Utilization of larkspur by sheep

M.H. RALPHS, J.E. BOWNS, AND G.D. MANNERS

Abstract

Sheep are more resistent to larkspur (*Delphinium* spp.) poisoning than are cattle, and may be used as a biological tool to graze larkspur prior to cattle turn-in to reduce the risk of cattle poisoning. Sheep utilization of 3 species of larkspur was measured at 3 phenological growth stages (vegetative, bud, and flower) at 5 locations. Utilization of waxy larkspur (*D. glaucescens* Wats), varied among years at Ruby, Mont. Use of duncecap larkspur (*D. occidental* S. Wats) at Oakley, Ida., was uniformly higher in all 3 growth stages due to closed herding practices. Use of tall larkspur *D. barbeyi* Huth) increased as it matured. Trailing sheep through larkspur patches, or bedding them in patches greatly increased trampling of larkspur stalks and utilization of heads and leaves.

Key Words: *Delphinium* spp., poisonous plant, sheep grazing, biological tool

Poisoning from ingestion of larkspur (*Delphinium* spp.) is the leading cause of cattle deaths on mountain rangeland (Aldous 1917, Nielsen and Ralphs 1988). Sheep, on the other hand, are more resistant to larkspur poisoning than cattle (Marsh et al. 1934, Olsen 1978), thus, forward grazing by sheep may be an effective strategy for reducing the availability and/or acceptability of larkspur to grazing cattle. This in turn should reduce cattle losses from larkspur poisoning.

Previous research examining the impact of forward grazing by sheep varied as a function of species of larkspur and season. For example, Marsh et al. (1934) reported sheep grazing stands of low larkspur (*Delphinium nelsonii* Greene) reduced incidence of cattle losses. Aldous (1917) reported that sheep grazing immature duncecap larkspur (*D. occidentale* S. Wats) early in the growing season eliminated subsequent poisoning of cattle. However, sheep grazed other forage in preference to tall larkspur (*D. barbeyi* Huth), thus increasing the threat to cattle.

The underlying hypothesis of this study is that forward grazing by sheep will subsequently reduce cattle losses to larkspur poisoning by reducing availability and/or acceptability of larkspur. This can be accomplished by sheep ingesting and/or trampling larkspur during the early portion of the growing season. The broad objective of the studies reported herein was to examine the impact of sheep grazing on 3 species of larkspur during early growth stages. Study 1 examined the variation in consumption of waxy larkspur (*D. glaucescens* Wats) in the bud growth stage over a 4-year period. Study 2 was designed to quantify the amount of duncecap and tall larkspur grazed and/or trampled by sheep during the vegetative, bud, and flower growth stages among 4 locations during a single year. In addition, the relative impacts of trampling and defoliation were examined when sheep were in the grazing, trailing, or bedding modes at 2 of these locations. Alkaloid concentrations in larkspur species were measured at each site to determine if alkaloid level influenced utilization of larkspur.

Methods

Study 1

The study was conducted in the upper Ruby River Valley 93 km south of Sheridan, Mont. The Upper Ruby Cattle Association traditionally graze 2,700 cows and yearlings on the allotment from June to October. Larkspur poisoning occurs intermittently in 3 higher elevation pastures, with the most recent event (1981) resulting in the deaths of 50 cattle. This prompted a change in management to include grazing a flock of sheep in these pastures 2 to 4 weeks prior to cattle turn-in.[1]

The study site was at 2,600 m elevation on a gentle sloping, north exposure ridge. Habitat type was mountain big sagebrush [*Artemisia tridentata* var *vaseyana* (Rydb.) J. Boivin]/Idaho fescue (*Festuca idahoensis* Elmer). Waxy larkspur density averaged 4.0 plants/m^2.

Four, 30-m permanent transects were established and 25 waxy larkspur plants per transect were permanently marked for study prior to sheep grazing. A band of 1,000 yearling ewes grazed the study area from 1987–1989 spending 1.5 hours grazing on 25–26 June 1987, and 4 hours on 22–23 June 1988. On 27 June 1989, they grazed over the site for about 1 hour before bedding on 2 of the transects for about 4 hours during mid-day. The band then drifted through the 2 other transects as they exited the area. In 1990, a band of 650 ewes with lambs stayed 16 days in the general area grazing intermittently on a 20 ha patch of waxy larkspur within which our study site was located.

