Utilization of White Locoweed (*Oxytropis sericea* Nutt.) by Range Cattle

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Abstract

Utilization studies conducted on a high mountain range determined the quantity and timing of white locoweed (*Oxytropis sericea* Nutt.) consumption by cattle. Paired plots (one caged and one grazed) were clipped at the end of the grazing season to determine seasonal utilization. Biweekly visual appraisals were used to estimate percentage leaf grazed and number of reproductive stalks grazed and thus determine utilization patterns as the season progressed. Loco comprised 26% of the standing crop. Thirty-four percent of the available loco was utilized during the grazing season. Loco flower and pods (heads) were preferred to leaves. Utilization of loco heads increased linearly as the season progressed. Loco leaves were not consumed until the last 3 weeks of the grazing season. Loco heads also contained the highest concentration of the toxic alkaloid, swainsonine.

Locoweed poisoning of livestock has been the most widespread poisonous plant problem in the western United States (James et al. 1981). Marsh (1909) reviewed reports of locoweed poisoning dating back to 1873 and conducted feeding trials that showed conclusively that white locoweed (*Astragalus lambertii* now considered to be *Oxytropis sericea* Nutt.) and wooly loco (*A. mollissimus* Torr.) caused locoism in cattle, sheep, and horses. Mathews (1932) conducted further studies to determine quantities of Earle loco (*A. mollissimus* var *earlei* Green ex Rydb.) and Garbancillo (*A. wootoni* Sheld.) required to produce clinical signs of toxicity in domestic livestock. The toxin in locoweeds has been identified as the indolizidine alkaloid swainsonine (Molyneux and James 1982).

Desert and semidesert locoweed species (*A. lentiginosus* Dougl., *A. pubentissimus* Torr. and Gray, *A. mollissimus* Torr.) characteristically germinate and become established during a warm, wet fall, remain green over winter, and accelerate growth in early spring. Most livestock losses occur during the winter and early spring when other forage is scarce, or the existing forage is dry and the locoweed is green (James et al. 1968, James et al. 1969). Due to the habituating properties of loco, livestock that begin eating it will continue to consume it even when good quality green feed is available (Peters and Sturdevent 1908, Marsh 1909, James et al. 1969).

White locoweed differs somewhat from other locoweed species. It occurs on the western plains and foothills of the Rocky mountains and up to 3,353 m on some Intermountain ranges (Barneby 1952). It is palatable and livestock graze it throughout the growing season (Marsh 1909). Its population cycles on high mountain ranges apparently are not influenced as much by weather conditions as other locoweed species (James personal observation). Payne (1957) classified it as an increaser species. Recently it has been identified as a predisposing factor in high mountain brisket disease, or congestive right-sided heart failure, in cattle (James et al. 1983). Economic loss occurs annually from the interaction of these two diseases (Barnard 1984).

Little is known about why livestock graze locoweeds. Marsh (1909) made some astute observations of livestock grazing white locoweed and made some broad general recommendations to reduce losses (Marsh 1913). However, until we know when cattle eat white locoweed, how much is required to produce intoxication, and what environmental or management factors influence consumption, little can be done to reduce losses other than keeping livestock off infested ranges. The purpose of this study was to describe utilization patterns of white locoweed by cattle on a high mountain range and identify factors that may influence consumption. Once we understand the conditions under which cattle consume white locoweed, management strategies can be developed to reduce losses.

Study Area

The study was conducted during 1979–1983 on a high mountain grassland in northwestern Utah. The site was a flat mountain top ranging in elevation from 2,900 to 3,050 m. The range site was a high mountain loam and supported a fairly homogeneous grass/-forb vegetation community. Dominant grass and sedge species included Idaho fescue (*Festuca idahoensis* Elmer), muttongrass

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The assistance of Steve Fitzwater for his assistance in data collection and Russ Molyneux for alkaloid determination is gratefully acknowledged.

This is Journal Paper Number 3103, Utah Agr. Exp. Sta.

Manuscript accepted 21 October 1985.

(*Poa fendlariana* (Stend.) Vasey), Kentucky bluegrass (*Poa pratensis* L.) and elk sedge (*Carex geyeri* Boott). Dominant forbs included white locoweed (*Oxytropis sericea* Nutt., hereafter referred to as loco), yarrow (*Achillea lanulosa* Nutt.), and sneezeweed (*Helenium hoopesii* Gray). Some subalpine big sagebrush (*Artemisia tridentata* spp *vaseyana* form *spiciformis* Ostech.) occurred on the unsprayed pastures.

