Five Poisonous Range Weeds—When and Why They Are Dangerous

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Highlight

Three larkspurs, halogeton, and western falsehellebore were examined for seasonal variation of their contained poisons. With the exception of low larkspur, greatest concentrations of the poisons were found in the leaves. Alkaloid concentration in tall larkspurs decreased with plant maturity. Cattle losses may be reduced if tall larkspurs are avoided during early vegetative growth. The alkaloid content of tall larkspurs was increased by treatment with 2,4,5-T and silvex. Only 2,4,5-T increased alkaloid content of western falsehellebore.

Poisonous plants have always constituted an indigenous component of the flora of the Western range. Halogeton *(Halogeton glomeratus* (M. Bieb.) C. A. Mey.) is the only one of our most troublesome poisonous weeds which has been introduced.

The native larkspurs *(Delphinium* spp.), western falsehellebore *(Veratrum californicum* Durand), and halogeton have become management problems by (1) introducing domestic animals where these weeds are prevalent; and (2) range misuse, particularly overgrazing, which permits weeds to increase in density and invade new areas at the expense of desirable vegetation.

Apart from recognizing these species in the field, few understand the complex physiological characteristics peculiar to each, such as the poison or poisons it contains; why only certain classes of livestock are poisoned; the distribution of the poison within the plant; how the poison content varies during the plant's life cycle, and the effect of climate and herbicides on the concentration of the poison.

Information on the characteristics and properties of plant poisons has been reported by Dye (1956), Williams (1960), Cook and Stoddart (1953), and Morton et al. (1959), on halogeton; Beath (1919, 1925), and Williams and Cronin (1963), on larkspurs; and Keeler and Binns (1964), on falsehellebore. Our continuing research was conducted with five poisonous species common in the Intermountain West: duncecap larkspur, *(Delphinium occidentale* S. Wats.; tall larkspur, *D. barbeyi* (Huth) Huth; low larkspur, *D. nelsonii* Greene; halogeton, *Halogeton glomeratus* (M. Bieb.) C. A. Mey.; and western falsehellebore *Veratrum californicum* Durand. With the exception of duncecap larkspur, the common names used are those approved by the Terminology Committee of the Weed Society of America (Darrow et al., 1962). Duncecap larkspur is designated as the common name for *Delphinium occidentale* in Standardized Plant Names (Kelsey and Dayton, 1942). Unfortunately, duncecap larkspur is usually called tall larkspur in the West and is therefore frequently confused with *Delphinium barbeyi.*

Materials and Methods

Plants were collected by locations, as follows: low larkspur, duncecap larkspur, and western falsehellebore, Wasatch Mountains east of Logan, Utah; tall larkspur, Wasatch Plateau east of Manti, Utah; halogeton, west of Snowville, Utah. Plants were sampled weekly in the field from soon after emergence until termination of their active growth. Plants were divided into leaf, stem, flower, and leaf-seed-sepal fractions, according to species and season. When possible, the same species was sampled at different elevations on the same date. The individual plant parts were dried for 24 hr at 60 C, ground to a 40-mesh powder, and stored in air-tight polyethylene containers.

Larkspurs and falsehellebore were analyzed for total alkaloids as previously described for tall larkspur (Williams and Cronin, 1963). Soluble and total oxalates in halogeton were determined by the method of Dye (1956). The above plants have, for a number of seasons, been analyzed for changes in the concentration of their contained poison following applications of experimental herbicides. Samples were taken 1, 2, and 3 weeks after treatment, and processed and analyzed as described.

Results and Discussion

Tall and Duncecap Larkspur.—More cattle are killed in the West by tall larkspurs than any other poisonous weed. Authenticated cattle losses attributed to tall larkspur on one grazing allotment in Utah have ranged from 2 to 12% during the last 10 years.

Plants begin growth in late spring as soon as snow has melted. As many as 20 to 30 shoots may arise from a single crown. In the vegetative stage, tall larkspurs resemble the poisonous monkshood, *Aconitum columbianum* Nutt. Tall larkspurs, however, have hollow stems and prefer well-drained soils, while monkshood has a solid, pithy stem and occurs on moist sites. Flowers of the two genera are easily distinguished because the calyx on monkshood lacks the spur characteristic of larkspurs.

