Physiologic Responses of Livestock to Toxic Plants

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Highlight: Information is presented to describe various disease syndromes in livestock resulting from the ingestion or exposure to toxic plants. Additional material is presented concerning diagnosis of plant-related animal diseases.

A toxic or poisonous plant is one which causes biochemical or physiologic changes when consumed by livestock. The effects of toxic plants may vary from mild sickness to death or produce interference with reproduction, milk production, wool production, or normal growth and maintenance.

Toxic compounds of known and unknown structures are present in over 200 range plants indigenous to the grazing lands of the United States. Numerous toxic plants native to the rangelands could be excellent feedstuffs if a practical means could be developed for controlling the toxic principle. The digestible protein for several toxic plants is as follows: guajillo seed (*Acacia berlandieri*), 16.4%; mesquite bean (*Prosopis glandulosa*), 31.2%; dried careless weed (*Amaranthus retroflexis*), 18%; coffeeweed seed (*Sesbania macrocarpa*), 17.8%; bitterweed (*Hymenoxys odorata*), 26.2%; and sneezeweed (*Helenium spp*), 13.8%. (Anon. 1971. Atlas of Nutritional Data on U.S. and Canadian Feeds. National Academy of Science).

In addition to indigenous toxic plants, there are numerous introduced plants which have been associated with disease syndromes. These plants include fescue grass (*Fescuta spp*), Kleingrass (*Panicum coloratum*), and Bermudagrass (*Cynodon dactylon*).

The toxic compounds in plants may produce a wide variety of clinical signs and disease states in livestock. In addition, there may be more than one toxic constituent in an individual plant; (e.g., cyanogenetic glycosides and nitrates in *Sorghums*) which further complicate the disease state.

Animal deaths subsequent to exposure to toxic plants are readily identifiable to the producer; consequently the producer may become more concerned with animal death than loss of production. Prior to death, animals will usually exhibit clinical signs which are characteristic of a particular group of plants. In many instances, the signs will be manifestations of an abnormal condition of a specific physiologic system of the animal. In some cases, the disease states may be treated if irreversible tissue damage has not occurred.

The purpose of this communication is to describe some of the clinical signs or physiologic responses of livestock to toxic plants which are commonly associated with one or more disease states.

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Cardio-Pulmonary System

The cardio-pulmonary system is comprised of the heart, lungs, blood, and the associated blood vessels (arteries, veins, and capillaries) necessary for getting oxygen to the tissues. Any toxicant which affects one of these structures will indirectly affect the other structures of the system. Those agents (plant constituents) which induce a primary effect on this system will produce signs in affected animals indicative of respiratory difficulties. These include gasping for breath, generalized weakness, and a change in the color of the mucous membranes and blood.

Plants high in nitrates (*Sorghum* spp, *Amaranthus* spp) cause a condition called methemoglobinemia (dark brown blood), which renders the blood incapable of carrying oxygen. Free cyanide, which can be released from cyanogenetic glycosides (*Sorghum* spp, *Prunus* spp), renders the animal incapable of utilizing oxygen and causes the blood to be a bright red. Other plants such as wild onions (*Allium* spp) can cause destruction of the red blood cells (hemolysis) further interfering with the carrying of oxygen. Hemolysis causes the release of hemoglobin from the red cells, and the hemoglobin will cause hemoglobinuria or red-colored urine (red water disease). *Pteridium* spp may interfere with the production of blood cells by the bone marrow, and *Melilotus* spp may contain coumarin derivatives that affect the blood clotting mechanisms (Table 1).

Table 1. Toxic plants which affect blood and blood-forming organs.

Scientific name	Common name	Syndrome
Allium spp	Onion	Hemolysis
Melilotus spp	Sweet clover	Anticlotting
Pteridium aquilinum	Bracken fern	Bone marrow

Plants that can produce an effect on the heart are listed in Table 2. Cardiac glycoside-containing plants such as *Oleander* spp and *Asclepias* spp may cause a slowing of the heart rate. Other plants such as *Veratrum* spp can cause hypotension or low blood pressure. In many instances, death may occur so rapidly that other clinical signs may not be observed.

