Bulletin No. 37 February, 1903

UNIVERSITY OF IDAHO

AGRICULTURAL EXPERIMENT STATION

Department of Chemistry

Some Conditions of Stock Poisoning in Idaho

By Henry B. Slade

North Idaho Star Print
Moscow, Idaho

IDAHO EXPERIMENT STATION.

ORGANIZATION.

BOARD OF REGENTS:

JOHN B. GOODE,	President, Rathdrum
MRS WM. H. RIDENBAUGH,	Vice President, Boise
GEO. C. PARKINSON,	Secretary, Preston
H. E. WALLACE,	Caldwell
GEO. W. CHAPIN,	Idaho Falls

EXECUTIVE COMMITTEE:

JOHN B. GOODE, GEO. C. PARKINSON, MRS. W.H. RIDENBAUGH

OFFICERS OF THE STATION:

JAMES A. MACLEAN,	President University
HIRAM T. FRENCH,	Director
WILLIAM L. PAYNE,	Treasurer
HERBERT T. CONDON,	Clerk

STATION STAFF:

HIRAM T. FRENCH,	Agriculturist, Director
LOUIS F. HENDERSON,	Botanist
JOHN M. ALDRICH,	Entomologist
JOHN E. BONEBRIGHT,	Meteorologist
LOWELL B. JUDSON,	Horticulturist
C. N. LITTLE	Irrigation Engineer
HENRY B. SLADE,	Chemist

BULLETINS.

The regular bulletins of the Station are sent free to all citizens of Idaho who request them. Late Bulletins are:

32. Feeding Steers and Lambs and Analysis of Stock Foods.
33. Some Grasses and Clovers and How to Grow Them in Idaho.
34 Tomato Culture.
35. Meteorological Records; Soil Temperatures.
36. The Codling Moth.

Some Conditions of Stock Poisoning In Idaho.

Despite heavy loss of stock each year, the scientific study of the conditions of stock-poisoning by native plants is comparatively new. The poisonous properties of many varieties have been discerned by experience, while others have been suspected with no basis save popular opinion. The dangerous character of death camas (*Zygadenus venenosus*,) the Wa-i-mas of the Nez Perces, has long been known to the Indians. Many poisonous plants have been employed by their medicine men, but no attempt has been made to gather up these facts in a systematic treatise on vegetable poisons, although a number of interesting bulletins on Indian uses of plants have been issued by the Smithsonian Institute. Reported cases of poisoning by plants are scattered through medical literature. In some cases the active principle has been isolated and extensively studied. In the vast majority of cases the action of the plant is practically unknown; the cause of plant toxicity or the conditions under which the poisons are formed in the plant still remain among the unsolved problems of vegetable physiology or pathology. Knowledge of our native poisonous plants is derived mostly from the researches of European investigators upon the same or similar species. In the last few years the U. S. Department of Agriculture has taken up this work, with the result that much valuable and authentic information upon the action of numerous plants has been gained. Most of the Western experiment stations have devoted some attention to this field of

inquiry. This bulletin presents some of the data which have been secured thus far. The statements made are based, for the most part, upon the works of Dragendorff, Kobert, Leruin, Comerin, Blyth, Rosenthal, Duchesne, and other Europeans; the bulletins of the U. S. Department of Agriculture by Chestnut and Wilcox and the publications of the various experiment stations. The files of the American, English, German and French veterinary journals have also been consulted for cases against various plants. It is hoped that the collection of such data will aid in lessening the loss of stock in the state by knowledge of the conditions under which they are poisoned, and that interest in this work may be stimulated, so that additional data may be secured.

No exact figures can be given on the annual loss of stock in the state. With a view of securing information upon this subject and other questions connected with the poisoning of stock by plants, a circular letter was sent out in the latter part of December. On the basis of the replies received the stock poisoned by plants during the past year had in round numbers an aggregate value of $50,000. While this sum represents only a small percentage of the total stock interests of the state, in the case of individual owners the loss has been large; nor is it apt to decrease until active measures to that end are taken.

Varieties of poisonous plants grow in all localities and under all conditions of soil fertility, moisture, climate, elevation and surroundings. The wild parsnip (*Cicuta*,) swamp laurel (*Kalmia glauca*,) swamp horsetail (*Equisetum limosum*,) *Stellaria graminea*, round-leaved sun-dew (*Drosera rotundifolia*), common scouring rush (*Equisetum hyemale*) are found in swamps, bogs or low meadows; varieties of larkspur (*Delphinium*), death camas, showy milkweed (*Asclepias speciosa*), bitter-sweet (*Solanum dulcamara*) in moist ground; the poison oak in dry soil. Prickly lettuce (*Lactuca Scariola*), dogsbane (*Apocynum androsaemifolium*), larkspur, death camas and many other varieties are found in fields. Mountain laurel (*Kalmia latifolia*) occurs in rocky soil on the

mountain sides; bitter-sweet grows in rich soil, while poison weed (*Datura stramonium*) flourishes on the refuse of ash heaps. Darnel (*Lolium temulentum*) is poisonous alike in cultivated and waste ground. Wild mustard (*Brassica sinapistrum*) and cockle or cowherb (*Vaccaria vaccaria*) are frequent in waste places. The latter is a troublesome weed in grain fields in this locality. Mountain laurel, skunk cabbage or California false hellebore (*Veratrum Californicum*), meadow sorrel (*Rumex acetosella*), dogsbane and larkspur occur at considerable elevations. Hardly a locality where any vegetable appears is entirely free from plants of a poisonous nature, though such plants are not always palatable to stock. The foregoing may give some idea of the wide range of conditions under which plants may elaborate poisonous principles.

In popular opinion a plant is considered poisonous only when it *always* produces fatal effects. No plant, however, is poisonous under all conditions. If such were the case stock-poisoning by plants would present no very difficult problem. The young shoots of the dangerous aconite are reported to be eaten in Norway without harm, while under conditions of stunted growth the innocent sorghum may develop fatal quantities of prussic acid, the most powerful poison known. Corn-stalks in the late fall and early winter often give rise to so many fatalities among stock that the trouble has come to be known as "cornstalk disease," which is probably due to a number of causes. In some instances abnormal quantities of saltpeter, formed under conditions still unknown, produce chronic or acute poisoning in cattle that eat unhealthy stalks, while in others a toxic compound formed by the action of bacteria upon the corn is the apparent explanation of the disease. The common potato (*Solanum tuberosum*) may become extremely poisonous to cows. If the tuber is exposed to the sunlight during its process of growth, the skin develops a green color, due to the formation of chlorophyll, with which the production of a poisonous alkaloid, solanine, is in some way connected. Even

under normal conditions the potato contains traces of solanine, but not in sufficient amounts to be dangerous. Other cases might be given but these cited are sufficient to illustrate the error of the popular view as to the absolutely poisonous nature of a plant.

Certain cases of poisoning, not due directly to the plant, are not considered here. Smutty grain is reported poisonous and one such case has been recently reported to the Station. Some plants, especially grasses or grains, may become infested with a parasite which produces the poisoning known as ergotrosin. Some forage crops, as alfalfa and clover, may cause bloating in cattle. All such cases are intoxications, the term employed by science for poisoning. The present bulletin discusses only such intoxications as are due to toxic substances normally present in the plant.

The amount eaten naturally determines at the start whether stock will be poisoned. A piece of the root of Oregon water hemlock (*Cicuta vagans*) the size of a walnut has proved fatal to a cow. Other plants contain equally powerful poisons but present in such small amount that only large quantities or continued feeding will give rise to poisoning The troublesome weed, wild or prickly lettuce (*Lactuca Scariola*), contains an extremely poisonous alkaloid, but in such minute traces that a relatively large amount could be fed before poisonous symptoms would appear. The sharp-tasting, milky juice of the plant renders it unacceptable to stock, so that cases of poisoning against it are unknown. The poisonous grass, darnel (*Lolium temulentum*), contains such a small percentage (.06 per cent.) of the active principle *temuline* that cows which constantly feed upon it may become immune. Stock may also become immune to the seeds of the cow-cockle (*Agrostemma githago*) which may contain as high as six per cent of the poisonous principle, saponin.

Some poisonous plants may contain such small amounts of poison in parts eaten by stock that no harm is done.

