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Managing leafy spurge with livestock

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Introduction

The goal of our research is to discover ways to manipulate either the grazing animal or the leafy spurge plant and cause leafy spurge to become a preferred forage.

Managing leafy spurge by livestock grazing is potentially the best solution for this and other exotic weeds on rangelands. Livestock grazing may not always provide a feasible solution, but when it will it has two definite advantages over other methods of controlling weeds. First, the use of pesticides and introduction of exotic insects and pathogens for biocontrol may have negative environmental or perceptual consequences. Second, instead of simply eliminating a plant that is considered a problem, grazing livestock could convert leafy spurge from a pest to forage. However, the use of livestock for grazing leafy spurge will require more dedication and greater managerial skills than other methods of weed control.

Regardless of the objective, successful grazing management requires an understanding of the factors that influence selective grazing and plant response to defoliation. Therefore, this paper will begin with a short review of some general principles that affect grazing management. Then we will present some specific results from research at the U.S. Sheep Experiment Station on grazing leafy spurge.

Leafy spurge and other plants classified as weeds on rangelands were usually introduced from another continent. Therefore, they have few natural enemies or pathogens and may be adapted to unexploited niches in natural communities. Secondly, these weed species are not consumed by herbivores either domestic or wild; vertebrate or invertebrate. This implies that for some reason they are not palatable to these animals. Rangeland weeds might be considered ecologically competitive plants that no one wants to eat.

When we talk about using livestock to control weeds the goal is to manipulate the patterns of defoliation and place a target plant at a competitive disadvantage. To use any type of biological control effectively we must understand the grazing behavior of the herbivore and the ecology of the target plant species. In other, words we need to understand both the target and the bullet.

There are two approaches that can be used either separately or in combination to place a weed at a competitive disadvantage to the other plants in the community.

- 1) Use grazing management to increase the probability the target plant will be defoliated at a phenological stage and/or frequency and intensity that is most detrimental to it.
- 2) Modify grazing behavior to cause animals to have a strong relative preference for the target weed.

Grazing management will do little to modify the selective grazing behavior except as the more preferred species are removed because of high grazing pressure and the animals are forced to graze less palatable species.

Grazing management

The principles of grazing management for controlling weeds are the same principles used regardless of the management objective i.e., proper: stocking rate, season of use, kind or mix of livestock, grazing distribution, frequency and intensity of grazing (grazing system). However, because of the low productivity of rangeland, controlling weeds with grazing management alone may require a greater intensity of management than is economically justifiable. Therefore, it is important to discover ways to modify the animals grazing behavior to induce it to have a high degree of preference for the target weed.

When using grazing management to place a weed at a competitive disadvantage to other plants in the community it is important to understand how plants are adapted to defoliation. Grazing resistance refers to mechanisms used by a plant to survive in the presence of defoliation. Plants resist the negative affects of defoliation by tolerance, and avoidance. Tolerance mechanisms increase growth following defoliation; while avoidance mechanisms reduce the probability and severity of defoliation. Most weed species rely on avoidance mechanism to resist grazing. These include spines or other physical deterrents, and aversive phytochemicals. The key to management of perennial herbaceous weeds by grazing may be simply to induce livestock to graze them. When they are grazed they may not have the tolerance mechanisms to replace lost photosynthetic material and may be out competed by other plants in the community, such as the grasses, that have well developed tolerance mechanisms. Ideally, grazing should be planned so that defoliation occurs when it is most detrimental to the target plant and at the point in its phenological development that it has the greatest preference compared to other species in the community.

Modifying grazing behavior

Grazing management manipulates patterns of defoliation by controlling the timing of grazing or by using high grazing pressures to force an animal to graze plants that are otherwise avoided. In contrast management of grazing behavior attempts to modify patterns of defoliation by directly manipulating preferences using diet training. Behavior is adap-

tive and survival is the motivating force for all behavior. This point will be important in evaluating the potential for modifying diet selection.

Animal behavior has both innate and learned components, but to consider these two facets independently from each other or the environment in which the behavior is performed is an unwarranted simplification.

Innate behaviors are responses that are not highly dependent on specific learning experiences. For instance, although diet selection appears plastic, the presences of innate stimulus filters may predetermine which plants are perceived as potentially palatable food items for a given kind of livestock. Certain general phenomenon such as food neophobia and diet sampling are innate. These behaviors can have an influence on diet selection. Food neophobia is the tendency of herbivores to avoid foods they have not previously encountered. It is obvious that such a behavior would inhibit the ability to induce livestock to consume a new weed. Conversely, the tendency of herbivores to explore and sample their environment could cause animals that were conditioned to consume a specific weed to discover other plants that are more desirable and thus stop eating the target weed. Species specific differences in an animal's ability to detoxify phytotoxins can cause one kind of animal to receive a positive post ingestive consequence from a particular weed while another kind of animal receives negative feedback from the same plant.