A plant that affects the lungs could interfere with oxygen uptake. Generally, if lungs respond to plant toxins, the primary response is that of development of pulmonary edema or an accumulation of fluid in the lungs, and the animal will suffocate from an accumulation of body fluids. The other response of the lungs to plant-related toxins is a thickening of the alveolar walls or pulmonary adenomatosis

Table 2. Plants which affect the heart.

Scientific name	Common name
Asclepias spp	Milkweed
Datura spp	Jimpson weed
Drymaria spp	Alfombrilla, Drymary
Nerium oleander	Oleander
Texas cuspidata	Yew
Veratrum spp	False hellebore, Skunk Cabbage

(fog fever). If either pulmonary edema or pulmonary adenomatosis occurs, oxygen will not be carried to the tissues of the body. Table 3 contains a partial list of plants which may affect the lungs.

Table 3. Plants which affect the lungs.

Scientific name	Common name
Brassica napus	Rape
Panicum antidotale	Blue panicum
Perilla frutescens	Beef steak plant
Salvia spp	

Nervous System

A large number of plant toxins affect the nervous system of livestock, primarily the central nervous system (CNS) or the brain. Other plants may interfere with spinal cord function or affect the autonomic nervous system. A few of the plants that affect the CNS are listed in Table 4.

Plant toxins will either stimulate or depress the CNS. An animal that is stimulated by a toxicant may exhibit signs from hyperexcitability to fine muscular tremors. As the CNS is further stimulated or the condition worsens, the signs may progress to gross muscular contractions and convulsions. Prolonged excitement or CNS stimulation is generally followed by depression.

Table 4. Toxic plants which affect the nervous system.

Scientific name	Common name
Acacia berlandieri	Guajillo
Aconitum spp	Monkshood
Aesculus spp	Buckeyes
Astragalus spp	Locoweeds, peavine
Asclepias spp	Milkweeds
Centaurea spp	Yellow star thistle
Cicuta maculata	Water hemlock
Claviceps spp	Ergot
Conium maculatum	Poison hemlock
Cynodon dactylon	Bermudagrass
Datura spp	Jimpson weed
Delphinium spp	Larkspur
Eupatorium rugosum	White snakeroot
Helenium spp	Sneezeweeds
Hymenoxys spp	Bitterweed
Isocoma spp	Rayless goldenrod
Kallstroemia spp	Caltrop
Lobelia spp	Indian tobacco
Lupinus spp	Lupine
Nicotiana spp	Tobacco
Notholaena sinuata var *cochisensis*	Jimmy fern
Oxytropis spp	Locoweed
Peganum harmala	African rue
Phalaris spp	Harding grass
Psilostrophe spp	Paperflower
Pteridium aquilinum	Bracken fern
Solanum spp	Nightshade
Sophora spp	Mescalbean, Mountain laurel
Strychnos nux-vomica	
Trifolium repens	White clover
Vicia villosa	Hairy vetch
Zygadenus nuttallii	Deathcamas

CNS depression is manifested in livestock by drowsiness and can progress to unconsciousness. Death in animals under the influence of CNS depressants is due to cessation of respiration or apnea. The animal is unable to respond to the usual respiratory stimulus of CO_2 build-up in the blood or hypercapnea.

Some plants produce physical damage or cell death (necrosis) in the nervous system. Cells in the CNS are incapable of regenerating; consequently the damage is permanent. Once a cell in the nervous system dies, the animal may exhibit either stimulation, depression, or loss of some body function. *Centaurea solstitalis* (yellow star thistle) and *Karwinskia humboldtiana* (Coyotillo) are two plants which can produce cell death in the CNS.

Gastrointestinal System

The gastro-intestinal (GI) system has the potential of being affected by all plants since all materials travel through this system when consumed. The primary injury seen in the GI tract is irritation, which is manifested by diarrhea in affected animals. In severe conditions, the lining of the GI tract (mucosa) may erode in some areas, exposing blood vessels and causing the feces to contain blood.