Sheep eat the tops of wild hellebore (*Veratrum Californicum*) with apparent relish, and suffer no injury. In changing from a

grass feed, however, sheep are apt to be sickened. In one case reported to the station half a band were thus affected with fatal results in four cases.

Continued feeding upon some plants may produce symptons of poisoning in stock, as in the case of Alsike clover (*Trifolium hybridum*) or the meadow sorrel (*Rumex acetosella*) which is especially relished by sheep.

Injurious, although not necessarily fatal, effects may be noticed in the case of many plants. After eating the broad-leaved cat tail (*Typha latifolia*) cows show increased rapidity of breathing and stiffened joints. The grass-leaved chickweed (*Stellaria graminea*) produces like symptons of poisoning in horses. The wind-flower (*Anemone quinquefolia*) causes bloody urine in sheep and cows, and varieties of figworts (*Scrophularia*) give the same effect in cows. The root of the water-plantain (*Alisma plantago*) acts upon the milk glands. The leaves of the hemlock water-parsnip (*Siuum latifolium,*) when eaten by cows, give a disagreeable flavor to the milk without producing any other noticeable effects. The common bracken fern (*Pteris aquilina var. lanuginosa,*) cypress spurge (*Euphorbia cyparissias*) and darnel are apparently poisonous only in large quantities. In Europe buckwheat (*Fagopyrum esculentum*) gives rise to peculiar disorders to which sheep are especially liable. Poisoning by this plant has also occurred in hogs. In this country buckwheat is fed to hogs, which take it safely, though somewhat unwillingly. All of the plants thus far mentioned contain poisonous principles, but are not considered poisonous in the popular meaning of the word.

In plants which are poisonous in relatively small amounts, the activity varies according to the stage of growth The wild parsnip (*Cicuta*) is most dangerous in early spring and late winter. In the early months of vegetation the death camas and the larkspur (*Delphinium*) cause much damage. In the summer months wild aconite (*Anconitum columbianum*) is most virulent, while death camas at this time has withered up and the larkspur ceased to be dan-

gerous. Lupines do much mischief in the late summer and fall when the pods are filled with seeds. The dangerous periods for stock are in general the periods of sprouting, flowering and seeding. Few plants will be fatal in all these periods, but their greatest toxicity to stock is apt to occur in one of these three stages. In the wet weather of the spring the number of plants on the foot hills and mountain ranges, which are most active at this period, would cause numerous fatalities, while the danger would cease later in the season when such plants had ceased to be inviting to stock on account of their rank growth. The mountain ranges then become comparatively safe for sheep. The wild parsnip of the lowlands is of rare occurrence and the death camas by this time has shrivelled up. Lupines alone constitute a source of danger and if the sheep are herded away from the areas where these plants grow, especially in the seeding period, the losses from poisonous vegetation will be much reduced. Most of the sheep lost during the past fall were poisoned, as it proved on investigation, by lupines, called by the herdsmen horse-bean or wild pea.

The variations in the activity of the plant according to the stage of growth form one of the problems in investigations of stock-poisoning. The plant may grow from a poisonous root or bulb which passes the noxious principle directly to the young parts, so that they are poisonous from the first moment of growth. At this stage skunk cabbage, death camas, and certain legumes are especially active. Some plants are dangerous only in this stage. In larkspur the tops and roots become less active as the plant approaches the flowering period, and finally harmless. Burweed (*Xanthium spinosum*) is poisonous in its early stages, but later is eaten by cows without injury. The roots of the wild parsnip or water hemlock, which are so virulent in the early spring, have been fed to cows in the late summer and early fall without ill effect. Another member of the same family, the hemlock water parsnip (*Sinum latifolium*,) has a root which is pois-

onous in the early spring but harmless after midsummer, while the roots of another plant of the carrot family, poison hemlock (*Conium maculatum*,) contain no trace of poison during March, April or May, although considerable quantities of the active principle, coniine, are present in the leaves and stems by May. Later in the season the root also becomes dangerous. The young parts of wild aconite when first starting from the ground are comparatively harmless. The roots of aconite and skunk cabbage or wild hellebore which are the most poisonous portions, are not obtainable by stock and so need not be considered here.

The flowering period, or just before, is the stage when the leaves of plants are generally most active. Cattle and horses have been poisoned by eating only small quantities of the flowering tops of aconite. The poison has been slowly elaborated by the plant from the early months when the young shoots were comparatively harmless. The different parts of aconite show a very unequal toxicity in the various stages of their growth. Next to the roots, the seeds and leaves are the most dangerous parts. The leaves are harmless at the time the young shoots are sprouting, most violent just before the time of flowering, and comparatively harmless at seeding, the poison having passed to the fruit. In poison hemlock the root at first contains no poison, while the leaves at the time of flowering contain 0.05 to 0.09 per cent of coniine. The leaves become less poisonous until finally most of the poison has passed to the fruit, which contains 0.7 per cent or more coniine. In the last months of the year the root becomes poisonous, only to lose its poison the season following. The common yew (*Taxus baccata*) affords a striking illustration of the influence of the stage of growth upon its poisonous properties. In this case on the same tree the young shoots and leaves are practically harmless, while the old leaves and boughs are intensely poisonous.

At seeding the plant may be a source of danger to stock. As appears from the illustration given, the poisonous principle leaves

the roots, stem and leaves to enter the seed. Wild aconite, poison hemlock, cockle (both *Vaccaria vaccaria* and *Agrostemma githago*,) darnel, red baneberry (*Actaea spicata*,) bitter-sweet (*Solanum dulcamara*,) black night shade (*Solanum nigrum*), Western wild cherry (*Prunus demissa*) and field sorrel (*Rumex acetosella*) are the common varieties of the state with poisonous seeds.

The parts of the plant which may be poisonous vary as widely as the activity of a part in its various stages of growth. In the case of wild hellebore, poison weed or thorn apple (*Datura Stramonium*,) wild aconite, red baneberry, cypress spurge (*Euphorbia cyparissias*,) showy milkweed (*Asclepias speciosa*) and others, the whole plant is poisonous to a greater or lesser degree. In plants which die down like death camas the root or bulb is apt to be the most dangerous portion. In the case of wild parsnip the tops were apparently inoffensive when fed to a cow. The opposite may also be true. The roots may be harmless and the tops poisonous as in the potato. The leaves are the poisonous part of the mountain laurel (*Kalmia latifolia.*) In certain milkweeds (*Asclepias*) the stem is the especially poisonous part. In bitter-sweet, red baneberry, the fruit and stem are poisonous, while in poison oak the same is true of all parts save the fruit. In wild cherry the bark as well as the leaves may be active. In members of the crowfoot family (*Ranunculaceae*) the flowers are poisonous; the other parts relatively inactive.

Not only may the poisonous nature of a plant vary according to the part and its stage of growth, but the same plant may vary in its toxicity according to the season, climate and other external conditions and without any apparent reason from year to year. In a dry season plants are much more apt to be active from the formation of a fatal amount of poison, as in the case of sorghum and apparently, of cornstalks. The same may be true doubtless in the case of wild plants. Observations have been made in some cases on the effect of climate. Aconite is more active in temperate zones; more so in the South than in the North. Poison hemlock

is said to be more poisonous in warm than in cold countries, and to be eaten in Halifax without any inconvenience being suffered. It does not appear to be so poisonous in England as in North France, while in South France it becomes more virulent and reaches its maximum of activity in Spain and Portugal. Darnel appears to be influenced in its posionous character by external conditions. Poison weed, a naturalized plant, is more active in America than in Europe. The berries of bitter-sweet growing in dry soil appear to be more active than that growing in moist soil. Wild Hellebore and aconite become much less poisonous under cultivation. Light seems to affect the noxious activity of plants. Poison oak is more dangerous by night than by day. On the other hand in cinchona Dr. J. C. Lotsy found more alkaloids in the leaf in the day and in the sunshine than at night or on cloudy days. The activity of the same plant may vary from year to year. In one case it was found that 4400 grams of cockle seed (*Agrostemma*) produced no symptons in horse, while only 300 grams of the next year's crop produced distinct signs of poisoning. Variations in the activity of plants from these causes have been little studied.

