

Alkaloid Content of Duncicap Larkspur after Two Years of Clipping

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Highlight: *Duncicap larkspur plants clipped in vegetative growth stage (late June) for 2 consecutive years produced only leaves and no flower stalks the third year. These plants were significantly smaller and contained a significantly lower concentration of total alkaloids than those plants clipped later in the summer or than unclipped control plants. This susceptibility to injury by clipping may help interpret results of other control methods. Total alkaloid content of previously unclipped larkspur plants was highest in the early growth stages and declined throughout the summer. Total alkaloid content in late June ranged from 1.7% to 2.8% and was not correlated with amount or pattern of precipitation.*

Duncicap larkspur (*Delphinium occidentale*), tall larkspur (*D. barbeyi*), and other species in the tall larkspur group have long been recognized as poisonous to cattle. Several methods have been studied in efforts to control or eliminate larkspur.

Early studies indicated that grubbing larkspur plants below the ground surface, if done properly, could kill more than 90% of the plants (Aldous, 1917). However, high cost and inconsistent results generally made grubbing an impractical method of larkspur control. Grubbing is similar to clipping except that it is more severe.

In the only previous study of the effects of clipping, Cronin (1971) concluded that 1 year of clipping at 1 or 2 week intervals throughout the summer reduced production that year but did not permanently injure any tall larkspur plants. The clipped plants did not flower the following year, however, indicating that there was a temporary effect. Total alkaloid content, an indicator of the level of toxicity, of the treated plants was not determined. The effects of clipping for more than 1 year have not been studied.

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The generally high palatability of the tall larkspurs to sheep and the relative immunity of sheep to larkspur poisoning resulted in early attempts to control larkspur by grazing infested areas heavily with sheep each year before cattle reached the areas (Aldous, 1917). This method reduced the amount of larkspur available to the cattle but was not effective as a permanent control measure. Modern herbicides have provided effective controls under certain conditions (Hervey and Klinger, 1961; Torrel and Haas, 1963; Cronin and Nielsen, 1972; and others).

Williams and Cronin (1963) determined that the alkaloid content of duncicap and tall larkspur doubled after the application of 2,4,5-T or 2,4,5-TP (Silvex). With this exception, no research has been done on the effect of control treatments on alkaloid content of larkspur plants.

This study was undertaken to determine the effects of 2 successive years of complete herbage removal at various times throughout the summer on the growth, vigor, and total alkaloid content of duncicap larkspur plants during the year following treatment. Clipping is not envisioned as a practical larkspur control method, but the effects of clipping may assist in interpreting the reaction of this species to other treatments such as herbicides.

Methods

The study was conducted in the Davis Basin area on the Malad District of the Caribou National Forest, Idaho. Elevation is about 7,000 ft. The vegetation is dominated by aspen (*Populus tremuloides*) with a forb-grass understory. The main herbaceous species is duncicap larkspur with butterweed groundsel (*Senecio serra*), western coneflower (*Rudbeckia occidentalis*), and mountain brome (*Bromus carinatus*) also prominent (Logan, 1973).

Two groups of larkspur plants in a protected area adjacent to experimental cattle pastures were clipped to ground level at weekly intervals during summer months, one group in 1968 and 1969 and the other in 1970 and 1971. In 1968, 10 plants were selected and clipped weekly, starting the third week in June and ending in mid-August. Plants were marked with numbered metal stakes and the same plants were clipped at approximately the same date in 1969. In 1970, all plants were allowed to grow to maturity and then clipped to ground level on August 3. Twelve untreated plants were selected in 1970 in

the same ungrazed area and harvested at the same time.

A different group of 76 previously unclipped plants was selected in early June 1970 and marked with numbered stakes. Eight plants were randomly selected to be clipped each week starting the third week in June and ending in mid-August in both 1970 and 1971. Twelve plants were designated as control or check plants to receive no treatment. In 1972 all plants were allowed to grow to maturity and then clipped at ground level on July 17.

Each year from 1968 through 1971, a composite sample of the plants clipped each week was dried and analyzed for total alkaloids by the methods of Williams and Cronin (1963).

