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Comparing Indicators of Sheep Grazing Leafy Spurge and Perennial Grasses

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Abstract

Sheep and goats are increasingly being used to control the invasive leafy spurge (*Euphorbia esula* L.). Our objective was to compare three indicators of sheep use of leafy spurge and two native bunchgrasses, Idaho fescue (*Festuca idahoensis* Elmer) and bluebunch wheatgrass (*Pseudoroegneria spicata* [Scribn. and Smith] A. Love) on an upland site in southwestern Montana. We used yearling Targhee ewes in a 3 year study (1992-1994). One group of ewes (naive) had no previous exposure to leafy spurge whereas the second group (experienced) had been pastured on a leafy spurge-infested (25-50% cover) foothill rangeland as lambs. Sheep were rotated through 3 paddocks for 9 grazing periods in 1992 and 7 grazing periods in 1993 and 1994. Grazed plant frequency (%) and canopy removed (%) were estimated after sheep were removed from each paddock. Time spent grazing (%) on the different species was estimated for one week periods in early, mid-, and late summer 1992 and 1993, and at five day intervals for the first 35 days in the 1994 grazing season. Overall, the 3 measures of use indicated leafy spurge was less likely to be grazed than the two native grasses in early summer, but more likely to be grazed in mid-and late summer. In general, the sheep removed more of the canopy of leafy spurge than of grasses. During the early summer grazing period, all 3 measures of use indicated experienced sheep were more likely to graze leafy spurge than naive sheep. As expected, grazed plant frequencies were often high because any evidence of grazing was noted, whereas canopy removed more closely reflects ecological impacts of grazing. The behavioral time spent grazing results usually concurred with grazed plant frequency and canopy removed measured after sheep were removed from a given paddock.

Key words: weed, *Euphorbia esula*, grazing, nutritive value

Introduction

Leafy spurge (*Euphorbia esula* L.), a taprooted perennial forb, was introduced to North America from Russia in the early 1800s and has become a noxious weed in the north central United States and southern Canada (Best et al. 1980). Herbicides will not eradicate extensive infestations of leafy spurge, although they can be used to control this invasive plant (Fay 1992). Sheep and goats will graze leafy spurge but most grazing trials have been on sites dominated by introduced grasses, e.g. crested wheatgrass (*Agropyron cristatum* [L.] Gaertn); and Kentucky bluegrass (*Poa pratensis* L.), (Johnston and Peake 1960, Kirby et al. 1997, Kronberg and Walker 1999). Leafy spurge is less frequent on uplands dominated by native cool-season grasses, which may simply mean that leafy spurge has not yet arrived on those sites.

Although sheep will graze leafy spurge, sheep also graze associated grasses and forbs. On these uplands, native bunchgrasses such as Idaho fescue (*Festuca idahoensis* Elmer) and bluebunch wheatgrass (*Pseudoroegneria spicata* [Scribn. and Smith] A. Love) tolerate grazing less than introduced grasses such as Kentucky bluegrass, smooth brome (*Bromus inermis* Leys.), and crested wheatgrass. Thus sheep have the potential to shift the competitive balance to favor leafy spurge if their use of native grasses exceeds that of leafy spurge (Olson 1999 a).

A series of studies was conducted on sheep grazing leafy spurge and associated grasses from 1992 to 1995 on a typical upland, foothill site in southwestern Montana. In these studies, it was determined that: 1) based on grazing behavior, experienced yearlings grazed leafy spurge more than inexperienced yearlings for the first 3-4 weeks of summer, but thereafter inexperienced yearlings grazed just as much leafy spurge (Olson et al. 1996), 2) sheep ingest and pass viable leafy spurge seed in the field (Olson et al. 1997), 3) three years of sheep grazing leafy spurge are needed before a decline in the vigor of leafy spurge is noticed (Olson and Wallander 1998), and 4) greater than 75% of leafy spurge in the diet has a negative effect on sheep rumen microbial activity and mass (Roberts and Olson 1999).