Equally little study has been made of the conditions under which plant poisons are formed. The active principle may exist preformed in the plant, as appears true in the majority of cases, or it may be formed by the action of the peculiar class of bodies known as ferments, generated in one part of the plant, upon a substance produced in another part of the plant tissue. When the plant is bruised or crushed the ferment and substance are brought together with the formation of a poisonous compound. Examples of the production of poisons by ferment action are furnished by the wild cherry, sorghum and the seeds of the common flax (*Linum usitatissimum*) which may yield the powerful poison, prussic acid. In wild mustard the poisonous oil of mustard is formed in the same way. White sweet clover (*Melilotus alba*) produces the poisonous substance, cumarin, which does not exist pre-

formed but is furnished in rubbing the plant. Wind flower owes its poisonous qualities to the decomposition of the non-poisonous anemonin into active substances. It is probable that in more cases than have hitherto been suspected the formation of the poison is due to ferment action. In many cases the existence of the substance preformed in the plant, would doubtless interfere with the life of the plant cell, at least if formed in any quantity, while in some cases the poison seems to serve as necessary material.

Under ordinary conditions stock will not eat poisonous plants. The conditions under which such plants are eaten form another of the problems of stock-poisoning. The crowfoot family (*Ranuncu laceae*), which includes many poisonous varieties, is extremely acrid and uninviting to stock. Most poisonous plants are bitter and are avoided by animals. Others like the poisonous hemlock (*Conium maculatum*), poison weed (*Datura stramonium*), and red baneberry (*Actaea spicata*) have such a rank and disagreeable odor that man and beast alike are repelled. No temptation is offered by such a plant to an animal with a full stomach. Intense hunger is the main cause in inducing stock to fill up with deadly species. Under present conditions the food supply of the range is uncertain. Sheep are often driven over long distances in a comparatively short time in changing from one feeding ground to another or to a shipping point. Under such circumstances the whole band become intensely hungry and eat poisonous and non-poisonous plants without distinction. Those in the center of the band have no chance to get even a mouthful and are particularly ravenous. The herder must be acquainted with the more common varieties of poisonous plants in order to avoid localities where they grow in abundance. In the early spring, stock are hungry for green feed and seize anything in sight without regard to consequences. Under normal conditions instinct seems to keep animals from eating noxious weeds. It is a common observation that new stock are much more apt to eat poisonous plants than

those accustomed to the range. Under the spur of hunger, however, instinct ceases to be a protection. Domestication seems to weaken this instinct, so that the care of the herdsman must guard sheep from noxious vegetation as well as from other sources of danger. Lack of regular salting may form a source of loss. In the majority of cases reported to the Station the animals had not been salted for some time previous to the poisoning. It seems probable that the salty taste of the active principle, which in many cases exists in the plant in the form of an organic salt, affords a certain relief to the craving for salt, so that the plant is eaten in fatal quantities. Irregular salting may even induce a preference in the animal for such dangerous means of satisfaction. A tendency or habit may thus be established. Cases are known where animals contract a peculiar taste for certain plants. In the matter of preferences in their diet they are quite human. The fondness of sheep for sorrel may prove fatal. Over indulgence leads to a chronic poisoning and often times the large amount of oxalic acid salts present brings on an acute form. The cow has a weakness for the tobacco plant and the horse seeks out the rhododendron of the garden though both will prove fatal. The "loco" habit is well known to stockmen. Lack of salting may not always be responsible for the contracting of such habits, nor will regular salting necessarily prevent serious cases of poisoning. Care in this respect, however, will go far as a preventive measure.

Noxious weeds in hay may be the source of poisoning. Cases of this kind have been reported to the Station from Blackfoot and other localities. Horses are often said to be "lobeliad" by hay containing *Zygadenus*. The poisoning may be acute or chronic. In a case in Silver City ten horses were fed from a bale of "lobelia hay" which contained considerable amounts of this weed. Within half an hour all ten were showing symptoms of poisoning. The horses ultimately recovered. Wild hay containing lupines in ripe pod is extremely dangerous. In case the animals are

made sick the feeding of the hay should at once be discontinued. In any case wild hay from vicinities where poisonous plants grow in any profusion should be rejected or fed only with extreme caution. Many plants such as members of the crowfoot family (*Ranunculaceae*) which are poisonous in a fresh condition lose their noxious principle on drying. Poison hemlock and wild aconite are much less active in a dry state. Even under these conditions hay badly contaminated with such weeds is unsafe and should be discarded until more is learned about the action of these plants. Accidental cases from poisonous plants taken along with healthy feed may happen in any locality where such plants grow. Wherever possible measures should be taken for their eradication.

Climatic conditions determine in part the conditions under which stock may be poisoned. In a dry year when succulent vegetation is scarce, poisonous plants which remain green become unusually tempting. At such times the permanent loss from such sources is apt to be large. After a heavy rainfall the softened condition of the ground enables stock to pull up poisonous roots or bulbs. Stockmen consider the root of the larkspur the poisonous portion, because most losses with this plant occur in the early spring after a rainfall when the root can be pulled up and eaten. In Montana, Chesnut and Wilcox found that under such conditions the bulb of the death camas, the most poisonous part of the plant, remained attached to the tops in three out of five cases. The same writers explain the prevalence of stock-poisoning after a snow storm in the late spring or early fall by the fact that the only plants then available for food, as the tall larkspur (*Delphinium glaucum*,) happen to be poisonous. In following the snow line stockmen have noticed that cases of poisoning are more apt to occur. Under these conditions the animals are exposed to conditions which lead to fatalities. The death camas appears before much grass is up and is often eaten on account of the dark green, tempting appearance of its grass-like leaves in the absence of other food. On a cold day some

poisons will be more active than under conditions of warmth. In poisons which attack the respiratory centers, the lessened air pressure of high elevations will increase the effect of the poison. The solubility of the poison is also an important factor. A soluble substance is readily absorbed and so acts more rapidly upon the system. All such variations in the action of plants must be considered in cases of stock poisoning.

The effect of poisonous plants varies with the age, sex, species, race and individuality of the animal. It is well known that the young are more susceptible to the action of all drugs than adults. This is not on account of their smaller size, for in speaking of the toxicity of a given substance toxicologists mean the amount per unit of body-weight, which is generally taken as a kilogram (2.2 pounds). It takes less per kilogram of body weight to kill a young animal than to kill an adult. Other things being equal a grown man, per kilogram of body-weight, can take sixteen times the amount which an infant can safely receive. The difference arises from the larger mass of nervous tissue relative to the total body weight in the young. A striking proof of this variation in the action of a poison is seen in the case of death camas, which may be eaten to a certain extent by the ewe without inconvenience, while the lamb will be poisoned by the milk which contains only small quantities of the active principle of the plant.

Female animals, like the young, on acconnt of their relatively greater mass of nervous tissue are more susceptible to the action of poisons. Variations of this sort are especially true of poisons which act upon the nervous system. Its explanation also rests upon sexual differences. Certain plants act upon the uterus and cause abortion, as common groundsel (*Senecio vulgaris*) and ergot. Cases of this kind are also known from the smut of grain. Certain plants act more particularly upon the mammary glands. Cockle is said to produce increased secretion of milk. Water plantain and hemlock water parsnip give milk a disagree-

able flavor. The male in such instances does not appear affected.

Peculiar variations in the action of the same plant upon different animals have been noted. Violent poisons to one species are without effect upon another. Sheep are especially susceptible to poisoning by the leaves of mountain laurel, while deer, goats and grouse are said to eat this plant with impunity. It is even claimed that grouse, living upon the laurel berries during the winter, may become so saturated with the poison that their flesh proves fatal to meat eating animals. Sorrel, which is so greedily eaten by sheep, is fatal to horses. Sheep are also affected when it is in seed. Donkeys are apparently immune to the very poisonous poison weed. Broad-leaved cat-tail (*Typha latifolia*) is sought by horses but acts upon cows. Cows will eat hemlock water-parsnip without suffering harm, but are poisoned by a small amount of another member of the family, wild parsnip, which is said to be without effect upon sheep and goats. Goats are fond of water plaintain, which affects cows. Horses cows, sheep and goats graze upon the foliage of poison oak without injury, according to earlier writers, while Leuvin states that the stomachs of sheep and goats are affected. Snowberry (*Symphoricarpos racemosus*) is eaten by rabbits, but poisons children. Cows and sheep eat large amounts of corn cockle (*Agrostemma*) without injury, while dogs are somewhat poisoned. Poultry appear unaffected although in some quarters its near neighbor, Vaccaria, which probably contains the same principle, is reputed poisonous to chickens. Certain milkweeds, varieties of rattle weed (*Astragalus*), cypress spurge, round-leaved sun-dew, buck-wheat under certain conditions, and the pods and seeds of sweet-clover (*Melilotus alba*) appear to be especially poisonous to sheep. The last named also affects horses. Variations in respect to species have been as little studied as other factors in stock-poisoning. It is apparent, however, from what has been said, that the effect of a given plant upon one animal is no basis for judgment as to what effect the same plant will have upon another species.