Constipation occurs when the ingested material stops GI motility by a direct effect on the smooth muscle of the intestinal tract. Bloat in ruminants may result from depressed smooth muscle motility or rumen stasis. Bloat occurs very rapidly and the increased pressure in the abdominal cavity will prevent adequate blood flow to and from the heart, thus leading to rapid death.

Table 5 lists a group of common plants which have a direct effect on the GI system.

Table 5. Toxic plants which affect the gastrointestinal tract.

Scientific name	Common name
Centaurium spp	Mountain pink
Euphorbia spp	Spurges
Flourensia cernua	Blackbrush, tarbush
Jatropha spp	Nettlespurge
Melia azedarach	Chinaberry
Phytolacca americana	Pokeweed
Quercus spp	Oak
Ricinus communis	Castorbean
Sesbania spp	Sesbane, rattlebox
Solanum spp	Nightshade
Xanthium spp	Cocklebur

Renal System

The kidneys and associated structures are necessary for normal body function. The kidneys excrete waste products and also aid the body in maintaining a homeostatic acid/base status, and proper electrolyte balance. Animals suffering from renal shutdown or dysfunction show CNS depression. Although animals with renal dysfunction develop uremia, the actual cause of death is due to an acid/base imbalance with an associated electrolyte imbalance.

There are several plants that contain toxicants that affect the kidneys (Table 6). Oak (*Quercus spp*) contains substances called tannins which are thought to play a role in the toxicity of the plant. Kidneys are severely affected in oak

Table 6. Toxic plants which affect the kidneys.

Scientific name	Common name
**Amaranthus* spp	Pigweed, carelessweed
**Beta vulgaris*	Beets
**Halogeton glomeratus*	Halogeton
**Kochia scoparia*	Summer cypress
Quercus spp	Oak
**Sarcobatus vermiculatus*	Greasewood

*Oxalate-producing plants

poisoning and renal shutdown is probably the cause of death.

Plants high in oxalates may also affect the kidneys. In addition, oxalates in large quantities also interfere with normal cellular metabolism, thus affecting life processes.

Hepatic System

Since most materials absorbed from the GI tract into the blood stream must pass through the liver prior to distribution to the remainder of the body, the liver is continually subjected to many foreign compounds. In addition, the liver is the primary site in the body for biotransformation and detoxification of foreign chemicals. Consequently, the hepatic system can be damaged by plant toxins.

Liver dysfunction may be manifested in animals by CNS depression due to build up of nonmetabolized substances or inadequate energy production. Liver injury may also be manifested by the development of photosensitization. Biliary stasis or jaundice may occur with either of these conditions.

One of the more notable plant toxins is pyrrolizidine alkaloid (Table 7). These phytotoxins cause cirrhosis (fibrosis) and enlarged hepatocytes (megalocytosis). The affected animals die due to hepatic insufficiency. Jaundice is not commonly found in pyrrolizidine alkaloid injury.

Table 7. Toxic plants which affect the liver and cause cirrhosis.

Scientific name	Common name
**Amsinckia intermedia*	Fiddleneck
**Crotalaria* spp	
**Echium plantagineum*	Viper's bugloss
**Heliotropium europeum*	
Phyllanthus abnormis	Abnormal leafflower
Sartwellia flaveriae	
**Senecio* spp	Groundsel

*Contain pyrrolizidine alkaloids.

Photosensitization is another disease condition generally associated with some types of liver injury. With this particular type of hepatic injury, the liver is incapable of biotransforming chlorophyll, and some of the intermediate metabolites of chlorophyll are photodynamic and may cause photosensitization. Photosensitization is described as an abnormal susceptibility of the skin to sunlight and results in blistering, peeling, and swelling. Lameness due to inflammed hoof tissues may result. The disease condition has been called big head or swell head, and in New Zealand, facial exema.

Several plants and certain fungi have been associated with photosensitization. Plants that will produce photosensitization are listed in Table 8. In addition some plants contain photodynamic agents which produce photosensitization without liver injury: desert parsley, for example. (*Cymopterus watsonii*)

Table 8. Toxic plants associated with photosensitization.