In 1970 and 1972, mature plants clipped the previous 2 years were analyzed for number of stems, average plant height, dry weight, and total alkaloid content. The plants collected in 1972 were also analyzed for nitrogen, phosphorus, and potassium content by the Utah State University Soil Testing Laboratory. Nitrogen was determined by the macro-Kjeldahl procedure. Phosphorus was determined by an ammonium vanadate colorimetric technique after digestion with nitric-perchloric acid. Potassium was determined by a flame emission method after digestion. Data were pooled into four sampling periods consisting of 2 weeks each for variance analyses, considering both years and dates of clipping as fixed variables. Difficulty in finding or correctly identifying some marked plants during the second or third year resulted in fewer plants than originally chosen being measured. Some plants undoubtedly died as a result of clipping; however, all missing plants were excluded from the statistical analyses. Consequently, the real differences in growth and vigor responses by clipping dates probably were greater than indicated.

Effects of Clipping

Early clipping greatly reduced plant vigor. The plants clipped in late June and early July had significantly fewer stems, were significantly shorter, and weighed significantly less than the control plants and those clipped in early August (Table 1). The plants clipped in late June were significantly shorter than all other plants, but did not differ significantly in number of stems or weight from those clipped in early July. Most plants clipped in late June for 2 consecutive years produced only leaves and no flower stalks in the third year, and the concentration of total alkaloids was significantly less than that in any other plants.

The four dates of clipping correspond roughly with the vegetative, bud, flower, and late flower to seed stages of larkspur development. However, late June frosts occurred on the study site all 4 years, resulting in many larkspur plants failing to produce flowers. Average plant height at the time of the late June clipping was 18 cm in 1969, 38 cm in 1970, and

28 cm in 1971. No heights were measured in 1968. At the time of the last clipping in early August, the average height was 48 cm in 1969 and 58 cm in 1970 and 1971.

The "year" and "year \times date interaction" terms in the analysis of variance were not significant at the 5% level for any of the plant characteristics measured. In 1972 the content of nitrogen, phosphorus, and potassium did not differ significantly among plants clipped at the various dates and the check plants. Levels ranged from 1.18 to 1.69% for nitrogen, 0.33 to 0.47% for phosphorus, and 2.8 to 4.4% for potassium. These percentages were similar to those reported by Logan (1973) for duncecap larkspur plants collected in the same area in 1971.

Trends in Alkaloid Content

The total alkaloid content of whole larkspur plants was highest in early June, ranging from 1.7% in 1969 to 2.8% in 1970 (Fig. 1). Alkaloid content decreased to 0.3% to 0.6% as the plants matured and began to dry in late August. The same pattern was evident both for plants clipped the first year (1968 and 1970) and for those clipped the second year (1969 and 1971).

Precipitation did not seem to be related to alkaloid content; both the highest (1970) and lowest (1969) alkaloid contents occurred in years with the least precipitation the preceding winter and spring. Precipitation in the preceding 12 months (June-May) and the preceding 2 months (April and May) also lacked any obvious correlation with alkaloid content.

Discussion

The low vigor and alkaloid contents of plants clipped in the vegetative stage in late June were not anticipated results. Many other forb species that grow in association with duncecap larkspur have been shown to be damaged more by clipping in the flowering stage than clipping in the prebloom stage. These include bluebell (*Mertensia arizonica* var. *leonardi*) (Laycock and Conrad, 1969); white polemonium (*Polemonium foliosissimum*) (McDonough and Laycock, in press); and Porter ligusticum (*Ligusticum porteri*), edible valerian (*Valeriana edulis*), and Richardson geranium (*Geranium richardsoni*), (Julander, 1968).

The highest concentration of total alkaloids occurred in early growth stages (Fig. 1). The plants stunted by clipping in late June for 2 years never progressed beyond the early growth stage, and I expected the total alkaloid content to be higher than that of more vigorous plants. The reason for the low alkaloid content is not known.

Table 1. 1970 and 1972 data on size and alkaloid content of mature duncecap larkspur plants after two successive years of clipping.

