Bulletin No. 231 - Poisonous Plants and Livestock Poisoning

University of Wyoming Agricultural Experiment Station
POISONOUS PLANTS AND LIVESTOCK POISONING

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POISONOUS PLANTS AND LIVESTOCK POISONING
O. A. BEATH, H. F. EPPSON
C. S. GILBERT AND W. B. BRADLEY

GENERAL DISCUSSION

Poisonous plants are a hazard to many livestock owners in Wyoming. During the past few years the interpretation of what constitutes a poisonous plant has been greatly broadened. In the light of recent discoveries regarding the activating influence of certain toxic minerals, it has become necessary to include a number of common forages that may be poisonous only under a specialized influence. Grass, cereals and a host of miscellaneous native plants, therefore, may in some areas, be capable of inducing serious ailments in livestock. Consequently the cause of many unusual or little understood stock losses is difficult to evaluate correctly. Chronic mineral cases should be included along with those caused by ingesting plants carrying organic poisons such as occur in the larkspurs, death camas, lupines, etc.

Reliable statistics are not available which show the total annual loss (including those severely emaciated) induced or influenced by poisonous plants. Aggregate losses vary from year to year. There is also a variation in the kind of stock affected for any one year. It is important to keep in mind that the total number of livestock in the state fluctuates considerably from time to time. A low level livestock population, other conditions being the same, should result in allowing the animals a wider choice of range forage, and hence, result in a lessened danger from plant poisoning. It is not known, however, if such a correlation actually exists. In instances where deaths are due to unascertained causes, a satisfactory diagnosis is difficult since some diseases produce symptoms closely resembling those of plant poisoning. When toxic minerals are involved, they are very certain to complicate the pathology in many instances.

Along with the gradual restriction of grazing areas and the improvement in the quality of livestock, there has been notable progress among stockmen in the acquisition of basic information
Trailing livestock through poisonous plant areas can be done safely if preliminary surveys have been made.

Concerning range plant hazards. In the early days of the livestock industry losses from plant poisoning were considered unavoidable. Gradually these beliefs became modified. Cooperative efforts, observations, experimentation, all have contributed in demonstrating that many losses can be avoided or greatly reduced. Superstition and superficial practices are on their way out.

This bulletin is a summary of the research and observation of the Wyoming Experiment Station in the field of poisonous plants. It is to replace Bulletin No. 200, now out of print. In the arrangement and presentation of subject matter in this edition, the authors have attempted to include in as brief a space as possible the latest information available to them. Some of the features occurring in Bulletin 200 have been enlarged upon or modified to conform with experimental data which have accumulated since 1934.

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, and in some cases such protective devices as spines. The depraved appetite for unusual and unappetizing plants is a factor of impor-
Late spring snows at the higher elevations occasionally cover range grasses. The further advanced weeds are generally left exposed: in this instance death camas.

tance 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 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. Native range 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.

After freezing temperatures occur in the fall, practically all the succulent poisonous plants disappear or lose their potency. A considerable amount of poisoning does occur, nevertheless, during the winter months. Some of the significant reasons for this are: (1) DELAYED EFFECT. By this is meant that cattle, sheep and horses grazing upon vegetation activated by toxic minerals
may not exhibit symptoms for many months after leaving the summer ranges. (2) GROUND LICHEN. Scarcity of forage may cause animals to eat the lichen resulting in the paralysis of sheep and cattle. (3) WEEDS IN HAY. Carelessness in cutting and stacking hay that includes arrow grass, lupines, or the two-groved milk vetch often results in losses of livestock. Sorghums cut and stacked before being properly cured may retain their poisonous properties for a long time after harvesting. (4) OAT HAY AND STRAW. Heavy cattle losses have occurred in the winter months from ingesting oat hay or straw. (5) OPEN GRAZING. It is known that many of the choice, palatable range plants that are rooted in poisonous shales retain their toxic character quite unaltered during freezing temperatures. Well-cured toxic cereals and forages that are poisonous because of their mineral content retain their potency for long periods.

Livestock vary in their tolerance to plant poisoning. Larkspurs, for instance, may be fatal to cattle but sheep are rarely affected.

Horses are more selective in their grazing habits than cattle. A hog can emit distasteful or irritating food by vomiting, while sheep, cattle and horses do so only rarely. Aside from the tolerance and individuality of an animal, one finds that its physical state and range environment greatly influence the actual losses from injurious plants. A change of range or pasture is always significant, particularly during the period of the spring and fall adjustments.

Trailing livestock through poisonous plant areas is always hazardous. Water holes and resting places are frequently selected because of their convenience. Trails, too often, are chosen to avoid physical barriers and distances. A serious hazard is to trail livestock through fenced lanes, particularly those known to carry dense growths of poisonous plants.

Fatigue, scarcity of palatable forage, lack of water and under-salting, all contribute to the stimulation of a depraved appetite in livestock.

The one-night camp for sheep is desirable in dangerous areas. The shortage of feed that naturally results in the immediate vicin-
A sheep trail confined to a narrow lane. Losses have been severe here in the fall of the year because of the abundance of seleniferous plants. In the fall of the year because of the abundance of seleniferous plants.

ity 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.

Although it is commonly thought by stockmen that toxic plants such as larkspur are more poisonous after they are wet with rain, there is no experimental evidence to substantiate this belief. The presence of moisture no doubt increases the rate of absorption of the poison from the plants, but the occurrence of many cases of poisoning in animals far from water sources indicates that additional water is not necessary to activate the poisonous constituent.

SALT REQUIREMENTS

In winter grazing many stockmen assume that the salt content of various forages is adequate to satisfy an animal's requirements. Consequently undersalting may result. It is our belief that a good grade of salt should be available throughout the season. Another common practice that is not justified in view of available chemical evidence is to undersalt where livestock have access to water in alkali basins.
Arrow grass, one of our troublesome poisonous plants, contains appreciable quantities of sodium chloride (common salt). There are numerous cases on record where undersalted livestock have grazed arrow grass for its salt content and with fatal results.

The salt requirements of stock vary with the season. The early spring feeds are lower in mineral matter than those occurring later in the season. As a general rule common salt need not be supplemented with costly mineral mixtures unless special cases of malnutrition occur. It is suggested that the stockowners submit these special problems to those qualified to pass judgment on them. If the cause is known, a satisfactory treatment procedure can usually be obtained.

The feeds grown on certain shale areas (see discussion on poisoning due to mineral-bearing plants, Part II) 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. An autopsy may show the rumen of such animals to contain an unbelievable quantity of odd objects, the most common being wire, nails and other metallic objects. In such an 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 and selenium which are 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 any calcium compound in which the calcium is readily available would be as efficient.

SEASONAL CONSIDERATIONS

While it is generally true that a normally developed poisonous plant does not vary appreciably in its poisonous properties from one soil to another, yet there is one factor that is important. During a period of drought many poisonous plants do not attain full maturity and retain the toxicity of young plants. If the following
season is favorable, the stimulation of normal or excessive growth may be anticipated, and with this an increase in the amount of plant poison may occur. In one instance it was found that the poison content of the flowers of a low larkspur species was nearly four times normal. There is reason to believe that some of the lupines, particularly the woolly lupine, may vary considerably from year to year in their poisonous properties. The lupines as a group concentrate the poisons (alkaloids) in the green fruits (pods and seeds). If the fruits fail to develop normally, there is evidence to indicate that the leaves acquire more than a normal amount of the poisonous substances.

PLANTS THAT ATTRACT

Some publications on poisonous plants seem to imply that by doing certain things or avoiding certain others, all trouble can be prevented. Those who have direct experience with livestock on the range know that not all losses from poisoning can be avoided by any one procedure. Livestock losses occur from time to time from plant poisoning when wholesome forages would appear adequate. Consequently the statement that livestock browse only on poisonous plants to escape starvation is not entirely a valid generalization.

A few illustrations are cited to explain some of the important exceptions. Larkspur flowers not only contain poisonous compounds but are rich in a sweetish substance known as mannitol. Consequently grazing animals are attracted to them. Some of the heaviest losses of cattle occur during the time that the larkspurs are in bloom, which very frequently occurs on ranges and in forests that are amply supplied with excellent safe forages. In the late summer and early fall cattle losses may reach alarming numbers from the preferential grazing of the poisonous two-grooved milk vetch. It is not uncommon for cattle to select this weed even in the presence of choice cut-over alfalfa and hay meadows. Arrow grass has been referred to in connection with its salt content. Sheep losses have occurred from grazing on death camas at a time when the plants were unattractive and other safe forages were available. The only interpretation one can place upon this kind of selective grazing is that these plants are sought out and
Larkspur flowers frequently attract cattle to them even on ranges amply supplied with wholesome forage.

eaten at times, presumably for some particular element or food substance not supplied by other forages on the same range.