Tall larkspurs produce flowers from July to September. The flowering plants average 3 to 4 ft in height but may reach 6 ft or more. Tall larkspurs grow at an elevation of 6,000 to 11,000 ft,

Table 1. Percent total alkaloids in plant tissue of duncecap larkspur, western falsehellebore, and low larkspur, 1965.

Date of Collection	Duncecap larkspur 7000 ft Apex	Duncecap larkspur 7000 ft Leaves	Duncecap larkspur 7000 ft Stems	Duncecap larkspur 8000 ft Apex	Duncecap larkspur 8000 ft Leaves	Duncecap larkspur 8000 ft Stems	Western falsehellebore 6000 ft Leaves	Western falsehellebore 6000 ft Stems	Western falsehellebore 8000 ft Leaves	Western falsehellebore 8000 ft Stems	Low larkspur 8000 ft Leaves	Low larkspur 8000 ft Stems	Low larkspur 8000 ft Flowers
May 28	—	—	—	—	—	—	0.3	0.5	—	—	—	—	—
June 3	—	—	—	—	—	—	0.3	0.2	—	—	—	—	—
June 10	4.1	3.7	2.6	—	—	—	0.2	0.2	—	—	—	—	—
June 17	2.5	2.4	1.5	—	—	—	0.2	0.1	—	—	—	—	—
June 23	3.0	2.3	1.1	5.4	3.5	3.5	0.2	0.2	0.4	0.4	0.2	0.1	—
June 29	2.6	2.1	1.0	4.6	4.5	3.4	0.2	0.2	0.5	0.3	0.2	0.2	—
July 8	3.3	2.1	0.7	3.1	2.7	1.5	0.2	0.2	0.2	0.2	0.2	0.4	0.5
July 15	3.3	1.8	0.6	3.3	3.2	1.1	0.3	0.3	0.2	0.2	0.3	0.3	0.6
July 21	2.8	1.6	0.7	3.5	2.8	1.1	0.2	0.1	0.2	0.2	0.2	0.2	0.4
July 28	2.3	1.3	0.8	3.3	2.2	1.1	0.2	0.2	0.2	0.2	—	0.3**	—
August 5	2.0	0.9	0.8	2.6	1.6	1.1	0.3	0.2	0.3	0.2	—	0.2**	—
August 12	2.1	1.2	0.6	2.0	1.6	0.6	0.2	0.1	0.2	0.1	—	0.2**	—
August 19	0.9	0.6	0.4	2.3	1.4	0.5	0.2	0.2	0.3	0.2	—	—	—
August 26	0.8	0.6	0.4	2.3	1.2	0.7	0.2*	0.2*	0.2	0.1	—	—	—
September 2	0.8	0.6	0.3	2.8	1.0	0.5	—	—	0.2*	0.2*	—	—	—
September 9	0.6	0.5	0.3	1.9	0.8	0.7	—	—	—	—	—	—	—
September 20	—	—	—	1.0*	0.3*	0.4*	—	—	—	—	—	—	—

* Plants dead
** Whole plant samples only

either on open meadows or interspersed among aspen and fir. Tall larkspur may be distinguished from duncecap larkspur by the tawny pubsecence of its inflorescence and by its tendency to produce bi-colored (light blue and dark blue) petals. Tall larkspur occurs in Arizona, New Mexico, Colorado, and Southern Wyoming and Utah (south of Provo). Duncecap larkspur grows generally north of tall larkspur in Northern Utah, Idaho, Nevada, Northern Wyoming, Montana, Oregon, and Washington.

The toxic substances in larkspurs are alkaloids. These compounds are complex organic molecules which contain, in addition to carbon, hydrogen and oxygen, a small amount of nitrogen. Alkaloids are widely distributed throughout the plant kingdom. Many that occur in small amounts in food are harmless but other alkaloids, such as morphine, atropine, and strychnine, are highly poisonous, though all three have great medicinal value under controlled use. Familiar examples of alkaloids are caffeine in coffee and nicotine in tobacco.

