newsletter. These sponsorships in no way imply the Departments' endorsement of the products and services offered by the sponsors. The Departments welcome inquiries from other individuals, associations and firms that may be interested in cosponsoring this publication.

Kansas K-State VETERINARY Quarterly
FOR THE PRACTICING VETERINARIAN

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