Scientific name	Common name
Ammi majus	Bishop's weed
Agave lecheguilla	Lechugilla
Avena sativa	Oats
**Cymopterus watsonii*	Desert parsley
Cynodon dactylon	Bermudagrass
**Hypericum perforatum*	St. Johnswort
Lantana spp	
Medicago spp	Alfalfa
Nolina spp	Sacahuista
Panicum coloratum	Kleingrass
**Polygonum fagopyrum*	Buckwheat
Tetradymia spp	Horsebrush
Tribulus terrestris	Goat head, puncture vine

*Primary photosensitizer

Musculo-Skeletal System

The musculo-skeletal system is comprised of muscle and bone. Fortunately, there are not too many plants which affect this system (Table 9).

Table 9. Toxic plants affecting the musculo-skeletal system.

Scientific name	Common name
Cassia spp	Senna
Lathyrus odoratus	Sweet pea
Solanum malacoxylon	

Myopathy or degeneration of skeletal muscle occurs in ruminants which have ingested some species of *Cassia*. The disease is characterized by acute posterior weakness and paralysis. Cattle may lie down and be unable to rise. The syndrome is associated with a white coloring of skeletal muscle in the rear legs and loin region reminiscent of a vitamen E - selenium deficiency. However, the administration of these nutrients to affected animals exacerbates the condition.

Lathyrus odorata (sweet pea) and *Solanum maxacoxylon* can cause deformities in bone and cartilage. In addition *Lathyrus spp* is a known teratogenic plant.

Reproductive System

The effects of toxic plants on the reproductive system may vary from abortion to teratogenesis, stillbirth, and delayed breeding. These effects may not be apparent to the producer for some time after the animal's exposure.

An abortion occurs at any time an embryo or fetus is expelled from the uterus prior to the stage of viability. Abortion may also occur at any time there is fetal death. Agents which produce or induce abortion are called abortifacients. Several plant species listed in Table 10 contain abortifacients and produce abortion as one of their effects on livestock.

Table 10. Toxic plants which may cause abortion.

Scientific name	Common name
Astragalus spp	Locoweeds
Gutierrezia spp	Perennial broomweed
(*Xanthocephalum* spp)	
Pinus ponderosa	Ponderosa pine

Teratogenesis or the production of fetal monsters may occur after the pregnant dam ingests certain toxic plants. In some cases, the plant must be ingested during a particular period of pregnancy in order to produce its teratogenic effect, i.e., *Astragalus* spp, in sheep on days 13 to 16. Other plants may produce some fetal changes at any time prior to the completion of development of the fetus. A list of teratogenic plants is presented in Table 11.

Table 11. Toxic plants associated with teratogenesis (birth defects).

Scientific name	Common name
Astragalus spp	Locoweeds
Conium maculatum	Poison hemlock
Lathyrus odoratus	Sweet pea
Lupinus sericeus	Bluebonnet
Nicotiana spp	Tobacco
Veratrum spp	False hellebore
Vicia spp	Vetch

In some regions of the world, clovers (*Melilotus spp*) may contain high concentrations of estrogenic hormones. There are also some fungi which produce estrogens. The estrogen hormone may induce abortion or cause a delay in conception and thereby cause a delay in the animal's being bred at the appropriate time.

Any time a pregnant animal is exposed to a toxic plant or chemical or has any active disease process present there is a distinct likelihood of an effect on the fetus, i.e., the lack of oxygen produced by nitrate poisoning may cause pregnant animals to abort because of fetal death. In addition, many plants which affect reproduction in animals may also produce other effects when ingested in larger quantities, e.g., CNS disturbances.

Selenium Intoxication

Several elements can be accumulated by plants. However selenium is one of the more important elements in the U.S. Selenium accumulator plants are listed in Table 12. Some of these plants are obligate selenium accumulators and will grow only in high seleniferous soils. Obligate selenium accumulators are called indicator plants. Other plants called facultative selenium accumulators will concentrate selenium to some degree but selenium is not necessary for their growth.

Table 12. Toxic plants which accumulate selenium.