Tall larkspurs are most poisonous during early growth, especially during the first few weeks following emergence (Table 1). Alkaloid content decreases rapidly until flowering, during which alkaloid levels drop more slowly. After the plants have reached full flower, alkaloids rapidly decline. At 7,000 ft elevation, the apex consisted of leaves June 10 to July 1; buds July 1 to 15; flowers July 15 to 30; and seed pods and seeds thereafter. Equivalent growth stages in plants collected at 8,000 ft occurred 2 to 3 weeks later.

The majority of the alkaloids are found in the green leaf. Young leaves, particularly the apical bud, are rich in alkaloids. Stems are high in alkaloids only when very young and succulent; and as they become more woody, the concentration of the poison drops very rapidly. Before the bud stage of development, the dry weight of the plant is about evenly distributed between the leaves and stems. After flowering the older leaves begin to die, thereby reducing the percent dry weight of the leaves in a whole plant sample.

In years when cattle losses from tall larkspurs are unusually heavy, ranchers frequently assume that the plants are more toxic than usual. This assumption is true if losses occur following a winter of above normal snowfall or if the spring is unusually cold. The toxicity of larkspur is dependent upon two conditions: date of emergence, largely determined by winter snowfall, and temperature following emergence. Toxicity corresponds very closely to stage of growth. The later the start of growth, the more toxic plants will be at any particular date during the growing season. Cold weather following emergence can further retard development.

Duncecap larkspur (Table 1) was collected at 7,000 and 8,000 ft elevations. Plants at 7,000 ft were 18 to 20 inches high before snow had melted at 8,000 ft. Consequently, the stage of development of plants at 8,000 ft was 3 weeks behind those at the lower elevation. Until late in the season, higher elevation plants contained a larger concentration of alkaloids than lower ones at each date of collection. Duncecap larkspur, collected on September 9, 1965, at a site above 8,000 ft, from which snow did not melt until August, contained 1.3% and 0.7% alkaloids in the leaves and stems, respectively. These plants were flowering, and at a stage of growth comparable to larkspur on July 28 on the 7,000 ft site. The similarity in alkaloid content is striking and emphasizes the close correlation between stage of growth and toxicity in tall larkspurs.

Because of above normal snowfall, tall larkspur at Manti did not emerge on many sites until August. The alkaloid content of both leaves and stems was much higher than at comparable dates in 1963, when the growing season began earlier (Table 2).

We have no information regarding larkspur toxicity as influenced by moist or dry growing-seasons. One would suspect that alkaloid metabolism in deep-rooted perennial tall larkspurs would seldom be affected by moisture limitations at higher elevations. Abnormally heavy cattle losses during a season when tall larkspur begins early growth cannot be traced to excessive toxicity in the plants; rather, conditions favoring increased consumption of the plants must be responsible—poor range condition, lack of forage, or releasing hungry animals onto land heavily infested with larkspur.

Table 2. Seasonal distribution of alkaloids (percent) in tall larkspur.

Date of collection*	1965 Lvs.	1965 Stems	1963 Lvs.	1963 Stems
July 10	—	—	2.8	2.8
July 18	—	—	2.5	1.4
July 23	3.4	2.1	1.9	0.9
July 30	2.8	1.6	1.8	0.5
Aug. 4	2.8	1.3	1.7	0.4
Aug. 11	1.9	1.4	1.2	0.4
Aug. 17	1.5	0.7	1.1	0.3
Aug. 27	1.3	0.4	1.0	0.2
Sept. 3	1.9	0.8	0.5	0.2
Sept. 7	0.9	0.7	0.4	0.1

* Dates are for 1965. Dates for 1963 were either the same or varied by only 1 or 2 days.

Most losses from tall larkspurs occur within 2 weeks after cattle reach infested areas. Plants usually have not reached full-bloom and are therefore highly poisonous. Few losses occur after the full-bloom stage of growth is over. Alkaloid level in duncecap larkspur at 7,000 ft declined to less than half by full-flower in mid-July. By September the plants were, at most, only about one-seventh as toxic as on June 10. Since stems account for an increasing percentage of the dry weight later in the season, the actual toxicity was undoubtedly much less.

