Bulletin No. 200 - Plants Poisonous to Livestock

University of Wyoming Agricultural Experiment Station

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Poisonous plants, while confined to certain areas of Wyoming, are nevertheless responsible for losses of considerable magnitude to stockmen. Available statistics are lacking, but, from an estimate based upon losses in several localities, it seems probable that the average must be as great as three per cent. As would be anticipated, there is a considerable variation from year to year not only in aggregate losses, but in the classes of stock affected. Many deaths, due to unascertained causes, are difficult to diagnose, inasmuch as certain diseases produce symptoms closely resembling those of plant poisoning.

As the area of the stock ranges becomes more and more restricted, the successful raising of livestock is certain to become more difficult, especially in districts where poisonous plants occur. In the past, the first suggestion of trouble has been the finding of animal carcasses, and then “poison weed” was given as the cause, although no particular weed was, perhaps, named. During the last few years, there has been a very creditable advance made by stockmen in attempting to get acquainted with the troublesome weeds. Through inability to recognize those that are detrimental, many owners suffer losses year after year, thinking that some other cause is responsible. Therefore, a simple illustrated bulletin, giving the most recent experimental data and the general location, period of activity, symptoms, and other details concerning the principal poisonous plants, has been demanded for some time. It is hoped that the information found herein will be a means of developing a keener interest in the general understanding of the poisonous plants of Wyoming. From whatever angle the problem is viewed, one is confronted with several difficulties. The varied distribution of the plants, the character of the poisons involved, and the methods of treatment under range conditions are in themselves problems which require at all times the best efforts of specialists on the one hand, cooperating with the stockowners on the other, to reduce losses to a minimum.
Trailing livestock through poisonous plant areas can be done safely if preliminary surveys have been made.

CONTRIBUTORY CAUSES

Contributing factors incidental to plant poisoning are numerous. Ordinarily, many plants are protected from animals by various means, such as unpleasant odor, acrid or bitter taste, toxic character, and in some cases such protective devices as spines. The depraved appetite for unusual and unappetizing plants is a factor of importance in livestock poisoning. In the early spring, animals are often tempted to eat those plants which are at the time palatable and succulent regardless of their toxic or poisonous nature. There are several poisonous plants which usually appear before the range grasses begin to freshen. Among the more conspicuous ones may be mentioned species of larkspur, vetches, and death camas. In this connection, a condition frequently prevails which is difficult to avoid, namely a late snowfall, which leaves the more advanced plants exposed. Naturally, the desire to obtain something green is instinctively followed by the animals, and many times these outstanding, attractive plants prove to be the animals’ only choice. In a state of nature, animals, as a rule, avoid plants of a toxic nature, whereas imported stock, and particularly those better bred, are more often poisoned because they do not easily acquire the habit of “rustling.” Sheep are especially variable in their choice of plants, not only individually in the flock, but from day to day.
Late spring snows at the higher elevations occasionally cover range grasses. The further advanced weeds are generally left exposed: in this instance death camas.

The susceptibility of different species of livestock is a factor of considerable importance. Certain species of livestock, particularly the ruminants, are not as susceptible to certain plant poisons as other species, for example, the horse. Aside from the individuality and susceptibility of an animal, one finds that its physical state and the condition of the range greatly affect the actual losses from injurious plants. During the spring and early summer of 1920, cattlemen of the state lost an unusually large number of cattle from larkspur poisoning. Two reasons may be advanced for this loss: First, the cattle were, generally speaking, poor, and consequently low in resistance; second, the larkspur appeared early and afforded about the only kind of available food. The aggregate loss resulting therefrom was surprisingly large.

The importance of the fatigue factor when taken into consideration with plant poisoning is too little emphasized in our literature.

The one-night camp for sheep is desirable in dangerous areas. The shortage of feed that naturally results in the immediate vicinity of a more or less permanent camping ground of necessity tempts sheep to eat injurious plants that ordinarily would not be touched. The bedding-out system appears to be practical and has many advantages other than eliminating hunger by unnecessary trailing.
SALT REQUIREMENTS

Arrow grass, one of our troublesome poisonous plants, contains appreciable quantities of sodium chloride (common salt). It has been generally believed that this plant is sought by stock for its salt content, especially by animals not getting sufficient salt.

The salt requirements of stock vary somewhat with the season. Most stockmen believe that in the spring of the year when new grass becomes available it fully satisfies the salt requirements. This is not necessarily so. Forage in late summer and fall is considerably richer in mineral salts than in the spring, and we believe it is a mistake to remove the source of salt as soon as winter feeding is stopped and the stock is turned on the range to graze. As a rule, most of the salt requirements of stock can be satisfied with common salt. The buying of complicated salt mixtures to satisfy needs of livestock is not always warranted. The use of common salt with good feeds should satisfy the normal requirement.

The feeds grown on certain shale areas (see discussion on poisoning due to mineral-bearing plants) may show by chemical analysis sufficient quantities of both calcium and phosphorus. Nevertheless, stock consuming these exhibit symptoms of phosphorus deficiency. The depraved appetites cause such animals to chew fence rails, metallic objects, pieces of bone, etc. At autopsy the rumen of such animals may contain an unbelievable quantity of odd objects, the most common being wire, nails, and other metallic objects. In this instance, therefore, the cause of the trouble cannot be attributed to a deficiency of either calcium or phosphorus in the feed. We believe that the presence of certain elements, notably molybdenum which is present in rather large quantities, relatively speaking, in these feeds, causes the disturbance in the normal phosphorus and calcium metabolism. A remarkable improvement is soon shown by these cases when given small quantities of a soluble calcium salt. In the experimental work calcium lactate was used. It is quite probable that calcium phosphate, which is readily available, would be as efficient.
IMPORTANT POISONOUS PLANTS

The principal poisonous plants of more or less general distribution include several species of larkspurs, lupines, woody aster, species of death camas, water hemlock, and *Astragali* (vetches).

The white and purple loco weeds are found in abundant quantities throughout the state but with few exceptions are not feared by stockmen.

Those plants occurring in more or less restricted areas include salt bush, milkweed, goldenrod, senecio, sneezeweed, and cocklebur.

Probably in discussing poisonous plants, mention should be made of the fact that forage plants are sometimes infested with fungi, such as rusts and moulds. These may be the cause of poisoning when found on forage which is ordinarily entirely harmless.

PREVENTIVE MEASURES

Frequently the question is asked, how may losses be prevented if animals are to be grazed where poisonous plants occur? Unfortunately, prevention cannot be obtained by vaccination, as is the case with several of the infectious diseases. Perhaps a partial answer would be to acquire accurate information relative to range stock and range conditions. Even then, some stockowners would be forced to meet the problem with considerable uncertainty. The fact that a certain class of stock may have grazed upon the same range for a number of years and escaped trouble gives no assurance that poisoning may not occur. On the other hand, it should be borne in mind that animals, as a rule, do not instinctively select toxic plants as a forage, that all classes of livestock are not necessarily susceptible to the same poisonous plants, that not all poisonous plants are dangerous from their initial appearance on to maturity, and that only in one or two instances do animals acquire a depraved appetite for harmful plants.

Emphasis should be placed upon the acquisition of fundamental data regarding any range, and information as to the chemical composition of such crops and feeds as are not giving satisfactory results.
Infection may be confused with plant poisoning.
Sheep suffering from tetanus.

**METHODS OF DIAGNOSIS IMPORTANT**

Those whose duty it is to attend to range animals subject to infectious and other diseases and poisoning by plants would find it profitable to acquaint themselves with the necessary information to diagnose most of the sickness which occurs in livestock. Such a common infectious disease as tetanus is often mistaken for plant poisoning with the result that the infection spreads before the real nature of the trouble is discovered and the proper precautionary measures are taken.

Again the poisoning caused by mineral-bearing plants has often been mistaken for hemorrhagic septicemia. In such cases considerable expense is incurred in the vaccination of the whole herd for a disease which is not present.

An incident of a little different nature came to the attention of the writers recently. On a certain ranch there had been from time to time losses of valuable draft horses. The owner did not realize that the musty and badly cured hay could account for his trouble, causing an unnecessary loss due to lack of information. During the course of a year many such cases come to the attention of the
writers. The proper diagnosis of the case at hand would often save an owner considerable expense and anxiety and at the same time point the proper remedial measures.

ANTIDOTES

Some poisonous plants are so generally distributed in certain areas of the state that it is difficult to avoid poisoning, even under the most careful methods of range management. Since poisoning is so difficult to avoid, considerable time was devoted during the past year to finding satisfactory antidotes for some of the more common forms of plant poisons.

To be practical an antidote must be such that it can be readily and quickly administered even by an unskilled hand. Consequently compounds requiring intravenous administration to be effective would never be practical on the range. The method of administration of the antidotes for arrow grass and death camas (Zygodenus) poisoning will be described later in the bulletin under the heading of the plant in question. By means of the specific antidotes for these plant poisons it has been possible to save animals receiving one and a half to two times the dose of either plant which is required to produce death. A method of treatment for animals suffering from the symptoms of poisoning often called "blind staggers" or "alkali disease" is also described under the section devoted to the mineral-bearing plants known to be responsible in part for this form of poisoning.
Plains Larkspur (Delphinium Geyeri Greene): In this species the stems rise from among a tuft of root-leaves and soon develop open clusters of blue flowers, as seen in the illustration. The parts of the seed capsule have spreading tips. This is the larkspur known as "poison weed," and this name should not be applied to other larkspurs or to any other plants.
Typical growth of plains larkspur in bloom.