The purplish flowered loco weed known to botanists as *Oxytropis besseyi* is responsible for heavy losses of sheep in the Owl Creek Mountains. Losses occur in wet seasons and dry. Consequently it is not a case of sheep being compelled to graze the loco weed to ward off starvation. Not all sheepmen using the Owl Creek Mountains encounter serious trouble from the loco. It is believed that the shale ranges lower down may contribute predisposing conditions that complicate and possibly activate effects of the loco later on. A survey of the region at the time of its use indicates that the loco weed is not sought out previous to the formation of the fruits. It is the authors' belief that these fruits attract sheep to them for their fatty matter in preference to forages not so constituted. Sheep of all ages and both sexes are involved. Following the full maturity of the fruits the grazing of the loco diminishes. The field evidence indicates that upon this particular range, sheep do not become addicts to the loco. This observation is further verified when the same sheep return to the mountains the following year. There is no indication that sheep which had been locoed the previous year select the loco in preference to other browse.
IMPORTANT POISONOUS PLANTS

Poisonous range plants may be conveniently grouped according to distribution. Those having a wide general occurrence include species of larkspurs, lupines, woody aster, death camas, cicuta, arrow grass, loco, milk vetches and Stanleyas. Those plants having more or less restricted distribution include species of wild asters, goldenrod, sneezeweed, cocklebur, ground lichen, chokecherry, senecios, salt bush, timber milk vetch, tansy aster, iron plant and of course many others that are under suspicion.

Ergot is common in some sections of the state, but it is not believed to be a serious problem to stockgrowers. Forage poisoning resulting from moldy hay, cornstalks, etc. is of minor significance.

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 that those in charge of livestock acquire accurate information relative to their animals and range conditions. Even then, some stock owners will 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 the time of their initial appearance on through to maturity and that only in a very few instances do animals acquire a depraved appetite for harmful plants.

Emphasis should be placed upon the importance of acquiring the fundamental data regarding any range, and facts about the chemical composition of the crops and feeds which 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 in which both, infectious and other diseases and poisoning by plants may occur, will find it profitable to acquaint themselves with the basic information needed to diagnose many of the ailments which occur 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 preventive measures 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. Coccidiosis is at times confused with irritant plant poisoning.

An incident of a little different nature came to the attention of the authors recently. On a certain ranch there had been from time to time losses of valuable horses. The owner did not realize that poisonous plants in his hay could account for his trouble. This unnecessary loss was due to lack of information. During the course of a year many such cases come to the attention of the
writers. A proper diagnosis of a given case would often have saved an owner considerable expense and anxiety and at the same time would have lead to worthwhile remedial measures.

ANTIDOTES

Some poisonous plants are so generally distributed in certain areas that it is impossible to escape them entirely even under the most careful methods of range management. As an illustration, consider the conditions that prevail at lambing time in many sections of Wyoming. The sheep are held or confined to limited areas in the vicinity of the lambing sheds or ground. This causes close grazing of all available forage. Death camas, woody aster, two-grooved milk vetch and a host of other poisonous plants may, to some degree, occupy these same ranges. Since poisoning under these and other unusual conditions is difficult to avoid, considerable time has been devoted to the study of 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 antidotes requiring intravenous (in the veins) administration to be effective would not in most cases be practical under range conditions. The drugs used and the method of treatment in poisoning from arrow grass, death camas, larkspur and ground lichen will be described later in the bulletin under the heading of the plant in question. By using 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 one of the foregoing plants 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 in section II devoted to the mineral-bearing plants known to be responsible in part for this form of poisoning.
I. PLANTS IN WHICH THE TOXIC MINERALS DO NOT SEEM TO BE OF SPECIAL SIGNIFICANCE.

PLAINS 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. It appears, as a rule, in April, and generally is in full bloom by the middle of June. After the flowering stage, unless the season is especially moist, the plants dry up rapidly and disappear from the range.

Propagation occurs under range conditions largely through root-budding. It is doubtful if this species spreads to any great extent by reseeding. In the spring of 1931 about 100 clumps of larkspur were removed from the range and transplanted on the campus. Growth the first season was somewhat retarded but since then an annual seed crop has been obtained. During the first four years the seeds were not viable. Suppressed germination was clearly demonstrated. The fifth year, however, the seeds
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 any other plants.
became viable and have continued to be for each crop since. Under range
conditions, though, one seldom observes new plants developing from seeds.

**Animals affected.** Poisoning from this plant is confined almost ex-
clusively to cattle. Forced feeding of young succulent plants to sheep in
amounts comparable to what would be obtained by normal grazing failed
to produce symptoms of poisoning. Horses and mules seldom eat quanti-
ties large enough to produce poisoning. Chickens when fed green chopped
plants with grain over a ten-day period showed no symptoms of poison-
ing. The quantity of plant necessary to affect an animal seriously varies,
depending upon 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 re-
growth 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 twitching of the side and legs
and frequently convulsive movements. The immediate cause of death is
respiratory paralysis. In severe cases there is acute nausea. Regurgi-
tated material from the first stomach may become lodged in the windpipe
and cause death by obstructing respiration. Bloating may occur in some
cases and not in others, depending upon the stage of growth of the lark-
spur, its water content and the condition of the animal. The erroneous
belief that larkspurs cause death only by bloating is quite generally ac-
cepted by stockmen.

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

**Remarks.** The crude protein content of the initial growth is com-
paratively high, although somewhat less than that of the tall species. Sup-
plementary feeding of concentrates rich in protein has proved to be a use-
ful preventive measure by diminishing the abnormal hunger for protein
which some animals have in the spring.

The poisonous properties of the larkspurs are due to organic com-
 pounds known as alkaloids. Four kinds have been isolated from the plains
larkspur. Each species, however, varies in the number and kind of alka-
loids. Physiologically there is a marked similarity in the symptoms of
cattle poisoned by the several kinds of larkspurs.
Natural habitat of the tall larkspur—*Delphinium barbeyi.*

**TALL LARKSPUR**

Tall larkspur (*Delphinium barbeyi*) is representative of the larkspurs found growing at the higher altitudes. It is a very poisonous plant, but fortunately its restricted growth in forest areas, 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 8,000 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 dangerous to sheep.

**Poisonous period.** It is dangerous from its earliest appearance until the flowers disappear, although in common with other species the maximum poison content is present in the early growth. The seeds are poison-
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.
ous, 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 the eating of this plant for its protein content.

In northwestern Wyoming the tall larkspur (*Delphinium cucullatum*) occurs in the foothills and mountains in dense patches. It is responsible for heavy cattle losses. Some seasons cattlemen have reported a twelve per cent death rate. Eradication measures have not been considered feasible by the U. S. Forest Service. Assistant Regional Forester, Mr. E. Winkla, Ogden, Utah, states, “Larkspur poisoning has been recognized as a problem on the Teton Forest cattle allotments for many years. The ranges are so heavily infested with both the tall and low larkspur species that eradication is considered impractical, under ordinary conditions, at least. Cheap labor, of course, would proportionately alter the situation. Past experience shows that the initial cost of grubbing tall larkspur runs from $6 to $10 per acre. The second time over costs from $2.50 to $4 per acre. Low larkspur which causes early spring losses, is usually of such density that eradication is not practical because of excessive costs, and consequently we have not attempted it. The tall larkspur is considered as an important forage for elk both summer and winter. Elk feed on this plant with no apparent ill effects. It is probable that sportsmen would raise objections to any large-scale program of eradication. Of course, the other plants would come in to replace the larkspur, but whether the replacement would be so valuable to the elk as the larkspur is problematic.” Mr. O. J. Murie, Biologist, of the U. S. Biological Survey, states, “I am inclined to agree with Mr. Winkla, of Ogden, in the matter of eradication of tall larkspur. It is true that the elk eat that plant greedily from mid-summer on, and it causes no losses among game animals here. Much of the northern part of Teton National Forest is designated a wilderness area and is devoted chiefly to game and recreation. Livestock occupy limited areas on the forest. Considering these circumstances I am sure that many would consider it hardly worth while carrying on an extensive program of larkspur eradication and such a difficult one as that would be here, when so much of the area is utilized by game.”

On the Laramie Plains an acre of *Delphinium geyeri* (poison weed) was staked off and a record made of the labor required to grub out the individual clumps in the spring of the year. On the plot selected a maximum growth was present. One acre was found to carry approximately
This tall larkspur (*Delphinium cucullatum*) is responsible for heavy cattle losses in northwestern Wyoming.

