Drought-Related Poisoning and Nutritional Risks to Cattle

Robert H. Poppenga, DVM, PhD, Veterinary Toxicologist, California Animal Health and Food Safety Laboratory System, School of Veterinary Medicine, University of California at Davis

Birgit Puschner, DVM, PhD, Veterinary Toxicologist, California Animal Health and Food Safety Laboratory System, School of Veterinary Medicine, University of California at Davis

According to the U.S. Drought Monitor, 28 percent of California is currently experiencing extreme drought; moderate to severe drought covers 88 percent of the state as of early January 2014 and precipitation predictions for the coming year are grim. According to the CA Department of Water Resources, the water content of the snowpack statewide is just 20 percent of the average for early January, which makes it the driest ever recorded for this time of year. It is likely, then, that CA cattle producers are in for a difficult water year which will necessitate additional vigilance to assure cattle health and productivity. Drought can increase the risks of animal poisonings and nutritional imbalances. In addition, should drought-breaking rains occur, the grazing conditions for cattle may dramatically change and pose additional health risks. The conditions mostly commonly associated with the end of severe drought conditions include bloat, plant poisonings, and clostridial diseases. The following are some drought-related threats to cattle health and productivity.

Water quality

Water is the most critical factor in the diet of food animals and is involved directly or indirectly with essentially all physiologic processes. When cattle don't drink enough clean and safe water every day, feed intake and productivity declines. Drought conditions can potentially affect all source of water, including groundwater, but surface waters are especially vulnerable. Streams and ponds can become completely dry, while water flows in rivers can be significantly decreased. During a drought it is especially important to frequently monitor water quality, especially as quantity becomes more limited, and have plans for alternate water sources.

Water consumption varies with age, weight, breed, species, ambient temperature, humidity, lactation status, diet, and level of production. Dry cows need 8 to 10 gallons of water daily, whereas cattle in the last 3 months of pregnancy might drink up to 15 gallons per day. Lactating cows require a water intake of approximately 5 times the volume of milk produced. Periodic assessment of basic water quality parameters such as total dissolved solids (TDS), sodium, sulfates, and nitrates/nitrites should be considered. There are a number of certified water testing laboratories throughout California that provide sample analysis and interpretation of results specifically for livestock.

Total dissolved solids

TDS are all of the organic and inorganic substances in water that can pass through a 2 micron filter. Elevated TDS adversely affects the palatability of water and, therefore, water consumption. In general, TDS concentrations < 1000 ppm (parts per million) should ensure the safety from almost all of the inorganic constituents present, whereas individual components should be identified and quantified to more fully characterize potential problems if TDS values are > 1000 ppm. Tables 1 and 2 provide guidelines for several commonly measured water parameters.

Sulfate

High sulfur (S) concentrations reduce feed and water intake in animals resulting in reduction of growth and performance. The most common form of S in water is sulfate. Outbreaks of polioencephalomalacia have occurred when water has been a significant source of S. During droughts, sulfate becomes more concentrated in water and water intake increases during periods of high ambient temperatures. It is recommended that water for livestock consumption contain < 500 ppm sulfate with a maximum safe level of 1000 ppm for cattle exposed to moderate dietary S concentrations or high ambient temperatures. Elevated sulfate concentrations (as low as 500 ppm) is reported to decrease copper absorption, thus potentially exacerbating marginal or low copper intakes.

Nitrate/Nitrite

Nitrate/nitrite contamination of water can occur from a variety of sources, mostly fertilizer and manure run-offs, but drought conditions can increase water concentrations. In addition, drought stunts plant growth, causing nitrate to accumulate in plants. Immediately after a rain, plants may take up even more nitrate and become particularly dangerous. Nitrate/nitrite can cause sudden death of ruminants and risk of intoxication needs to consider intake of nitrate/nitrite from both feed (see discussion of plant nitrate accumulation below) and water. Frequent monitoring of water nitrate/nitrite concentrations is recommended. Nitrate/nitrite screening tests are quick and inexpensive. Water nitrate concentrations < 400 mg/L and nitrite concentrations < 100 mg/L should not cause poisoning in livestock. Water nitrate concentrations > 750 mg/L can be hazardous to non-adapted ruminants.