I. PLANTS IN WHICH THE TOXIC MINERALS DO NOT SEEM TO BE OF SPECIAL SIGNIFICANCE.

PLAIN LARKSPUR

This species of larkspur is the most common of the Wyoming larkspurs. It is responsible for more losses among cattle than all the other larkspurs of the state combined. Under favorable conditions of growth dense patches may be found which add much to the picturesqueness of the landscape. The average height of this larkspur is about 15 inches.

Where it grows. Found quite generally distributed over the state at altitudes varying from 4000 to 8000 feet. It thrives best on a rather coarse, well-drained type of soil. Its tolerance for alkalies is considerable, since stands of appreciable magnitude are found on geological formations containing large amounts of alkali salts. This plant grows only in open areas on the plains and foothills.

When it appears. Under normal conditions young plants are recognizable in April and in the flowering stage; unless the season is unusually moist, the plants dry up rapidly and disappear from the range.

Propagation occurs under range conditions through root-budding. It is doubtful if this species produces viable seeds normally. A three-year test has shown that under ideal conditions of moisture and soil well-matured seeds seldom germinate.
Animals Affected. Poisoning from this plant is confined almost exclusively to cattle. Forced feeding of young succulent plants to sheep in amounts comparable to that obtained under normal grazing failed to produce symptoms of poisoning. Horses and mules seldom eat quantities large enough to produce poisoning. Chickens when fed green chopped plants with grain over a ten-day period showed no symptoms of poisoning. The quantity of plant necessary to affect an animal seriously varies with the amount eaten at one time, the stage of growth, and the condition of the animal.

Poisonous Period. Dangerous throughout its growth. Poisoning is due to definite, active principles (alkaloids), occurring mostly in the leaves. A popular belief that the roots have to be eaten to produce poisoning is erroneous. As a rule, the heaviest losses occur during the early stage of the plant's development. Occasionally, and with fatal results, cattle prefer the flowering larkspur tops, even if good forage is available. The regrowth following cutting or grazing is less poisonous than the initial or original plants.

Symptoms. Vary more or less depending largely upon the severity of poisoning. Those most characteristic are: Inability to walk without staggering or falling, nausea, salivation, pronounced sweating, bloating (quite common in later stages), muscular twitchings of the side and legs, and frequently convulsive movements. The immediate cause of death is respiratory paralysis.

Treatment. Where prevention cannot be strictly carried out, the treatment recommended by the U. S. Bureau of Animal Industry undoubtedly is the most effective (see Low Larkspur.)

Remarks. The crude protein content of the initial growth is comparatively high although somewhat less than that of the tall species. Supplementary feeding of concentrates rich in protein has proved to be a useful preventive measure by diminishing the abnormal hunger for protein which some animals have in the spring.
TALL LARKSPUR

Tall larkspur (Delphinium Barbeyi) is the most common of the larkspurs found growing at the higher altitudes. It is a very poisonous plant but fortunately its restricted growth in forest reserves, coupled with the fact that in many instances sheep only are grazed where the plants occur, very materially lessens stock losses. As in the case of the plains larkspurs, there are areas where the tall larkspur forms dense patches. The height of this plant varies from 2 to 5 feet. For a more detailed study of this and other larkspurs of the state see Wyoming Experiment Station Bulletins Nos. 120 and 143.

Where it grows. Occurs in all the national forests of the state at altitudes ranging from 8000 to 11,000 feet. It thrives best in open draws and mountain parks. The soils in these areas are black due to the decay of leaves and other vegetative matter.

When it appears. It is usually up by the middle of June. The time of blooming varies with the season and altitude.

Animals Affected. Are the same as for other species of larkspurs. Records from forest supervisors indicate that this species under range conditions is not regarded as a plant hazard to sheep.

Poisonous period. It is dangerous from its earliest appearance until the flowers disappear, although in common with other species the
TALL LARKSPUR (Delphinium Barbeyi Huth): Attention is called to the stoutish stems, the coarser and fewer leaves, and the dense cylindrical cluster of deep blue flowers.
maximum poison content is present in the early growth. The seeds are poisonous, but very few losses result from this source. The mature stems, leaves, and pods contain but little poisonous matter.

**Symptoms.** See plains larkspur. The symptoms are similar.

**Treatment.** See low larkspur. The treatment is similar.

**Remarks.** The crude protein content of the young plants is very high compared to grasses. Cattlemen in some sections of Wyoming use supplements rich in protein before cattle are grazed on larkspur areas to prevent or alleviate their eating this plant for its protein content.
LOW LARKSPUR (Delphinium Nelsonii Greene): Always growing as simple individuals from a cluster of small tuber-like roots as just shown here. Flowers from pale to dark blue.
LOW LARKSPUR

The low larkspurs are quite insignificant as poisonous plants. The type growing in northeastern Wyoming (*Delphinium bicolor*) occurs in dense zones in parts of the Big Horn Mountains and some cattle losses have resulted. *Delphinium Nelsonii* is widely scattered over the state. *Delphinium venenosum* A. Nels. is widely and densely found in the Wyoming National Forest in western Wyoming.

Where it grows. It is found at altitudes of from 4000 to 10,000 feet on open hillsides and mountain parks. The plants seldom grow over one foot in height. They are frequently associated with sage brush zones.

When it appears. It is one of the early appearing range plants in the spring. In the foothills the flowering plants may be found by June 1. At higher altitudes (9000 to 10,000 feet) the flowers may not appear until nearly a month later.

Animals affected. Are cattle, mainly. Sheep browse upon low larkspurs eagerly and without noticeable harmful results.

Poisonous period. It is poisonous during the whole life of the plant, but particularly during the pre-bloom stage.

Symptoms. Same as for other species of larkspurs.

Treatment. Any treatment that is to be effective should be applied as promptly as possible. Animals poisoned by larkspur should be kept quiet, with head higher than rest of body. Bloating should be relieved by sticking. The use of a trocar is advisable for this purpose. The general practice of bleeding is often detrimental in larkspur poisoning. The hypodermic administration of the following substances is recommended by the U. S. Bureau of Animal Industry:

- Physostigmin salicylate \[1\text{ grain}\]
- Philocarpine hydrochloride \[2\text{ grains}\]
- Strychnine sulfate \[\frac{1}{2}\text{ grain}\]

This quantity dissolved in approximately 1 tablespoon of water would be the proper dose for an animal weighing 500 to 600 pounds. An animal of about double this weight would receive twice the quantity given in the formula. The syringe commonly used in blackleg vaccination will answer the purpose in most cases. The injection is usually made in the shoulder. The ingredients in this formula may be obtained from drug dealers or through county agricultural agents.

Remarks. Ordinarily the low larkspurs are desirable forage for sheep.
Method of making hypodermic injection of larkspur antidote.
The result of plowing up water hemlock tubers in November.
The new tubers develop before the old ones die.

**WATER HEMLOCK**

There are several plants which belong to the parsnip family occurring in the same places as the water hemlock (*Cicuta*). The non-botanist may, therefore, be confused in his identification unless considerable care is taken. The giant angelica might easily be taken for water hemlock, so far as appearance, odor, and location are concerned. Fortunately, the poisonous properties of the *Cicuta* are confined to the underground tubers and early shoots. The aggregate losses are never alarmingly high.

**Where it grows.** It is quite generally distributed over the state, principally along irrigation ditches and streams and in swampy meadows.

**When it appears.** Since the above-ground portion is harmless to livestock after some growth, one is concerned mainly with the underground portions of the plant. Normally shoots appear the last of May. At lower elevations and under favorable protection plants might be distinguishable the last of April. As the plant matures in the late summer, the tubers give rise to new tubers, and the old ones dry up. The young plants in the fall may attain some size before freezing temperatures prevail.

**Animals affected.** It is poisonous to all classes of livestock.
Wyoming Agricultural Experiment Station, Bul. 200

*Wyrea* (Cota occidentalis Greene). Left: portions of young and mature plants showing characteristic tubers, leaves, and seed heads. Right: young plants developing from old tubers in the late fall.
Poisonous period. Tubers and young shoots are dangerous at any season of the year, particularly in the spring and fall.

Symptoms. Acute abdominal pain, mental excitement, and finally violent convulsions.

Treatment. The poison in water hemlock is one of the most rapidly acting known. Avoidance is the only suggestion that can be given.

Remarks. In removing water hemlock plants from ditches and streams care should be taken to destroy them. If thrown into a stream, they might accumulate on a barrier and cause severe poisoning, when thus encountered by livestock. In plowing up meadow land containing water hemlock, precautions should be taken to destroy the root tubers.
Silvery Lupine (*Lupinus argenteus* Pursh.): Plants occur singly or in clumps, the branched stems erect or spreading. Flowers vary from blue to cream color or even purplish. Pods silvery-silky-hairy, as is the rest of the plant.
A natural growth of the mountain lupine—*Lupinus alpestris*.

**LUPINES**

There are several species of lupines in the state, but fortunately not all of them are poisonous, at least, not to the same extent. The silvery lupine (*Lupinus argenteus*) is the most common species on the plains and *alpestris* the most common in the mountainous regions. The “wooly” lupine (*L. leucophyllus*) is confined to the western part of the state where it is found to occur in plentiful stands.

A brief description of the silvery lupine is given here to serve in a general way as an illustration of the other lupines.

**Where it grows.** It thrives best along streams and irrigation ditches where the soil is moistened to some extent by seepage water. The soil on which it grows is quite free from alkali and contains more humus than is required by many of the other poisonous plants. It propagates by seeds and underground roots.