17,500 plants. To grub these out it required about 75 man hours of labor. The cost in this instance for a heavily infested area would be about $20 an acre. Other areas carrying fewer plants could be cleaned up for much less.

**LOW LARKSPUR**

The low larkspurs are quite insignificant as poisonous plants. The type growing in northeastern Wyoming (*Delphinium bicolor*) occurs in dense patches in parts of the Big Horn Mountains and some cattle losses have resulted. *D. nelsonii* is widely scattered over the state. *D. venenosum* A. Nels. is widely and densely found in the Wyoming National Forest in western Wyoming. *D. mensiesii* DC. does not occur in Wyoming.

**Where it grows.** It is found at altitudes of from 4,000 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 (9,000 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 noticeably harmful results.
LOW LARKSPUR (*Delphinium nelsonii* Greene): Always growing as simple individuals from a cluster of small tuberlike roots as shown here. Flowers from pale to dark blue.
Poisonous period. It is poisonous during the whole life of the plant but particularly during the pre-bloom stage. Heavy cattle losses have occurred during the flowering stage, e. g. Bear Lodge Forest June, 1936.

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 grain
- Philocarpine hydrochloride.......................... 2 grains
- Strychnine sulphate.................................. ½ grain

It is now put up in tablet form and is generally known as larkspur tablets.

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.
Animal critically poisoned by plains larkspur.

Same animal after one injection of larkspur antidote. Trocar in position to relieve excessive gas.
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.

**Poisonous period.** Tubers and young shoots are dangerous at any season of the year, particularly in the spring and fall.
WATER HEMLOCK (Cicuta 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.
Symptoms. Acute abdominal pains, 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.

The poisonous principle in water hemlock is a yellowish unstable resinous substance called cicutoxin. It has been assigned an empirical formula of $C_6H_{26}O_5$. According to Jacobson* cicutoxin is a complex pyrone derivative.

The cicutas are, however, not to be confused with spotted hemlock (Conium maculatum) of Socrates fame. It is not believed that Conium maculatum occurs in Wyoming. Since it is an introduced species one cannot be certain as to where it may occur.

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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 region. The “woolly” 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.

*Poisonous period.* This plant should be considered dangerous from the time the green pods appear until the plants dry up in the fall. Distinct-
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.
The green fruits of the silvery lupine.

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

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

**Symptoms.** Animals may die shortly after the first symptoms appear or may live several days. A day may elapse between the eating of

*Toxicity of *L. leucophyllus* arbitrarily taken as 100.
The silvery lupine thrives best along the well drained banks of streams. 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. The poisonous properties of the lupines are due to alkaloids. The character of the crude alkaloids in *L. argenteus* varies with the season.

Van Es, et al.*, in their investigation of “the walking disease of horses,” fed considerable quantities of *Lupinus argenteus* without ill effect. One 4 year old gelding weighing 1200 pounds, consumed 352 pounds of green and dried plants (representing 640 pounds of fresh plants) during a period of 4 months. The quantity eaten ranged between 1 and 8 pounds daily. The horse was killed and autopsied about 2 weeks later without showing anything of an abnormal nature.

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DEATH CAMAS

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.

**Animals 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.
DEATH CAMAS (Zyadenus gramineus Rydb): The illustration is distinctive, showing the characteristic bulbs, leaves and flowers (Right). Seed heads, weathered leaves and smaller bulb (Left).
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.

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 (gen-
Sheep poisoned by *Zyadenus paniculatus*.

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.

**Treatment.** 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

This prescription is now available in tablet form and generally called death camas tablets.

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.

The poisonous properties of the species of death camas are due to alkaloids. A crystalline alkaloid has been isolated from *Zygaena gramineus* known as *Zyadenine.* The amorphous alkaloids from *S. paniculatus* and *Z. elegans* have resisted efforts to date in securing crystalline alkaloids or alkaloidal salts.

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.
ARROW GRASS

Feeding experiments corroborated by range observations have shown that arrow grass is poisonous to sheep and cattle. The most common species is *Triglochin maritima*. *T. palustris* is smaller and occurs sparingly. Its poisonous properties have not been studied critically. Contact with arrow grass is usually made in three ways, (a) summer pasturing of livestock in areas involving poorly drained swamps and alkali lakes; (b) cutover meadows used for late summer and fall grazing; and (c) in cured hay.

The summary which follows pertains to *T. maritima*:

**Where it grows.** It is widely distributed over the state in wet alkaline soil 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.

**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 has been definitely shown to be poisonous to sheep and cattle. There is no information available as to its effect upon horses.

**Poisonous period.** Arrow grass is dangerous from early spring to late fall, though under certain growing conditions the amount of hydrocyanic acid contained in this plant is too small to cause trouble. Even after being cured in hay, it may retain enough of its toxic substance to render it dangerous. This is especially true when the arrow grass becomes concentrated in spots within the stack.

**Variations in content of poison.** The toxicity of this plant can be roughly correlated with the condition of growth. In general, plants growing in water are less toxic than plants growing on dry ground. Contrary to general opinion, arrow grass does not have to be stunted in order to be toxic. Large, healthy plants grown under rather dry conditions have been found to contain as much hydrocyanic acid as small stunted plants grown under the same conditions. It so happens, however, that the natural environment of this plant is the shallow water of sloughs and the edges of lakes so that this is conducive to larger growth than can be obtained under more severe conditions, as is shown in the accompanying picture.

**Symptoms.** After consuming a quantity of arrow grass sufficient to kill, the animal exhibits the following progressive symptoms. The breathing is the first to become involved, the rate being much accelerated 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. The heart rate is greatly accelerated. Urination and defecation are frequent. The animal
soon exhibits trembling and muscular twitchings. The hind legs appear paralyzed, the animal falling backwards or on its side as the hind legs are no longer able to support its weight. Vomiting may accompany expiratory efforts though this is usually not the case. The head is then pulled far back, the legs and back exhibiting tense muscular contractions. Dilation of the pupils indicates marked asphyxia, and the breathing becomes very irregular. The animal's mouth is wide open and is wet with foamy saliva as it gasps for air. Mild convulsions occur at this stage, and when the respiration has become so inefficient that it consists of gasps only, violent convulsions with stiffening of extremities occur. This is quickly followed by death though the heart beats a short time after res-
piration has ceased. Cyanosis, if it does appear, is seen only during the last stages. At autopsy the viscera show congestion, the blood is usually bright red and fluid.

Treatment. Because of the rapid course of hydrocyanic acid poisoning it is necessary to apply treatment as rapidly as possible. The treatment recommended by us is the immediate injection of sodium thiosulphate and sodium nitrite. The dose for sheep is 2 grams of the former and 1 gram of the latter. It has been found that if the thiosulphate is injected intravenously and the nitrite subcutaneously, recovery is more rapid and more certain than if the thiosulphate is injected intraperitoneally or subcutaneously. Sheep have been fed arrow grass in quantities up to 4 times that quantity necessary to kill and after going down have been given 2 grams of thiosulphate intravenously and 1 gram of nitrite subcutaneously. Within 20 to 30 minutes these sheep were on their feet and apparently normal. For cattle it is recommended that the dose be 1 gram of thiosulphate and \( \frac{1}{2} \) gram of nitrite per hundred pounds weight of animal.

Because of the fact that sodium tetrathionate is not available to the average rancher and because it has been shown that the thiosulphate and nitrite are somewhat superior, the former is no longer recommended by us as an antidote for cyanide poisoning. The same treatment should be given to animals poisoned by sorghums, sudan grass, chokecherry leaves, flax, millet, etc.

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 poisonous properties of arrow grass are due to hydrocyanic acid. No one has as yet demonstrated how it is combined in the plant. Attempts to isolate a glucoside have proved futile. A quantitative assay of the hydrocyanic acid content of arrow grass is a fairly reliable index of how much of the green plant must be ingested to induce fatal results. Arrow grass containing less than twelve milligrams of hydrocyanic acid per hundred grams of green plant may be considered non-toxic. Above this amount gradations in toxicity will occur depending upon the amount of hydrocyanic acid present and the quantity ingested at one feeding. In high concentrations of hydrocyanic acid (50-60 mg. per 100 gms.) fatal poisoning of sheep has been obtained on as little as 0.5 pound of green arrow grass per hundred weight of sheep. Even higher concentrations of hydrocyanic acid have been obtained from arrow grass. It is concluded that the fatal dose could be considerably less than 0.5 pound with the amount of hydrocyanic acid approaching 90 to 100 mgs. per 100 grams of green arrow grass.