Comerin, the French veterinarian, has made experiments on the susceptibility of different species to the same poisonous plant. He found that domestic animals in the ease with which they are affected stand in the following order: Ass, mule, horse, cat, dog, pig, poultry, guinea pig, cattle, sheep and goat, rabbit. The poisonous effect of a plant appears to depend upon the development of the nervous organization and digestive organs in the animal. Where digestion is rapid and complete and the mass of nerve tissue relatively large, the poison is quickly extracted from the plant and absorbed into the blood. The action is also more intense. On the other hand, where digestion is slow and imperfect, not enough poison is absorbed into the blood at any one time to produce serious consequences. Susceptibility is a penalty of superior organization. Since cattle and sheep stand near the foot of the list, it would seem that they are affected only by plants which contain unusually virulent or soluble poisons.

Variations in the action of the same plant according to race and individuality must also be considered in the effect of poisonous plants. Racial immunity to certain diseases is well known to students of the subject. The blacks of the tropics are immune to the toxin formed by yellow fever germs, which prove so deadly to white people. The poisonous components in plants appear similar in many respects to the poisons elaborated by these lower vegetable organisms and like variations in immunity would naturally be expected. Such difference of immunity appears in breeds of sheep. Southdowns imported into France are poisoned by plants which are fed with perfect safety to native herds. Observations upon this point are lacking in Idaho, but it is a matter to be considered by wool-growers in importing new breeds of stock.

The individuality or idiosyncracy of the animal to the action of poisonous plants is summed up in the popular observation, "What is one man's meat is another man's poison." The susceptibility of different persons to poison oak is well known. Var-

ieties of St. John's wort (*Hyperieum*) are said to poison only white sheep.

White sheep are stated by Kobert to be more susceptible to the poisonous action of buckwheat. The cause of such variations remains to be worked out. Observations on the actions of drugs as influenced by individual temperament have been made by numerous physicians. Wide variations in the action of the same drug from this cause have made a rational system of medicine apparently impossible. The whole subject is still in darkness. Apparent discrepancies in the same plant upon different animals, other things being equal, may find their explanation from this source. Such differences are worthy of careful note.

The specific remedy in cases of stock poisoning depends upon the source of the poisoning. In most cases the poison of the plant is not known; much less a remedy. A knowledge of the leading symptoms produced by the various classes of poisons may aid, however, in deciding upon what treatment to adopt. No attempt is made here towards a classification which will make a complete diagnosis possible, even could such be made in all cases. The following classification adapted from the works of various toxicologists may be useful:

A. Poisons causing death instantly or in a few minutes: prussic acid, the cyanides, oxalic acid and, in certain cases, strychnine.

B. Irritant poisons: main symptoms, pain, vomiting and purging and in some cases more or less excitement and signs of brain affection: lead, alkali, oxalic acid, corrosive sublimate, bites of poisonous insects and snakes, red baneberry, bracken fern, cypress spurge, hemlock water-parsnip, wild mustard, buckwheat, cornstalks. In most cases of this class the lining of the mouth or stomach is attacked and blackened with other decided anatomical changes. No general remedy is known.

C. Blood poisons: symptoms, labored breathing, loss of consciousness, luna or excitement, jaundice appearance, bloody urine;

lupines, poisonous mushrooms, corn cockle, cow-herb, wild cherry, sorghum and other prussic-acid-yielding plants.

D. Nerve poisons: symptoms, delirium or paralysis; hearing, sight or other organs of sense affected; increased or decreased heart action; spasms, complete insensibility and in general complex nervous symptoms; darnel, jimson weed, loco-plants (*Astragalus*), poison hemlock, wild parsnip, skunk cabbage, death camas, wild aconite, larkspur, mountain laurel and strychnine (produces peculiar, characteristic, atonic convulsions).

From the list as given it appears that by far the majority of the poisonous plants of the state contain poisons acting upon the nervous system. In almost all of these plants the poisonous principle consists of one or more alkaloids. In general the treatment of poisons consists in rendering the poison insoluble by a chemical antidote to prevent absorption into the system and in getting rid of the insoluble substance thus formed by the use of emetics and purgatives. In prussic acid poisoning the effects are so rapid that treatment may prove of no avail. In animals doses of ferrous sulphate (copperas) with the ferric salt change the prussic acid to a non-poisonous, insoluble compound and have been employed with success. Lime water should be employed in oxalic acid poisoning. Lead and corrosive sublimate form insoluble compounds with the whites of eggs. In alkali poisoning weak acids are given to neutralize the alkali. Mustard in hot water is an emetic and salts may be used as a purgative as usual.

Under present conditions of herding sheep it is generally impossible for one herdsman to attempt to save the animals when any number are attacked. The main thing is to move the herd from the locality. Affected animals should not be forced to follow the band, as such efforts generally result in increasing the severity of the symptoms and the chances of a fatal termination of the attack. Often times the animals will recover if allowed to rest quietly and the tragglers can then be herded in if the main band is not far away. In some cases reported to the Station during

the fall, the whole band showed symptoms of poisoning with fatal results in nearly twenty-five per cent of the number affected. In such an event some form of treatment is the only resort.

No general remedy for stock-poisoning which will be efficacious in all cases is known. Bleeding is a remedy freely practiced by stockmen. Where the poison increases the action of the heart this remedy may prove of avail, but most of the poisonous plants of Idaho lower the heart pressure. Bleeding in such cases simply aids the action of the poison. In one such case this fall, bleeding was employed, and fifty or more sheep bled were the first to die. Blood-letting as a general practice is not to be recommended under conditions in this state. It is noticeable that many of the herdsmen who employ this remedy most freely came from the South or areas where poisonous plants act mostly in increasing the blood pressure, so that bleeding would afford relief. Melted lard, milk, flour and other simple remedies are favorites with stockmen. Melted lard may be a benefit in preventing the ready absorption of the poison, and the purgative effect of many such remedies is useful. In general it may be said that such remedies can be successful only in mild cases of poisoning where the animal would probably have recovered without any treatment. Where the nature of the poison is unknown the success of the treatment is entirely a chance. Treatment in any case must be given as soon as possible if the animal is to be saved. A substance which will destroy the poisonous compound before any quantity is absorbed by the system will prove a valuable antidote. Such an antidote which will act upon many of the classes of nerve poisons, is furnished by a permanganate mixture which was used with great success by Chestnut and Wilcox in cases of stock-poisoning in Montana. These investigators found it especially efficacious in poisoning by larkspur or death camas, and they also recommend its employment in cases of lupine poisoning and other intoxications. It does not provide an absolute remedy in all cases, but is probably the easiest and most efficacious remedy which can be suggested with our present knowledge of vegetable poisons.

The permanganate mixture consists of a one per cent solution of potassium permanganate solution in water and alike solution of aluminum sulphate. The solutions are administered as a drench. These salts may be procured at almost any drugstore and dissolved in water when needed. One-third of an ounce in a quart of water is a dose for 20 to 30 sheep, 7 to 10 horses and 3 to 5 cows. The water used in making the solution should not be alkaline or only slightly so, as the aluminum sulphate is employed to give a slight acid reaction. Care should be taken that the salts are completely dissolved, as they may prove poisonous to the animal in case some of the solid lodges in the throat. Neither salt is very soluble. In a powdered form the salts dissolve more readily. In the case of the permanganate the dark color of the solution makes it impossible to see whether any crystals remain undissolved. This may be ascertained by pouring off the solution with care, when any undissolved portion will be found at the bottom of the vessel used, or the scratching of the crystals against the side of the vessel on shaking may show that solution is not complete. The solution should not be kept ready made up, as it deteriorates on standing, nor should organic matter of any sort be given at the same time. Where the remedy is to be kept on hand for use in large quantities, it is convenient to have it in packets containing an amount which can be dissolved in water, so that the solution shall be of the required strength. The dose should be 5 to 10 grains for sheep, 15 to 20 grains for horses and 30 to 50 grains for cattle. The salt should be dissolved in a pint to a quart of water. It should never be employed in a strong solution. An ounce of the salt would be a dose for 48 to 96 sheep, according to the amount of the dose, and should be dissolved in six gallons of water, when a pint is used as a drench. In the case of young animals the dose should be correspondingly reduced. In general the ratio is one-fifth to one, one being the unit dose for the grown animal. Thus if a sheep is three-fifths grown the maximum dose would be three-fifths of the maximum of a grown sheep or six grains.