Grazing of plant species can be measured by observing the animal and counting bites or determining time spent grazing (Olson et al. 1996), microhistological or near infrared spectroscopy of feces (Kirby et al. 1997, Walker et al. 2002), or pre-and post trial measures on individual plants or plant parts (this study). Observing animals is labor intensive, may influence their grazing

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behavior, and is limited to when a particular animal is being observed. Microhistological analysis of feces underestimates highly digestible forbs, such as leafy spurge. Further, observations and microhistological analysis only address relative use, often limited to species composition or growth form. Measures on individual plants or plant parts provides an index of use on individual plants within the community. Our objective was to compare two plant indicators of use (grazed plant frequency and percent canopy removed) with a behavioral indicator of use (time spent grazing) on leafy spurge and two native grasses on a foothill range site in southwestern Montana.

Materials and Methods

The study site was in Gallatin County in southwestern Montana (111˚33' W 45˚40' N), 1480 m in elevation on northeast facing bluffs overlooking the Madison River. Soils are loamy skeletal mixed Aridic Calciborolls. The rangeland cover type is Idaho fescue-bluebunch wheatgrass (Shiflet 1994).

Grazing Treatments

Two groups of yearling Targhee ewes were used during the summers of 1992-1994 (Olson et al. 1996). One group of yearlings (naive) had no previous exposure to leafy spurge as lambs, whereas the second group (experienced) had been pastured on a leafy spurge-infested (25-50% cover) rangeland with their mothers. As lambs, both groups had access to similar cool-season, perennial grasses on foothill rangelands.

Within the study site, a 5.1 ha area was divided into three 1.7 ha blocks; each block was divided into 2 lanes of similar size (Fig. 1). One experienced group and one naive group were assigned randomly to each lane. Five yearlings grazed each lane in 1992 (n = 30 sheep total), whereas 4 yearlings grazed each lane in 1993 and 1994 (n = 24 sheep total). Stocking rates were approximately 0.5 AUMs ha^{-1} in 1992 and 1994, and 0.4 AUMs ha^{-1} in 1993. Each lane was further subdivided into 3 different paddocks (1, 2, C). Sheep were rotated through these 3 paddocks for 9 grazing periods in 1992 and 7 grazing periods in 1993 and 1994. Time in each paddock varied from 3 to 20 d (Fig. 1) based on available forage. Paddock C was usually grazed between Paddocks 1 and 2 during each rotation. Paddock C was about twice as large as Paddocks 1 and 2, thus it was usually grazed twice as long as Paddocks 1 and 2 each summer. All sheep were moved at the same time into the next scheduled paddock.

Based on a visual estimate, canopy cover of leafy spurge varied from 35-65%, other forbs comprised 1-10%, and cool-season perennial grasses comprised the rest of the plant community at the beginning of each grazing season. The distribution of leafy spurge was not uniform in each paddock.

Plant Based Indicators - Grazed Plant Frequency and Canopy Removed

Permanent 10 m transects were established outside each of 2 small exclosures (4 m x 12 m) within large patches of leafy spurge in each paddock (2 exclosures/paddock x 3 paddocks/lane x 2 lanes/ block x 3 blocks = 36 exclosures). Permanent plots (0.25-m^2) were established at 1-m intervals along each transect. The nearest leafy spurge stem and Idaho fescue and bluebunch wheatgrass plant to each corner of each 0.25-m^2 plots were selected to assess these two indicators of grazing patterns. Thus, at the end of each grazing period, we measured 1,440 plants of each species of interest (4 plants of each species per plot x 10 plots per transect x 2 transects per paddock x 3 paddocks per lane x 2 lanes per block x 3 blocks).

After the sheep left each grazed paddock, we determined grazed plant frequency by recording impact on the selected plant as none, grazed, trampled, or grazed and trampled. Grazed and grazed and trampled categories were combined to determine grazed plant frequency. This included any evidence of grazing during that grazing period. A lack of necrotic tissue at grazed leaf tips indicated recent grazing compared with necrotic tissue at leaf tips which indicated grazing during the previous grazing period.

Percent canopy removed was estimated by visually comparing what remained of grazed plants outside exclosures with ungrazed plants of similar basal area inside exclosures. Therefore canopy removed (%) reflected how much plant material had been removed from the plant collectively, including material possibly removed in previous grazing periods.

Animal Based Indicator - Time Spent Grazing

Using focal animals, diet selectivity was assessed by determining time spent grazing leafy spurge and native bunchgrasses as a percent of total time spent grazing (Olson et al. 1996). However, whether sheep were grazing Idaho fescue or bluebunch wheatgrass was difficult to discern because these two bunchgrasses were often intermixed. To distinguish use, observers would have had to be extremely close to the sheep, which in turn may influence grazing behavior.