Learning is a process by which behavior is acquired or changed by reacting to a situation. The degree to which diet selection is learned will decide the degree to which we can hope to influence this behavior. New responses are always being acquired and old ones lost on a daily basis usually without our knowledge. Through learning an organism can deal with a variable and changing environment where programmed and specific modes of response may be maladaptive.

A principle of learning is that an established response decreases if the stimulus is repeatedly presented without a consequence. This process is known as extinction. Extinction is just as important an adaptive mechanism as conditioning, because a continued response to cues that are no longer significant is not in the animals' best interest.

It appears likely that animals exhibit associative learning, because the brain has evolved to enable animals to distinguish events that reliably and predictably occur together from those that are unrelated. In other words, the brain has evolved as a detector of causal relationships in the environment.

Summarizing the aspects of animal behavior that influence diet selection it appears that diet selection is under the influence of innate and learned behaviors. Innate behaviors will place limits on the degree that diet selection can be modified by learned behaviors. Learning is a somewhat permanent change in behavior resulting from experience. The learned behavior will eventually cease when the stimulus no longer reliably predicts a future consequence. The existence of observational learning and sensitive periods for learning may present special opportunities for modifying diet selection. Efforts to modify diet selection that lowers an animals fitness compared to a diet that does not contain the target species is destined for failure because behavior is adaptive and survival is the motivating force for all behavior.

Results from grazing studies

Many studies on using sheep and goats to graze leafy spurge have been conducted at the U.S. Sheep Experiment Station since 1989. These studies have involved small pasture grazing trials and pen feeding trials. In the grazing trials animals graze small spurge infested pastures for periods of 1 to 2 weeks by which time pastures are generally 70% utilized. Data collected include bite counts to determine diet selection, and frequent biomass estimates of available forage and level of utilization. Trials have included studies on the effect of previous experience, species of livestock (sheep vs. goats) and location on the palatability and preference for leafy spurge.

Previous experience

The objective of the study was to decide if exposure of young lambs to leafy spurge would increase the consumption of this plant. Orphan lambs were exposed to leafy spurge from birth to 11 weeks of age as a water soluble extract mixed with milk replacer and as freshly harvested plants. Ewe-reared lambs were exposed to leafy spurge by grazing them on a leafy spurge infested pasture. Three studies were conducted to determine the effect of early exposure on preference for leafy spurge.

Study 1 investigated the consumption of vegetative and flowering leafy spurge paired with arrowleaf balsamroot by orphan lambs during a 30-minute feeding period. Experienced lambs consumed a higher percentage leafy spurge than naive lambs. The interaction of leafy spurge phenophase and previous experience showed that experienced lambs preferred leafy spurge despite phenophase (70% of intake) and naive lambs only preferred leafy spurge when it was vegetative.

Study 2 investigated the preference for leafy spurge on pastures with high or low leafy spurge biomass. Experienced compared to naive lambs had a higher percentage of bites and preferred leafy spurge in the high spurge biomass pasture, but not in low biomass pastures. Naive lambs avoided leafy spurge in both pastures.

Study 3 was a pasture trial that investigated spurge consumption by orphan and ewe-reared lambs. Percent bites and time spent grazing leafy spurge were not affected by previous exposure, but herbage removal was greater in pastures grazed by experienced compared to naive lambs (876 vs. 685 g/lamb, respectively). Experienced ewe-reared lambs had a higher rate of biting on leafy spurge than naive or orphan lambs. These studies indicate that previous experience will be an important factor affecting the use of sheep as a biological control agent for leafy spurge.

Sheep vs. goats

Preference for leafy spurge by sheep and goats has not been directly compared. In this study mature animals with no previous experience grazing leafy spurge were used.

Innate differences in preference for leafy spurge by sheep compared to goats was tested using paired confinement feeding trials and pasture trials.

In the paired feeding trials leafy spurge was paired with either arrowleaf balsamroot or crested wheatgrass. There was a significant interaction between kind of livestock and plant species paired with leafy spurge. Sheep avoided leafy spurge despite the other species of forage it was paired with. Goats avoided leafy spurge when paired with crested wheatgrass (33% of intake) but preferred spurge when it was paired with arrowleaf balsamroot (80% of intake). Averaged across both species of other forages offered, goats consumed 57% of their intake from leafy spurge during the 30-minute feeding trial compared to 28% for sheep.

In a pasture trial goats took 74% of their bites from leafy spurge compared to 16% for sheep. Pastures were grazed until total biomass utilization was 77%. Goat utilization of leafy spurge was 21 and 69% at mid and end of trial compared to 5 and 54% for sheep. Work is continuing to determine the effect of previous experience on preference for leafy spurge by sheep and goats.

Trials completed June 1992 suggest that differences between sheep and goats in their preference for leafy spurge may be moderated by the physiological condition of the ewe. Utilization of leafy spurge biomass was 42% greater for lactating compared to dry ewes. While the lactating nannies had a utilization rate only 10% higher than lactating ewes. We hypothesize that hormonal differences between dry and lactating ewes are ameliorating the aversive consequences of leafy spurge in these animals.