On the range poisonous plants cannot be destroyed by cultivtion as on farms where dangerous plants are found in the fields. In Montana the Austrian brome grass (*Bromus inermis*) has been used with reported success to choke out such weeds. It reproduces by the roots so that a thick sod is soon formed and poisonous weeds soon killed out. It stands a large amount of trampling and furnishes a good feed for stock. Under existing conditions stock should be herded away from localities especially rich in dangerous vegetation. To aid in their recognition some of the more common varieties of poisonous plants in the State which have proved to be the source of greatest loss, are described here. By studying the accompanying plates stock owners may render themselves familiar with these varieties and take steps to avoid loss from such sources.

The Wild Parsnip.

(*Cicuta.*)

One of the most violently poisonous plants of the Northwest is Cicuta. The variety known as Oregon water hemlock (*Cicuta vagans*) is shown in the plate and may serve as the type of what is known in this State as wild parsnip. Other species are known by such names as musquash root, spotted cowbane, beaver poison, muskrat root, children's bane, death of man, wild hemlock, spotted parsley, spotted hemlock, snake weed, water parsnip, cowbane and snake root. The multiplicity of names creates some confusion and the use of the one term, Cicuta, would aid materially in identifying the cause of reported cases of poisoning.

Cicuta grows in moist places along rivers and ditches and in lowlands and marshes. It is a tall, smooth plant, with rigid or straggling, hollow stems. The leaves are compound and spring directly from the root. The flowers are white. After flowering in July, the top dies down. The plant has the strong, penetrating odor of the carrot family to which it belongs and is most easily

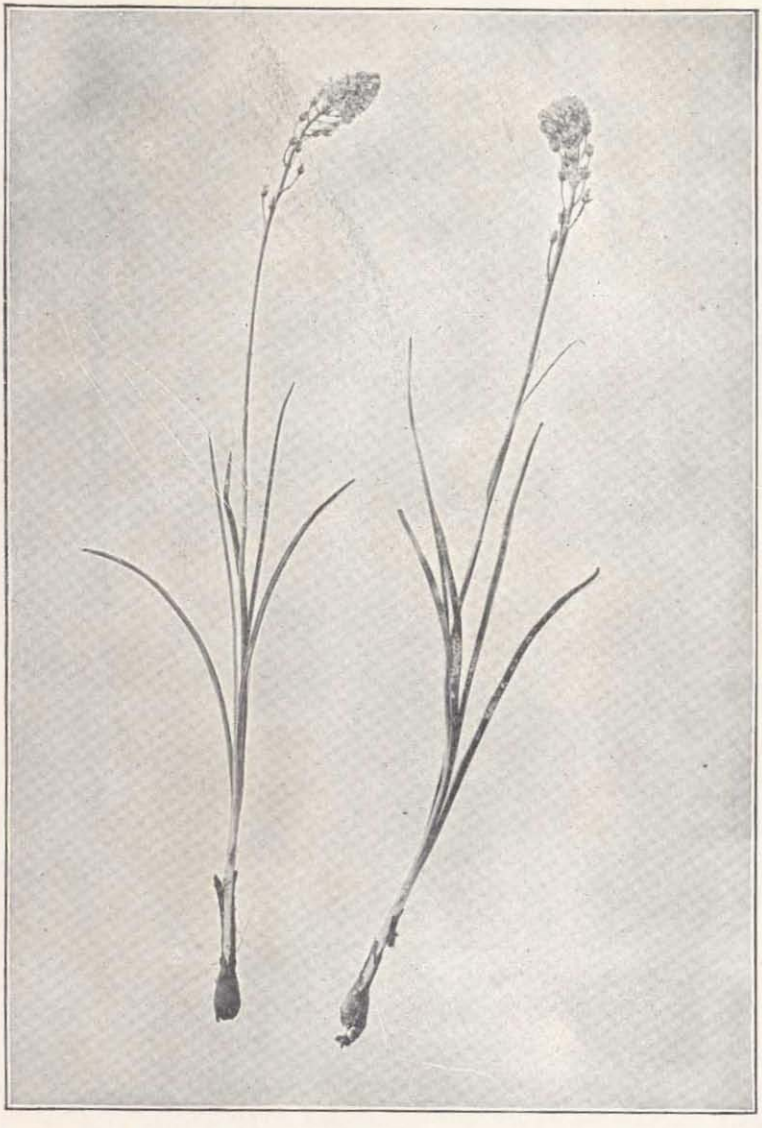
identified by the roots, which are characteristic, and the poisonous part. The roots consist of two parts. The main part is a vertical root stock, one to six inches long by one to two inches thick, divided by horizontal partitions into small chambers which are filled with a yellow, disagreeable-smelling juice which contains the active principle of the plant. The other part consists of solid, fleshy fibers which grow out from the root stock just under the surface of the ground and send down numerous rootlets.

Cicuta is intensely poisonous to man and beast. Falck in 1880 collected 31 cases of poisoning from the literature of the subject in the case of human beings. 63 per cent of them were fatal. In this country cases of Cicuta poisoning are frequently reported. Children often mistake the root for horseradish or for other edible roots. In this manner eight children were poisoned in New Jersey in 1896. With cattle, cases of poisoning have been reported in Europe for the last 150 years. In this country the loss annually from this source is considerable. The estimated number of deaths from Cicuta in Oregon is one hundred annually. During the past year several cases of poisoning reported to the Idaho Station were probably due to this plant. During the late winter and early spring the plant is particularly virulent. Cattle trample the roots in the marshes where the plant grows and are poisoned by drinking the water which has thus been contaminated by the plant juice. It is said by some that all parts of the plant are active in the course of the year, but the root is the most dangerous portion.

Cicuta was investigated in 1896 at the Oregon Station. It was found by experiment that a piece of the root, the size of a walnut, quickly killed a cow, the symptoms appearing within 20 minutes after the cow had eaten the root. Death took place in a few hours. In 1901 experiments in feeding Cicuta were made at the Washington station. The upper parts of the plant tried at various times of the year had little or no effect. The first part of

November the roots were fed to a heifer without result but toward the last of the month the same part of the plant proved fatal to a steer. Another series of experiments in Montana by Chestnut and Wilcox proved beyond doubt that the plant was extremely poisonous. Prof. Ladd of the North Dakota Station found that hay contaminated with Cicuta proved poisonous to a bull.

From the European variety of Cicuta the active principle of the plant, cicutoxin, has been isolated. It constitutes about 0.2 of one per cent of the fresh plant. From the similar effects produced by the American forms it has been inferred that the same active principle is present, but no actual examination of the plant appears to have been made. The Chemical Department of the Idaho Station has been supplied with a sample by Mr. John Ohs, of Coeur d'Alene, and the isolation of the poison with a view of discovering an antidote through a study of its properties is planned. 2-3 mg. (.045 grs.) of cicutoxin is a fatal dose for a frog and 0.05 grams (.75 grs.) per Kilo (2.2 lbs.) of body weight is fatal to cats. The first symptoms in animals appear in 15-30 minutes after eating the plant. Men are fatally affected in from 3 to 16 hours. In the case of the European variety the characteristic symptoms in animals are heightened vitality, loud groaning, twitching, rapid breathing and at intervals convulsions. At the Oregon Station the symptoms noted were uneasiness in the animal followed by twitchings about the nose and mouth, watery eyes, much perspiration, high temperature, continued urination and finally violent convulsions ending in death. Other observed symptoms in some cases are bloating, increased flow of saliva, severe pain in the stomach and widely dilated pupils. The post-mortem examination of the animal reveals little. In case the animal has eaten a considerable quantity, pieces of the root found in the stomach afford the most certain clue to the cause of the death. In one case of Cicuta poisoning the lining of the stomach was found blackened and so soft that it could be scraped off with a stick.