Clipping date	1970 data from plants clipped in 1968 and 1969					1972 data from plants clipped in 1970 and 1971					Combined 1970 and 1972 data			
	No. of plants clipped	No. of stems	Avg dry wt (g)	Avg ht (cm)	Total alkaloid content (%)	No. of plants clipped	No. of stems	Avg dry wt (g)	Avg ht (cm)	Total alkaloid content (%)	No. of stems	Avg dry wt (g)	Avg ht (cm)	Total alkaloid content (%)
Late June	15	1.5	0.8	19	0.5	8	1.5	0.4	15	0.6	1.5 ^{a1}	0.7 ^a	17 ^a	0.5 ^a
Early July	15	1.5	2.1	33	0.8	11	1.3	2.5	39	1.0	1.4 ^a	2.3 ^{ab}	36 ^b	0.9 ^b
Late July	16	3.5	3.9	35	1.3	9	3.2	5.5	34	1.0	3.4 ^b	4.5 ^{bc}	35 ^b	1.2 ^b
Early August	11	2.6	9.3	53	0.9	11	1.9	4.2	49	1.0	2.3 ^b	6.8 ^c	51 ^c	0.9 ^b
Control (no clip)	12	2.5	5.1	48	0.9	8	2.4	9.1	55	1.2	2.5 ^b	6.7 ^c	51 ^c	1.1 ^b

¹Within each column, means followed by a common letter are not significantly different at the 5% level as determined by Duncan's (1955) Multiple Range Test.

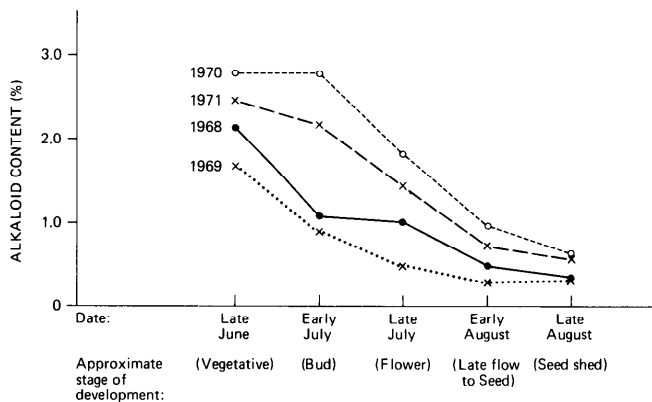


Fig. 1. Concentrations of total alkaloids in whole larkspur plants collected from the Davis Basin Study area. Plants collected in 1968 and 1970 had not been previously clipped; those collected in 1969 and 1971 had been clipped the previous year.

Williams and Cronin (1963, 1966) determined that application of 2,4,5-T or 2,4,5-TP (Silvex) increased the alkaloid content in both tall and duncecap larkspur for 2 or 3 weeks following treatment. These herbicides killed many plants and drastically reduced vigor in many others. However, the alkaloid content of the remaining stunted plants in following years has never been determined.

Cronin (1971) found that 1 year of clipping caused no permanent injury to tall larkspur plants. Differences in site or species may account for the different response. Cronin (1971) clipped *D. barbeyi* in a snowbank area where soil moisture probably was not limiting. In the present study, *D. occidentale* was clipped on a drier site with much earlier snowmelt and infrequent summer storms.

The results of any clipping study must be interpreted with caution because the competitive effects of unclipped surrounding plants can modify the results (Mueggler, 1970, 1972). However, the effects of clipping can help to interpret the influences of other treatments on tall larkspur. Cronin and Nielsen (1972) reported an increased intensity of grazing by cattle, following herbicide treatment of tall larkspur. They also noted greater reduction in larkspur after spraying on grazed than on ungrazed plots. The high susceptibility to damage caused by foliage removal indicated in the Davis Basin study may account for the decrease in larkspur on the grazed plots.

Binns et al. (1971) found that a one-time combined application of 2,4,5-T and ammonium sulfate fertilizer effectively eliminated tall larkspur from plots. They concluded that the control resulted from "the decreased vitality of the larkspur due to the herbicide, the stimulation of the grass by the nitrogen which increased competition for the weakened larkspur, and the increased preference for cattle to graze the

nitrogen-treated plots." They also stated that results suggested that larkspur control may be obtained from fertilizer alone.

Nitrogen fertilizer is known to increase protein content and palatability of grasses under some circumstances. If the fertilizer did increase cattle use of these plots because of increased palatability, the larkspur control might have been effected by the cattle. Continued close cropping of the larkspur, eaten along with the more palatable grass, could easily have killed many larkspur plants. The plots on which the control was achieved were not observed for a 10-year period before final measurement, so this assumption cannot be verified. However, if larkspur was killed by grazing, nitrogen fertilizer applied either alone or in combination with an herbicide would not necessarily have the same effect when applied on a large scale. Only when increased grazing pressure caused by the fertilizer could be confined to small areas, such as experimental plots, would the grazing probably be intense enough to have a significant effect on the larkspur.

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