The grazing system on the allotment for the first 2 years was a Hormay four-pasture, one-herd rest rotation system in which 465 cow/calf pairs grazed one pasture for about 30 days and were then rotated through 2 other pastures leaving one totally rested each year. The system was changed in 1981 to a four-pasture, three-herd rotation system in which one third of the herd was grazed in each of 3 pastures for the entire season and 1 pasture was rested (Ralphs et al. 1984). Two similar pastures, A and B, were used to compare livestock performance. Pasture A (172 ha) was sprayed with 2,4-D in 1969 to control loco and sagebrush. Both loco and sagebrush had reestablished to pretreatment levels by 1978. Pasture B (210 ha) was aerial sprayed in 1981 to control loco. All of the loco and sagebrush on the deeper soils were killed. Some loco remained on the shallow soils around the perimeter of the pasture. The 2 pastures provided a good comparison between a loco-infested and loco-free pasture.

Methods

Two methods were employed to measure utilization. Paired caged plots were used to determine loco utilization in 1979 in pastures B and C and in 1981 in pastures A and C. From 10 to 26 pairs of plots were randomly located throughout each pasture. One plot was caged and an adjacent open plot was selected at the beginning of the grazing season. Loco was clipped from both plots at the end of the season and dried at 60° C for 48 hours to determine dry weight (kg/ha). Differences in loco standing crop between the paired plots were analyzed with paired-sample *t*-tests.

The second method estimated loco utilization at biweekly intervals during the grazing seasons from 1981–1983. Visual estimates of loco utilization in Pasture A were made in conjunction with reading permanent frequency transects established in 1981. Ten transects were located at 161-m intervals and alternately extended at right angles from a line running down the middle of the pasture. Ten plots per transect were read by placing a .09-m^2 hoop at the point of the toe at five-step intervals along the transect. In addition, 2 transects of 50 plots each were located in dense concentrations of loco at the west end of the pasture. Percent loco leaf utilized was estimated. Total number of reproductive heads and number of heads grazed were counted. In 1983, an ocular estimate was also made of the percent utilization of the important grass species. Frequency values (percentage of plots in which the species occurred) show the relative abundance of the important species.

Standing crop (total above-ground plant biomass at a given time) was sampled at biweekly intervals in 1983. Four uniform 1-m^2 plots were located in a cluster at the beginning of the grazing season. Twelve clusters were randomly located in pasture A and 11 clusters in pasture B. One plot per cluster was clipped at 2-week intervals and the vegetation was separated into grasses, forbs, loco leaf, loco heads, and sagebrush. The samples were bagged and weighed on the site, then dried for 48–72 hours at 60° C in a forced air oven. The difference between fresh weight and oven-dry weight (percentage water) was used as a measure of succulence. The samples were then analyzed for crude protein (CP) (AOAC 1970) and neutral detergent fiber (NDF) (Goering and Van Soest 1970) on an organic matter basis.

The toxic alkaloid swainsonine is found in minute quantities in locoweeds (Molyneux and James 1983). There is no good analytical technique to measure concentrations of swainsonine. Therefore the relative difference in concentration between loco parts and growth stages was estimated by the intensity of dots in thin layer chromatography (R.J. Molyneux, personal communication) and expressed on a relative scale (low, moderate, high).

To determine differences in average daily gains, 40 calves from each of pastures A and B were randomly selected by a gate cut, and were tagged and weighed at the beginning of the grazing season in 1983. A gate was opened accidently in pasture A 1 week before the end of the grazing season and two-thirds of the tagged calves left the allotment without being weighed. Eleven tagged calves that remained in pasture A were paired with calves of similar beginning weights in pasture B and a *t*-test was used to compare average daily gains (ADG).

Botanical composition of plant fragments in cattle feces in both pastures was determined by microhistological analysis (Sparks and Malechek 1968) of fecal samples collected weekly. A tablespoon of fecal material was taken from about 50 fresh fecal pats. Half of each sample was preserved in salt for microhistological analysis. The other half was frozen for fecal nitrogen determination. Samples preserved in salt were air dried and ground in a mill over a 1-mm mesh. Prior to mounting on microscope slides, samples were rinsed in household bleach for 1 minute to remove pigments. Five slides were prepared from each composite sample and 20 fields per slide were read. A field consisted of the identifiable fragments visible in a field of view at 100-power magnification. Relative frequencies of loco, forbs, and grasses were converted to relative density.