**When it appears.** Under normal conditions, the silvery lupine appears early in June and is in partial bloom by the first of July. The fruit appears shortly afterwards, and from then on one may find flowers and green and mature pods all on the same plant.

**Animals affected.** It affects sheep mainly. Other animals, horses, cattle, swine, and goats, may be poisoned if enough of the fruits are eaten. A species of lupine known as *L. laxiflorus* is reported to be more poisonous to cattle than sheep. This plant is known to occur in the Wind River Mountains and possibly in other nearby ranges.
The green fruits of the silvery lupine.

Poisonous period. This plant should be considered dangerous from the time the green pods appear until the plants dry up in the fall. Distinctly toxic substances occur in the leaves and flowers but apparently in too small quantities to be effective. The seeds and pods retain their poisonous properties when cut and cured quickly, and occasional losses result from the feeding of hay so contaminated.

Of the three species investigated for comparative toxicity L. leucophyllus was found to be the most toxic, L. argenteus next, and L. alpestris the least.

The results of an experiment with guinea pigs follow:

<table>
<thead>
<tr>
<th>PLANT</th>
<th>*Index of Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. leucophyllus</td>
<td>100</td>
</tr>
<tr>
<td>L. argenteus</td>
<td>71.8</td>
</tr>
<tr>
<td>L. alpestris</td>
<td>59.6</td>
</tr>
</tbody>
</table>

Guinea pigs weighing approximately 500 grams were used. All doses were administered intraperitoneally.

*Toxicity of L. leucophyllus arbitrarily taken as 100.
The silvery lupine thrives best along the well drained banks of streams.

**Symptoms.** Animals may die shortly after the first symptoms appear or may live several days. A day may elapse between the eating of lupine and the appearance of symptoms, so that animals may trail a long distance from the seat of trouble before suspicion is aroused. With reference to symptoms exhibited by sheep, there may be frothing at the mouth, more or less trembling, nausea, and bloating. Symptoms especially characteristic are: Excitement, leading to running about and butting into other animals and objects; convulsions, accompanying attacks of labored breathing.

**Treatment.** No satisfactory remedy is known that can be used advantageously for range animals. Most lupine poisoning may be avoided by keeping hungry animals away from lupine patches until their appetites are at least partially satisfied.

**Remarks.** Lupines are largely poisons which affect livestock that are being trailed. The oily fruits are attractive to hungry animals, especially sheep.
DEATH CAMAS (Zygadenus gramineus Rydb.) The illustration is distinctive, showing the characteristic bulbs, leaves, and flowers (Right). Seed heads, weathered leaves, and smaller bulb (Left).
The most common species of death camas in the state is *Zygadenus gramineus*. Another species equally as poisonous, when small, is *Z. paniculatus*. Its distribution, however, is limited to southwestern Wyoming. *Z. elegans* occurs in the mountainous regions and along some of the adjacent streams. This species causes very little trouble in Wyoming. Occasional sheep losses would seem to be due to this plant. For detailed information regarding distribution, poisonous properties, etc., of the death camas species of the state, the reader is referred to Wyoming Experiment Station Bulletin No. 194.

The summary that follows pertains to *Z. gramineus*:

**Where it grows.** It appears to thrive on the sandy plains as well as in the drier and stonier foothills. Its most favorable location is in sandy swales where the soil remains moist for a comparatively long time. The plant is seldom found above an elevation of 8000 feet.

**When it appears.** The grass-like leaves appear early in the spring, usually by the first of April. These leaves are soon followed by the flower stalk which becomes six to ten inches high, terminating in a spike-like cluster of yellowish-green flowers. The flowering stage is generally reached by June 15. As the season advances, the flower stalk lengthens out slightly into a nearly naked seed stalk bearing rather large capsules.
Animal affected. Sheep are more frequently poisoned than cattle and horses. This is probably not because sheep are more susceptible, but rather to the manner in which sheep are managed upon the range.

Poisonous period. This plant is dangerous throughout its life. Losses under range conditions usually occur in the spring. The poison content of the leaves is highest at this time and gradually decreases. The bulbs, though not accessible to livestock, are comparatively low in poison at all stages of growth. The fruiting heads are very poisonous, although unattractive. At this stage the trailing of cattle or sheep through camas areas is dangerous.

Symptoms. Symptoms of *Zygadenus* poisoning appear very early after the ingestion of a toxic dose. Salivation (slobbering) is first noted, and soon thereafter an acceleration of the respiratory rate. The acceleration and the increase in depth of the respiration varies considerably with different animals. Pronounced nausea, leading in some cases to emesis, appears quite early in the stage of poisoning. The vomit containing a part of the ingested *Zygadenus* is sometimes a helpful feature in that not enough of the dose is retained to produce death.

Poisoned animals show a rise in body temperature for the first two or three hours after ingestion of a dose. This rise of temperature is followed by a fall to a point which may be much below normal, in case the animals enter a state of prolonged coma. This fall of body temperature while in a state of coma is most severe when the toxic agent is *Z. gramineus* or *Z. paniculatus*. The body temperature in fatal cases never approaches normal again while the animal is in a comatose state.

Previous to the stage of coma, when such occurs, animals exhibit weakness, especially in the hind legs. The weakness progresses to a point at which the animal staggers and falls. Convulsions are often noted at this stage. The character of the respiration changes at this stage of poisoning, the rate is less than normal, and the expirations are labored and often accompanied by a grunt. The heart apparently becomes involved at this stage also, the pulse gradually becomes weaker, and the heart rate is decreased. Before the comatose stage manifests itself, animals generally exhibit pronounced aesthesia, that is, a noise or sudden startling of the animal elicits a heightened reflex response. As stated above, the period of coma is variable. Cases have been observed in sheep and cattle in which partial recovery from the comatose state occurs, at least to the extent that the affected animals, although unable to move, are nevertheless able to eat and drink. Special care given these animals often brings about their recovery. Deaths resulting shortly after the ingestion of a dose are due to respiratory failure; otherwise they are the result of a failing heart and circulation.
Sheep poisoned by *Zyadenus paniculatus*.

During the early period the animal salivates (slobbers), shows considerable uneasiness or mild excitement, and often will not eat and will stand humped up. As poisoning progresses the animal occasionally shows vomiting and a rapid respiration. After a variable period of time (generally several hours) the animal becomes paralyzed. The paralysis in death camas poisoning is not a true paralysis but a severe nervous and muscular exhaustion. Treatment will not overcome this paralysis once it has appeared but will save life.

It cannot be emphasized too strongly that the animals be treated with the onset of the first symptoms.

Formula for treatment of death camas poisoning:

Atropine sulfate .................. 2 milligrams
or 1/30 grain

Picrotoxin ......................... 8 milligrams
or 1/8 grain

The above quantity of drugs should be dissolved in five cubic centimeters of water. This will constitute one dose for a sheep weighing approximately one hundred pounds. Fifty to sixty pound lambs should take one-half to three-quarters of this dose. The most convenient method consists in dissolving ten tablets or ten times the above quantity of drug in 50 cubic centimeters of water or about five dessert tablespoons of clean water, shake well to obtain a clear solution and keep
in tightly corked containers. The herder may draw from this the quantity necessary for the doses. It may be necessary to repeat the injection two or three times. The indications for the repetition of the dose will be the reappearance of the symptoms of death camas poisoning. Unless the animal has eaten a very large quantity of death camas, it will not be necessary to give more than two or three injections. In any case it is not advisable to repeat the dose oftener than every two hours.

An all-metal hypodermic syringe will be found most satisfactory. The injections are made hypodermically (under the skin) in the region of the shoulder. It is important that poisoned animals be treated as early as possible. The herder should make it a practice, if the band has grazed or trailed over a dangerous camas territory during the day, to inspect closely the animals before bedding down at night and to treat any sick animals.

**Remarks.** Taking care to graze sheep in the morning on areas or ridges free from camas will result beneficially. This practice should be continued until the range grasses are well established.
ARROW GRASS

Feeding experiments corroborated by range observations have shown that arrow grass is poisonous to sheep and cattle. The most common and also the most poisonous species of arrow grass is Tri-glochin maritima. The smaller species, T. palustris, is not as common as the T. maritima. Contact with arrow grass is usually made in two ways, (a) summer pasturing of livestock in areas involving poorly drained swamps and alkali lakes and (b) cutover meadows used for late summer and fall grazing.

The summary which follows pertains to T. maritima:

Where it grows. It is widely distributed over the state in wet, alkaline soils, and along the edges of bogs and sloughs. In some meadows the flowering stalks of arrow grass may be entirely absent and the stool-like clusters of leaves be mistaken for wire grass. The flowers and seed-pods are sometimes confused with those of water plantain.

In addition to the cyanide carried by this plant, selenium has been found to occur in the seed heads. The occurrence of this element is apparently limited to those plants growing on well-defined geological formations, commonly referred to as shales, and identified as Niobrara, Steeple, Morrison, and others. Selenium produces a chronic, well-defined type of poisoning with characteristic pathological changes. (See Section II of this bulletin.) Livestock suffering from a milder form of selenium poisoning quickly reach a fatal stage after the ingestion of arrow grass. This apparent combined action of cyanide and selenium makes arrow grass an extremely dangerous plant.

When it appears. Arrow grass is one of the first plants to appear in the spring. The flowers usually appear about the first of July and the seeds about a month later. The plants remain green until late in the fall.

Animals affected. Arrow grass is poisonous to sheep and cattle, but there is no information available as to its effect on horses.