Toxic Blue-Green Algae

During periods of hot and dry conditions, rapid proliferation of blue-green algae (Cyanobacteria) in water is more common. Increases in the number of blue-green algae result in noticeable bluish-greenish "blooms". Stagnant water conditions and high levels of nutrients increase the potential for bloom formation. Blue-green algal blooms can reduce water quality and intake, and be potentially toxic. Windy conditions can concentrate algal blooms along water edges increasing the risk of ingesting algae. If algal blooms are noticed, testing of water for toxins is recommended as not all algal blooms produce toxins. Cyanobacteria can produce toxins that can affect the liver and nervous system. Depending on the specific toxin and amount ingested, animals may die suddenly, or suffer from weakness, staggering, or photosensitization. It is important to limit access to water that has visible algal blooms until tested

negative. Additional information about blue-green algal blooms can be found on the CA Department of Public Health website (http://www.cdph.ca.gov/HEALTHINFO/ENVIRONHEALTH/WATER/Pages/Bluegreenalgae.aspx).

Feed Quality and Nutritional Deficiencies

Drought conditions frequently result in the need to feed poor quality forages or to switch to alternative feed sources. Both can affect animal nutrition and increase the risk for intoxications. Use of poor quality forages can cause or exacerbate deficiencies of important minerals such as selenium, copper, and phosphorus and vitamins such as vitamins A and E. In addition, drought affected forages are often deficient in energy and protein. Even in non-drought years, deficiencies in selenium and copper are common in CA cattle, particularly beef cattle.

Copper

Soils in many regions are low in copper resulting in low copper concentrations in forages. Copper deficiency is one of the most frequent mineral deficiencies identified by the California Animal Health and Food Safety Laboratory in pastured cattle not receiving mineral supplementation. Forages for cattle are copper deficient if copper concentrations are < 7 ppm on a dry weight basis; total rations are deficient with copper concentrations are < 10 ppm on a dry weight basis. One of the earliest manifestations of copper deficiency is loss of hair color in dark-haired breeds of cattle and rough hair coats. Other manifestations of copper deficiency include ill thrift (poor doers), reduced production, diarrhea, decreased resistance to infectious agents and parasites, poor vaccine response, loss of bone strength in calves, weakness and wobbling in neonates, reproductive failure, and sudden death of adult animals. Severe copper deficiencies can be diagnosed in live animals from serum testing whereas liver testing is used to diagnose deficiencies in animals that die.

Selenium

Selenium is essential to help protect cells from day-to-day damage and is a critical component of the body's critical antioxidant enzymes. Soil and forage selenium concentrations are either marginally adequate or deficient in many areas of California. Like copper, selenium deficiency is one of the more frequently diagnosed mineral deficiencies in the State (combined copper and selenium deficiencies are common, particularly in unsupplemented beef cattle). Selenium deficiency causes white muscle disease of skeletal and heart muscle resulting in stiff gaits, slow movement, heart damage and weak neonates. Ill-thrift (poor doers) and reduced production occur and, similar to copper deficient animals, there is less resistance to infectious agents and parasites. Selenium status of live animals can be assessed based upon testing of whole blood samples. Liver selenium concentrations are used to diagnose selenium deficiency in dead animals.

Vitamin E

Vitamin E is an antioxidant that helps to protect cell membranes. Its actions are complimentary to those of selenium. Thus, an adequate intake of one can help, but not completely prevent, the adverse effects of a deficiency of the other. A concomitant deficiency of both can have significant adverse effects. Vitamin E deficiency occurs most commonly when animals are fed inferior quality hay or straw; this is more likely during periods of drought. Clinical signs of vitamin E deficiency are similar to those listed for selenium. The vitamin E status of animals can be assessed by testing serum or liver samples. Vitamin E in serum is susceptible to degradation so sample quality is critical; veterinarians should be consulted to assure proper collection and storage of samples.