Fecal nitrogen (N) was determined from the frozen fecal sample to estimate differences in relative diet quality (Holechek et al. 1982) between the 2 pastures. Fecal N does not accurately estimate diet N when diets are comprised of mixed forage classes (Carter 1985) or when feeds are high in tannins (Mould and Robbins 1981). On this uniform grassland with diets dominated by grasses, however, fecal N should provide a reasonable index of diet N. The minute amount of alkaloid in loco (<.07% of the dry weight, and one N in a single ring configuration, Molyneux and James 1983) would not be expected to significantly affect the N concentration in the feces or in the diet.

Results and Discussion

Utilization

Mean grass standing crop of pasture A was about 75% that of pasture B (Table 1). Standing crop of forbs (excluding loco) in

Table 1. Mean standing crop (kg/ha) and standard error (in parentheses) of forage classes through the grazing season 1983.

Pasture	Forage class	25 July	8 Aug.	22 Aug.	14 Sept.	Mean for season
A	Grass	541 (34)	423 (60)	358 (43)	278 (32)	400
(loco-infested)	Forb	826 (64)	760 (29)	540 (78)	503 (66)	657
	Loco leaf	416 (34)	358 (43)	377 (48)	288 (49)	360
	Loco head	69 (7)	71 (20)	58 (19)	78 (18)	69
	Sagebrush	129 (41)	124 (40)	180 (53)	105 (28)	134
	Total	1981	1736	1513	1252	1620
B	Grass	707 (102)	625 (66)	487 (84)	359 (88)	545
(loco-free)	Forb	262 (33)	315 (41)	202 (32)	157 (28)	234
	Total	969	940	689	516	779

Table 2. Loco utilization from paired plots in 1979 and 1981.

Pasture	Year	n	Standing Crop (kg/ha) Caged	Grazed	% Utilization	p[1]
A	1981	22	413 (39.99)[2]	347 (66.87)	16	NS
A[3]	1981	8	461 (44.94)	156 (32.16)	66	<.001
B	1979	10	705 (107.64)	419 (32.16)	41	<.01
C	1979	18	173 (65.07)	21 (7.87)	88	<.01
C	1981	26	524 (49.20)	363 (30.98)	31	<.05

[1]Probability of Type I error.
[2]Standard error in parentheses.
[3]From plots in the heavily used west one-third of pasture.

pasture A was 2.8 times greater than in pasture B, reflecting the effect of herbicide treatment of pasture B in 1981. Standing crop of both grasses and forbs declined as the grazing season progressed in both pastures. Since western yarrow was the dominant forb species, the decline in forbs was probably due mostly to senescence rather than grazing. The decline in grasses reflected their progressive utilization by cattle.

Loco was a major proportion of the standing crop in pasture A (27%). There was little change in loco leaf standing crop except during the last sampling period. The lack of change in loco head standing crop could have been due to the increasing weight of the seed pods as they matured and thus offsetting utilization, or to sampling error from the small number of clusters and the difficulty of selecting homogeneous plots in a cluster.

Utilization of loco varied greatly between years, pastures, and parts of pastures (Table 2). Mean utilization was 36% over years and pastures. Loco standing crop in the paired caged and grazed plots was significantly different ($P<.05$) in all pastures and years, except for the whole of pasture A in 1981. Stock water was available only in the west end of pasture A so cattle congregated in the west one-third of the pasture. Cattle utilized significantly more loco in this part of the pasture.

Utilization of loco reproductive heads increased as the season progressed. Percent of heads grazed was 26% after the first 2 weeks and increased steadily to 69% at the end of the 7-week grazing season (Table 3).

There was little consumption of the loco leaf at the beginning of the season, but utilization increased during the last 3 weeks (Table 3). Increased grazing pressure on grass may have caused the cattle to shift to the abundant loco leaf. Cattle may have also acquired a taste for the plant by grazing the heads, and utilized loco leaves as the supply of heads diminished. Marsh (1909) and James et al. (1969) reported the habituating effect of locoweeds.

Alkaloid and Nutrient Content of Loco

Loco heads contained higher quantities of the toxic alkaloid swainsonine than the leaves (Table 4). The concentration of swainsonine in loco leaf appears to have remained constant throughout the grazing season. The blooms contained substantially more swainsonine than the leaves. The immature pods initially contained less swainsonine than the blooms, but their swainsonine content increased with maturity as the seeds contributed an increasing proportion to the total weight of the pod.

Loco parts contained more water and crude protein (CP) and less NDF than did grass (Table 4). The higher water content of loco parts indicates that loco was more succulent than grass. The higher water and CP content and lower fiber content of loco leaf as compared to grass may have also influenced cattle selection of loco leaf in the latter part of the grazing season.