Poisonous period. It is dangerous from early spring to late fall. The regrowth developing from cut-over meadows is particularly dangerous because of: (a) its saline, succulent character, (b) its freedom from stems and its comparatively high hydrocyanic content, and (c) its increasing chance of being eaten by livestock owing to the practice of grazing cut-over meadows in the late summer and fall.

Arrow grass occupies a unique position among poisonous plants, in that the dried plant harvested in the hay may retain enough of its toxic substance to render it dangerous. In this manner the plant represents a year-round hazard to the stockman.
ARROW GRASS (*Triglochin maritima* L.): Readily distinguished from grasses by the long jointless stem and the fleshy sheathing rush-like basal leaves. Flowers in terminal spikes, inconspicuous and greenish.
For more complete information concerning arrow grass the reader is referred to Wyoming Experiment Station Bulletin No. 193.

**Symptoms.** After the administration of a dose large enough to kill an animal the progressive symptoms of poisoning are as follows: The breathing is the first to become involved. The rate is much accelerated at first with an increase in depth. The expiratory efforts appear to be labored and in sheep are often accompanied by a grunt. At this stage the animal may hold its head down and appear to be leaning forward. Urination and defecation are frequent. It soon exhibits trembling and muscular twitchings. This is often followed by irregularity of respiration, with salivation. The irregular breathing of the animal is often accompanied by swallowing and retching movements. The hind legs appear paralyzed, the animal falling on its side as the hind legs are no longer able to support its weight. Vomiting accompanies many expiratory efforts. The animal then pulls its head far back, the legs and back exhibiting tense muscular contractions (opisthotonos). Cyanosis and dilatation of the pupils indicate marked asphyxia with the breathing being very irregular (Cheyne-Stokes type). The animal's mouth is wide open and gasps for air. Often mild convulsions appear at this stage. When the respiration has become so inefficient that it consists of gasps only, violent convulsions with stiffening of extremities occur, which are quickly followed by death. Since the heart beats for a short while after complete arrest of respiration, death is due to respiratory failure. Autopsies reveal no characteristic lesions except those of asphyxia.

**Treatment.** The finding of a satisfactory antidote for cyanide poisoning has become of economic importance because it can be applied successfully to livestock poisoned with arrow grass.

The plant is, however, the most rapidly acting poisonous species found on the western stock range, and consequently treatment must be applied soon after the appearance of symptoms of poisoning, at least before the onset of the first convulsions. The animal will survive but a few minutes after the first convulsions. They do not appear, however, until twenty to forty minutes after the ingestion of the lethal dose. Symptoms of uneasiness and the change in the rate of breathing precede the convulsive stage by a period of fifteen to twenty minutes, so that an alert herder or attendant has ample time to apply the treatment.

The treatment for sheep consists in the injection of a 5 per cent solution of sodium tetrathionate intraperitoneally. It is best to have a 50 cubic centimeter syringe at hand and to inject this quantity (50 cc.) of the above solution immediately upon the appearance of symp-
toms of poisoning. This dose may have to be repeated one and a half to two hours later, depending on the size of the ingested dose of arrow grass. The size of the dose of plant ingested will depend largely on the predominance of arrow grass in the area grazed and in what state of hunger the animal happens to have been. To antidote one and one-half times the killing dose of arrow grass it may be found necessary to give three injections of the size indicated above. In any case, it is best not to repeat the above injections at less than one and one-half to two hour intervals. The indication for the repetition of the dose will be the reappearance of the symptoms of arrow grass poisoning.

The same procedure should be followed for the treatment of cattle. The dose for a five to six hundred pound steer will be about twice the dose for sheep. The injections are to be repeated as in the case of sheep.

Remarks. An extract of arrow grass upon concentration yields a considerable quantity of common salt (sodium chloride). Lack of salt would naturally lead livestock to the selection of this plant for their requirements.
The white loco in bloom.

**WHITE LOCO**

White loco (*Oxytropis saximontana*) is the plant commonly known in Wyoming as the "loco." It is widely distributed over the state, at elevations ranging from 4000 to 10,000 feet. The loco plants in general have long, semi-fleshy roots which enable them to withstand severe droughts. The extent to which animals in Wyoming, particularly horses, are injured by white loco is quite a difficult question to answer. Naturally, there is, from year to year, more or less loco poisoning; but, on the whole, it is not comparable with losses encountered in some of the neighboring states.

In some sections of the state the so-called loco weeds represent the primary forage cover, and yet very few complaints are received from stockmen. It is possible that in the past some confusion has arisen from the related disease caused by the associated mineral-bearing *Astragalus*. Further investigation is needed to determine correctly the role loco plants may play as poisonous or undesirable weeds.

Another species of loco, *Oxytropis bilocularis*, is also common in Wyoming. It has bluish-purple blossoms and in many respects closely resembles the white loco. Wooly loco (*Astragalus mollissimus*) occurs sparingly in the southeastern section of the state. Because of its limited distribution, it is not to be regarded as an important poisonous plant.

**Where it grows.** It grows largely on knolls and on ridges and often in great field-like patches on the plains. It thrives in sandy soil.

**When it appears.** The white loco, in common with some other species, remains green throughout the early winter. The flowers usu-
WHITE LOCO (*Oxytropis saximontana* A. Nels.): This loco has a large semi-woody root from the crown of which spring the numerous leaves and white flower stalks. The purple loco (*Oxytropis bilocularis* A. Nels.) is taller, more slender and less tufted.
ally appear by the first of June, although the season and elevation greatly modify the growth of the plant.

**Animals affected.** While horses, cattle, and sheep are susceptible to the disease, the principal losses in Wyoming are said to occur among horses.

**Poisonous period.** The loco appears to be a dangerous plant at any season of the year. The active principle, whatever it may be, is quite equally distributed throughout the whole plant.

**Symptoms.** In contrast to the action of most poisonous plants, the effects of loco progress slowly. Usually several weeks or months elapse before the disease is observed to be present. The important symptoms are: Loss of flesh; irregularity of gait; weakness; and lack of muscular coordination. Symptoms exhibited by different classes of stock naturally vary within certain limits. For details relating to the loco disease, Farmers’ Bulletin No. 1054 of the U. S. Department of Agriculture should be consulted.

**Treatment.** No antidote has been found which is uniformly successful. If practical, locoed animals should be removed from infested areas and given nutritious food.
ACONITE (Aconitum columbianum Nutt.): The careless observer might readily pass this for a larkspur, but attention to the blue blossom shows instead of the "spur" a rounded "hood"; hence the common name "monkshood" is sometimes used.
ACONITE

While the aconites are poisonous plants, it is pretty definitely settled that they do not poison range stock. Mention is made of the aconite (*A. columbianum*) because it not only grows in close proximity to the tall larkspur, but may be confused with it.

**Where it grows.** This species of aconite grows at elevations ranging from 5000 to 10,000 feet, along brooks and springs and in low ground. Outside of Yellowstone Park, the aconite occurs only in scattered districts.

**When it appears.** The aconite and tall larkspur have about the same seasonal growth.

**Animals affected.** It has been demonstrated that cattle are not susceptible. Sheep and horses may be poisoned fatally by aconite.

**Poisonous period.** The poison is said to be largely in the seeds and roots so that there is greater danger to grazing animals during the seeding stage.

**Symptoms.** Closely resemble those produced by the larkspur.

**Treatment.** No specific antidote is known.
LICHEN (Parmelia mollisscula Ack.) This particular lichen is one of the free forms, that is, it is not attached to any supporting surface as most of the lichens are, but simply lies on the ground and is readily driven about by the wind. It consists of gray-green flakes of very irregular shape somewhat darker on one side than on the other. When dry, the flakes are much curled and brittle, becoming rather rubbery and flattening out when moist.

LICHEN

While this lichen, Parmelia mollisscula, is not to be regarded as a serious menace to livestock, yet there are times, usually during the winter months, when it has caused poisoning. The nature of the poison and the symptoms produced have been investigated quite thoroughly.

Where it is found. It is quite generally distributed over the state. Since it has no root system, it is blown about by the wind, frequently forming drifts of considerable size.

When it appears. It is present throughout the year, although more noticeable during the winter season. It propagates from broken fragments of the old plants.

Animals affected. Are sheep and cattle mainly.

Poisonous period. No particular variation with seasons or with localities.
Mixture of lichen and snow. Photo taken during March.

**Symptoms.** In mild cases of poisoning there is only evidence of lack of coordination in the movement of the hind legs. In the more severe cases, however, the animal gets down and is unable to move either front or hind legs. There is also mild depression in the severely poisoned cases. A characteristic diagnostic feature of this form of plant poisoning is that the hind legs are affected first and are the last to recover from the paralysis. No lesions nor any characteristic pathology develops. The death rate is not high. Usually an animal continues to eat and drink even though it may not be able to stand up.

**Treatment.** A change to desirable feed usually is sufficient. If not, measures should be taken to flush the stomach and intestinal tract with warm water in copious amounts.

**Remarks.** On ranges where feed is scarce and unpalatable this lichen is most likely to cause trouble. This animal poisoned by lichen is unable to stand. Otherwise it showed no symptoms of distress.
II. PLANTS IN WHICH THE POISONOUS PROPERTIES SEEM TO BE INFLUENCED BY THE CONTENT OF TOXIC MINERALS.

Poisonous Plants in Relation to Cretaceous Shales.