Results from confinement feeding studies and aversion trials help provide an explanation for the difference in preference for leafy spurge between sheep and goats. When leafy spurge is used as an aversive agent in a classical food aversion trial sheep are averted to a novel feed but goats are not. This suggests the presence of a phyto-chemical in leafy spurge that stimulates the emetic system and causes this aversion. Another study that investigated the affect of the percent spurge in a ground forage diet showed that as percent leafy spurge increased intake decreased. The slope of the line that predicted intake from spurge concentration was greater for sheep than goats. This shows that sheep are more responsive than goats to aversive phyto-chemicals in leafy spurge. Furthermore, we believe that these yet unidentified phyto-chemicals cause cattle to avoid leafy spurge to a greater degree than sheep. Identification and understanding of the phyto-chemicals in leafy spurge that cause this plant that otherwise is a nutritious forage to be classified as a noxious weed will be the key to manipulating livestock preference for it.

Effect of location

Anecdotal evidence suggests that livestock preference for leafy spurge varies among populations of this plant. Chromatographic analysis, DNA sequences and morphological differences support the observation that large variation exists among accessions of leafy spurge. Reports from Montana and North Dakota (ND) suggest that sheep will readily eat large amounts of leafy spurge on range and pasture land. In contrast, we observe that sheep in southeast Idaho (ID) are reluctant consumers of the weed. An experiment was conducted to decide if spurge palatability differed between ND and ID and if characteris-

tics that separated palatable from unpalatable accessions could be identified. This information could be used to identify leafy spurge populations that would be susceptible to control by sheep grazing. The objective of this project was to determine if differences in preference and utilization of leafy spurge growing in different locations could be shown and if the plants could be differentiated by gas chromatography.

Ten sheep from each state were placed on small, spurge-infested pastures in southeast ID and central ND. The trials were conducted in early- and mid-June in ID and ND, respectively. The alternative forages were primarily crested wheatgrass in ID and smooth brome in ND. Standing crop, number of grazed and ungrazed spurge stems and diet composition was recorded at the beginning, middle and end of each trial. At the start of the trials, the percent grass in the standing crop was 61 and 74 in ID and ND, respectively, while the percent spurge was 30 and 24 in ID and ND, respectively. Sheep grazed pastures until approximately 50% of the initial standing crop was removed.

Sheep grazed a greater percent of spurge stems in ND compared to ID (P) but utilization of spurge stems was not affected by the origin of the sheep. By the end of a trial sheep grazed 99% of the spurge stems in North Dakota compared to 70% in Idaho. In Idaho, sheep did not consume large amounts of leafy spurge until the second half of a trial. This showed that at this location significant utilization will not occur until other forages have been consumed. Relative preference for leafy spurge further demonstrated the importance of location on palatability of spurge. With one exception, sheep avoided spurge in Idaho but in North Dakota the contribution to the diet was about equal to its availability in the standing crop. The interaction of location x origin x trial for relative preference substantiated previous work at the Sheep Station that showed how experience can affect preference for leafy spurge. North Dakota sheep showed a strong preference for leafy spurge during the first half of the ID trial. We hypothesize this may have been caused by their familiarity with spurge that was presumably low in aversive phytochemicals.

We conclude that differential grazing of leafy spurge by sheep on sites in Idaho and North Dakota is a result of differences in palatability or post ingestive consequences of spurge growing on these sites. Gas chromatography of latex from these two accessions showed differences between peaks at 3.15, 33.43 and 36.98 minutes. This suggests that this procedure can be used to differentiate among spurge accessions of different palatability.

Conclusions

These studies show how innate and learned behavior will interact with the nutritional and anti-quality characteristics of the target plant to influence diet selection. Previous experience was shown to influence sheep preference for leafy spurge, by presumably modifying the animal's neophobic response to a novel food. However, experience alone did not decrease the apparent negative post-ingestive feedback that sheep receive when they consume leafy spurge. The presence of phytochemicals that cause negative post-ingestive consequences was shown by using leafy spurge to produce a conditioned food aversion. The ability to modify leafy spurge palatability, presumably by altering aversive

phyto-chemicals in the plant, was suggested by the change in preference between locations in Idaho and North Dakota. Finally, the ability to alter preference genetically was shown by the difference between sheep and goats. We conclude that, under conditions of free choice, preference for leafy spurge will be determined by the concentration of yet unidentified phyto-chemicals or the animal's ability to ameliorate the aversive affects of these chemicals. Furthermore, if animals are to be used to graze leafy spurge without intensive management and fencing that force them to graze the plant then it will be necessary to manipulate either the plant or the animal such that leafy spurge becomes a preferred forage. Presently the lack of information on the chemical compounds in leafy spurge that cause aversion is the main obstacle in advancing to our goal of manipulating either the grazing animal or the leafy spurge plant so that it becomes a preferred forage.