In 1992 and 1993, sheep were observed when leafy spurge was growing rapidly (3 June - 10 June 1992; 25 May - 1 June 1993), during early-seed set (3 July -10 July 1992; 27 June - 2 July 1993), and post-seed set (27 July -1 August 1992; 29 July - 5 August 1993). In 1994, yearlings were observed only during their first 35 days on the pasture (27 May - 1 July 1994) because our results from 1992 and 1993 indicated naive yearlings readily grazed leafy spurge within one month after exposure. Yearlings were observed the evening of the day they were turned into the pasture and the following morning. This sequence was then repeated every five days for 35 days.

Statistical Analysis

Grazed plant frequency (%; 1992-1994) and canopy removed (%; 1993-1994 only) were analyzed with a split-plot analysis of variance in a randomized complete block design (n = 3 blocks; GLM, SAS 1988). Treatment (naive and experienced) and year served as the main effects, with grazing period within year serving as the split plot. The behavioral indicator, time spent grazing, was analyzed as a randomized block design (n = 3; GLM, SAS 1988), where groups of sheep were experimental units (see Olson et al., 1996). Percentage data were arcsin square root transformed. Least square means of non-transformed data are presented in figures.

Results

Leafy Spurge

Grazed plant frequency within years differed between naive and experienced sheep (treatment by period within year interaction; $P = 0.02$ (Figs. 2-4), especially in the first 2 (1992, 1993) to 3 (1994) grazing periods each year when experienced sheep grazed more leafy spurge stems than naive sheep. Similarly, experienced sheep removed more canopy from leafy spurge than naive sheep (treatment, $P = 0.001$), especially in 1994 (year by treatment interaction, $P = 0.09$). Like grazed plant frequency, differences in percent canopy removed between experienced and naive yearlings were most pronounced early in the grazing season.

In 1992, time spent grazing leafy spurge by experienced and naive yearlings were less than 5% during the first observation period, whereas grazed plant frequency indicated that experienced yearlings were grazing, at least, parts of more leafy spurge stems than naive yearlings (Fig. 2). Both time spent grazing and grazed plant frequency indicated the differences (late June-early July) and similarities (early August) of use between experienced and naive yearlings.

In 1993, time spent grazing, grazed plant frequency, and percent canopy removed also indicated the difference in early season use (early June), and similarities in mid- and late season (early July, early August) use of leafy spurge by experienced and naive yearlings (Fig. 3). In 1994, when observations were recorded for the first 35 d, early season differences between experienced and naive yearlings grazing leafy spurge were present in all three indicators (Fig. 4).

As expected, percent canopy removed (1993, range 19-77%; 1994, range 11-86%) from leafy spurge was lower than grazed plant frequency (1992, 6-99%; 1993, range 57-96%; 1994, range 21-98%). Time spent grazing (%; 1992, range 1-42%; 1993, range 5-33%; 1994, range 2-45%) leafy spurge was always less than grazed plant frequency and percent canopy removed. Low time spent grazing but high grazed plant frequency and percent canopy removed could indicate low plant availability, or that they were selectively removing plant parts of high nutritive value.

Bunchgrasses

Grazed plant frequency of Idaho fescue plants was similar each year (year, $P = 0.42$; Figs. 2-4), although grazed plant frequency varied among periods within years, especially in 1992 and 1994 (period within year, $P = 0.001$ both years). In 1992, grazed plant frequency of both groups was similar, whereas experienced sheep grazed Idaho fescue more than naive sheep in 1993 and naive sheep grazed Idaho fescue more than experienced sheep in 1994 (treatment by year interaction, $P = 0.001$).

Percent canopy removed of Idaho fescue was similar between experienced and naive yearlings in 1993, whereas naive sheep consistently removed more canopy from Idaho fescue than experienced sheep in 1994 (year by treatment interaction, $P = 0.002$; Figs. 3, 4). Percent canopy removed of Idaho fescue varied among periods within years (period within year, $P = 0.001$).

Grazed plant frequency of bluebunch wheatgrass was greatest in 1992, intermediate in 1994, and lowest in 1993 (year, $P = 0.04$; Figs. 2-4). Grazed plant frequency of bluebunch wheatgrass varied within years, especially in 1992 (period within year, $P = 0.001$). Grazed plant frequency by experienced and naive sheep was similar across the three years (treatment, $P = 0.50$).