The group of poisonous plants represented by the larkspurs, lupines, and species of camas, contain poisonous principles that do not vary appreciably with soil types, if corresponding stages of growth of a particular plant are considered. During the past few years the attention of the writers has been given to a group of plants that do vary with soil types. Up to this time the Wyoming investigations have demonstrated that several such plants are selective in their mineral utilization or absorption. This is particularly the case when plants of this character grow on soils derived from those geological formations which are essentially shales. These shales are known as the Benton, Niobrara, Steel, and Pierre formations. These shaly composites, as a group, represent a geological era in which a large part of the present Rocky Mountain region was covered with a shallow sea. Concurrently, mountain erosion contributed a marked amount of wash into this sea, so that the combined result was the deposition of a series or bands of sediments that are known geologically as Cretaceous shales.

Out of the total number of native range plants growing on these shales, only a comparatively few take up minerals in toxic amounts. The outstanding mineral involved with this selective group of plants is selenium. Other minerals of importance have also been found.

These shale bands vary either in the amount of selenium or in its stability and resistance to plant-root action. This conclusion is based upon the fact that the same plant, for example the woody aster,
is normally more poisonous on the Niobrara, Steele, and Pierre shales than on the Benton, Lewis, Hilyard-Cody, and Wasatch. In general this line of reasoning applies to the whole group of mineral-bearing plants, at least as far as the present studies have gone.

Normally these shale areas have not been found to impart toxicity to crops and forages except in isolated areas where selenium-bearing plants have been involved as an intermediary influence. Further investigations are now under way to determine as definitely as possible the extent of these mineral-bearing plants with regard to the ranges and irrigated sections of the state.

Selenium once established in the body of these mineral-bearing plants becomes available, through the decay of roots, stems, and leaves, to normal plant growth. Whether under range conditions such contaminations may obtain a depth or concentration to impart selenium to plants that initially do not take up this mineral from mineralized shales has not been determined for deep rooted plants. A few representative range grasses and shallow rooted plants have been found to be so influenced.

Mineral-bearing Plants in Relation to “Alkali Disease”

In a recent paper* a type of poisoning was described which accounts for considerable annual livestock losses in Wyoming, “blind staggers,” “alkali disease,” etc., are terms used by the stockmen to designate symptoms which appear in this form of poisoning. The cause of the trouble has not been recognized until recently. Even today some prominent cattlemen believe the malady is infectious, others that the intense light of the sun causes the blindness in stock unable to find shade or shelter. The most popular belief, however, as to the cause of “alkali disease” is that it is due to the drinking of water charged with alkaline salts. Since the affliction is not caused by the drinking of saline water, the term “alkali disease” is a misnomer.

Two diverse types of root systems, (left) two-grooved milk vetch, (right) and woody aster. Both select poisonous minerals when growing on certain geological formations.

Heller† in a detailed study of the effects of saline and alkaline waters on domestic animals concludes that concentrations up to 1.5 per cent of alkaline salts in the water are not seriously detrimental to stock, that the resulting damage to stock utilizing

†The Effect of Saline and Alkaline Waters on Domestic Animals. V. G. Heller, Oklahoma Bulletin No. 217 (1933).
A dairy cow which had developed into an advanced case of "blind stagers" was given treatment described on page 56. After apparent recovery the animal was given good feed and care. A year later when the above picture was taken the animal was in poor condition. At autopsy the heart and liver were found severely atrophied.

saline or alkaline drinking waters seem to depend on the total concentration rather than the kinds of salts present, and that with very alkaline water a chronic enteritis develops. This investigator also noted that the water consumption is reduced somewhat during an adjustment period which all animals require when suddenly restricted to saline waters for drinking purposes.

The observations of the writers with livestock on the Wyoming ranges are in accordance with Heller's findings. When restricted to an area whose sole source of drinking water may be only the alkaline water of a lake or stagnant pool, the animals at first exhibit diarrhoea and lessened water consumption. After a
Animal suffering from "alkali disease" developed while feeding on native hay grown on Morrison shale.

short time, however, the animals adjust themselves to the conditions so that no marked detrimental effects are observed. "Alkali disease," "blind stagers" and similar diseases are affections which, in the light of our present knowledge, develop irrespective of the source of drinking water. A considerable number of the cases observed by the authors were in herds whose sole source of drinking water was from mountain streams, the waters of which are uncontaminated with alkaline or other salts. The terms "blind stagers" and "alkali disease" are used interchangeably by stockmen.

Note the condition of the rear hoofs. This typical range case was autopsied. The heart, liver, and kidneys showed severe injury.
Another range case of "alkali disease." Note the condition of the hoofs which produced soreness of the feet. This condition made walking very painful. The animal was in fair condition.

Although it is evident that the causes of both conditions are quite similar, the authors prefer to designate those cases which exhibit impairment of vision as "blind staggers" and the cases which exhibit bone and hoof affections particularly as "alkali disease." The writers do not believe that a distinction such as the above is proper, since so many of the symptoms and the pathological lesions of both maladies are similar. Ash analyses of the plants which may produce this poisoning reveal the presence of
one or a number of the following elements: Selenium, molybdenum, arsenic, tin, manganese, copper. Whether all these elements are present in the plant in toxic combination and in sufficient quantities to exert toxic effects is not known. It is believed that the variations in number and kind of elements present in the various plants may account for the slight variation in symptoms and hence the justification for designating certain groupings of symptoms as "blind staggers" and others as "alkali disease."

The desirable vegetation, for grazing purposes, growing on certain Cretaceous shales, for example, Niobrara, Steele, and Morrison, carries varying amounts of these poisonous elements. In a sense the desirable forage growing on such shales becomes poisonous. This form of poisoning is insidious, since it is so chronic it requires from six months to two or even three years for its development.

The untrained man does not easily recognize the symptoms of this type of poisoning until the case is well developed. By that time the liver and heart are permanently injured. Plants causing acute deaths are ones which always elaborate a toxic principle regardless of their soil association such as death camas, (Zygadenus), larkspur, arrow grass, etc., and which may be partially avoided by the careful handling of the stock in the infested areas and by the proper use of specific antidotes. When stock is restricted in its grazing to the vegetation of one of the above mentioned dangerous areas, it is obvious that it will be difficult to prevent poisoning.

Progress and Symptoms of Poisoning by Mineral-bearing Plants

As stated in the foregoing paragraphs, this form of poisoning is chronic and may require from a few months to several years to develop. It resembles locoism as the latter is observed in this state. Since there is such a variable period in the development of the symptoms, it is believed that certain areas either carry the toxic elements in greater concentrations or in a more available form. It is also probable that the type vegetation growing on these shale areas in which there is a more rapid development of the poisoning has greater selectivity for the dangerous elements.
This heifer received small quantities of selenium as sodium selenide over a period of four months.

The affected animals exhibit roughened coats and are in poor flesh. There are serious nutritional disturbances, especially pertaining to the calcium and phosphorus metabolism. The writers believe that glands of internal secretion are involved. Parathyroid glands have not been studied histologically. The adrenals in the early stages of poisoning are hemorrhagic and later become atrophied.

In the first stages of "blind staggers" the animal may only show a tendency to stray from the main herd. There is at this stage a slight impairment
Two calves have received small quantities of molybdenum over a period of two months. These animals are almost rabid in the manner in which they chew bones and metallic objects.

of vision, which may not be noticeable except for the apparent misjudging of objects in its path or distances. The next stage is characterized by more pronounced blindness and the development in the majority of cases of a depraved appetite, generally seeking a particular plant such as salt bush (Atriplex Nuttallii).

At this stage, too, the deprived appetite is made manifest by the animal's desire to chew fence rails, pieces of bone, wire, nails or any metallic object it may have available.

A condition somewhat similar is observed in sheep. It is not uncommon in sheep flocks exhibiting these abnormalities to have weak lambs. Although proof is lacking for a direct correlation, there is evidence that the injury to the mother partially accounts for this condition. The more severely affected lambs at birth are weak, some even too weak to stand, and die of starvation. Others that are able to suckle develop almost from the first day of life an appetite for chewing and even eating foreign material. At autopsy
wool, sticks, and other foreign substances may be found in relatively large quantities in the digestive tract.

In cattle, as blindness develops, the animal shows a greater tendency to wander, often aimlessly in circles. Should the animal encounter a solid object such as a building or a fence, an effort is made to push the body forward with the result that the forepart of the body may slump forward, with the neck resting against the encountered object. The animal seems unable to realize that it has only to turn to the side to be free. In the last stage, which is characterized by varying degrees of paralysis, most animals are nearly blind. There is evidence of severe abdominal pain. The animal grates its teeth, salivates (drools) profusely, and emits grunts. At regular repeated intervals it exhibits a quick start, as if it had been given an electrical shock. The paralysis becomes more or less complete as it is no longer able to hold its head up or execute swallowing movements. Death is caused by the failure of the respiration.

A few hours prior to death the respiration is greatly accelerated although pronouncedly labored.

It must not be inferred that all animals develop the eye affection. The majority of cases do. The eyelids become swollen
Illustrates the first stage of poisoning by mineral-bearing plants. This animal exhibits no marked abnormality save for an impairment of vision.

The eye of an advanced case of mineral poisoning. The whole cornea is an opaque white tumorous mass exhibiting areas of hemorrhage in the sclera.

and tears flow profusely. Again the internal changes in the eye ball vary even in cases in the last stages of poisoning.

Some cases only reveal a slight turbidity of the aqueous humor, while in others the whole cornea may become a white opaque tumorous mass protruding beyond the curvature of the eye ball, making it impossible to distinguish between cornea and sclera.

This white opaque tumorous mass may show in some cases areas of hemorrhage, as if the sclera of the eye were richly supplied with blood vessels which are greatly dilated.