Scientific name	Common name
Astragalus spp	Locoweeds
Atriplex nuttallii	Saltbrush
Oonopsis spp	Goldenweed
Stanleya pinnata	Prince's plume
Xylorrhiza spp	Woody aster

Acute selenium intoxication is characterized by abdominal pain, CNS depression, and paralysis. Chronic selenium intoxication has been separated into two conditions, blind staggers and alkali disease. In both conditions, there may be CNS problems along with loss of mane and tail hair, liver injury, and heart injury. An animal may progress through all three syndromes, depending upon the amount of selenium ingested with the plants.

Malnutrition Syndromes

Malnutrition or at least lack of adequate nutrients should be considered when animals ingest toxic plants. However, this is not always true since some toxic plants are very attractive to animals and they will ingest them to the exclusion of more nutritious forage and forbs.

There are several plants which may be used as a portion of the animal's diet but should not make up the entire diet. These plants (Table 13) when ingested exclusively or excessively may produce a malnutrition syndrome. A suspect chemical has not been isolated from these plants but it appears as if some constituent in these plants interferes with normal body digestion and/or metabolism.

Table 13. Toxic plants associated with malnutrition syndromes.

Scientific name	Common name
Allium spp	Wild onions
Aloysia lycioides	Whitebrush
Prosopis spp	Mesquite

Fescue-Ergot Syndrome

Fescue and chronic ergotism are syndromes characterized by dry gangrene of extremities, i.e., hooves, tails, and ears. The dry gangrene is a result of loss of blood supply to the affected areas, and after several days the dead areas will be clearly delineated. Fescue grass (*Fescuta arundinacea*) and the ergot fungus (*Claviceps spp*) produce an effect on the capillaries and small blood vessels causing them to constrict and finally close off. This loss of adequate blood supply cause the tissue to die and the gangrene results. Ergot alkaloids also produce a CNS syndrome and may be associated with abortion, but the last two syndromes have not been associated with fescue grass.

Mycotoxins

Fungal toxins or mycotoxins in addition to ergot alkaloids are capable of producing physiologic effects on most of the body's systems. Mycotoxins are difficult to diagnose since analytical techniques are not adequate or sensitive enough to detect the offending mycotoxin. Mycotoxicosis should be kept in mind when a disease syndrome occurs in livestock, especially when known toxic plants, chemical toxicants, and infectious diseases are not identified.

Diagnosis of Plant Poisoning

The diagnosis of plant poisoning in livestock is difficult and requires detailed investigation. The mere presence of a toxic plant in a pasture or a history of plant intoxications in other years is not *prima facie* evidence of the presence of an intoxication.

There are several factors which must be considered when attempting to ascertain if a plant-related disease is occurring in animals. If a suspect plant is present, a determination must be made if the animal species concerned has grazed the plant. Other factors which must be considered include: plane of nutrition and presence of an adequate water supply, climatic conditions (i.e., rainfall, frost, etc.), and whether the animals of interest are familiar to the area or newly introduced. Animals may consume large quantities of plant material just prior to or subsequent to a storm. Very thirsty animals will attempt to fill up on any plant species after drinking water, and hungry animals will ingest many materials including toxic plants.

The following information is requisite for determining the presence or absence of a plant intoxication:

1. Adequate history including management, number of animals involved, etc.
2. Presence of syndrome and/or clinical signs.
3. Suspected plant material has been grazed by the species concerned.
4. Determination of seeds or plant material in rumen, stomach contents, or feces on autopsy.
5. Post mortem lesions.

Conclusions

Animal diseases related to plants are commonly diagnosed when animals die under range conditions. This type of diagnosis is rendered because the animal has been dead too long for an adequate post mortem examination or because the animal gets sick and the owner does not deem it necessary to confer with a veterinarian. Although plant intoxications occur in animals under range conditions, there are other disease conditions which might occur, such as chemical poisoning and especially infectious disease processes. The utilization of proper animal health care and management techniques will help prevent many animal deaths under range conditions and allow the producer to harvest more saleable goods from his rangelands.