Death Camas.

(*Zygadenus venenosus.*)

Chestnut and Wilcox, Bulletin No. 26, U. S. Department of Agriculture, Division of Botany.

No good remedy in case of Cicuta poisoning is known. Frohner, a leading German toxicologist, recommends tannin and chloral hydrate with hypodermic injections of morphine. Treatment, however, is difficult because the poison renders the animal wild and unmanageable. Melted lard, administered two or three times daily has been found efficacious by stockmen in milder cases. Kobert recommends chloroforming during the attack and cleansing of the stomach. Flour, milk and other simple remedies sometimes used may avail in light cases but in a severe attack there is little hope of saving an animal with any of the remedies now in use. Whenever possible the plant should be eradicated by going over the field with a sharp spade or hoe. Cutting and exposing to the action of sun or frost soon kills the plant. If this is impossible animals should be kept as much as possible from moist places where the plant is known to grow.

Other plants may sometimes be mistaken for Cicuta. Among these are wild celery which grows almost entirely in running water, sweet celery which grows on dry as well as marshy land, and poison hemlock. None of these have a root like the specimen in the plate, and so may be distinguished from the true Cicuta.

The hemlock water parsnip, as it is popularly called, and the cow parsnip (*Heracleum lanatum*) have been suspected of poisoning stock. The Washington Station has published a bulletin on Poison Parsnip in which these varieties are stated to be harmless. Further experiments along this line are necessary to be conclusive.

Death Camas or Lobelia.

(*Zygadenus venenosus*)

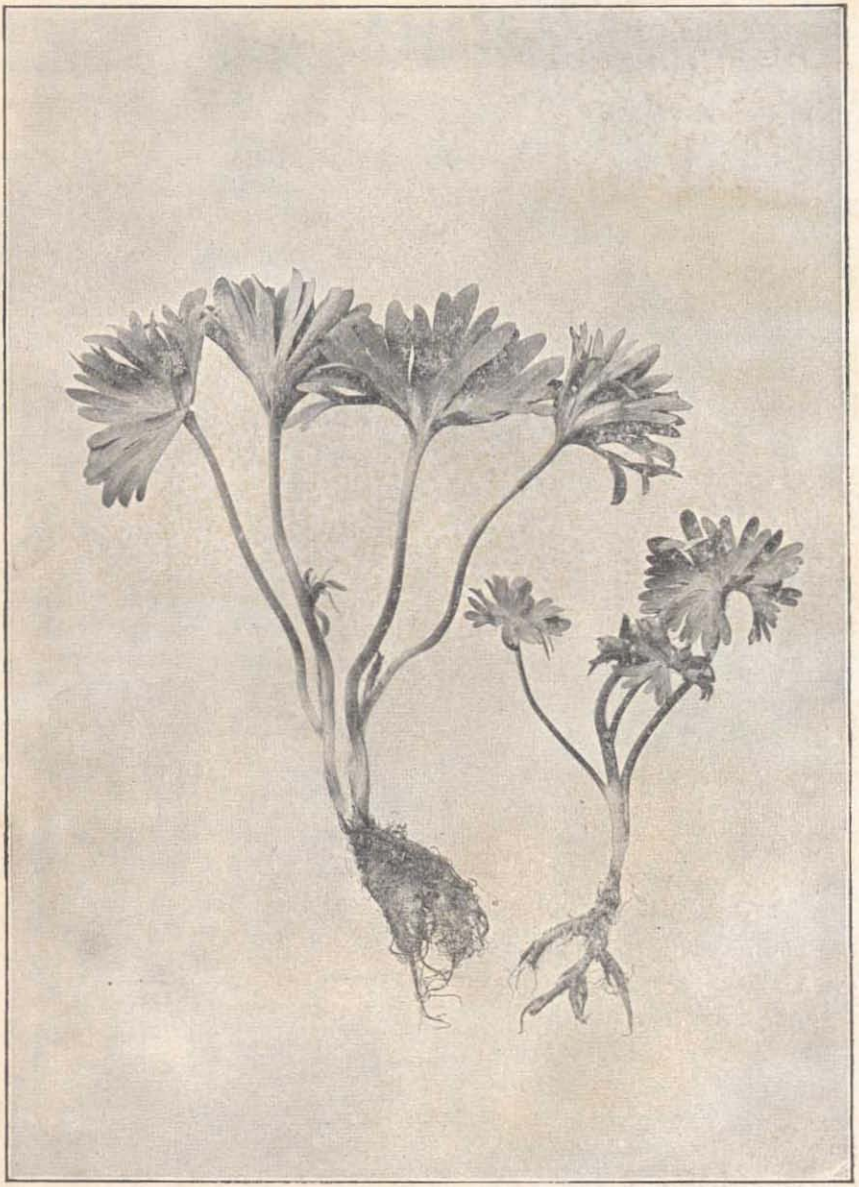
In this state possibly more damage is caused to stock by the death camas or lobelia than by any variey of Cicuta just described. Death camas is also known by its botanical name, Zygadenus.

Its appearance is shown in the accompanying plate. It is a smooth, single-stemmed, onion-like plant, one-half to three feet

high, with an unscented bulb resembling a small onion, and a cluster of yellowish-white flowers. In its early stages it looks like grass and at this period is particularly dangerous. When first appearing in the spring it is often known as crowfoot, according to Mr. V. K. Chestnut, from the three shoots which branch out like the foot of a crow. After the first of June the leaves dry up and the bulb alone is then dangerous. The favorite growing place of the death camas is a shallow depression in a mountain pasture where there is a slow seepage of ground water.

The poisonous nature of the death camas has long been known to the Indians. During the past year the tops were found by the Agricultural Department at Washington to contain a poisonous substance, one of the powerful veratrine alkaloids. The bulbs which have been reputed poisonous were not examined. A study of this part of the plant in the Chemical Laboratoryof the Idaho Experiment Station showed the presence of at least three alkaloids similar to veratrine, the most important of which appeared to be related to the violent poison of hellebore. A single milligram, which is only one-fiftieth of a grain, killed a frog in two minutes. The dose of strychnine fatal to a frog is twice that amount, from which some idea of ihe intensely poisonous nature of the bulbs may be gathered.

The damage to stock from death camas is large and much of the loss from vegetation in the Northwest may be traced to this one plant. In 1900 over 3,000 sheep in Montana died from this cause. The symptoms noted by Chestnut and Wilcox, to whom most of our knowledge of the poisonous qualities of the death camas is due, are uneasiness, staggering, frothing at the mouth, continued swallowing and labored, irregular breathing. Toward the end the breathing is exceedingly fast and shallow. The final stage is complete collapse, the animal lying on its side for hours without motion and apparently dead. The pulse remains normal throughout, the brain unaffected and there is little disturbance in the digestive tract. In horses and cattle spasms are also a symptom in addition to the above.



Purple Larkspur.

(*Delphinium bicolor.*)

Chestnut and Wilcox, Bulletin No. 26, U. S. Department of Agriculture, Department of Botany.

Salt, soda, lard and pork are remedies used by stockmen but the results are not satisfactory. Chesnut and Wilcox found the permanganate mixture, already described, efficacious.

As a result of further experiments upon the effect of the active principle isolatd from the plant these authors recommend hypodermic injections of caffeine diuretin as an antidote.