Tall larkspurs are not unpalatable to cattle, and releasing a hungry herd onto an infested area merely invites disaster.

Low larkspur.—Low larkspur is widely distributed from South Dakota westward to Colorado, Wyoming, Utah, and Idaho, where it thrives on foothills, plains, and open mountain meadows. The plants emerge in early spring after snow melt, flower in June and July, then dry up and disappear. Each plant consists of one or two stems, two to six leaves, and, when in full flower, it reaches a height of 1 to 2 ft.

Low larkspur alkaloid levels do not vary greatly during its short growing season except that they tend to be higher during flowering. The small leaves dry rapidly after flowering; therefore, only whole plant samples were collected late in the season (Table 1). The alkaloid content is only 10 to 20% of that found in the tall larkspurs; therefore, cattle losses tend to be less severe. At the site where these collections were made, the plants had largely matured and disappeared before cattle were released on the area.

Alkaloid concentration does not, alone, determine larkspur toxicity. Each species contains several alkaloids, some of which are more toxic than others; therefore, the toxicity of individual species will depend upon type and concentration of alkaloid. The same alkaloid may occur in several species of larkspur; others are unique only to one species. Beath (1925) extracted crude alkaloids from five species of larkspur, including those discussed here, and evaluated their relative toxicity via intravenous injections in rabbits. Alkaloids from low larkspur were most toxic, while alkaloids from tall larkspur were only slightly less poisonous. Alkaloids from tall and low larkspurs were three and four times more poisonous, respectively, than alkaloids from duncecap larkspur. The alkaloids of duncecap larkspur were the least poisonous of the five species examined. On the range, however, duncecap larkspur is actually more poisonous than low larkspur, since it contains up to 10 times more alkaloids per gram of plant tissue. Tall larkspur not only contains the more poisonous types of alkaloids, but produces them in concentrations equal to any other tall larkspur. The heavy cattle losses caused by this species are, therefore, not suprising. Clawson (1933) reported that the lethal dose of young tall larkspur may be as low as 0.7% of an animal's weight, or roughly 3.5 lb for a 500-lb animal.

A few seconds of additional grazing on any larkspur species may mean the difference between mild symptoms and fatal poisoning. It should not, for practical purposes, be inferred that alkaloid toxicity varies to the extent that various species can be categorized as "more toxic" or "less toxic". All species are dangerous. But cattle losses recorded over the years suggest that tall larkspur must rank first as a killer in the Rocky Mountain region.

Western Falsehellebore.—Western falsehellebore is a tall,

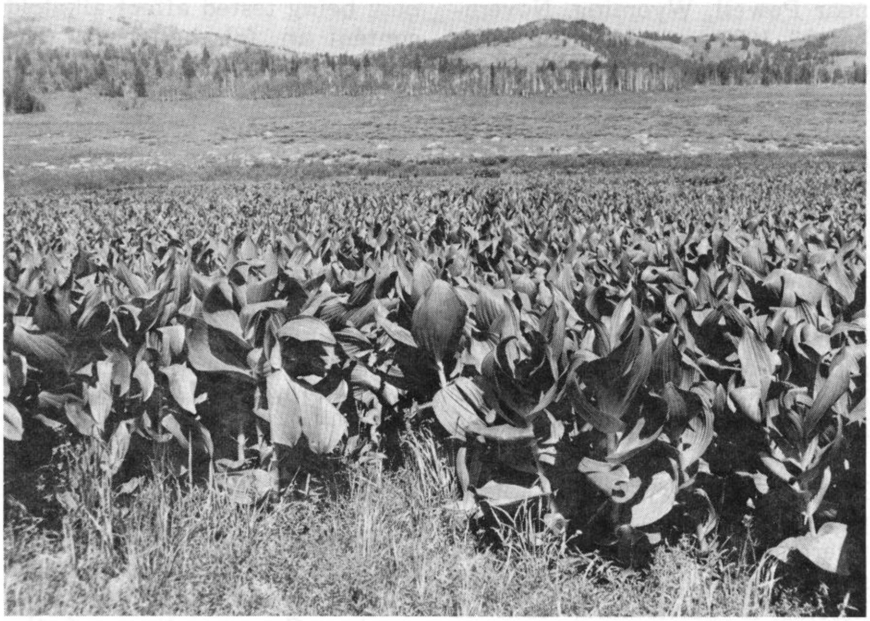

FIG. 1. Western falsehellebore infestation on a mountain meadow, Cache National Forest, Idaho.