From our experimental data it is impossible to assign a value that represents an average fatal dose of arrow grass.
In response to a request from the authors, Dr. Aven Nelson, Botanist of the University of Wyoming, has given the following report on the standing and distribution of those species of Loco (Oxytropis) which are of significance in Wyoming.

This report is based upon a careful review of the hundreds of specimens accumulated to date in the Rocky Mountain Herbarium. No attempt is made here to review the genus as a whole, nor to place in their taxonomic relationship all the species that have been proposed in this perplexing genus. Probably it will serve your purpose best if in this outline only those concerning which there should be no controversy are introduced.

Pronouncements on the geographical distribution of the several sections of the genus must rest, of course, upon the constantly accumulating specimens. Field work in old areas and in new discloses also the extent of variation, due to ecological factors, in the fundamental species. It is clear, therefore, that in this relatively new West, no one is prepared to say the final word on the questions raised.

Dr. P. A. Rydberg in his “Flora of the Rocky Mountains” divides the genus into six sections but in order to do so it is necessary to use characters that overlap in two or more of the sections. Not much, therefore, has been gained, and so for the purpose of this report, it seems to be best to contrast only certain pairs of the few species involved.

FIRST PAIR:

_Oxytropis lamberti_ Pursh. For purposes of identification this may be known as the “Purple Loco.” The type of this species came from some place near Yankton, South Dakota. It is essentially a plant of the plains. Its geographical distribution seems to be the plains of the Dakotas and Nebraska, extending westward into the plains areas of eastern Wyoming. Judging by the relatively few specimens available, it is not generally distributed throughout this area. It probably requires certain soil characteristics which I am not prepared to discuss.
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 Colorado loco (Oxytropis bilocularis A. Nels.) is more slender and less tufted.
A near relative of *Oxytropis saximontana* is *O. paysoniana*, Ashley National Forest southwestern Wyoming.

*Oxytropis bilocularis* A. Nels. The common name “Colorado Loco,” was suggested because Colorado seems to be the center of its distribution. It is found more or less abundantly throughout a wide area—the foothills and adjacent valleys in the Rocky Mountains from the Canadian provinces to New Mexico and Arizona and even in western Texas.

In this pair of species the color is variable—purplish-red, bluish-purple or pink—never white or yellow. The latter of the two is usually stouter and more inclined to form a definite clump of stems that are more erect and taller than its analogue. Tabulated characters as below will help to distinguish the two.

1. *O. lamberti*. Stems few, curved-ascending, usually less than 2 dm. high; pod one-half 2-celled, its tip slender and divergent.
2. *O. bilocularis*. Stems several, erect, usually more than 2 dm. high; pod complete 2-celled, 3 times as long as the calyx, tapering to a slender tip.

SECOND PAIR:

*Oxytropis saximontana* A. Nels. This group in contrast with the preceding pair has a much stouter woody caudex, freely branched and therefore with more numerous leaves and naked flower-stalks, forming sturdy clumps. On these characters alone the plants may be recognized as far as they can be seen.

*Oxytropis paysoniana* A. Nels. This may bear the name “Wyoming Loco” though it is not confined to Wyoming. Its greatest abundance occurs in western Wyoming, but it has been found in adjacent Utah and Idaho. It seems to prefer denuded soils on high benches and ridges. Like the preceding it has a sturdy woody base with even heavier and shorter branches than in the preceding.
May, 1939 Poisonous Plants and Livestock Poisoning

1. O. saximontana. Leaves grayish-strigose; flower-stalks stout erect, 1.5-4 dm. high, much longer than the leaves; flowers white, usually with a purple spot on the keel; pod tough and thick, oblong-lanceolate, tapering into a sharp beak.

2. O. paysoniana. Leaves grayish; flower-stalks short, stout, only a little longer than the leaves; flowers cream-yellow; pod short, somewhat flattened, oblong, abruptly narrowed to a short straight beak, completely 2-celled.

THIRD PAIR:
These two are very similar in general appearance, both being rather low with an abundance of soft silky hair and both with gradually enlarging calyx as the pod develops; both have purple flowers, but characters shown below will readily distinguish one from the other. The first is largely confined to Wyoming, and the second reaches its best development in Montana. They are

Oxytropis besseyi Rydb. "Bessey's Loco"
Oxytropis blankinshipii A. Nels. "Blankinship's Loco"

1. O. besseyi. Leaflets 17-25; pubescence silky and spreading; calyx dilated but the pod exerted by half its length, one-half 2-celled.

2. O. blankinshipii. Leaflets 9-15; pubescence loose and widely spreading; calyx greatly distended by the short thick pod which remains wholly enclosed, completely 2-celled.

NOTE—It is not to be inferred that in the areas referred to above there are no other species. In the score or more of valid species there may be much overlapping but these others do not fall within the present inquiry.—A. N.

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 4,000 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 Astragalii. Further investigation is needed to determine correctly the role loco plants may play as poisonous or undesirable weeds.

Where it grows. It grows largely on knolls and on ridges and often in great field-like patches on the plains. It thrives best in non-saline soils.

When it appears. The basal leaves may remain green throughout the winter. This is particularly significant where the leafage is of con-
siderable volume. Due to snow pressure the leaves become matted. Those protected from the rigors of weathering usually are quite fresh and green. A sample of leaves collected February 2nd were found to contain 26.7% moisture. Horses grazing upon the loco leaves in mid-winter have been in some instances seriously affected.

**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 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.

*Oxytropis bilocularis* is common in southeastern Wyoming. From an economic viewpoint the Colorado loco is probably of minor significance. So far as its occurrence in Wyoming is concerned no fear is entertained as to its effect upon livestock. Feeding tests extending over a period of three months failed to induce any ill-effects in sheep. The plants were in the early seed stage of growth. A maximum of 180 pounds based on green weight was fed.

The dominant and troublesome loco *Oxytropis besseyi* occurs in dense patches in the Owl Creek Mountains of northwestern Wyoming. This is the only area in the state where serious losses of sheep occur from grazing loco. Reference has been made to the fact that some operators graze their sheep year after year with only minor losses, while others have heavy annual losses regardless of range conditions. We have concluded that complications are involved in certain cases especially where sheep are held on certain shales during the lambing period. Confirmation of this belief is now being studied experimentally by changing the lambing operations of one cooperator from the shale areas to a range free of mineralized forage.

*Oxytropis condensata* is a loco plant closely akin to the white flowered *O. saximontana*. It is commonly referred to as “bunch loco.”
condensata occurs in the western half of southern Wyoming, a part of which is known as the Red Desert. It seems to be generally associated with saline soils. To what extent this loco may be considered a hazard to range livestock is not known to us.

Oxytropis lamberti occurs sparingly on the plains of eastern Wyoming. This species has a bad reputation in several of the plains states.

Woolly loco (Astragalus mollissimus) occurs sparingly in the southeastern section of the state. Because of its limited distribution, it is not regarded as an important poisonous plant.

Remarks. The active principle or principles in the loco plants is not well understood. Fraps* and coworkers of Texas isolated and identified an organic substance from Astragalus earlei that was named locoine.

The active principle in Oxytropis saximontana and Astragalus mollissimus is believed by Fraps† to be the same as found in Astragalus earlei.

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†Personal communication from G. S. Fraps.
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 5,000 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.
LICHEM (*Parmelia molliuscula* 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.
Mixture of lichen and snow. Photo taken during March.

**LICHEN**

While this lichen, *Parmelia molliscula*, 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.** Sheep and cattle mainly.

**Poisonous period.** No particular variation with seasons or with localities.

**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 cattle continue to eat and drink even though they may not be able to stand up.
This animal poisoned by lichen is unable to stand. Otherwise it showed no symptoms of distress.

Treatment.

Sheep. If affected animals are put at once on a change of feed, recovery will be hastened, thus obviating taking the chance of loss of weight and depreciation with its attendant complications. When sheep become seriously affected, they have no desire to eat or drink. Stubborn cases will be aided by drenching liberally with warm water. Palatable feed should be available at all times.

Cattle. Hypodermic injections of strychnine are beneficial and aid recovery. (For sheep this treatment cannot be recommended.) Inject a solution containing 1/13 grain or 5 milligrams of strychnine sulphate for a 500 to 600 pound animal. For other weights give in proportion. Inject under the skin. The region of the shoulder is a satisfactory site. Repeat the dose in two hours if necessary. Discontinue injections if the animal becomes saturated with strychnine, i.e., when the animal starts or jumps when tapped sharply on the back.