The nerve and eye affections as well as the nature of the growth of the young animals indicate a lack of one or more vitamins. In the seriously poisoned young animals there is a nearly complete arrestment of growth, dullness, and weakness with varying degrees of functional paralyses. There is icterus and anemia. The outstanding lesions in the parenchymatous organs are found in the liver, heart, and gastrointestinal tract. The liver exhibits congestion with mild parenchymatous degeneration in the first stages of poison-
The liver and gall bladder of a sheep which had grazed on vegetation growing on Morrison shale. Compare the size of the distended gall bladder with the liver.

...ing and often assumes a deep yellowish color. In the late stages there is cirrhosis and the organ may atrophy, often developing areas of focal necrosis. It would seem that the poisonous substance is acutely toxic to the liver cell. The gall bladder is usually distended with the bile which, except in rare cases, is normal both as to color and consistency.

In the advanced stages of the disease there is an abnormal stasis of food in the first three stomachs. In the winter cases of this form of poisoning, the contents appear caked in these three organs. The abomasum and intestinal tract generally exhibit varying degrees of irritation leading to hemorrhage in extreme cases. The spleen and lungs are congested. The heart becomes very flabby and inefficient; its musculature becomes atrophic. In the chronic cases the endocardium shows inflammation. It is not uncommon to find numerous areas of hemorrhage in the epicardium. The kidney in the early form of the disease may show but slight parenchymatous degeneration. In the advanced
cases, however, there is marked irritation in the tubules, the whole medulla being hemorrhagic. The abdominal cavity contains ascitic fluid. The bone marrow is fatty.

The ends of long bones may show marked erosion.

**Treatment.** The treatment of the "blind staggers" group of symptoms in cattle is successful for all stages prior to the final paralytic stage. It is important to treat before the oncoming paralysis begins to involve the respiration, however. The treatment consists of giving hypodermic injections of strychnine sulphate and drenching with water as warm as will not cause injury (120-130° F.). A solution of the drug is prepared by adding 250 milligrams or 4 grains of strychnine sulfate to 50 cc. or 5 dessert tablespoons of clear water. Each cubic centimeter of the above solution will contain 5 milligrams or 1/13 grain of strychnine. For a five to six hundred pound animals inject 1 cc. (5 milligrams) every two hours until three or four doses have been given. For animals up to eleven hundred pounds increase the dose accordingly to 2 cc. (10 milligrams). The region of the shoulder is a convenient place to inject. It is never advisable to inject more than 10 milligrams or less than 5 milligrams at one injection. Animals in the advanced stage of "blind staggers" are administered only 1 cc. (5 milligrams) regardless of size and such injections continued for a longer period. Although three or four injections are usually sufficient, the condition of the animal will determine the number of injections necessary to make. The indication that the animal
is becoming saturated with drug will be a sudden start or jump when it is tapped gently on the back. Do not inject more drug while the animal gives such an exaggerated jerk or jump. Simultaneously with the administration of the strychnine should be the drenching of the animal with warm water as indicated above. Drench one-half to 3 gallons of water every two hours. This drenching should be continued through the second day of treatment or as the case at hand will require. After this treatment ordinary cases overcome the stupor and blindness and are able to eat and drink by themselves. In advanced cases of poisoning the treatment may have to be prolonged and hand feeding resorted to for a few days.

A good concentrated feed such as a little grain or cottonseed cake with good hay will cause the rapid recovery of the animal when it is again able to feed.

A small 2 or 5 cc. all-metal syringe is most convenient for the injections. Before any injections are made, make sure that the right amount of drug is being given. Boil the syringe after each injection to insure sterilization.
Two-Grooved Milk Vetch (Astragalus bicusculus [Hook] Gray): This legume forms large clumps and is readily distinguished by the violet flowers and by the pods which on the lower side have a marked ridge with a sharp groove on either side of the ridge.
TWO-GROOVED MILK VETCH

In a previous publication the statement was made that two-grooved milk vetch (*Astragalus bisulcatus*) seemed to be variable in its poisonous properties. It is now known definitely that it is variable depending upon the type of soil upon which growth occurs. It is a deep rooted plant, in fact, in this respect it resembles a shrub. The presence of a characteristic, disagreeable odor has been found to be a certain indication that (a) that plant has been produced on a Cretaceous shale, and (b) the poisonous mineral selenium is present.

The near relative *A. scobinatus*, occurring in the southwestern part of the state, likewise, is much more poisonous when occurring on a shale area such as the Lewis, Bridger, etc. The summary that follows pertains to *A. bisulcatus* (two-grooved milk vetch).

Where it grows. Quite generally scattered over the state. Grows in dense clumps and attains a height of from two to three feet. It grows mostly on the moist sides of ravines and gentle slopes and on soils carrying more or less alkali.

When it appears. Usually well advanced by the middle of May, in bloom by June, and quite matured by the last of July. Variations in altitude, moisture, and weather conditions naturally modify this or any other plant’s growing period. The plant can withstand moderate frosts so that parts of the plant remain green until late October or early November.

Animals affected. Poisonous to sheep and cattle. No definite information available on other types of livestock.

Poisonous period. It is a dangerous plant during its entire growth. The poison is quite thoroughly distributed in the stems, leaves, flowers, and seeds. When growing upon such geological formations as Niobrara, Steele, and Morrison the plants are much more toxic than those growing on soils where poisonous minerals are not taken up.

This vetch, along with other selenium-bearing plants, is also involved in imparting toxicity to at least several of the important forages. The decay of roots and old plant parts returned annually to the soil becomes a potential source of selenium, molybdenum, etc., which are available to growing crops.


Treatment. Described on page 56.

Remarks. This plant is frequently confused with the plains larkspur. It is highly desirable that one should recognize this vetch and particularly so if there is a possibility that it is growing on soils from which poisonous minerals are taken up.

Above—Two-Grooved Vetch on soil from Niobrara shale.

Below—Vetch plowed under and ground sown to barley. The mature grain was found to be toxic.
TIMBER MILK VETCH

This vetch, in common with certain other related plants, has a highly selective root system. Plant collections taken from one of its natural ranges in Uinta County, on the Bishop conglomerate, have been studied chemically and physiologically. The conglomerate referred to above is a geological formation derived largely from the adjoining Uinta Mountains that are quartzitic in character.

The mineral-bearing plants associated with the Cretaceous shales normally carry a relatively high ash content (inorganic matter). This is to be expected, since these shales carry considerable saline material. The timber milk vetch is low in ash, but the number of constituents taken up by this plant is significant. Since poisoning by this plant has shown pronounced evidences of mineral activation, a quantitative chemical analysis of the inorganic elements has been made.

Analysis of the plant ash:

- Sand and Silica ........................................... 6.02%
- Lime (CaO) .................................................. 14.66%
- Magnesium (MgO) ......................................... 6.01%
- Lithium, Copper, and Manganese ........ Small Amount
- Arsenic and Molybdeum .......................... Trace

These percentages are computed with the total ash as the base which in turn was 6.08% of the air dried plant.

The following additional inorganic constituents were found. The percentages have been computed directly on the basis of the air-dried plants:

- Phosphorus (P₂O₅) ........................................ 0.50%
- Sulfur (S) .................................................... 0.16%
- Chlorine ..................................................... 0.17%
- Sodium and Potassium (Chlorides) .......... 4.72%
- Potassium Chloride .................................... 4.49%
- Tin (Sn) ....................................................... 0.0029%
- Selenium .................................................... Trace

This particular vetch is a choice forage because of its fine stems and leaves. Sheep held experimentally on an area carrying timber milk vetch as the major cover will select it in preference to other feed. The danger zones in Wyoming lie in the western slope of the Hayden Forest, the foothills of the Uinta Range, and scattered patches in the Wyoming National Forest. The eating of this plant does not appear to be an acquired habit.
Timber Milk Vetch (*Astragalus campestris* Gray; *Astragalus hypophyllus* (Rydb.) A. Nels): Photograph shows a few of the timber milk vetch branches. In nature it grows in roundish tufts. The little pea-like scanty flowers vary in color from creamy white to bluish. Its habitat is limited to aspen groves. Average height 6 to 8 inches.
Natural habitat of timber milk vetch among aspen associations.

Where it grows. Among aspen groves (6000 to 8000 feet) in southwestern and western Wyoming. Collections to date for experimental purposes have been obtained from those geological formations classified as the Bishop conglomerates. To what extent it may be found on the Cretaceous or related formations has not been determined. It is possible that the timber milk vetch may vary in its toxicity in a manner similar to *Astragalus pectinatus* and *A. bisulcatus* depending upon the character of the soil upon which the individual plants grow.

When it appears. It is well established the last of May, blossoms in June or early July, and seeds shortly thereafter. It grows in shady areas and retains its freshness until late fall.

Animals affected. Sheep and cattle mainly.

Poisonous period. Is not definitely known. However, few losses are reported as occurring before July. Restricted grazing on forests might account for this. No experimental feeding has been done in Wyoming on the young plants.

Cattle are very susceptible to poisoning by this plant. Whereas 500 grams of air-dried plant is sufficient to kill a 300-pound calf when such an amount is given in two daily doses, a tolerance can be built in another calf to withstand a daily dose of 300 grams for ten days if the said animal be given previously small daily doses of 25 grams and the dose is gradually increased over a matter of three to four weeks to a dose of 300 grams.
Symptoms. In general animals to which this plant has been administered exhibit symptoms similar to those described on page 50. However, the poisoning is more severe. There is anemia. Prior to death the animal in walking knocks its heels together. This is undoubtedly due to constitutional weakness.