Vitamin A

Primary vitamin A deficiency occurs in beef cattle on dry range pasture during periods of drought. Deficiency requires prolonged low intakes due to relatively good storage in the liver. Cattle can subsist on naturally deficient diets for 5 to 18 months before clinical signs of deficiency appear. Clinical signs in cattle include night blindness, dry eye, retarded growth rate, reproductive failures, and increased mortality. Beef calves coming off dry summer pastures at 6 to 8 months of age are commonly marginally deficient. A maternal deficiency of vitamin A can result in herd outbreaks of congenital vitamin A deficiency in calves. Maternal deficiency of vitamin A can cause abortions, stillbirths, or calves born alive but blind and weak and death within 1 to 3 days. Cows should be given an injection of vitamin A (and D) about 30 days prior to calving and calves should be given a vitamin A injection at birth. Vitamin A status can be assessed through the testing of serum and liver samples. Like vitamin E, sample quality is critical for proper determination of status based upon serum testing.

Mechanically Irritating Grasses

Grazing animals that eat sharp grass awns, spiny plants such as prickly pear cactus (*Optunia* spp.) or those with bur such as burdock (*Arctium minus*) and cocklebur (*Xanthium* spp.) can injure the lining of their mouths and digestive tracts. Some common grasses such as foxtain barley (*Hordeum jubatum*) and bristle grass (*Setaria* spp.) have seed with sharp awns that can become embedded in the tongue and gums of animals ingesting them. Initially excessive salivation occurs, but embedded awns or spines eventually lead to large ulcers. Some sharp grass awns can also penetrate an animal's skin, migrate through the tissues, and cause abscesses and draining wounds far from the point of entry.

Alternative Feeds

The higher cost of feeds and forages during periods of drought results in increased use of less common "alternative" feeds.

Moldy sweet potatoes: Sweet potatoes are a good energy source for cattle. Because of the high amount of readily available fermentable starch, cattle should be gradually adjusted to sweet potatoes in their ration to prevent ruminal acidosis. In addition, sweet potatoes that are infested with a fungus, can

contain a mycotoxin called 4-ipomeanol. The toxin results in severe lung damage, and cows develop acute respiratory distress.

Moldy pomegranates: Pomegranate byproduct has a wide assortment of nutrients that support productive purposes in dairy cattle. However, pomegranates contain tannins and other polyphenolic compounds that at some unknown levels might have negative effects on animal performance. In addition, the sugar in pomegranates is readily available to bacteria and fungi to support their growth when there is adequate air, moisture and heat present. Fungi (molds) produce mycotoxins that can negatively impact animal health. From limited reports, moldy pomegranates may cause liver disease in cattle.

Increased Incidence of Plant Poisonings

Drought conditions increase the risk of plant poisonings in situations available feed/forage is inadequate to maintain cattle. Cattle will seek out and consume plants that they would not otherwise find palatable. While only a few of the potentially toxic plants are discussed below, a comprehensive resource for common poisonous plants in CA can be found at: http://anrcatalog.ucdavis.edu/pdf/8398.pdf

Plant-Associated Nitrate Poisoning

Nitrate poisoning is one of the most common plant associated intoxications diagnosed by the California Animal Health and Food Safety Laboratory. Drought conditions can result in high accumulation of nitrates with plant tissues. Normally, plants absorb nitrates for the soil converting the nitrate into plant proteins. Application of nitrate fertilizers along with stunting of plant growth as a result of drought can cause potentially toxic concentrations of nitrates to occur. The highest concentrations of plant nitrate typically occur in stems and not in leaves, flowers, or fruits. Therefore nitrate poisoning is unlikely to occur when cereal grains are fed.