Remarks. This plant tends to cause the most trouble on winter ranges where there is a scarcity of forage. The toxic principle is believed to be usnic acid. Air dried material yields approximately 1.6 per cent of the acid. Carbon bisulphide is a very satisfactory solvent for its isolation from the dry powdered plants. Usnic acid is not soluble in water.

Because of the symptoms and because of the beneficial results of strychnine in cattle poisoned with lichen, it would appear that the action of the toxic principle is on the spinal cord. However, with sheep, whose symptoms are not noticeably alleviated by this treatment, the paralysis may be of cerebral origin.
OAT HAY AND STRAW POISONING

There have been reported several cases of cattle poisoning due to the feeding of oat straw or oat hay. Most of these cases have involved the loss of from 10 to 60 animals within a few hours after eating this material. Cows not fatally poisoned may abort dead calves within a week. There has also been one case reported of ewes aborting their lambs and sheep dying after eating well-cured oat hay. Only recently has it been established that sheep are susceptible to oat hay poisoning. No cases have been reported of horses being killed by eating oat hay or straw.

This is an acute type of poisoning, cattle dying within 2 to 10 hours after ingesting the hay or straw. The symptoms are characterized by depression, rapid pulse and respiration which is frequently very noisy as if the animal were in great pain. The mucosa, sclera of the eyes, and exposed skin take on a dark color like that obtained when an animal's air supply is choked off. The animal becomes too weak to stand, and often this weakness makes its appearance so suddenly that the animal plunges to the ground. Death is accompanied by some convulsive movements of the legs.

Oat hays and straws which cause this poisoning are found to contain high concentrations of potassium nitrate (saltpeter). This varies considerably in the toxic hays examined, some containing as little as 1.2 per cent and others running as high as 8.0 per cent. The amount of oat hay or straw necessary to produce death, of course, depends upon the concentration of saltpeter in the hay or straw. These toxic oat hays and straws have usually been well cured and are relatively free from weeds.

The potassium nitrate is converted in the stomach or intestine of the animal into potassium nitrite. The nitrite causes the hemoglobin to be converted into methemoglobin which is incapable of carrying oxygen from the lungs to the tissues. Methemoglobin is brown, thus causing the blood of affected animals to assume a chocolate brown color. Because the blood is incapable of transporting oxygen, the animal dies from asphyxia much as if it was choked to death. Due to the irritating action of potassium nitrate, autopsy usually reveals a very irritated and congested fourth stomach and intestine.

If a pregnant cow does not eat enough toxic oat hay to kill her but does eat enough to produce considerable methemoglobin, enough of the air supply to the fetus may be cut off to cause its death and subsequent abortion.

Approximately 0.5 gram of potassium nitrate per pound of animal is necessary to cause death. Thus if a hay contained 5 per cent saltpeter, it would be necessary to feed only ten pounds to kill a 500-pound animal.

There is also some evidence to show that instead of a tolerance being built up by the continued feeding of feeds high in nitrate, the reverse is
A stack of poisonous oat straw. In appearance, odor or taste there is nothing to suggest its poisonous character.
true, and the animal becomes more susceptible to it. Therefore, a feed containing about 1 per cent saltpeter which would not hurt cattle even after several days feeding may cause death if fed for longer periods of time.

To diagnose with certainty that nitrate is the cause of an animal's death, a sample of fresh blood and urine or bile taken after death is necessary. The blood can be tested for methemoglobin, and the urine and bile can be analyzed for nitrate and nitrite. Before feeding oat hay, it should be carefully sampled by taking small portions here and there throughout the stack (not the outermost hay which has been leached out by rain). These samples should be sent to the experiment station or some other laboratory for analysis. It should be accompanied by a request for the determination of potassium nitrate.

Remarks. Deaths have been caused by cattle eating pigweed which contained a high concentration of saltpeter. Perhaps also feeds other than oat hay or oat straw, such as wheat and barley straw, may sometimes contain sufficient potassium nitrate to be poisonous. There are some deaths from sorghums which contain too little cyanide to be poisonous that might be explained by an accumulation of saltpeter in the plant.
II. PLANTS IN WHICH THE POISONOUS PROPERTIES ARE INFLUENCED BY TOXIC MINERALS

POISONOUS PLANTS CORRELATED WITH GEOLOGICAL FORMATIONS

It is generally recognized that those poisonous plants represented by the larkspur, lupines, death camas and others described in the foregoing pages contain active principles that do not vary appreciably with soil types, if corresponding stages of growth of a particular plant are considered. Furthermore, when these plants decay, there are no residual poisonous substances that return to the soil to contaminate it. During recent years the attention of the writers has been given to a group of plants which in contrast to the foregoing group do vary with soil types.

The first announcement of this kind of behavior was made by the writers in 1934. At that time it was stated that certain plant species were selective in their mineral utilization or absorption. It was concluded that some native plants do require a soil which carries certain toxic minerals. Such soils are associated with or derived from rocks belonging to definite geological formations. In Wyoming these formations include a great many rock types. As far as our investigations have gone, it is known that seleniferous rocks belong to the Permian, Triassic, Jurassic, Cretaceous and Tertiary systems. (For more detailed information on the occurrence of seleniferous rocks in Wyoming the reader is referred to Wyo. Agr. Exp. Sta. Bul. No. 221.)

Out of the total number of native plants growing on naturally occurring soils only a comparatively few take up trace minerals in toxic amounts. The significant mineral involved in the selective group of plants is selenium. Other minerals of importance have also been found, particularly molybdenum. The toxicity of this element in barley hay was reported on in 1935. (Wyo. Agr. Exp. Sta. Bul. No. 206.) Recently molybdenum has been suspected to be the active poison in pasture grass in Somerset, England.*

The natural occurrence of selenium in soils is characterized by its stability and resistance to the normal root action of com-

mon plants. This feature has been stressed in all our published reports on selenium in relation to plants.

Native seleniferous plants may be conveniently placed in two broad groups, viz., primary and secondary.* The primary group includes those native plants that are believed to require selenium for normal growth and development. This relationship has been discussed by Trelease.†

Representative plants in this group include all of the species in the genera Stanleya, Xylorrhiza, and Oonopsis. In addition to these are included certain species of Astragalus having genetic relationships that are typified by such groups as Bisulcati, Podosclerocarpi, Preussii, etc. This genetic relationship is marked if one follows the classification given by Jones.§ Plants thus classified are quite universally seleniferous, at least in some phase of their annual growth. The degree of selenium absorption is dependent upon several factors. Some of the more conspicuous ones are stage of growth, species of plant, geological formation, age of plant and seasonal influences. Detailed information on selenium occurrences in vegetation have been published in the Am. Pharm. Assn. Vol. 26, No. 5, 1937 and in Wyo. Agr. Exp. Sta. Bul. No.'s 206 and 221.

The group of native plants designated as secondary may be defined as those which are generally seleniferous if rooted in selenium-bearing soils, but are not confined in their growth to them. Since plants in this group may be expected to grow widely distributed, they are not necessarily indicators of a seleniferous area. Representative plants in this group include Aster commutatis, A. glaucus, A. adscendens, A. ericoides, Machaeranthera ramosa, Sideranthus grindelioides and Mentzelia decapetala. In addition, Atriplex nuttallii and A. canescens are usually seleniferous when growing in soils of Pierre and Niobrara origin.


Several plant species in the secondary group are palatable to grazing livestock. Any of the plants in this group may be considered to be hazards to livestock if found to occur on selenium bearing soils. On the other hand they are safe when they occur on non-selenium bearing soils. It is not always possible from range observations to distinguish the soils that carry selenium and those that do not. In doubtful areas a chemical analysis is essential to establish the selenium content of the plants.

In some restricted areas all of the indigenous vegetation may be more or less seleniferous because of the availability of selenium. Under these conditions grasses, and other palatable forages may absorb enough selenium to be poisonous. Proof of this was established by selecting soils from toxic areas that had not been enriched by local seleniferous plants and testing their potential selenium availability by cropping tests. Under ordinary conditions cereals, grasses and root crops are not toxic when grown in naturally occurring seleniferous soils and shales. The origin of available selenium in certain areas in Wyoming is conjectural. Where highly seleniferous plants are found in dense patches it is usual to find that native grasses and other palatable forages are toxic when growing near these seleniferous plants. This rela-
Aster commutatis on Pierre loam. Grasses near the Aster clumps contain nearly five times as much selenium as those farther away.

The relationship is easily understood. For example, under range conditions stands of sage (Artemisia tridentata) occur that have become seleniferous through the influence of woody aster. Normally species of sage do not absorb selenium from raw shales. The influence of highly seleniferous weeds upon shallow-rooted vegetation such as grasses, cereals and root crops is generally recognized, particularly in areas where the seleniferous weeds grow densely.* Moxon (1938) of South Dakota found that, “the selenium content of the more common grain plants is very closely associated with the organic selenium content of the soil in which they grow.”