Treatment. Described on page 56.

Remarks. Stock poisoned by this plant exhibit symptoms suggestive of metallic poisoning. Ash analysis of the plant reveals the presence of comparatively large amounts of tin. It is probable that the presence of this element in organic combination exerts, at first, effects characteristic of the organic compound in question, and that upon dissociation the metallic ion produces the physiological effect more or less common to all metallic ions.
Woody aster is known to be more than a poisonous plant—it arrests growth of other vegetation and contaminates the soil with poisonous minerals it has liberated through its root system.

**WOODYASTER**

In years past woody aster (*Xylorhiza Parryi*) has been accused of being the sole cause of severe losses of sheep in certain areas. It is now believed that other closely associated mineral-bearing plants, particularly *Astragalus Grayi* and *Oonopsis condensata* shared in the poisoning. At the present time, acute losses are being greatly reduced by careful practices in the handling of sheep. Woody aster varies widely in its poisonous properties dependent upon the type of soil upon which it grows. It is quite exclusively associated with those geological formations known as Cretaceous shales. In fact, this plant may be quite safely taken as an indicator of soils containing the poisonous mineral selenium.

It propagates by seeds and through underground root budding.

**Where it grows.** It is very selective in its habitat and is confined quite exclusively to those geological formations which are essentially shales. During the past two decades it has spread to practically every county in the state. The woody aster is shallow rooted. Once it becomes established on a range its dominant character is conspicuous. Woody aster may in some instances be confused with other plants such as *Oonopsis condensata* and *Erigeron pumilus*. A close inspection of the root systems and flower arrangement will enable one readily to distinguish the true woody aster.
Woody Aster (Xylorhiza Parryi Gray): The upper picture illustrates a clump of aster in bloom. The large daisy-like white flower heads are borne upon branches emanating from one root. The basal portion of the plant is shown in the lower photograph.
When it appears. It can usually be recognized by May 1. The flowers appear about the middle of June. About July 1 the plants begin to dry out, and by August the above-ground portion disappears through the action of weathering and trampling of livestock.

Animals affected. Sheep mainly. One cannot say to what extent other types of livestock may be affected indirectly through the contamination of grasses and other palatable forages.

Poisonous period. Forced feeding of sheep has shown that plants from one geological formation vary but little throughout the active growing period. It may be stated as a general thing that woody aster from such geological formations as the Benton, Lewis, Hilyard-Cody, and Wasatch are very much less poisonous than those occurring on the Niobrara, Steele, and Pierre shales. This is in part explained by the varying selenium content in the plants.

The poison is cumulative. Small daily feedings of approximately 5 ounces of green plant per hundredweight of sheep have resulted fatally in three to four days. Deaths have been obtained in a few hours by forced feeding of as little as 14 ounces of green plant per hundredweight of sheep.

Symptoms. Described on page 50.

Treatment. Described on page 56.
NARROW-LEAVED MILK VETCH (Astragalus pectinatus Doug.) In this vetch the leaves consist of many small leaflets which are very narrow and regularly spaced in pairs along the mid-rib. The plant springs from underground root-stalks and becomes 9 to 18 inches high. The branches are low and spreading. The large pale yellow or almost white flowers are conspicuous and produce numerous oblong pointed pods, from a half to one inch in length, which when almost ripe become red or red-brown. When mature the pods are tough and leathery, though somewhat fleshy on the outside and contain several small grey-brown seeds.
NARROW-LEAVED MILK VETCH

The narrow-leaved milk vetch (*Astragalus pectinatus*) has not been referred to previously as a poisonous plant. It has a wide distribution. To what extent the plant is eaten by livestock is not known. Nevertheless, the presence of selenium, molybdenum, and other poisonous minerals in the plant places it at least in the class of a soil contaminant. Its root system resembles that of the two-grooved milk vetch. In its selection of rare minerals it has been found to differ from the other mineral-bearing plants listed, in that appreciable amounts of selenium have been found in specimens collected on the Chugwater (Red Beds) and the White River formations where no other species has been found which contained this element.

Where it grows. Quite generally distributed over eastern Wyoming. Its habitat is quite similar to the other poisonous vetch, *A. bisulcatus*, although not so much restricted as to soil types.

When it appears. Usually does not appear as early as the two-grooved milk vetch. It is in full bloom in June. The conspicuous fruits appear during July and remain for some time. In some instances these fruits make up 70 per cent of the total weight of the above-ground portion of the plant.

It is propagated by seeds and underground root-stalks.

Animals affected. No definite data. Forced feeding has demonstrated it to be equal to the two-grooved milk vetch in its toxicity.

Symptoms. Described on page 50.

Treatment. Described on page 56.

Remarks. Since this is a deep rooted plant and propagates by underground roots, it is evident that a soil will in time become badly infested with decayed roots. If the plant has grown upon soils derived from one or more of the mineralized shales, it will follow that such soils will cause normal forage to become toxic.
Oonopsis (Oonopsis condensata A. Nels.) This is a low, very leafy plant with several dull yellow flowers crowded together in a leafy cluster at the top of each short stem. The root is woody and the stems grow from the permanent crown or crowns. The leaves are long and narrow and bright green in color.
Oonopsis condensata is the most uniform concentrator of selenium, molybdenum, etc., examined by this Experiment Station to date. It is doubtful if the plant is eaten by livestock, if so, only sparingly. The dried stalks and leaves normally remain in position throughout the winter. Like the woody aster, it dominates a range once it has become firmly established. Ground Oonopsis mixed with a fertile soil is extremely toxic to plant growth, probably due mainly to the toxicity of the element selenium as combined in this particular plant.

Where it grows. This particular species like woody aster has spread considerably during the past few decades. Since other species of Oonopsis occur widely distributed over the state and no chemical tests have been made as to their selenium content, it is not possible at this time to comment on them. Oonopsis condensata was originally reported to occur in restricted areas on the Laramie Plains. This species has not been observed to occur off the Cretaceous shales.

When it appears. It appears about the same time as woody aster but remains green until late summer.

Animals affected. No definite data.

Poisonous period. Throughout its active growth. The dried-up stems and leaves contain toxic quantities of selenium. Feeding tests have demonstrated it to be a very poisonous plant.

Through its contamination of the soil with poisonous minerals it naturally becomes a menace to other forages.

Symptoms. Very similar to Gray's vetch and woody aster in producing more nearly the true metallic type of poisoning. See description on page 50.

Treatment. Described on page 56.
Gray's Milk Vetch (*Astragalus Grayi* Parry). This milk vetch is quite similar to the narrow-leaved species but the leaflets are broader and more strongly veined and the pods stand up instead of drooping, besides being smaller and lacking the red-brown coloration of the pods of the narrow-leaved milk vetch.
GRAY'S VETCH

Gray's vetch and the woody aster are usually associated together, although the latter has a wider distribution. Gray's vetch propagates by seeds and underground root-stalks. It has not been observed to grow other than on the Cretaceous shales. No samples have been collected to date which have not contained selenium. Usually molybdenum is also present.

Where it grows. Through the western half of Wyoming.

When it appears. Has about the same period of growth as two-grooved milk vetch.

Animals affected. No definite information.

Symptoms. Described on page 50.

Treatment. Described on page 56.
Nuttall's Saltbush (*Atriplex Nuttallii* Wats). This plant is sometimes erroneously called salt sage. It is a perennial with a woody root and a spreading crown of short woody stems, from which spring numerous annual upright twigs that bear the leaves and the inconspicuous flowers. The stamens and the pistils are borne on different plants, and therefore only about half of the plants bear the seeds. This species may be recognized by the large rough irregular tubercled seeds which are borne in abundance in the axils of the leaves.
NUTTALL'S SALTBUSH

Nuttall's saltbush (*Atriplex Nuttallii*) has a wide distribution over the state and constitutes ordinarily an excellent forage for livestock, particularly sheep. It is commonly called salt sage. From time to time sheep losses have occurred in localized areas from what appears to have been plant poisoning, and this saltbush was the dominant forage. In our preliminary survey of native plants occurring on geological formations grouped as Cretaceous, it was found that this species invariably carried selenium when collected from the Niobrara shale unaltered or slightly so. Specimens obtained from other shale areas, with the exception of the Wasatch, have not been found to contain selenium.

**When it appears.** It is quite succulent throughout the year.

**Animals affected.** No definite information. Because it is largely a sheep forage, the probable conclusion would be that most injury would involve this class of livestock. Lambs weighing 40 to 45 pounds were force fed upon Nuttall's saltbush from Niobrara formations in moderate daily amounts. They lost during the experiment as high as 22 per cent of their body weight. During this time supplementary feeds of good quality were used. These lambs developed impairment of vision and became stunted. When they were placed upon good quality alfalfa hay and cottonseed cake without the saltbush, no gain in weight was made in one month's time, indicating more or less permanent injury. They were then released from the experimental pens.

The saltbush used in this work contained medium amounts of selenium. The occurrence of selenium in saltbush taken from the Wasatch shales is localized. The studies at this station have not been broad enough to draw conclusions as to what extent this saltbush may be contaminated with poisonous minerals.

**Where it grows.** It is common throughout the state where soils carry appreciable amounts of saline matter, but appears generally to be a safe forage. Some of the poisonous saltbush areas of the state have been definitely mapped. Others will be as time and funds permit.

**Treatment.** Probably the same as for the two-grooved milk vetch.

**Remarks.** Medium traces of molybdenum have been found in some samples. Here again the mineral has been found to be localized in certain areas but always associated with definite shale formations.