Experienced sheep removed more canopy from bluebunch wheatgrass than naive sheep in 1993, whereas naive sheep removed more canopy from this species in 1994 (year by treatment interaction, $P = 0.06$; Figs. 3, 4). Overall, percent canopy removed of bluebunch wheatgrass was similar in 1993 and 1994 (year, $P = 0.85$), and consistent among periods within years (period within year, $P = 0.87$).

While determining time spent grazing, we could not readily differentiate the two main bunchgrass species so the observers simply noted time spent grazing bunchgrasses. In 1992, naive yearlings spent more time grazing bunchgrasses than experienced yearlings in mid-summer (Fig. 2), which agrees with our grazed plant frequency measures on June 30 and July 10. In early- and late summer, similarities between naive and experienced yearlings in time spent grazing agreed with grazed plant frequencies.

In early summer 1993, naive yearlings spent more time grazing perennial grasses than experienced yearlings, agreeing with our observations on grazed plant frequency (Fig. 3). In mid- and late summer, time spent grazing was similar between naive and experienced yearlings, whereas percent canopy removed, and especially grazed plant frequency, indicated differences.

In 1994, naive yearlings spent more time grazing perennial grasses than experienced yearlings during most of the 35-day observation period (Fig. 4). The plant indicators of use were not as consistent in expressing differences in use between naive and experienced yearlings.

Percent canopy removed (1993, range 13-58%; 1994, range 17-57%) from bunchgrasses was usually lower than grazed plant frequency (1992, 57-99%; 1993, range 27-97%; 1994, range 16-95%). Time spent grazing (%; 1992, range 51-95%; 1993, range 45-85%; 1994, range 50-95%) bunchgrasses was similar to or slightly lower than grazed plant frequency.

Discussion

The objective of this study was to compare three indicators of sheep grazing leafy spurge and native bunchgrasses. Plant indicators (grazed plant frequency and percent canopy removed) were determined after the sheep were removed from a paddock and therefore represented a composite of the entire grazing period. Unlike time spent grazing, our measure of sheep behavior, grazed plant frequency and percent canopy removed cannot describe grazing dynamics within a grazing period whereby animals may develop a preference or avoidance for certain species, resulting in fairly rapid shifts in diet selection (Olson et al. 1996). However preference or avoidance can be detected from period to period with these plant indicators of use. For example, during the first 2-3 grazing periods, sheep grazed fewer leafy spurge plants than the two native grasses based on grazed plant frequency. This agreed with time spent grazing. However, sheep often removed more canopy from leafy spurge than from grasses in early summer, which is difficult to quantify through animal observations. In general, sheep continued to remove more canopy from leafy spurge than the bunchgrasses in mid- and late summer.

Removing greater percent canopy from leafy

spurge, especially later in summer, may reflect learning (Provenza and Balph 1987), a sheep's predilection for grazing forbs such as leafy spurge (Olson 1999b), or the higher nutritive value of leafy spurge than the native grasses (Olson et al. 1996). However, concentrations of condensed tannins in leafy spurge, which can inhibit digestibility, increase as summer progresses (Roberts and Olson 1999). Apparently, the high crude protein content and dry matter digestibility of leafy spurge leaves in mid- and late summer offset any aversive effects associated with greater levels of condensed tannins.

Directly observing animals can detect rapid changes in plant use patterns and diet selection within grazing periods, however it can be labor intensive and thus not conducive for 24 h per day, 7 d per week observations. Although limited in scope, our direct animal observations usually concurred with grazed plant frequency and canopy removed, which provided an index of use on these key species during the entire grazing period. For example, all 3 measures indicated that experienced and naive sheep were grazing greater numbers of stems of leafy spurge and removing more canopy from leafy spurge than the grasses within 3 to 4 weeks.

Grazed plant frequency, percent canopy removed, and time spent grazing were not expected to produce identical results. Grazed plant frequency is objective, addressing the simple question was a plant grazed or not, whereas percent canopy removed is subjective, a visual estimate of the percent of the canopy removed compared with a nearby, intact canopy. Time spent grazing, based on observing animals, is also subjective. Without a complete pre-and post-grazing census of all plants in all pastures, we cannot ascribe one as a more accurate indicator of use than another. Again, each measures a different attribute of use on a plant community, therefore we did not expect data to match perfectly.