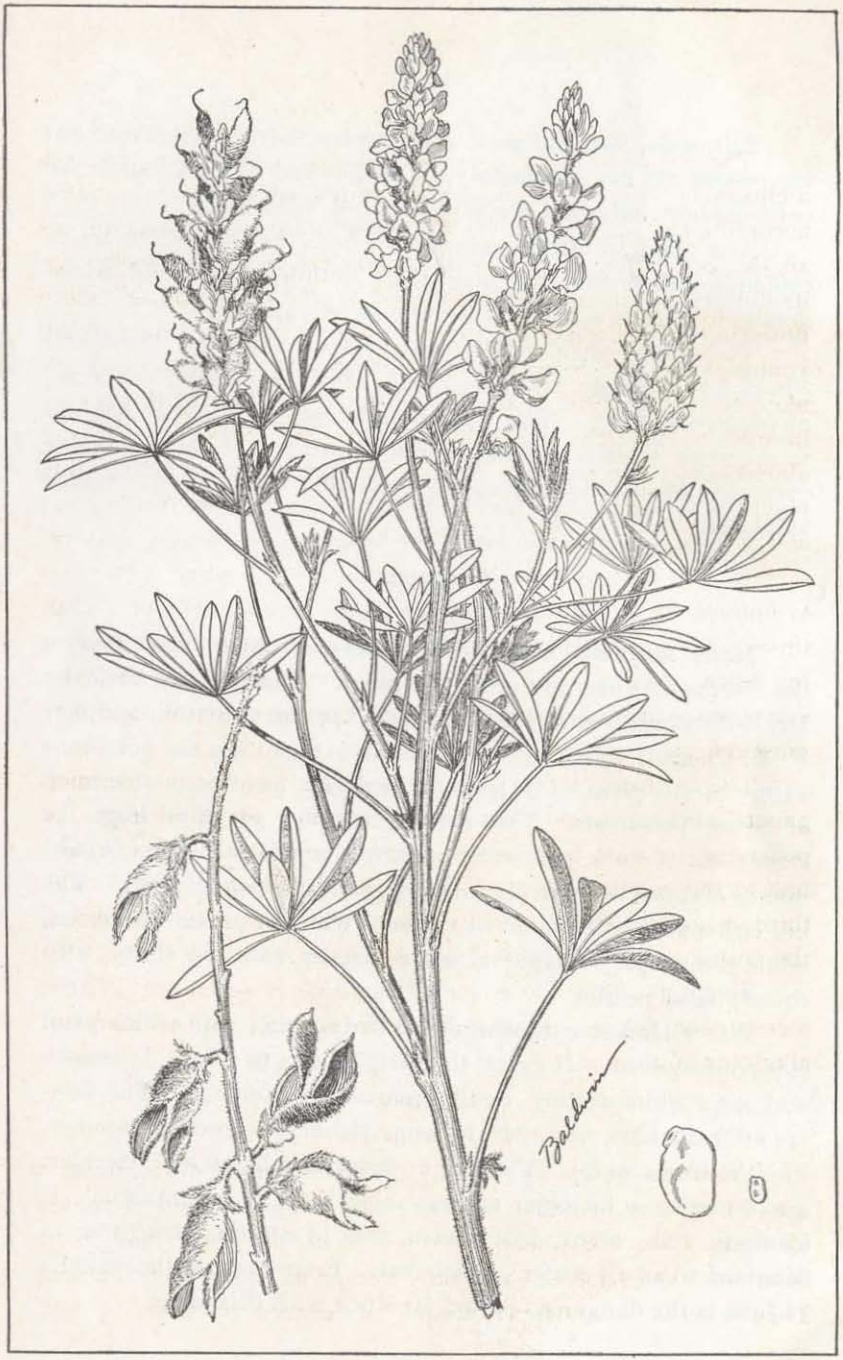
The swamp camas (*Zygadenus elegans*) and sego (*Zygadenus paniculatus*) closely resemble death camas and have the same physiological effect. The "skunk cabbage" (*Veratum*) belongs to the same family as death camas and from a study now being made by the Station appears to contain the same or similar alkaloids.

Larkspur.

(*Delphinium*)

Many stockmen consider that larkspur causes more loss in the Northwest than any other one plant. Through the work by Dr. Wilcox when with the Montana Experiment Station and Mr. V. K. Chesnut, much has been learned regarding the poisonous nature of this plant. At least six varieties have been suspected of being poisonous. The most important varieties from the standpoint of stock poisoning appear to be tall larkspur (*Delphinium glaucum*) and purple larkspur (*Delphinium bicolor*). The tall larkspur is eaten more by cattle to which it proves poisonous, while the purple larkspur is more usually eaten by sheep with equally fatal results.

The tall larkspur is ofentimes called aconite, with which plant it is confounded. It grows to a height of 4 to 7 feet, is smooth and has a white coating, easily removed by rubbing. The flowers are pale blue, arranged in long, slender, terminal racemes, like the true aconite. The larger leaves are broad and circular, 4 to 6 inches in diameter and resemble those of a geranium. It grows in rich, moist, half-shaded soils in Eastern Idaho and in Montana to an elevation of 9000 feet. From May to the middle of June is the dangerous period for stock with this plant.



Lupine.

(*Lupinus leucophyllus.*)

Chestnut and Wilcox, Bulletin Fo. 26, U. S. Department of Agriculture, Division of Botany.

The purple larkspur grows to a height of 1 to 2 feet, and has a cluster of rich purple flowers appearing from May to August according to the latitude. In Montana it occurs at elevations of 10,500 feet. The plant, rare in Idaho, can be distinguished by its flowers, but its dangerous period is the early spring before flowering. The accompanying plate shows the appearance of the young plant. At this early stage of growth the plant is much more succulent. Herdsmen should know the plant at this period in order to herd the sheep from localities where it grows in any abundance. Sheep appear to vary in their habits of eating this plant from year to year, according to the observations of Chestnut and Wilcox. The symptoms of the larkspur poisoning closely resemble the first stages of poisoning by death camas. The first symptoms are a stiffness and irregular, straddling gait. Continued swallowing characterizes both, more pronounced in cases by death camas. With larkspur violent spasms are the first symptoms while in death camas the first symptom is complete muscular paralysis.

The treatment for larkspur poisoning should be the permanganate mixture already described. In more advanced stages of poisoning atropine may be given hypodermically in doses of one-half to one grain with cattle and horses and one-tenth to one-third of a grain in the case of sheep. This acts in counteracting the poison already absorbed into the system.

The active principle of native larkspur is unknown. Other members of the genus contain alkaloids similar to the powerful alkaloids of aconite.

Lupines.

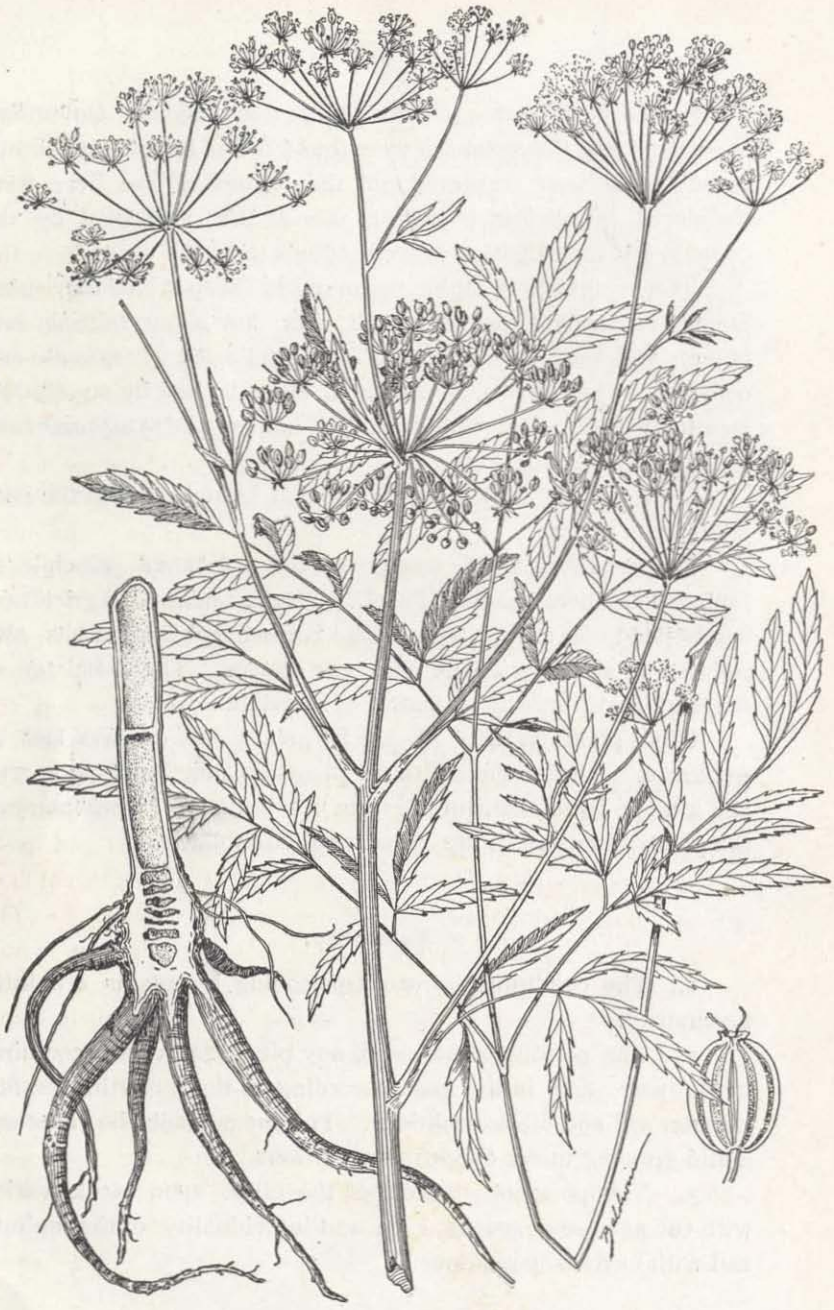
(*Lupinus*)