It is doubtful if saltbush is responsible for many acute or sudden deaths. The poisonous influences are more apt to be cumulative and result in stunted growth, partial blindness, perhaps, too, in the sloughing of wool.
STANLEYA (Stanleya bipinnata Greene). This member of the mustard family is a comparatively large plant with a large fleshy taproot and few or sometimes several stout spreading stems 1 to 2 feet high. The leaves are large, pale green and somewhat thickened and fleshy, being often entire but mostly with elongated lobes on the sides and these again may be cut or lobed. The leaves are mostly crowded on the lower half of the stem, the upper part consisting of a crowded spike of large yellow flowers. The flowers are soon replaced by narrow twisted pods that are raised out of the calyx on a slender stalk (stipe).
STANLEYA

This plant is probably not important as a poisonous plant. Yet it has been found to contain selenium; and on a range where a variety of selenium-bearing plants occur one cannot be certain which species are the cause of particular cases of poisoning.

Stanleya bipinnata is quite leafy and succulent. Collections made on typical Cretaceous shales have invariably shown the presence of selenium in rather large amounts. Other species of Stanleya occurring in the state have not been examined.

Where it grows. It is usually found in restricted areas, but widely distributed over the state.

When it appears. It has about the same cycle of growth as the vetches.

Animals affected. No definite data.

Poisonous period. Feeding tests and chemical analysis of its selenium content point to the fact that it is poisonous throughout its growing period.

Symptoms. Typical of those produced by the general group of mineral-bearing plants. See description on page 50.

Treatment. Described on page 50.
Mentzelia (Mentzelia decapetala [Pursh] Urban and Gilg.)
The Mentzelia is large and coarse with several stems from the top of the deep-set root. It becomes 2 to 3 feet high, bears several large showy white flowers that open in the evening (around 5 o’clock). When fully open these are 2 to 3 inches across, with 10 petals and numerous stamens. The leaves are quite rough with short hooked hairs, so that if the plant comes in contact with one’s clothing it clings quite tenaciously.
MENTZELIA

*Mentzelia decapetala* is probably not of importance, directly, as a poisonous plant. It seldom occurs on suspicious shales in quantities of any considerable magnitude. The plants are large and leafy, consequently some selenium concentrators some significance must be given them. Other species have not been examined.

**Where it grows.** It is widely distributed and in a variety of soil types. The studies at this station have been given only to those plants taken from representative Cretaceous shales such as Niobrara, Fort Steele, etc.

**When it appears.** Usually during May. Fully matured plants may be found by August, although altitude and weather conditions greatly modify its growing period.

**Animals affected.** No definite data.

**Poisonous period.** Like all of the native selenium-bearing plants it is doubtless toxic throughout its growth.

**Symptoms.** Feeding tests indicate the same general type of poisoning as described on page 50.

**Treatment.** Described on page 56.

**Remarks.** While the fleshy part of the plant carries no objectionable odor or taste, yet its composition or texture renders it quite unpalatable to livestock.
III. PLANTS WHICH ARE SOMETIMES POISONOUS TO DOMESTIC ANIMALS

There are times when minor livestock losses occur, and the cause or contributing agencies are not evident upon a casual examination of the suspected ranges. In instances of this kind attention to those plants not ordinarily suspected frequently leads to the correct interpretation of the trouble.

From time to time in eastern Wyoming there has developed an ailment among horses which, in general, resembles lichen poisoning in its symptoms. It is now certain that the plant responsible is *Artemisia filifolia* (true sage). The disease is referred to as "sage sickness." Briefly the symptoms noted are: Temperatures normal, respiration somewhat rapid, nervousness, tendency to fall when compelled to move quickly. In the act of walking the hindquarters seem to execute normal movements while the fore limbs seem partly paralyzed. Horses continue to eat and drink normally; in fact, besides the unsteady gait no marked injury results.

The "sage sickness" develops within a few days after horses have access to the sage. After a time a tolerance develops so that an animal may eat large quantities of this sage daily and show no ill effects. The substance responsible for this action is contained in the volatile oil of the sage. A change of feed accompanied by the administration of a laxative is a satisfactory treatment.

Unless horses which have not previously acquired tolerance are suddenly introduced in an area where large quantities of sage will be eaten due to the scarcity of other vegetation, "sage sickness" need not be feared.

The *Solidagos* (goldenrods), particularly the dwarfed types, occasionally are responsible for livestock losses. The most common range species are *Solidago mollis* and *S. cocinna*. *S. mollis* is the more toxic of the two mentioned goldenrods.

The toxic principle of the goldenrod is very irritating. Two doses of one pound of the partially air dried plant given four
hours apart caused the death of a sheep twelve hours later with symptoms of nausea, vomiting, general distress, and an accelerated respiration. The resins isolated from the plant were found corrosive when administered to small laboratory animals. The administration of small quantities of the plant in the feed of calves and sheep causes loss of body weight. The administration of small quantities of extracts of the plant to small laboratory animals produces also a severe loss of body weight.

American groundsels (species of Senecios) should be included in the list of minor poisonous plants. Some trouble has been reported from eastern Wyoming which may have involved some one of the groundsels, possibly S. Riddellii. For detailed information the reader is referred to the experimental work of Van Es*, Cantwell, Martin and Kramer, and of Mathews†.

Cockleburs occur widely distributed in the state, chiefly in river bottoms or flats covered with wash from nearby hills. Only the young plants are toxic. Those beyond the cotyledon stage are said to be so mildly toxic as to be relatively unimportant as poisonous plants. Marsh‡ reports that young cockleburs are poisonous to swine, cattle, sheep, and chickens and that beneficial remedial effects may be produced by the use of milk, oils or fats.

Flag Lily (Iris missouriensis) occurs widely distributed over the state. The corms or root-like tubers have been reported by Parmmel¶ to be poisonous. Since this plant is frequently cut along with native hay some question has arisen as to its possible poisonous properties. The coarse leaves when dry are unpalatable but under range conditions they are eaten nevertheless.

The physiological work on this plant has been restricted to laboratory animals. The plant is not dangerous unless ingested in large quantities. The poisoned animals are depressed with the respiration being seriously involved. Previous to death the respira-

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*On the Nature and Cause of the "Walking Disease" of Northwestern Nebraska. Nebraska Agricultural Experiment Station Research Bulletin 43-47 pp. (1929.)
†Texas Agricultural Experiment Station Bulletin No. 481. (October, 1933).
tory rate is lessened and there is dyspnœa (labored breathing). Death is due to respiratory failure.

**Ergot.** Poisoning due to ergot is relatively unimportant in this state. Although stockmen occasionally suspect ergot, upon investigation the trouble can generally be attributed to other causes. Horses and cattle seem quite susceptible to this form of poisoning. There is a disturbance of the gastro-intestinal tract. Ulcer formation is not uncommon. Animals seriously poisoned do not seem to recover fully even under the best of conditions.

**Moldy Hay.** Poisoning due to moldy or improperly cured hay is rather common. It is mentioned here because it is often confused with poisoning caused by poisonous plants. Horses are much more susceptible to this type of poisoning than other animals. The symptoms are those of severe indigestion with colicky pains. The respiration becomes accelerated and labored. Convulsions appear after the animal has exhibited much distress.
The following publications of the Wyoming Experiment Station may be had upon request: (Revised list, May, 1933.)

**ANNUAL REPORTS—**
12th to 40th, inclusive (1901-2 to 1928-31, inclusive).

**INDEX BULLETINS—**
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**STATE FARMS BULLETINS—**
4. Some results from Agricultural Stations over the State from 1923 Report.
7. The Service of the State Experiment Farms.

**CIRCULAR—**
17. Feeding Yearling Steers.
18. Abortion Disease in Wyoming.

**BULLETINS—**
92. The Value of Fiber Testing Machines for Measuring the Strength and Elasticity of Wool.
101. Zygadenine, the Crystallin Alkaloid of Zygadenus intermedius.
110. Sweet Clover.
112. The Poisonous Properties of the Two-Grooved Milk Vetch (*Astragalus bisulcatus*).
113. The Effect of Alkali upon Portland Cement.
116. Winter Grains.
134. Wintering Range Calves.
139. Climatological Data for Wyoming.
158. Use of Calcium Cyanide in the Apiary.
163. Results with Tree Planting at the Sheridan Field Station.
169. Artificial Incubation at High Altitudes.
171. Varietal Tests with Wheat at Sheridan Field Station.
174. Studies with Rambouillet Sheep, No. II.
176. Mexican Bean Beetle.
177. Bacterial Wilt of Alfalfa.
180. Vegetable Cookery at High Altitudes.
182. Grain Mixtures Supplementary to Wyoming Native Hay for Milk Production.
184. Wyo. Forage Plants and Their Chemical Composition No. 9.
185. Barley Tests at the Sheridan Field Station.
188. Studies with Hampshire Sheep No. II.
189. Three Poisonous Vetches.
190. Drifting of Honeybees.
193. Arrow Grass—Chemical and Physiological Considerations.
194. Three Species of Zygadenus (Death Camas).
195. Grasses, Alfalfa, and Sweet Clover at the Archer Field Station.
196. Wool Inheritance in Hampshire-Rambouillet Crossbreds.
197. Range Cattle Production on Mountain Valley Ranches.
198. Influence of Storage upon the Bread Making Qualities of Wyoming Hard Wheat Flours.
199. Factors Influencing the Palatability of Hay.
200. Plants Poisonous to Livestock.


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