The potential for nitrate poisoning to occur is increased when livestock water sources also contain elevated concentrations (see above). The threat of nitrate poisoning is greatest in ruminant animals since the environment of the rumen results in the reduction of nitrate to toxic nitrite. Nitrite interferes with normal oxygen delivery to tissues. Many common weeds, forage crops and cereal grain plants have the potential for nitrate accumulation during drought conditions (see Table 3). The first sign of nitrate poisoning is often the sudden and unexplained deaths of one or more animals. Other clinical signs include drowsiness, weakness, muscle tremors, increased heart and respiratory rates, staggering, recumbency. Signs can develop with several hours of ingesting a toxic amount of nitrate. Nitrate concentrations can be easily and cheaply determined from samples submitted to a veterinary diagnostic laboratory for testing. It is a good idea to consider testing forage samples prior to feeding to livestock when the potential for nitrate accumulation is high. Serum samples can be tested for nitrate levels from live animals showing clinical signs. A variety of samples including postmortem blood samples and ocular fluid can be used to diagnosis nitrate poisoning in dead animals.

Properly prepared silage from impacted forage crops reduces nitrate concentrations significantly while there is little reduction of nitrate in dried hay. The use of some herbicides such as 2,4-D can increase the accumulation of nitrate within plants and also increase the palatability of treated plants, thus increasing the risk of intoxication.

Oaks/acorns

Acorns and oak leaves might be attractive to livestock during periods of scarce forage. There are a number of oak species (*Quercus* spp.) in California. High acorn production can occur during periods of drought. All parts of oak trees contain tannins and phenols and are potentially toxic. Young oak buds emerging in the spring contain the highest concentrations of tannins. Poisoning is most typically associated with consumption of large amounts of buds, leaves, or acorns over a several day period. Signs of poisoning vary with the amount of plant ingested. Initially, animals stop eating, become depressed, and develop intestinal stasis. Excessive thirst and frequent urination might be noted. Initially feces are hard and dark, but black tarry diarrhea occurs later. Teeth grinding and hunched back are often indicative of abdominal pain. Severe liver and kidney damage occurs. Animals might live for 5 to 7 days after the onset of clinical signs. A condition called "acorn calf syndrome" can occur in calves born to cows on a low plain of nutrition and which have consumed large quantities of acorns during the third to seventh months of pregnancy. Clinical signs in affected calves include joint laxity, shortened legs, deformed hooves, and either a doomed skull or long narrow head.

Conclusion

During periods of drought, cattle producers should be especially careful about the quality of feed and water available for their animals. Consideration should be given to monitoring water quality parameters that might indicate the potential for problems. Pastures and hay should be scrutinized for the presence of weeds or mechanically irritating grasses. Animals on over-grazed pastures should be provided with supplemental feed and adequate vitamins and minerals. If additional information is needed or, in the unfortunate event that one or more animals become ill and/or die, you can contact your local veterinarian or the California Animal Health and Food Safety Laboratory System (www.cahfs.ucdavis.edu) for assistance. Specific contact information of the CAHFS Branch Laboratories is:

CAHFS – Davis
620 W. Health Sciences Drive
University of California
Davis, CA 95616
Phone: 530-752-8700

CAHFS – Turlock
1550 Soderquist Road
Turlock, CA 95381
Phone: 209-634-5837
(Poultry lab)

CAHFS – Tulare
18830 Road 112
Tulare, CA 93274
Phone: 559-688-7543

CAHFS – San Bernardino
105 W. Central Avenue
San Bernardino, CA 92408
Phone: 909-383-4287

Table 1: Safe levels for basic water quality parameters.

Parameter	*Acceptable Range*
pH	5.5 to 9.0
Nitrate	< 100 mg/L or < 400 mg/L in a well-managed herd
Nitrite	< 33 mg/ml
Sulfate	500 mg/L; < 1000 mg/L is a maximum safe level for cattle exposed to moderate dietary sulfur levels or high ambient temperatures
Total Solids (TDS)	< 1000 mg/L is idea; more can be tolerated (see Table 2)

From S. E. Morgan, Water Quality for Cattle, Veterinary Clinics of North America: Food Animal Practice, Ruminant Toxicology, 2011.