From the reports received by the Station more range animals are lost from lupines than from any other plant. Common names for lupines are horse-bean, wild pea, blue pea, blue vine, wild bean and pea vine. There are numerous species of lupines. Their general characteristics may be learned by studying the

accompanying plate. In general they are silky-haired plants with racemes of blue flowers, resembling those of a bean, and long-stemmed leaves which are divided into leaflets which radiate from a common point. The bean-like pod, containing several dark, somewhat flattened seeds, gives the common name to the plant. It is at the period of seeding that lupines are especially dangerous. The variety shown in the cut is a *Lupinus leucophyllus.*

According to the observations of Chestnut and Wilcox sheep do not eat lupines to any extent in the spring or summer. In the late fall the plant is one of the few which afford succulent feed and at such times numerous fatalities among sheep are apt to occur. Lupine is cut for hay in Montana and California. Under certain conditions, apparently when the hay is cut from the plant in mature pod, cases of poisoning occur. In Europe chronic poisoning from lupines has received the name lupinosis.

Lupines grow abundantly through South Idaho and during the fall several cases of poisoning by this plant occurred. In one case 800 sheep out of a band of 6000 died from lupines and the whole band was affected. The poisoning occurred at the head of Squaw Creek near Van Wyck at an elevation of 7000 feet. The sheep were being trailed down towards Long Valley the first part of October. They had not been salted for some time and were extremely hungry when the band reached the extensive patch of lupines about four o'clock in the afternoon of October 5. The sheep ate heartily of the lupines. The next morning the whole band was found affected. The sheep were lying in a drowsy condition and refused to get up. Some stood with their heads down in the same condition of stupor and frothing at the mouth. The sheep died in spasms, 400 being lost the first day. The spasms strongly resemble the tetanic convulsions caused by strychnine. The symptoms on the second day were somewhat different. The sheep showed decided signs of mental frenzy, leaving the herd and rushing in a straight line and running into anything that happened to be in the way. The sheep



Wyoming Water Hemlock.

(*Cicuta occidentalis.*)

Chestnut and Wilcox, Bulletin No. 26, U. S. Department of Agriculture, Division of Botany.

finally died in the same strychnine-like convulsions. On cutting open the sheep the stomachs were found full of lupines, numerous blood vessels were ruptured and the lesions of the liver were discolored. Malicious poisoning was at first suspected by the owners, but investigation proved lupines to be the cause.

The symptoms of lupine poisoning in sheep are usually great mental excitement, during which they run about butting into objects and into each other. This is followed by spasms and collapse. The convulsions resemble those caused by strychnine. Death may take place within one-half hour or the symptoms may continue from 2 to 4 days.

Chestnut and Wilcox recommended treatment with the permanganate mixture.

Numerous chemical studies of the poisonous principle of lupines have been made. The U. S. Department of Agriculture has isolated one such. The Idaho Experiment Station has also isolated an active principle from one species. The chemistry of the subject still remains a matter of research.

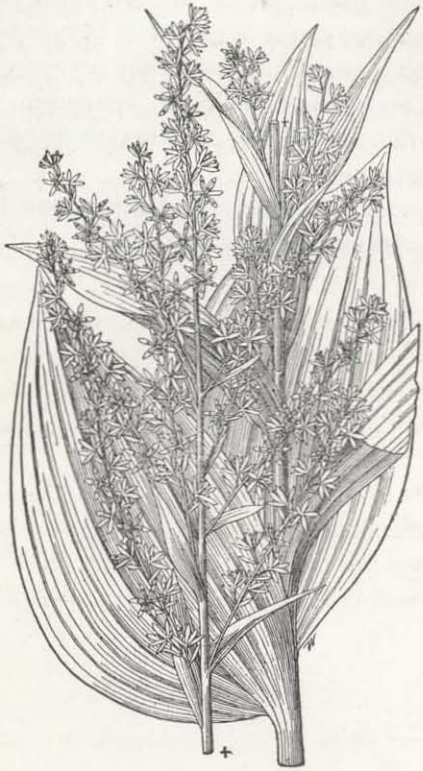
Other plants in the state are frequently the cause of loss to stockmen. A catalogue of such plants is now being prepared and may be issued later in the form of a bulletin. A summary of the points discussed in the present bulletin follows:

Summary.

1. The conditions of stock-poisoning by plants are little understood.

2. The poisonous nature of any plant may vary according to the part, and in the part according to the growth, season, climate, soil and other conditions. Poisonous plants, however are found growing under almost all conditions.

3. The poisonous action of the plant upon stock varies with the age, sex, species, race and individuality of the animal and with external couditions.



White Hellebore—Skunk Cabbage.

(*Veratrum Californicum.*)

4. The conditions under which poisonous plants are eaten arise from an uncertain food supply, lack of salting, selection of plants on part of animals, and conditions which render the poisonous part of the plant available.

5. Poisonous plants act as irritant, blood or nerve poison. Most of the poisonous plants of the State belong to the last class.

6. The best general antidote is the permanganate mixture proposed by Chestnut and Wilcox. Herdsmen should be acquainted with the appearance of poisonous plants to avoid the areas where they grow.

7. Wild parsnip, death camas, larkspur and lupines are the most common poisonous plants of the state.

BULLETINS

Issued by the

University of Idaho Agricultural Experiment Station

1. Preliminary Statement.
2. Proposed Plans of Work.
3. The Application of Chemistry to the Agricultural Development of Idaho.
4. I. Methods of Preventing Smut in Wheat and Oats.
   II. Carbon Bisulfid as a Squirrel Exterminator.
   III. A New Squirrel Exterminator.
5. The Relation of Meteorology to the Agricultural Interests of Idaho.
6. Annual Report for 1893.
7. Insceticides and Spraying.
8. Water and Water Analyses.
9. I. Idaho Soils: Their Origin and Composition.
   II. Miscellaneous Analyses.
10. Idaho Agriculture, Descriptive and Experimental.
11. Smuts and Rusts of Grain in Idaho, and the Most Approved Methods of Dealing With Them.
12. Sugar Beets in Idaho.
13. Meteorology.
14. Twelve of Idaho's Worst Weeds.
15. Annual Reports, 1897-1898, and Miscellaneous Information.
16. The San Jose Scale in Idaho.
17. Construction and Management of Hotbeds.
18. Sugar Beet Investigations in 1898.
19. Miscellaneous Analyses.
20. Apple Scab in the Potlatch.
21. The Codlin Moth.
22. Onion Growing.
23. Meteorological Records and Prediction of Frosts.
24. Cattle Feeding and Crop Tests.
25. The Composition of Arsenical Insecticides.
26. (1) Crude Petroleum, (2) The Elm Louse, (3) The Pear Leaf Blister Mite
28. Some Idaho Soils.
29. (1) Annual Report of Director, (2) Meteorological Records.
30. The Service of Soils.
31. Some Spraying Experiments for 1901.
32. Feeding Steers and Lambs and Analysis of Stock Foods.
33. Some Grasses and Clovers and How to Grow Them in Idaho.
34. Tomato Culture.
35. Meteorological Records and Soil Temperatures.
36. The Codling Moth.
37. Some Conditions of Stock Poisoning in Idaho.