robust member of the lily family which grows above 5,500 ft elevation. In flower the plant stands 6 to 8 ft tall. Individual leaves measure up to 9 x 12 inches. Plants emerge as soon as snow melts, flower in July and August, and set seed in September. Seed production is erratic, however, and in some years plants may dry up and become dormant while in full flower. Plants rooted in moist seeps become dormant as rapidly as those on dry sites. In 1964, seed production was abundant. In 1965, few flowers and no seed were produced on the same area even though moisture and growing conditions were more favorable than during the preceeding year.

Several alkaloids are found in western falsehellebore (Keeler and Binns, 1964). One or more of these acts as a teratogenic agent which causes severe malformations in lambs if the ewe eats the plant during the very early stages of gestation (Binns et al., 1963). This problem has been particularly severe in Idaho where ewes are bred on the range for early lamb production. Both larkspurs and falsehellebore contain monobasic and steroidal-type alkaloids, but are not known to contain the same specific alkaloids. Falsehellebore is seldom grazed by cattle; therefore losses are almost entirely confined to sheep.

Alkaloid content in falsehellebore is highest when plants emerge. The level drops quickly to about 0.2% of the dry weight of the plant. The alkaloid concentration varies slightly above or below this figure throughout the season until the plant dies. The stems contain slightly less alkaloid. Flowers have little or no alkaloid content.

The altitude difference in Table 1 represents 2,000 ft. Late emerging plants were higher in alkaloids than older plants at lower elevations only for a period of 2 weeks. After July 8, no significant differences in alkaloid levels were apparent.

The data indicates that falsehellebore is capable of producing its toxic effects with almost uniform intensity throughout the growing season. Dead but undecomposed leaves are frequently as high in alkaloids as the green leaf.

Halogeton. — Halogeton is an annual of the goosefoot family which, since its introduction 30 years ago, has invaded 12 million acres of Western rangeland. The plant contains unusually heavy concentrations of soluble oxalates which are bound primarily as sodium salts. Oxalates are readily absorbed into the circulatory system of the affected animal. There the two sodium ions are replaced by one calcium withdrawn from the serum calcium. Excessive depression of the serum calcium level is inevitably fatal. Calcium oxalates are then precipitated primarily in the liver and kidneys where they interfere with normal function of these organs.

Soluble oxalates are highest in the leaves and lowest in stems of halogeton (Table 3). Seed contains about 2% soluble oxalates (Williams, 1960). Though halogeton produces primarily soluble oxalates, some insoluble oxalates, primarily salts of calcium, are present. Insoluble oxalates are not absorbed; therefore they are nontoxic. Soluble oxalates predominate in the leaves while insoluble oxalates occur in higher concentrations in the stems.

The oxalate content of the halogeton leaf tends to be relatively high during midsummer, then peak in September (Williams, 1960). The data in Table 3,

Table 3. Seasonal distribution of soluble and insoluble oxalates (percent) in stem and leaf-seed-sepal fractions of halogeton.

Date of collection	Lf.-seed-sepal Sol.	Lf.-seed-sepal Insol.	Stems Sol.	Stems Insol.
June 24	25.0	3.2	3.4	7.6
July 9	24.3	4.5	2.9	6.0
July 22	22.6	4.9	4.1	6.1
Aug. 6	22.3	5.3	2.3	2.6
Aug. 19	22.9	1.7	3.8	4.5
Sept. 3	19.1	5.4	1.1	3.7
Sept. 17	16.4	3.5	1.6	5.5
Oct. 1	16.3	3.4	1.6	4.2
Oct. 15	24.5	3.9	4.0	3.9
Oct. 28	24.4	9.0	2.1	4.8
Nov. 12	25.5	3.1	1.9	2.6
Nov. 23	19.1	3.0	1.9	3.6

however, represent a leaf-seed-sepal fraction, so that the lower oxalate content noted from September to early October represents inclusion of flowers, seeds, and sepals — all of which are lower in oxalates and thereby dilute the overall oxalate concentration. By mid-October seeds began to disperse, samples contained a greater percentage of leaves, and oxalate percentage responded upward accordingly. When only pure leaf samples are collected, one may expect soluble oxalate content to exceed 30% from late August or early September to frost and later, depending upon climatic conditions. A leaf sample collected near Cisco, Utah, in November contained 38.25% soluble oxalates, the highest concentration that we have found.