Grazed plant frequencies were usually much greater than percent canopy removed because even a small bite from a plant constitutes grazed. Grazed plant frequencies often exceeded 60% which may seem excessive. In contrast, percent canopy removed was usually much lower, indicating the sheep were sampling most plants, not excessively grazing all plants. Further, percent canopy removed represents less impact than measures of biomass removed because the preponderance of biomass is near the base of bunchgrasses such as Idaho fescue and bluebunch wheatgrass.

Within a few weeks of entering the leafy spurge-infested paddocks, the sheep were more likely to graze leafy spurge than the native grasses. Thus, the native grasses should be at a competitive advantage if leafy spurge and the grasses had similar responses to grazing. After three years of repeated sheep grazing, leafy spurge seed in the seedbank, seedling densities, and stem heights were lower in grazed areas; however, the density of leafy spurge stems was similar on grazed and ungrazed areas (Olson and Wallander 1998). Other studies indicate that sheep must graze leafy spurge at least four years before a noticeable reduction in leafy spurge is realized (Johnston and Peake 1960, Bowes and Thomas 1978). Even though leafy spurge was more likely to be grazed than the grasses, the lack of a quick reduction in stem densities may reflect a strong tolerance of leafy spurge to defoliation (Selleck et al. 1962, Olson and Wallander 1999).

Plant measures indicated that Idaho fescue was more likely to be grazed than bluebunch wheatgrass. In the foothills and mountains area of Montana, Idaho fescue increases whereas bluebunch wheatgrass decreases with sheep and cattle grazing (SCS 1983). Plants increasing or decreasing due to grazier species reflects the grazier's preference, or lack thereof, for the plant and the plants grazing tolerance or ability to recover. On this site, repeated sheep grazing increased density of Idaho fescue, but reduced density of bluebunch wheatgrass (Olson and Wallander 1998). Bluebunch wheatgrass plants exposed to grazing were slightly shorter than plants inside exclosures, whereas grazing had no discernible effect on heights of Idaho fescue. Thus, even though Idaho fescue was usually more likely to be grazed than bluebunch wheatgrass, its grazing response indicates a greater tolerance, not avoidance, to defoliation, and supports its "increaser" label.

Conclusions

Our objective was to compare grazed plant frequency, percent canopy removed, and time spent grazing leafy spurge and native grasses by sheep on a foothill range site in southwestern Montana. Overall, the 3 measures of use indicated leafy spurge was less likely to be grazed than the two native grasses in early summer, but more likely to be grazed in mid-and late summer. Greater use of leafy spurge than the grasses in mid- and late summer may reflect learning, the higher nutritive value of the plant, and (or) a sheep's natural preference for forbs such as leafy spurge. As expected, grazed plant frequencies were often high because any evidence of grazing was noted, whereas canopy removed more closely reflects the ecological impact of grazing. In general, sheep removed more of the canopy of leafy spurge than of grasses. Although limited in scope, the behavioral time spent grazing results supported grazed plant frequency and canopy removed measured after sheep wee removed from a given paddock.

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Literature Cited

AOAC. 1984. Official methods of analysis (14th ed.). Association of Official Analytical Chemists. Washington, D.C.

Best, K.F., G.G. Bowes, A.G. Thomas, and M.G. Maw. 1980. The biology of Canadian weeds. 39. *Euphorbia esula* L. Can. J. Plant Sci. 60:651-663.

Bonham, C.D. 1989. Measurements for terrestrial vegetation. John Wiley & Sons. New York.

Bowes,G.G., and A.G. Thomas. 1978. Longevity of leafy spurge seeds in the soil following various control programs. J. Range Manage. 31:137-140.

Fay, P.K. 1992. The role of herbicides in weed management. Western Wildlands, Summer Issue.

Goering, H.K., and P.J. Van Soest. 1970. Forage fiber analysis. Agr. Handb. No. 379. USDA, U.S. Government Printing Office, Wash., D.C.

Johnston, A., and R.W. Peake. 1960. Effect of selective grazing by sheep on the control of leafy spurge (*Euphorbia esula* L.). J. Range Manage. 13:192-195.