Following grazing, total number of stalks per marked plant, number of flowering racemes (heads) decapitated, and defoliation of leaves were recorded in all 4 years.

Study 2

Utilization of duncecap and tall larkspur was measured at 4 locations in 1989 at the vegetative, bud, and flower growth stages to compare the amount of larkspur consumed or trampled among growth stages. Larkspur patches were selected in grazing allotments where sheep would normally graze at the specified growth stages. Since the objective of this study was to measure utilization under normal grazing conditions, time spent in larkspur stands, grazing pressure, and utilization of associated species varied between sites and locations. Table 1 gives details of the location, habitat type, time sheep grazed the areas, and sampling design.

Oakley, Idaho

Utilization of duncecap larkspur was measured on the South Hills, 24 km west of Oakley, between 2,200 and 2,400 m elevation. Utilization during the vegetative stage was measured at Worm Corral. Habitat type was snowberry (*Symphoricarpos oreophilus* Gray)/slender wheatgrass (*Elymus trachylcaulus* (Link) Gould ex Shinners). A band of 1,900 ewes with lambs were herded onto the patch for the entire day of 8 June. Three areas were delineated where sheep: (1) grazed through in an open herd (grazing mode); (2) bedded during the middle part of the day (bed mode); and (3) trailed out in a tight herd (trailing mode).

Utilization during the bud stage was measured at Willow Creek where larkspur occurred in the bottoms of draws in the mountain big sagebrush/basin wildrye (*Elymus cincereus* Scribn. & Merr.) habitat type. Utilization during the flower stage was measured at Gravel Springs in an aspen (*Populus tremuloides* Michx)/snowberry habitat type.

Authors are range scientist, USDA/ARS Poisonous Plant Research Laboratory, Logan, Utah; and professor range science, Utah Agr. Exp. Sta., Southern Utah State University, Cedar City, Utah; and chemist, USDA/ARS Western Regional Research Center, Albany, Calif.

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[1]Alexander, J.D. III and J.E. Taylor 1986. Sheep utilization as a control method on tall larkspur infested cattle range. Abstract 241. 39th Annual Meeting, Society for Range Management, Kissimmee, Fla. Feb. 9–14, 1986.

Table 1. Sampling scheme used to estimate sheep utilization of 3 species of larkspur.

Larkspur	Location	Elevation	growth stage	Sampling data	Habitat type	Larkspur plant density	Activity mode	Number of larkspur patches	Number of transects per patch[1]	Average stems per plant	Average patch size	Time spent in area	Flock size
						No/m²					ha	days	1000 ylg.
Waxy	Ruby, MT	2600m	Bud		Mountain big sagebrush/ Idaho fescue	4	Graze	1	10	3	20	1-14	
Duncecap	Oakley, ID	2200m	Vegetative	8 June 1989	Snowberry/ slender wheatgrass	7.5	Graze Trail Bed	1 1 1	5 4 5	13 13 13	4 2 2	1	1900 ewes with lambs
		2400m	Bud	14 July	Mountain big sagebrush/ basin wildrye		Graze	3	5	11	3	14	
		2500m	Flower	10 Aug.	Aspen/ snowberry		Graze	2	5	7	6	3	
Barbeyi	Ferron, UT	3200m	Vegetative	1 July 1989	Larkspur/ western coneflower	2.4	Graze Trail	2 2	5 5	31 31	3 2	3	2000 ewes with lambs
		3000m	Bud	20 July	Aspen/tall forb		Graze	2	5	12	2	10	
		3200m	Flower	15 Aug.	Larkspur/ western coneflower		Graze	4	5	28	5	7	
	Salina, UT	3000m	Bud	18 July 1989	Aspen/ larkspur/ mountain brome	2.2	Graze	3	5	7	5	20	2000 ewes with lambs
			Flower	1 Aug.			Graze	2	5	14	2	12	
	Cedar, UT	3000m	Bud	19 July 1989	Aspen/ orchard grass	3.0	Graze	1	10[2]	3	12	43	200 ewes

[1]Ten larkspur plants were selected on each paced transect at 5 or 10 step intervals.
[2]Ten permanent transects were established at Cedar and 10 plants were marked by a stake on each transect.