The soils were taken from farms where toxic wheat and corn had been grown. The much publicized inhibitory effect of sulphur or soluble sulphates upon the intake of selenium was found by Moxon to be without significance. It is interesting to note that

this is the first experimental evidence so far submitted that is representative of actual farming conditions. The Wyoming investigators have shown experimentally that raw seleniferous shales can be made to yield selenium which is available to small grains and forages. This was accomplished by introducing seeds of seleniferous range plants in a plot of raw Steele shale and permitting the foliage to leach out naturally. In this sense these seleniferous plants may be called selenium converters. This form of conversion occurs quite generally on all the toxic soil areas in the Rocky Mountain region. Although other writers have advanced other theories to explain this phenomenon, we are certain that a complete understanding of the action of converter plants makes other explanation unnecessary. Practical remedial measures must of necessity begin with conditions as they exist. The removal of converter plants on a large scale from infested ranges in northern New Mexico resulted in improved livestock in two years time.

Mineral-bearing Plants in Relation to "Alkali Disease"

In 1934* a type of poisoning was described which accounts for considerable annual livestock losses in Wyoming. "Blind staggerers," "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.

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 detri-

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†The Effect of Saline and Alkaline Waters on Domestic Animals. V. G. Heller, Oklahoma Bulletin No. 217 (1933).
mental to stock, that the resulting damage to stock utilizing saline or alkaline drinking waters seems 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 where the sole source of drinking water may be only the alkaline water of a lake or stagnant pool, the animals at first exhibit diarrhea and lessened water consumption. After a short time, however, the animals adjust themselves to the conditions so that no marked detrimental effects are observed. Alkali disease, blind staggers 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 staggers” and “alkali disease” are used interchangeably by stockmen.

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 symp-
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.

toms 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.
A dairy cow which had developed into an advanced case of "blind staggers" was given the treatment described on page 71. 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.

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, 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 animals are restricted in their grazing to the vegetation of one of the above mentioned dangerous areas, it is obvious that it will be difficult to prevent poisoning.
Animal suffering from "alkali disease" developed while feeding on native forages.

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.

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
This heifer received small quantities of selenium as sodium selenide over a period of four months.

the early stages of poisoning are hemorrhagic and later become atrophied.

In the first stage of "blind staggers" the animal may only show a tendency to stray from the main herd. There is at this stage a slight impairment 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 nuttalli).

Note the irregularities of the first permanent incisors. This condition is often noted in range cases.
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.

At this stage, too, the depraved 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. 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
Sickly, deformed lambs resulting from pre-natal absorption of selenium. The mothers had grazed over seleniferous ranges during the winter months.

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 regularly 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 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 protuding 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 poisoning 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 organs. The fourth stomach 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 kidneys 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.

A range case chewing on a piece of bone. The abnormal appetites of the cattle at this ranch were also evidenced by their chewing the rails of the corral fence. The native hay fed and the vegetation grazed by this herd was grown on Morrison shale. Analysis of the hay did not show phosphorus or calcium deficiency. It is believed that the presence of certain elements in the hay disturbs the normal mineral metabolism in the affected stock.
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 sulphate to 50 cc. or 5 dessert tablespoons of clear water. Each cubic centimeter of the above solution will contain 5 milligrams or 1/13
A grain of strychnine. For a five to six hundred pound animal 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 staggerers" 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 with 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 unaided. 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

In a previous publication* one of the authors made the statement that two-grooved milk vetch (*Astragalus bisulcatus*) seemed to be variable in its poisonous properties. It is now known definitely that such is the case and that this plant 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) the plant has been produced on a seleniferous soil, and (b) the poisonous mineral selenium is present.

The near relative, *A. scobinatulus*, occurs in the southwestern part of the state. It is always associated with a seleniferous soil. 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 bottom lands carrying more or less alkali.

**When it appears.** Usually well advanced by the middle of May, in bloom by June, and well matured by the last of July. Variations in altitude, moisture and weather conditions naturally modify this or any other plant's growing period. About 8,500 feet elevation is the maximum altitude at which the *A. bisulcatus* grows. It is frequently found in native hay and alfalfa fields. Being a perennial, new growths may appear that are attractive to grazing livestock. The plant can withstand moderate frosts, so that parts of the plant remain green until late fall.

**Animals affected.** Poisonous to sheep and cattle. It can produce acute poisoning even though the plants are low in selenium. Consequently a non-mineral poison is normally present. However, the presence of selenium greatly activates the poisonous properties of the plant. Chronic poisoning is common in sheep and cattle. This effect is believed to be due to the mineral content of the two-grooved milk vetch. Plants with a very low selenium value were without effect upon mature cows when fed small amounts of vetch leaves, about 2½ pounds daily, over a two months period. Whereas this same vetch, high in selenium, has produced definite chronic poisoning when fed over a time interval of two months.

**Poisonous period.** It is a dangerous plant during its entire period of growth. The poison (non-mineral) is quite uniformly distributed in the flowers, seeds and leaves. When growing upon such geological formations as Niobrara, Steele, Pierre and Wind River the plants are much more toxic than those growing on soils low in selenium. 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 residues returned annually to the soil becomes a potential source of available selenium, molybdenum, etc., which may be absorbed by growing crops. In addition to this it may be harvested along with certain forages and thus

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TWO-GROOVED MILK VETCH (*Astragalus bisulcatus* [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.

Induce poisoning when fed to livestock. Many such instances are a matter of record.

**Symptoms.** See discussions of Mineral Poisoning on page 65.

**Treatment.** Described on page 71.

**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 in toxic quantities.
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

Timber Milk Vetch (Astragalus campestris Gray; Astragalus hylophilus (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. Average height 6 to 8 inches.

TIMBER MILK VETCH

This vetch, Astragalus hylophilus, 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 most poisonous timber milk vetch plants develop on the Bishop and Hanna conglomerates. (These geological formations have been treated in Ecology, Vol. 17, No. 4, October, 1936).

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 Molybdenum: Trace
The timber milk vetch produces a chronic type of disease that is comparable in several respects to mineral poisoning.

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 (now Medicine Bow) and foothills of the Uinta Range. Scattered patches occur in the Wyoming National Forest, Teton Mountains, Owl Creek Mountains, Big Horn Mountains near Shell and in the Wind River Mountains near Dubois. Outside of the occurrences on the Bishop and Hanna geological formations the timber milk vetch is not considered to be troublesome to livestock.

Mr. Arthur Buckingham, Acting Supervisor of the Teton National Forest, states, "No losses of livestock have been attributed to eating of..."
milk vetch, and we do not believe the stockmen in this vicinity consider it to have toxic properties." A collection from the Teton Forest was without effect on a sheep which was fed four pounds of air dry material. The toxic timber milk vetch from the Bishop conglomerate in southwestern Wyoming was capable of causing death in a 300-pound calf which was fed approximately one pound of air dry plant in two daily doses. Attempts to secure a quantity of the timber milk vetch from the Big Horn Mountains were unsuccessful during the 1938 season, because of the scarcity of the plant and the additional fact that what little material was known to occur had been browsed off by cattle. Forest officials in the Big Horn region do not regard the timber milk vetch to be a troublesome poisonous plant.

An extensive growth of the timber milk vetch occurs on the slopes and top of Bull Mountain in Larimer County, northern Colorado. It is distributed over several geological formations, viz., the Dakota conglomerate, Morrison, Sundance and Chugwater. No selenium was found in any of the collections from this region. The elevation of Bull Mountain is approximately 10,000 feet. A large collection of plants was made in 1937 and again in 1938 when the vetch was in flower.
It was fed to sheep and cattle. A typical chronic case was developed in a sheep in about three weeks' time. A mature cow succumbed after being fed seven pounds of air dry plant. This was distributed over a three day period as follows: January 26, two pounds; January 27, two pounds; January 28, three pounds. Sheep required about a pound and a half of dried plant per hundred weight to kill. On the whole the vetch plants from the Bull Mountain area are less toxic than those found in southwestern Wyoming.

From the data available to us it is concluded that the timber milk vetch varies in its toxicity depending upon the soil in which it grows. Its spotty occurrences, and its absence in many of the principal mountain ranges of Wyoming are evidence that the plant is selective in its habitat. It is impossible to account for its distribution solely on the basis of elevation as a controlling factor. As a poisonous plant hazard in Wyoming it is restricted to two geological formations, viz., the Hanna and Bishop conglomerates of southwestern Wyoming.