Kirby, D.R., T.P. Hanson, and C.H. Sieg. 1997. Diets of angora goats grazing leafy spurge (*Euphorbia esula*)-infested

rangeland. Weed Tech. 11:734-738.
Kronberg, S.L., and J. W. Walker. 1999. Sheep preference for leafy spurge from Idaho and North Dakota. J. Range Manage. 52:39-44.
Olson, B.E. 1999a. Grazing and weeds. p. 85-96. *In*: R.L. Sheley and J.K. Petroff (eds), Biology and management of noxious rangeland weeds. Oregon State University Press, Corvallis, Oregon.
Olson, B.E. 1999b. Manipulating diet selection to control weeds. *In:* K.L. Launchbaugh, K.D. Sanders and J.C. Mosley (eds), Grazing behavior of livestock and wildlife. Idaho Forest, Wildlife and Range Stat Bull #70, pp 36-44, Moscow ID.
Olson, B.E., and R.T. Wallander. 1998. Effect of sheep grazing on a leafy spurge infested-Idaho fescue community. J. Range Manage. 51:247-252.
Olson, B.E., and R.T. Wallander. 1999. Carbon allocation in *Euphorbia esula* and neighbours after defoliation. Can. J. Bot. 77:1641-1647.
Olson, B.E., R.T. Wallander, and R.W. Kott. 1997. Recovery of leafy spurge seed from sheep. J. Range Manage. 50:10-15.
Olson, B.E., R.T. Wallander, V.M. Thomas, and R.W. Kott. 1996. Effect of previous experience on sheep grazing leafy spurge. Appl. Anim. Behav. Sci. 50:161-176.
Provenza, F.D., and D.F. Balph. 1987. Diet learning by domestic ruminants: theory, evidence and practical implications. Appl. Anim. Behav. Sci. 18:211-232.
Roberts, J., and B.E. Olson. 1999. Effect of *Euphorbia esula* on sheep rumen microbial activity and mass in vitro. J. Chem. Ecol. 25:297-314.
SAS. 1988. Statistical analysis system. SAS Institute Inc. Raleigh, North Carolina.
SCS. 1983. Soil Conservation Service. Montana Technical Guide. Section II-E-4.
Selleck, G.W., R.T. Coupland, and C. Frankton. 1962. Leafy spurge in Saskatchewan. Ecol. Mono. 32:1-29.
Shiflet, T.N. 1994. Rangeland cover types. Soc. Range Manage. Denver, Colo.
Walker, J.W., S.D. McCoy, K.L. Launchbaugh, M.J. Fraker, and J. Powell. 2002. Cailbrating fecal NRS equations for predicting botanical composition of diets. J. Range Manage. 55:374-382.

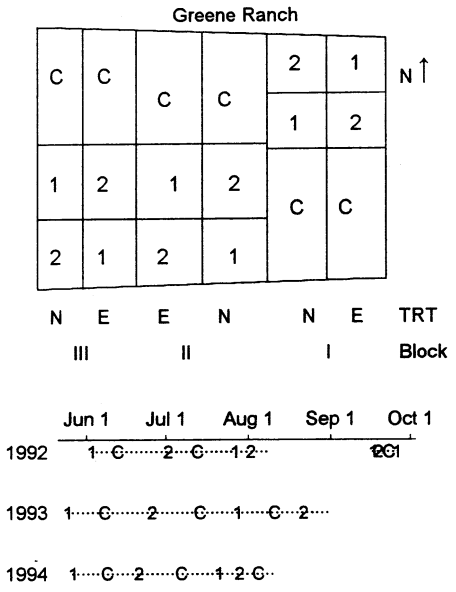

Figure 1. Pasture layout and grazing rotation of sheep among Paddocks 1, 2, and C. The schedule varied within years and from year to year based on forage availability.