Ferron, Utah

Utilization in both the grazing and trailing activity mode was measured during the vegetative growth stage of tall larkspur at Ferron Reservoir, 46 km west of Ferron. The habitat type was a larkspur/western coneflower (*Rudbeckia occidentalis* Nutt) type interspersed among Engelman spruce (*Picea pungens* Engelm.) at 3,200 m elevation. This band was managed as an open herd and were not gathered to bed grounds, thus precluding utilization in the bed mode.

Utilization during the bud stage was measured in an aspen/tall forb habitat type at 3,000 m elevation. Utilization during the flower stage was also measured in the larkspur/western coneflower habitat type about 2 km from the area grazed in the vegetative stage.

Salina, Utah

The study area was located 40 km east of Salina at an elevation of 3,000 m. Sheep did not enter the allotment until tall larkspur was in the bud growth stage, thus utilization was measured for only the bud and flower stages. Habitat type was aspen/larkspur/mountain brome (*Bromus carinatus* H & H).

Cedar City, Utah

Utilization of tall larkspur on Cedar Mountain, 35 km east of Cedar City, was measured in the early grazed pasture of a deferred rotation grazing system. Habitat type was aspen/orchard grass (*Dactylis glomerata* L.) at 2,800 m elevation. No utilization was observed on these plants during the vegetative stage, but all plants were heavily grazed during the bud stage, thus utilization was measured only during the bud stage.

One to 4 larkspur patches were selected for each growth stage at each location (Table 1). Five paced transects were established in each patch and 10 plants per transect were selected using step point procedures. Measurements taken were: number of stalks per plant, number of stalks trampled, number of reproductive heads grazed, number of grazed and ungrazed leaves, and overall number of plants grazed.

Alkaloid concentration was measured in larkspur plant parts (leaves and reproductive raceme) at each location at the time of grazing. Samples were air dried and analyzed for total alkaloid concentration (Manners and Ralphs 1989). Percentage utilization of larkspur leaves and heads were correlated with total alkaloid concentration in the respective larkspur plant parts and correlation coefficients (r) were calculated to determine if larkspur utilization was related to alkaloid levels in the plant.

Data Summarization and Analysis

Larkspur utilization at all locations and growth stages was estimated by counting number of heads decapitated and leaves grazed on each sampled plant. Number of broken stems was counted to access impact of trampling. The total number of plants grazed per transect was determined and percentage calculated. Since the number of stalks per plant differed greatly between species and locations (Table 1), we summed total number of stalks and leaves present by transect and then calculated percentage of heads and leaves grazed, and stems trampled. Percentage data were transformed by arcsin and analyzed by analysis of variance (ANOVA), rather than by Chi Square because Chi Square analysis of count data would have precluded evaluating variability among transects or patches.

Transects were used to test for differences in utilization of waxy larkspur between years in study 1. In study 2, utilization was not measured at all growth stages at each location because of changes in grazing and herding patterns. Thus, data were analyzed separately for each location. Data were analyzed in a nested model in which transects were nested within patches and used to test for difference in utilization between growth stages. Utilization and trampling during different activity modes (grazing, trailing, and bedding modes at Oakley and grazing and trailing modes at Ferron) were compared in a similar model. Means were separated by Duncan's multiple range test. Nontransformed means are presented in the tables.

Results and Discussion

Study 1

Sheep consumed varying amounts of waxy larkspur over the years at Ruby. Percent of heads grazed on marked plants declined from 70% in 1987, to 14% in 1989, but increased to 73% in 1990 (Table 2). Stem height was reduced an average of 36% when the heads were grazed. Sheep consumed no larkspur leaves in 1987, but use of leaves increased to 89% in 1990.

Table 2. Sheep utilization (%) of waxy larkspur plants during bud stage on permanent and paced transects at Ruby River, Montana.

Transect type	Year	Heads grazed	Stalks having leaves grazed
		%	
Permanent	1987	70[a]	0[c]
	1988	36[b]	22[b]
	1989	14[c]	25[b]
	1990	73[a]	89[a]

[abc]Means in the same column transect type not followed by the same letter are significantly different ($P<.05$).

There was no apparent relationship between amount of time sheep spent on a site and degree of larkspur use. In the first year of the study, sheep spent only 1.5 hours on the site and selectivity removed 70% of the heads. They selectively grazed most of the elongating buds, with little apparent use of associated plant species. This was as desired because larkspur heads are very toxic and preferred by cattle. In 1990, sheep spent 14 days in the area and repeatedly grazed over the transects, heavily utilizing both larkspur heads and leaves. Larkspur utilization was low in the 2 middle years.