Where it grows. In southwestern Wyoming it occurs quite exclusively in the shaded areas of aspens and pine trees. Its distribution is confined exclusively to the Bishop conglomerate in the Uinta Mountain section and to the Hanna conglomerate in the sandstone area south of Rawlins. These formations occur at elevations ranging from 6,000 to 8,000 feet. Plants may grow at elevations of 10,000 feet as noted on Bull Mountain, northern Larimer County, Colorado. In this region the timber milk vetch occurs not only in aspen groves but extends into the open sagebrush areas bordering on these.
When it appears. It is well established the last of May, blossoms in June or early July, and seeds shortly thereafter. The plants are susceptible to light frosts, consequently they lose their freshness early in the fall season.

Animals affected. Sheep and cattle mainly.

Poisonous period. It is not definitely known. However, few losses are reported as occurring before July first. Restricted grazing on forests might account for this. No experimental feeding has been done in Wyoming on the young plants. Air dried plants stored in containers have been found to retain their potency, unaltered, for at least seven years.

Symptoms. Acute poisoning of sheep and cattle is characterized by failure of respiration. Any betterment of the respiration acts beneficially upon the heart and circulation. Chronic cases developed experimentally exhibit symptoms similar to those described on page 65. However, the poisoning is more severe. There is anemia. The heart is flabby with dilated chambers, and the walls are thinner than normal. Such hearts undoubtedly are inefficient. The dyspnoea (difficult breathing), so constantly observed in advanced cases of poisoning, can well be attributed to the chronic, passive congestion in the lungs which in turn results from the failing respiration. Chronically poisoned cattle knock their heels together; hence, the common name “cracker-heel” disease. This is undoubtedly due to constitutional weakness. The mode of death in chronic cases is very likely due to a failing circulation, whereas acute death from one massive dose is caused by failure of respiration. It is believed that the timber milk vetch is at the bottom of a considerable amount of lung trouble in sheep and cattle.

Treatment. Livestock should be removed from timber milk vetch areas and given nutritious feeds.

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 causes the plant at first to exert effects characteristic of the organic compound in question, and that later upon dissociation the metallic ion produces the physiological effect more or less common to all metallic poisons.
Woody aster is known to be more than a poisonous plant—it arrests growth of other vegetation and contaminates the soil with poisonous minerals.

**WOODY ASTER**

In Wyoming the name woody aster is quite synonymous with *Xylocyphis parryi*. However, there are other species of prominence in the state, particularly *X. villosa*. In years past, woody aster 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 in which it grows. It is exclusively associated with certain geological formations. In fact, this plant may be safely taken as an indicator of soils containing the poisonous mineral selenium. Propagation takes place through the seeds and 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. It is associated with the greasewood type of vegetation. Under favorable weather conditions extensive areas occur on the plains.
WOODY ASTER (Xylorrhiza 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.
that may be quite continuous over several sections of land. Woody aster being a selenium absorbing plant indicates by its presence that other forages not generally suspected of being poisonous, may need to be examined.

**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 effected 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 65.

**Treatment.** Described on page 71.
Narrow-Leaved Milk Vetch (*Astragalus pectinatus* Dougl.) 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 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 contaminator. Its root system resembles that of the two-grooved milk vetch.

\(A. pectinatus\) is a dependable indicator of a seleniferous soil. Like most of the other mineral bearing plant species, it can be relied upon to indicate as to whether or not a soil is low or high in selenium by the amount of selenium it absorbs. Plants rooted in a lean seleniferous soil such as is found in the White River formations will be quite generally low in selenium, whereas the more seleniferous soils derived from the Niobrara or Wind River formations will result in the plants being much higher in selenium. The avidity this \(Astragalus\) has for selenium is illustrated by the fact that seedlings can absorb high concentrations of selenium from a soil containing only elemental selenium. This laboratory has analyzed several hundred \(Astragalus pectinatus\) plants, not only from Wyoming but from a number of the Rocky Mountain states, during the past seven years. Our records show that selenium has been found in every sample analyzed.

Where it grows. Quite generally distributed on the plains over the eastern half of Wyoming.

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% 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 65.

Treatment. Described on page 71.

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. Since the plant grows upon soils containing selenium, it naturally follows that some of the associated vegetation may 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**

*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.** *Oonopsis condensata* like woody aster has spread considerably during the past few decades. In central and northeastern Wyoming *Oonopsis argillacea* occurs on many of the barren slopes. It too, is invariably seleniferous, but never as high as *O. condensata* even on comparable soil types. *O. multicaulus* is reported to occur in northwestern Wyoming. It has not been examined for selenium by us.

**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 woody aster in producing more nearly the true metallic type of poisoning. See description on page 65.

**Treatment.** Described on page 71.
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 seleniferous soils. 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 65.

Treatment. Described on page 71.
NUTTALL'S SALTBUSH (*Atriplex nuttallii* Wats.). This plant is sometimes erroneously called salt sage. It is 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 Wind River, have not been found to contain selenium in toxic amounts. *A. cones-cens* is generally seleniferous when growing on Pierre and Niobrara shales.

**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. Saltbush leaves incorporated in the balanced diet of rats was found to be fatal when the level was raised to 15 parts per million selenium. At this level the saltbush is as toxic as wheat having the same selenium value.

The saltbush used in this work contained medium amounts of selenium. The occurrence of selenium in saltbush taken from the Wind River 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

The Stanleyas are always indicators of a selenium bearing soil. To what extent they may be eaten by livestock is uncertain. *Stanleya bipinnata* occurs in scattered patches in eastern Wyoming. It is the most toxic of the Stanleyas in Wyoming because of its usual higher selenium content. Other species known to occur are *S. intergrifolia*, *S. tomentosa*, *S. viridiflora*, and *S. pinnata*. All are seleniferous, hence their occurrences are confined to definite geological horizons.

**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 *Astragalus bisulcatus*.

**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 65.

**Treatment.** Described on page 71.
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 as possible selenium concentrators some significance must be given to them. The selenium content of this species is low at any stage of its growth. Other *Mentzelia* species occur in Wyoming, but in most instances they do not absorb selenium in toxic amounts, even on highly seleniferous soils.

The data following pertains to *M. decapetala*.

**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, 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 65.

**Treatment.** Described on page 71.

**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. POISONOUS PLANTS OF MINOR IMPORTANCE

There are times when livestock losses occur, and the cause or contributing agencies are not always evident upon a casual examination of the suspected ranges or feeds. In other cases, the cause may involve but one plant. Losses from sorghums or Sudan grass illustrate cases of this kind and are not ordinarily confused with other forms of poisoning. Uncertainty in interpreting causes usually pertains to those plants and feeds in which two or more possibilities occur. The larger the number of suspected plants in a particular case, the more difficult diagnosis becomes. In fact, poisoning cases develop in which a number of plants are involved.

The poisonous plants and forages considered in this section are classed as minor insofar as livestock losses are concerned. Some are very poisonous, but their distribution is limited. Others occur widely distributed but due to favorable range conditions and good management, losses from them are not serious.

_Artemisia_. 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_ (sand sagebrush). 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, except for 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 to be 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.

**Senecios.** American groundsels 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 upon 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 Pammel§ to be poisonous. Since this plant is frequently cut along with native hay, some question has arisen as to its possible poisonous properties. The course 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 respiratory rate is lessened and there is dyspnoea (labored breathing). Death is due to respiratory failure.

**Ergot.** Poisoning due to ergot is relatively unimportant in this state. Wild rye and some of the wheat grass may carry ergot in dangerous amounts, but stockmen generally recognize ergot and the danger of feeding it.

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†Texas Agricultural Experiment Station Bulletin No. 481. (October, 1933).
Horses and cattle seem quite susceptible to this form of poisoning. There is a disturbance of the gastro-intestinal tract. Gangrene 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.

**Greasewood.** The leaves of this shrub are responsible for some livestock losses. It requires a large amount at one feeding to poison. The leaves and twigs are high in ash. This causes undersalted animals to seek out this saline material to satisfy their requirements. Poisoning sometimes occurs when sheep are held on greasewood areas during trailing or in other situations in which scanty forage is an important contributing factor. The young shoots carry an abundance of large succulent leaves in the spring of the year which are easy to browse upon. Associated with the greasewood one can frequently find selenium-bearing plants such as *Stanleya, Astragali, Xylorrhiza, Oonopsis,* and others that should also be considered when greasewood poisoning is suspected. This condition has been observed by the senior author to prevail in many sections of the West.