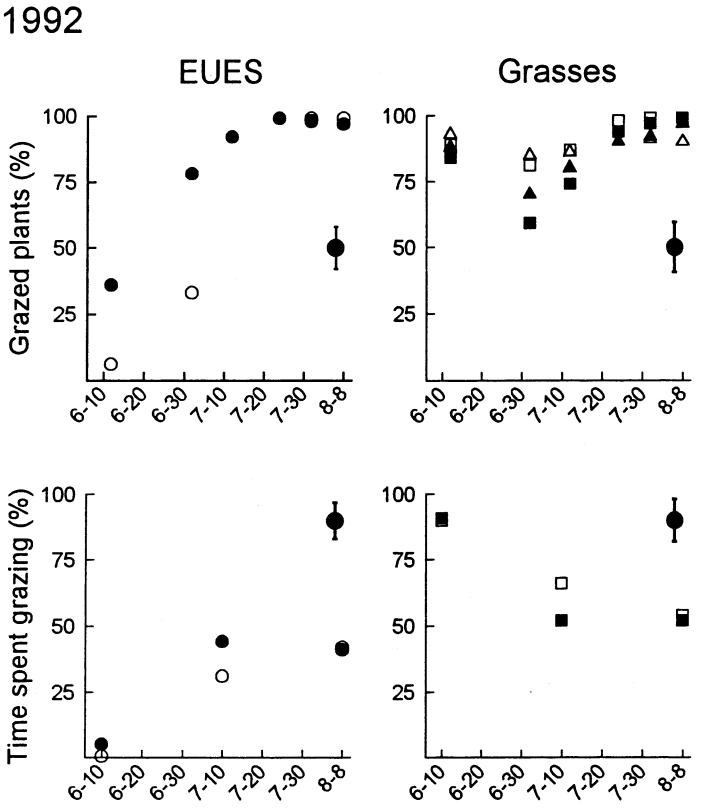

Figure 2. Grazed plant frequency (%) and time spent grazing (%) by experienced and naive yearling sheep of leafy spurge (*Euphorbia esula* EUES; experienced ●; naive ❍) and grasses [(*Festuca idahoensis* (experienced ■; naive ❑), and *Pseudoroegneria spicata* (experienced ▲; naive Δ)] during the summer of 1992. Time spent grazing (%) is adapted from Olson et al. (1996). Unlike grazed plant frequency, we could not distinguish time spent grazing (%) of different perennial grass species so these symbols represent use on perennial grasses, not just *Festuca idahoensis*. Non-transformed least square means, and season-long standard errors are presented.