In 1989, there was a difference in utilization among transects. Sheep bedded on 2 of the transects and trampled 37% of the marked plants, grazed 28% of the reproductive heads, and 48% of the plants had leaves grazed. Very little larkspur was grazed in the grazing mode on the other 2 transects.

The sheep owner observed over the years that sheep preferred the elongating larkspur bud (Joe Helle, personal communication, 1988). He stated that sheep made little use of waxy larkspur in the years they grazed the allotment prior to the bud stage. We observed that sheep rejected waxy larkspur in the flowering stage. Comments from the herder indicate that sheep prefer the waxy larkspur bud when it is crisp and moist, when it is covered with dew in the early morning, or following storms. Bedding on waxy larkspur patches (as in 1989) and grazing over the patches several times (as in 1990) appear to increase utilization and trampling.

Study 2

Oakley

Sheep grazed almost all of duncecap larkspur plants during all 3 growth stages (Table 3). There were slight differences in the percent of reproductive heads grazed between growth stages (55–79%) but not in percentage of leaves grazed (21–29%). An average of 31% of the stems were trampled. The relatively high level of larkspur utilization in all growth stages differs from trends of use in other locations. Sheep at Oakely stayed in a fairly tight bunch, due to being tormented by gnats and closed herding practices. Nonselective grazing while in a tight group, may account for the high larkspur utilization.

Table 3. Utilization (%) by grazing sheep of 2 species of larkspur in 4 grazing allotments during 3 growth stages.

Larkspur species	Location	Growth stage	Plants grazed	Stems trampled	Heads grazed	Leaves grazed
			%			
Duncecap	Oakley	Veg	98[a]	27[a]	55[b]	29[a]
		Bud	92[ab]	36[a]	79[a]	21[a]
		Flower	85[b]	30[a]	56[b]	31[a]
Tall	Ferron	Veg	5[b]	16[a]	0[c]	0[c]
		Bud	93[a]	20[a]	19[b]	45[a]
		Flower	91[a]	23[a]	29[a]	25[b]
	Salina	Bud	22[b]	12[b]	5[b]	1[b]
		Flower	90[a]	21[a]	50[a]	48[a]
	Cedar City	Veg	0	0	0	0
		Bud	100	45	50	91

[abc]Means within the same column within locations not followed by the same letter are significantly different ($P<.05$).

Ferron

Very little tall larkspur was utilized in the vegetative stage (Table 3). The extremely high concentration of alkaloids in the vegetative leaves (6.75%, Table 5) may have contributed to their avoidance. Ralphs et al. (1988) hypothesized that there is a negative relationship between alkaloid levels and palatability of larkspur.

Sheep increased consumption of both heads and leaves of tall larkspur as plants matured from the vegetative to bud stage. The number of plants grazed increased from only 5% in the vegetative stage to 91–93% in the flower and bud stage (Table 3).

Sheep consumed slightly more of the larkspur heads in the flowering stage compared to the bud stage. However, substantially more leaves were consumed in the bud stage (Table 3). Tall larkspur patches sampled during the bud stage were near a small watering pond. Sheep likely passed through these patches each day grazing to and from water, and thus had more opportunity to graze larkspur. The larkspur patches sampled during the flower stage were more than 1 km from water and sheep had to travel a greater distance to reach the larkspur patches.

Salina

Sheep were not on this allotment when larkspur was in the vegetative growth stage. Only 22% of tall larkspur plants were grazed in the bud stage compared to 90% in the flower stage (Table

Table 4. Differential use of larkspur during grazing, trailing and bedding modes at Ferron and Oakley during the vegetative growth stage.

Larkspur species	Location	Activity	Plants grazed	Stems trampled	Heads grazed	Leaves grazed
			----------	%	----------	
Duncecap	Oakley	Graze	98[a]	27[b]	55[b]	29[b]
		Trail	85[b]	87[a]	48[b]	11[b]
		Bed	100[a]	90[a]	68[a]	83[a]
Tall	Ferron	Graze	5[a]	16[b]	0[a]	0[a]
		Trail	4[a]	48[a]	0[a]	0[a]

[abc]Means within the same column within locations followed by the same letter are not significantly different ($P<.05$), as determined by Duncan's multiple range test.