**Bighead.** Bighead is a form of photosensitization (abnormal sensitivity to light) which occurs to a slight extent in sheep in the western part of Wyoming. Bighead as its name implies is characterized by the development of an unusually large head due to the swelling of the skin in this region. This symptom of bighead can be alleviated by keeping the sheep in the shade away from sunlight for the action of the sun on the sensitized skin is necessary for the formation of the edema. There is, however, considerable liver damage which accompanies this disease, and even though affected animals are kept in the shade, they may succumb due to the impairment of the normal liver functions.

The two plants believed to cause this condition in sheep are *Tetradymia glabrata* Gray commonly known as little-leaf horsebrush or coal oil bush and *Tetradymia inermis* Nutt. or *T. canescens* DC., commonly known as spineless horsebrush. These plants are most toxic during the period of their most rapid growth, and at this time as little as ½ pound per hundred weight is sufficient to cause bighead. Sometimes the eating of this plant will cause death without any swelling of the head. There are many other plants known to cause photosensitization, and it is quite possible that there are other plants on Wyoming ranges which are capable under certain conditions of producing bighead.
Sneezeweed. This plant, Dugaldia hoopesii, occurs in scattered patches in the western part of the state. It is not believed to be an important poisonous plant in Wyoming. Farther west considerable trouble has been encountered by sheep operators. Under range conditions cattle are not reported to be seriously involved. The outstanding symptoms of sneezeweed poisoning are excessive spewing accompanied by loss of appetite and general emaciation. There is reason to suspect that poisonous properties of this plant are influenced by the soil in which the plants grow.

Chokecherry leaves. Some sheep and cattle losses occur occasionally which are due to poisoning by chokecherry leaves. Poisoning is usually confined to the low growing or shrubby chokecherry. The active principle in the leaves is hydrocyanic acid. Fleming et al. have reported (Nev. Agr. Exp. Sta. Bul. No. 109, 1926) that (1) the leaves are poisonous to sheep and cattle from the end of April to the end of August, (2) they become less dangerous after August and by October have lost their poisonous properties, (3) the leaves are not more toxic in a wilted condition and (4) the leaves from the new shoots were found to be more toxic than those from the old wood.

Henbane. During the past few years black henbane (Hyoscyamus niger) has spread along the highways and in waste places in several areas in Wyoming. This illustrates how a plant starting, perhaps, in flower gardens may become widely distributed. Henbane is a poisonous plant. The cultivated plants yield drugs of importance.

Lathyrism. The wild pea (Lathyrus inconus) has been suspected of poisoning horses in Laramie and Goshen counties. The authors have not confirmed these reports experimentally. Native hay from farms where horses were poisoned was found to contain an abundance of seeds and pods of Lathyrus inconus. Typical symptoms are reported to be motor paralysis, apparently cerebral, and increase then decrease of spinal reflexes. Both weaken the heart.

Sweetclover. Spoiled sweetclover hay may be poisonous to livestock. It produces a disease characterized by low clotting power of the blood and the development of extensive hemorrhages. A few reports have come to the writers' attention of trouble of this character in Wyoming.

It appears to be a demonstrated fact that sweetclover hay has to be spoiled to render it toxic. Smith and Brink* of Wisconsin believe the probable cause to be due to coumarin interacting with another constituent or constituents of the plant tissue under conditions favorable for spoilage. This gives rise to a specific toxic substance which is responsible for the sweetclover disease in animals.

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Suckleya. We have no evidence that *Suckleya suckleyana* has caused livestock losses in Wyoming. It occurs throughout our range but owing to low density is not a hazard. A composite sample from the Graneros shale in Weston County contained appreciable amounts of selenium. Thorp and co-authors (Colo. Agr. Exp. Sta. Bul. No. 22, 1937) have reported that *Suckleya suckleyana* has caused cattle losses in northeastern Colorado. The active principle was found to be hydrocyanic acid. Feeding tests confirmed the poisonous properties of the plant.

**Sudan grass and sorghums.** Livestock losses from Sudan grass poisoning in Wyoming are rare. Occasionally some trouble is experienced with sweet and grain sorghums. The common belief that Sudan grass and sorghums have to be stunted, dwarfed or frozen to be poisonous must be modified to conform with recent experimental evidence. Rogers and Boyd* (1936) of Minnesota reported that more hydrocyanic acid developed in the rapid growing tissues than the more backward stunted plants. Feeding tests were carried out by these investigators with cattle and sheep using Sudan grass, sorghums, millet, flaxseed, etc., grown under normal and abnormal conditions. Unfortunately Rogers and Boyd did not report upon the quantitative amount of hydrocyanic acid in the forages investigated. Boyd† and co-author (1938) of Wisconsin concluded that (1) it is the short dark green Sudan grass which is high in cyanide and which is dangerous to pasture, (2) Sudan grass after reaching a height of 18 inches or more is relatively safe to feed, (3) soils low in phosphorus and high in nitrates tend to favor hydrocyanic acid formation, (4) the regrowth or second growth Sudan grass may be dangerous and (5) no increase in the cyanide content was found when Sudan grass was frosted.

The number of cases of poisoning from Sudan grass and sorghums which have been reported to us from Wyoming are inconsequential. Chemical analyses made upon a large number of samples as precautionary measures show that in most cases, our soil and climatic conditions are unfavorable for the development of toxic amounts of hydrocyanic acid.

**Salvia lanceolata.** This plant has only recently come to our attention as a dangerous plant in Wyoming. It belongs to the mint family. Until recently *Salvia* was rare in this state. Our attention was called to a case of cattle poisoning in Converse County in which this plant was involved. Alfalfa hay containing a high percentage of *Salvia* had been fed to 100 head of cattle. The following day 7 died and a number of others were seriously affected. A sample of infested hay was analyzed and found to contain toxic compounds. The symptoms of poisoned animals are characterized by muscular weakness, accompanied with intense inflammation of the gastro-intestinal tract.

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IV. MINERAL MALNUTRITION

Calcium and Phosphorus. A chemical study of the lime content of representative forages and browse plants shows that lime is quite generally satisfactory. There are no extensive areas in the state where phosphorus is deficient in the soils or in the forages indigenous to them. Some limited areas in southwestern Wyoming might be considered border line cases as indicated by soil and forage analyses.

Lime inactivation. A form of malnutrition is known to occur in several areas in Wyoming. Outward indications are characterized by bone-chewing, eroded joints, deformed or weakened offspring, blindness and other abnormalities. The fact that cases of this kind may develop in spite of rations amply supplied with lime, phosphorus and vitamins is evidence that deep-seated nutritional disturbances are suggested. An observant ranchman reported as follows: “I have observed for some time that the cattle on my ranch are doing a good deal of bone-chewing, in spite of the fact that the grasses here have always been considered amply supplied with calcium and phosphorus, and that the subsoil is limestone. Furthermore, all the block salt we feed contains phosphorus; and besides this we have mixed loose salt and spent bone-black in salt troughs scattered over the entire ranch. I invariably called the veterinarian who pronounced it hemorrhagic and gave a serum for it, which I believe never produced any benefit in any case. The animal practically always died or wasted away.”

An investigation was made of the range at this ranch and the trouble traced to selenium-bearing plants. The suggestion was made that the infested areas be freed of the contaminating influences. Two years later the ranchman reported, “I believe I have not had any of this (referring to the disease of cattle) on my place since I cleaned it up.”

Selenium is known to be a contributing factor in several forms of malnutrition in livestock. Its presence in the animal’s body may result in: (1) inactivation of lime metabolism resulting in bone erosion, (2) permanent injury to the fetus of pregnant animals, (3) abortion, possibly, (4) intestinal irritation resulting in bloody stools and (5) impairment of the organs of elimination.
Corrective measures. The ranges in the state supporting mineral-bearing plants are fairly well mapped. Several palatable plant species occur that normally are not suspected of being poisonous. Many of these species retain their mineral content throughout the winter season. Consequently selenium may be considered as a year long hazard on some ranges. Since most of the bad areas are known it is possible, by proper range management, to avoid any prolonged contact with them.

Calcium in the form of a water soluble compound as calcium lactate, or the lime sludge from sugar beet factories is a valuable counteractant to many selenium induced forms of malnutrition. Even finely ground limestone mixed with salt has proved to be helpful in these cases.
The following publications of the Wyoming Experiment Station may be had upon request: (Revised list May, 1939.)

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227. Sugar Beet Tops, Cottonseed Cake and Mono-Calcium Phosphate in Rations for Steers.
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232. Breastbones of Turkeys in Relation to Roosting.
234. The Cellar Wintering of Bees.


Address requests: Bulletin Department, Experiment Station, Laramie, Wyoming.