The toxicity of the dead plants during the winter is largely dependent upon weather. Windstorms, hail, and heavy rain will remove leaves from standing plants, reducing oxalate content. Rain will leach some soluble oxalates from the leaves. A record November rainfall occurred throughout Northern Utah from November 12 through November 25, 1965. The leaching effect of this precipitation may be noted in the markedly decreased soluble oxalate content in leaves collected on November 23 (Table 3). If fall and winter precipitation is light, the leaf-seed-sepal fraction may contain more than 30% soluble oxalates as late as mid-February (Dye, 1956). Since dead halogeton remains almost as poisonous as the living plant, it should be avoided at all times.

Halogeton is confined largely to desert valleys; therefore, oxalate concentration is not affected by changes in elevation. Oxalates occur in such copious quantities that geographical distribution, as it now exists, would not cause notable, or significant, differences in the oxalate levels of halogeton. Halogeton collected near Powell, Wyoming, November 26, 1965, contained the same concentration of soluble oxalates found in plants from Snowville, Utah. In Wyoming Bohmont et al. (1955) found that oxalate content in halogeton ranged from 14 to 21%; this is no different from whole plant analyses made in Utah, Nevada, and Idaho. The fact that sheep are rarely lost to halogeton in Wyoming must be attributed to good management, better range condition, and perhaps lower halogeton densities.

Type of Livestock Poisoned.— For almost every kind of plant poison there is a difference in tolerance with each class of livestock. Tolerance of cattle for alkaloids is particularly low. A dose of larkspur fatal for cattle, based on body weight, may or may not even produce symptoms in sheep. The reasons for these differences are not known. Apparently the microflora of the sheep's digestive system are more efficient in breaking down or detoxifying alkaloids. Cattle escape halogeton and falsehellebore poisoning largely because they avoid these species. The few authenticated examples of halogeton poisoning in cattle were reported from an area where this weed constituted virtually the only available herbage.

Herbicides. — Two herbicides, 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and 2-(2,4,5-trichlorophenoxy) propionic acid (silvex), increased alkaloid content in tall larkspur (Williams and Cronin, 1963) and duncecap larkspur. In some years application of these herbicides has doubled the alkaloid content of the leaves and stems for 2 or 3 weeks after treatment. Among the many experimental herbicides evaluated for control of western falsehellebore, only 2,4,5-T increases alkaloid content. Fortunately, the low effectiveness of this herbicide precludes its use in controlling this species.

None of the five best herbicides now being tested affect alkaloid content in falsehellebore. The concentrations of oxalates in halogeton and alkaloids in low larkspur have been neither raised nor lowered by any herbicides thus far evaluated, including 2,4,5-T and silvex. Because the tall larkspurs may be more toxic following applications of phenoxy herbicides, particularly silvex and 2,4,5-T, posttreatment grazing should be restricted 2 to 3 weeks after treatment and until the plants begin to dry and lose their palatability.

Summary

Distribution and seasonal changes of toxic compounds were studied in five poisonous range species. Concentrations of the poisons declined with maturity in two tall larkspurs; remained relatively unchanged in western falsehellebore and halogeton; and peaked at flowering in low larkspur. With the exception of low larkspur, the majority of the toxic principle was always found in the leaves.

The toxicity of tall and duncecap larkspur was closely determined by stage of maturity. These species tend to be more poisonous later in the season if their emergence is delayed by late snow melt, or if subsequent growth is retarded by cold weather. As elevation increased, duncecap larkspur contained a greater concentration of alkaloids at any given date.

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