Table 2: Guide for Use of Saline Water for Cattle

Total Dissolved Solids (TDS) Equivalent to ppm (or mg/L)	*Expected and/or Documented Health and Performance Effects*
< 1000 ppm; fresh water	Acceptable with no reported side effects
1000 to 2999 ppm; slightly saline	Few health or performance effects but might cause temporary mild diarrhea and/or production loss in dairy cows. At 2500 ppm TDS, water intake can increase while feed consumption and milk yield decline.
3000 to 4999 ppm; moderately saline	Can cause diarrhea, especially on initial consumption. Young dairy heifers had reduced water intake at 3500 ppm.
5000 to 6999 ppm; saline	Can be used with reasonable safety for adult ruminants although there is increased risk of adverse effects if sulfate is a high proportion of the total TDS. Such levels should generally be avoided for pregnant cattle and young milk-fed calves.
7000 to 10,000 ppm; very saline	Avoid if possible; pregnant, lactating, stressed, or young animals can be affected.
➢ 10,000 ppm; brine	Unsafe under any conditions. Concentrations of 12,500 ppm can result in sodium ion poisoning of cattle.

From S. E. Morgan, Water Quality for Cattle, Veterinary Clinics of North America: Food Animal Practice, Ruminant Toxicology, 2011.

Table 3: Plants known to accumulate nitrates

Common Name	Botanical Name
Ragweeds	*Ambrosia spp.*
Pigweeds	*Amaranthus spp.*
Wild oat grass	*Avena fatua*
Lamb's-quarter	*Chenopodium spp.*
Canada thistle	*Cirsium arvense*
Field bindweed	*Convolvolus arvense*

Jimsonweed	*Datura stramonium*
Barnyard grass	*Echinochloa spp.*
Sunflower	*Helianthus annuus*
Kochia weed	*Kochia scoparia*
Cheeseweed	*Malva spp.*
Sweet clover	*Melilotus spp.*
Smart weed	*Polygonum spp.*
Curly dock	*Rumex spp.*
Russian thistle	*Salsola kali*
Nightshades	*Solanum spp.*
Goldenrods	*Solidago spp.*
Johnson grass	*Sorghum halapense*
Oats	*Avena sativa*
Sugar beets	*Beta vulgaris*
Rape	*Brassica napus*
Soybean	*Glycine max*
Flax	*Linum spp.*
Alfalfa	*Medicago sativa*
Pearl millet	*Pennisetum glauca*
Rye	*Secale cereale*
Sudan grass	*Sorghum vulgare*
Wheat	*Triticum aestivum*
Corn	*Zea mays*

From A.P. Knight and R.G. Walter, A Guide to Plant Poisoning of Animals in North America, 2001.

Table 4: Recommendations for feeding forages containing nitrates (based upon the form of measured nitrate.

NO_3-N_2	NO_3	NO_3-N	Feeding Level
< 0.10 %	< 0.44 %	1000 ppm	Safe at all levels
0.10 to 0.15 %	0.44 to 0.66 %	1000 to 1500 ppm	Safe at all levels to non-pregnant animals. Limit use to 50% of diet dry matter for pregnant animals
0.15 to 0.20 %	0.66 to 0.88 %	1500 to 2000 ppm	Safe if less than 50% of diet dry matter
0.20 to 0.35 %	0.88 to 1.54 %	2000 to 3500 ppm	Safe if less than 35% of diet dry matter
0.35 to 0.40 %	1.54 to 1.76 %	3500 to 4000 ppm	Safe for non-pregnant animals at less than 25% of diet dry matter. Not for pregnant animals.
➢ 0.40 %	➢ 1.76%	➢ 4000 ppm	Potentially toxic to ruminants.

% - based upon % of dry matter

From L.R. James, M.H. Ralphs, and D.B. Nielson: The Ecology and Economic Impact of Poisonous Plants on Livestock Production, 1988.