CP concentration of loco heads did not decline as the season progressed. The mean CP concentration of loco heads was 17.1%, which was 5% higher than the loco leaves and 10% higher than the grass. Of the parameters measured only CP could explain the difference in selection of the loco head in preference to the loco leaf. Other studies have shown livestock prefer plants or varieties containing less alkaloids (Arnold and Hill 1972, Simons and Marten 1971, Williams et al. 1971, Becker et al. 1935) indicating an inverse relationship between alkaloids and palatability. Perhaps the high CP content of the loco heads in this study, may have offset the negative influence of the high alkaloid concentration.

Livestock Response

Loco in cattle feces ranged from 8–11% for the first 4 weeks of the grazing season. Percentage loco in the feces increased to 18% by 22 August and then dropped to 14% on 14 September. The gates were opened after 7 September and two-thirds of the cattle moved out, thus reducing the grazing pressure on the available grasses. The percentage of loco in the feces agrees fairly well with the estimates of loco leaf utilization (Table 3). However, the loco flowers and succulent pods would not be expected to show up in the fecal analysis (Anthony and Smith 1974); therefore the fecal analysis does not reflect the heavy utilization of the loco heads seen in Table 3.

There was no significant difference in fecal N from cattle in pastures A and B, indicating that there was probably little or no difference in diet quality between the 2 pastures. However, average daily gains (ADG) of calves in pastures A were significantly lower than those of calves in pasture B (.41 vs .74 kg/day, $P<.05$). Weight loss or lack of gain is one of the first symptoms of locoweed poisoning (Marsh 1909, Mathews 1932, James et al. 1981). In

Table 3. Percentage frequency, utilization and standard error (in parentheses) of loco parts, grasses and forbs in pasture A in 1983.

Species	Frequency	Utilization % by week 8 Aug.	22 Aug.	14 Sept.
Loco leaf[1]	58	1 (0.22)	2 (0.90)	8 (2.42)
Loco head	29	26 (3.51)	44 (5.2)	69 (11.03)
Idaho fescue	33	12 (2.17)	13 (1.98)	29 (4.54)
Muttongrass	54	5 (1.24)	5 (0.90)	30 (4.69)
Kentucky bluegrass	29	4 (1.08)	7 (3.30)	26 (5.19)
Western wheatgrass	52	3 (0.83)	4 (0.89)	6 (2.72)
King fescue	15	2 (0.91)	4 (1.47)	8 (3.18)
Sedge	27	9 (3.69)	10 (2.97)	24 (4.28)

[1]Percentage utilization of loco leaf and head is the mean of 3 years (1981–1983). Utilization of grasses is for 1983 only.

Table 4. Relative concentration of alkaloids, percentage of water, crude protein (CP) and neutral detergent fiber (NDF) and standard errors (in parentheses) of locoweed parts and grass as the 1983 grazing season progressed.

Pasture	Nutrient	Species/part	25 July[1]	8 Aug.	22 Aug.	14 Sept.	Mean
A	Alkaloids	loco head	high	moderate	moderate	high	
		loco leaf	low	low	low	low	
	Water	loco head	65 (1.83)	60 (3.16)	57 (2.53)	43 (2.34)	58
		loco leaf	69 (0.78)	65 (1.08)	65 (1.12)	51 (1.90)	63
		grass	51 (0.77)	49 (2.40)	49 (1.68)	31 (1.59)	46
	CP	loco head	17.3(0.38)	17.3(0.24)	17.4(0.30)	16.4(0.77)	17.1
		loco leaf	12.9(0.48)	12.1(0.49)	11.8(0.24)	11.1(0.27)	12.1
		grass	8.3(0.26)	7.6(0.24)	6.8(0.19)	6.2(0.25)	7.2
	NDF	loco head	26 (0.59)	38 (3.68)	41 (0.57)	40 (0.47)	34
		loco leaf	32 (0.85)	36 (0.89)	36 (0.64)	36 (0.82)	35
		grass	51 (0.54)	54 (0.79)	51 (0.87)	51 (0.83)	52
B	Water	grass	6.2(0.88)	63 (0.74)	49 (1.23)	36 (1.25)	53
	CP	grass	11.0(0.46)	9.1(0.23)	8.5(0.36)	7.3(0.25)	8.9
	NDF	grass	49 (0.55)	55 (0.76)	50 (1.83)	49 (2.12)	51

[1]Phenological development of locoweed: 25 July = bloom, 8 and 22 Aug. = immature pod, 14 Sept. = mature pod.

addition, 1 cow and 8 calves in pasture A developed clinical signs of congestive right-sided heart failure and were removed prior to the end of the 1983 grazing season. No clinical signs of the disease were observed in cattle in pasture B.