3). Fifty percent of the reproductive heads and 48% of the leaves were grazed during the flower stage. The larkspur patch near water sustained heavier use compared to one 1.6 km away due to its more frequent visitation by sheep.

Cedar City

Sheep did not graze tall larkspur in the vegetative stage. However, they consumed or trampled almost all of the larkspur plants during the bud stage. Over 90% of the leaves and 50% of the heads were grazed, and 45% of the stems were trampled (Table 3).

The heavy use of tall larkspur in the bud stage at this site can be attributed to several factors. Unlike the other locations where the sheep were periodically moved to fresh feed, this pasture was the heavily grazed pasture of a deferred rotation grazing system. Grazing pressure increased as other forage was depleted. Utilization of orchard grass and Kentucky bluegrass (*Poa pratensis* L.) was 70% (Bowns, unpublished data). Utilization on other desirable forbs was not measured, but it was obviously greater than the utilization of these 2 key grasses. The sheep may have been forced to consume larkspur as other forage became limited. Two other reasons may account for larkspur's increased acceptability. Sheep generally graze larkspur later in the grazing season when summer rains wash aspen sap off its leaves (Bowns, personal observation). Larkspur may also have increased in palatability as it matured and alkaloid levels declined (Pfister et al. 1988a,b).

Activity Modes

Sheep trampled a larger number of larkspur stems during the trailing and bedding mode at Oakley and trailing mode at Ferron than they did in the grazing mode (Table 4). Furthermore, 80% of the trampled stems at Oakley were dry and desiccated after 30 days, while untrampled stems were green and growing. Sheep also consumed more duncecap larkspur heads and leaves (68% of heads and 83% of leaves) while they were milling about in the bedding mode at Oakley. No leaves were consumed in the trailing mode at Ferron, presumably due to the high alkaloid levels (Table 5).

Alkaloids

Alkaloid levels generally declined as the plants matured, except for tall larkspur heads at Ferron (Table 5). There was low correlation ($r = -.30$) between alkaloid level and larkspur consumption when both larkspur heads and leaves were included in the equation. When consumption of larkspur leaves and heads were analyzed separately, correlation between alkaloid level and consumption of larkspur leaves improved somewhat ($r = -.44$), while the correlation with heads declined ($r = -.05$). Ralphs et al. (1988) hypothesized that high levels of alkaloids in larkspur plant parts in early growth stages deterred grazing, and suggested a negative relationship between alkaloid levels and palatability. Cattle consumption of tall larkspur increased dramatically as plants matured beyond the flower growth stage (Pfister et al. 1988 a,b). Sheep have also been observed to utilize both duncecap and tall larkspur leaves heavily during the later part of the growing season (authors' personal observations). Further research is necessary to determine the relationship between alkaloid levels and palatability.

Table 5. Total alkaloid concentration (%) in 3 species of larkspur, at 5 locations, during the vegetative, bud and flower growth stages.

Larkspur species	Location	Growth stage	Total alkaloids Head	Total alkaloids Leaf
			----------	% ----------
Waxy	Ruby	1987 Bud	1.26	0.90
		1988 Bud	2.10	0.60
		1989 Bud	1.36	0.41
Duncecap	Oakley	Veg	——	2.60
		Bud	2.20	2.40
		Flower	1.74	.91
Tall	Ferron	Veg	——	6.75
		Bud	.91	1.45
		Flower	2.10	1.13
	Salina	Bud	1.46	1.26
		Flower	.75	.78
	Cedar	Bud	1.22	1.08

Management Implications

Under some conditions, sheep will utilize large amounts of all 3 larkspur species. They may not voluntarily graze larkspur during the vegetative and bud stages of growth, but they may be compelled to utilize it by trailing or bedding on larkspur patches. Trailing sheep through larkspur patches increased the number of larkspur stalks trampled. The hollow stems break easily when trampled and are likely to senesce rapidly. Bedding sheep in larkspur patches increased both the number of stalks trampled and greatly increased utilization of larkspur heads and leaves. Intensive mangement of a sheep herd either by bedding or holding them on a larskpur patch may cause heavy non-selective grazing of larkspur. Further research is necessary to determine what level of larkspur use is required to reduce the risk of poisoning in cattle grazing afterward.

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