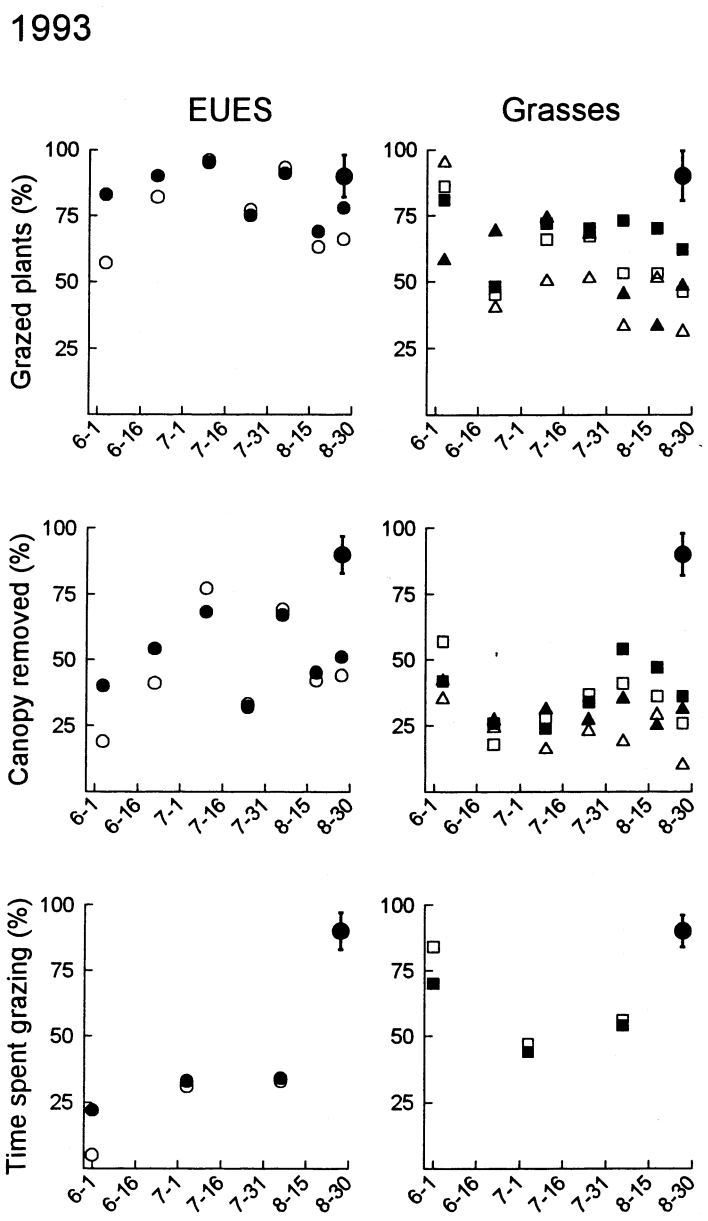

Figure 3. Grazed plant frequency (%), canopy removed (%), and time spent grazing (%) by experienced and naive yearling sheep of leafy spurge (*Euphorbia esula* EUES; experienced ●; naive ❍) and grasses [(*Festuca idahoensis* (experienced ■; naive ❑),and *Pseudoroegneria spicata* (experienced ▲; naive Δ)] during the summer of 1993. See Figure 2 legend for additional details. Non-transformed least square means, and season-long standard errors are presented.

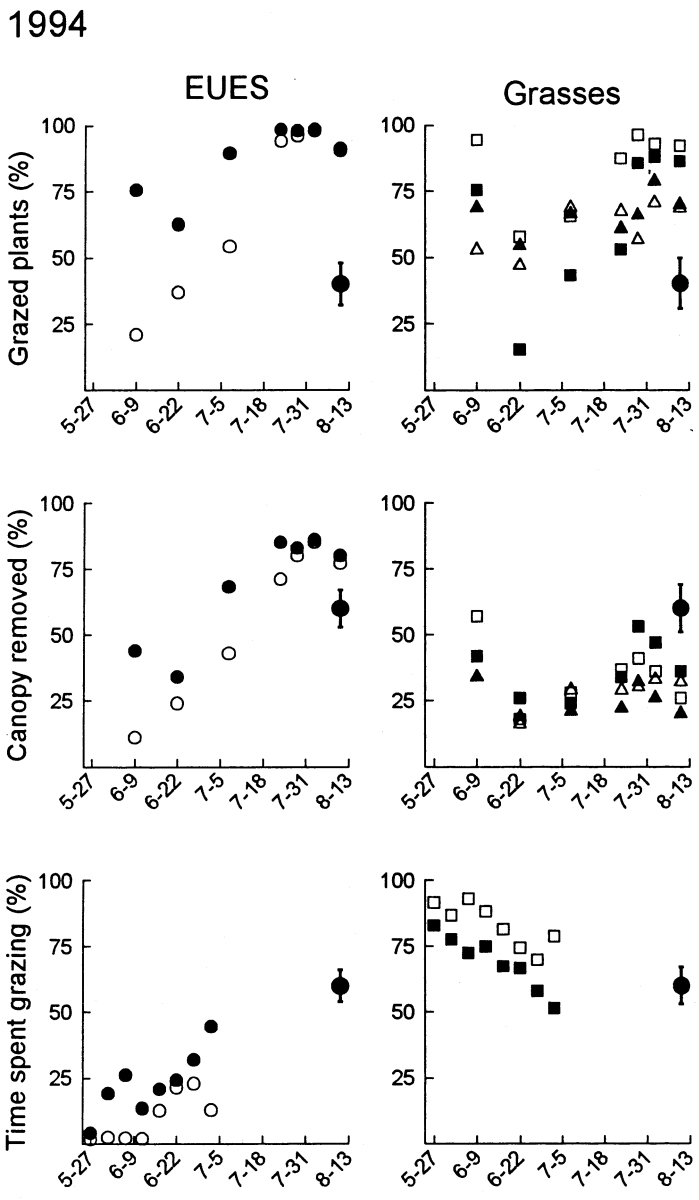

Figure 4. Grazed plant frequency (%), canopy removed (%), and time spent grazing (%) by experienced and naive yearling sheep of leafy spurge (*Euphorbia esula* EUES; experienced ●; naive ❍) and grasses [(*Festuca idahoensis* (experienced ■; naive ❑),and *Pseudoroegneria spicata* (experienced ▲; naive Δ)] during the summer of 1994. Unlike 1992 and 1993,time spent grazing (%) was only assessed for the first 35 days at 5 day intervals in 1994. See Figure 2 legend for additional details. Non-transformed least square means, and season-long standard errors are presented.