These data suggest that cattle prefer the reproductive loco heads. Little loco leaf was consumed until the last 3 weeks of the grazing season. Grazing pressure, relative nutrient quality, and the habituating effect from the higher alkaloid concentration in the reproductive heads may have influenced the changes in selection patterns. Further research is necessary to elucidate these factors in order to develop management strategies to reduce cattle loss to white locoweed.

Literature Cited

A.O.A.C. 1970. Official methods of analysis. (11th ed.) Ass. Off. Agr. Chem., Washington D.C.

Arnold, G.W., and J.L. Hill. 1972. Chemical factors affecting selection of food plants by ruminants. *In:* J.B. Harborne (ed.) Phytochemical Ecology. Academic Press, New York.

Anthony, R.C., and N.S. Smith. 1974. Comparison of rumen and fecal analysis to describe deer diets. J. Wildl. Manage. 38:535-540.

Barnard, J.E. 1984. Locoweed poisoning in cattle: An overview of the economic problems associated with these ranges. M.S. Thesis, Utah State Univ., Logan.

Barneby, R.C. 1952. A revision of the North America species of *Oxytropis* DC. Proc. California Academy of Sciences. Vol. XXVII, No. 7, 177-312.

Becker, R.B., W.M. Neal, P.T.D. Arnold, and A.L. Shealy. 1935. A study of the palatability and possible toxicity of eleven species of *Crotalaria,* especially of *C. spectabilis.* J. Agr. Res. 50:911-922.

Carter, H.C. 1985. Fecal nitrogen and phosphorus as indicators of intake and quality of Angora goat diets. M.S. Thesis, Texas A&M Univ. College Station.

Goering, H.K., and P.J. VanSoest. 1970. Forage fiber analyses. USDA/-ARS Agr. Handbook. 379.

Holechek, J.L., M. Vavra, and R.D. Pieper. 1982. Methods of determining the nutritive quality of range ruminant diets: A review. J. Anim. Sci. 54:365-376.

James, L.F., W.J. Hartley, and K.R. Van Kampen. 1981. Syndromes of *Astragalus* poisoning in livestock. J. Amer. Vet. Med. Ass. 178:146-150.

James, L.F., W.J. Hartley, K.R. Van Kampen, D.B. Nielsen. 1983. Relationship between ingestion of locoweed *(Oxytropis sericea)* and congestive right-sided heart failure in cattle. Amer. J. Vet. Res. 44:254-259.

James, L.F., K.L. Bennett, K.G. Parker, R.F. Keeler, W. Binns, and B. Lindsay. 1968. Loco plant poisoning in sheep. J. Range Manage. 21:360-365.

James, L.F., K.R. Van Kampen, and G.R. Staker. 1969. Locoweed *(Atragalus lentiginosus)* poisoning in cattle and horses. J. Amer. Med. Ass. 155:525-530.

Marsh, C.D. 1909. The locoweed disease of the plains. USDA Bull. 112.

Marsch, C.D. 1913. Stocking poisoning due to scarcity of food. USDA Farmers Bull, 536.

Mathews, F.P. 1932. Locoism in domestic animals. Texas Agr. Exp. Sta. Bull. 456.

Mould, E.D. and C.T. Robbins. 1981. Nitrogen metabolism in elk. J. Wildl. Manage. 45:323-337.

Molyneux, R.J., and L.F. James. 1982. Loco intoxication: Indolizidine alkaloids of spotted locoweeds *(Astragalus lentiginosus).* Science 216:190-191.

Payne, G.F. 1957. Certain aspects of the ecology and life history of the poisonous plant, white pointloco (*Oxytropis sericea* Nutt.). Ph.D. Diss. Texas A&M Univ., College Station.

Peters, A.T., and L.B. Sturdevant. 1908. Locoweed poisoning in horses. Neb. Agr. Exp. Station 21st Annu. Rep. p. 74-105.

Ralphs, M.H., L.F. James, D.B. Nielsen, and K.E. Panter. 1984. Management practices reduce cattle loss to locoweed on high mountain range. Rangelands. 6:175-177.

Simons, A.B., and C.G. Marten. 1971. Relationship of indole alkaloids to palatability of *Phalaris arundinacea* L. Agron. J. 63:915-919.

Sparks, D.R., and J.C. Malechek. 1968. Estimating percentage dry weight in diets using a microscope technique. J. Range Manage. 21:264-265.

Williams, M., R. Barnes, and J. Cassady. 1971. Characterization of alkaloides in palatable and unpalatable clones of *Phalaris arundinacea* L. Crop Sci. 11:213-217.