Preferential grazing of leafy spurge (Euphorbia esula L.) by sheep

by Barbara Kay Landgraf

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Range Science
Montana State University

Abstract:
Leafy spurge (Euphorbia esula L.) is an introduced perennial weed infesting over one-half million acres of rangeland in Montana. Eradication of leafy spurge is difficult due to its extensive root system. Biological and chemical control methods can be costly and as yet, are ineffective in eradicating leafy spurge. A two-part study examined the use of leafy spurge by sheep.

A feeding experiment was conducted for 3 months during the winter of 1981 to determine if leafy spurge hay would have deleterious effects upon sheep. Three groups of sheep were fed a hay ration of introduced grass species, an increasing level of leafy spurge or entirely leafy spurge. Blood samples were analyzed throughout the experiment to detect internal physiological effects. The ewes receiving leafy spurge hay did not demonstrate any deleterious effects in the blood. Abnormalities in liver, kidney, muscle and gastrointestinal systems were examined along with levels of total protein, minerals and the blood count. A weight gain was shown by ewes receiving grass hay while those receiving leafy spurge hay lost weight. The loss of 2 to 4 kg was not considered harmful to mature ewes for a 3 month period during the winter. Additionally, the weight loss was attributed to the lower nitrogen and caloric content of the leafy spurge hay per unit weight relative to the control grass hay.

A field grazing study was conducted during the summer of 1981 to determine whether the intake of leafy spurge would be influenced by the level of pasture infestation. Esophageal fistulated ewes were placed in pastures containing light, moderate or heavy infestations of leafy spurge. No definite preference for or an avoidance of leafy spurge was observed. There was a 1 to 3 week initial adjustment period before sheep selected a significant amount of leafy spurge. Intake of leafy spurge steadily increased during the study to 40 to 50% of the diet for all 3 groups. Weights of the ewes in leafy spurge infested pastures were not significantly different from those in control pastures containing no leafy spurge. Ewes with previous experience with leafy spurge hay did not consume a greater amount of this plant in summer pastures than ewes with no experience.

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Date May 28, 1982

To Banjo and Squeakie

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Approved:

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Leafy spurge (*Euphorbia esula* L.) is an introduced perennial weed infesting over one-half million acres of rangeland in Montana. Eradication of leafy spurge is difficult due to its extensive root system. Biological and chemical control methods can be costly and as yet, are ineffective in eradicating leafy spurge. A two-part study examined the use of leafy spurge by sheep.

A feeding experiment was conducted for 3 months during the winter of 1981 to determine if leafy spurge hay would have deleterious effects upon sheep. Three groups of sheep were fed a hay ration of introduced grass species, an increasing level of leafy spurge or entirely leafy spurge. Blood samples were analyzed throughout the experiment to detect internal physiological effects. The ewes receiving leafy spurge hay did not demonstrate any deleterious effects in the blood. Abnormalities in liver, kidney, muscle and gastrointestinal systems were examined along with levels of total protein, minerals and the blood count. A weight gain was shown by ewes receiving grass hay while those receiving leafy spurge hay lost weight. The loss of 2 to 4 kg was not considered harmful to mature ewes for a 3 month period during the winter. Additionally, the weight loss was attributed to the lower nitrogen and caloric content of the leafy spurge hay per unit weight relative to the control grass hay.

A field grazing study was conducted during the summer of 1981 to determine whether the intake of leafy spurge would be influenced by the level of pasture infestation. Esophageal fistulated ewes were placed in pastures containing light, moderate or heavy infestations of leafy spurge. No definite preference for or an avoidance of leafy spurge was observed. There was a 1 to 3 week initial adjustment period before sheep selected a significant amount of leafy spurge. Intake of leafy spurge steadily increased during the study to 40 to 50% of the diet for all 3 groups. Weights of the ewes in leafy spurge infested pastures were not significantly different from those in control pastures containing no leafy spurge. Ewes with previous experience with leafy spurge hay did not consume a greater amount of this plant in summer pastures than ewes with no experience.

Chapter One

LITERATURE REVIEW

Leafy spurge (*Euphorbia esula* L.) is a perennial noxious weed which infests over 1 million hectares in the northern United States and prairie provinces of Canada (Noble et al. 1979). In Montana, there are more than 200,000 hectares of infested land, most of which is found on rangeland (Noble et al. 1979). Leafy spurge persists by means of an extensive root system which permits efficient vegetative reproduction. Roots of this species can penetrate to a depth of more than 4.5 meters (Messersmith 1979).

It is estimated that private landowners in Montana are spending more than $2.5 million per year in an attempt to control leafy spurge (Reilly and Kaufman 1979). There are no herbicides available which will effectively eradicate leafy spurge (Alley 1979). Several herbicides will provide control of topgrowth and must be applied every 1 to 3 years (Alley 1979). The cost of these herbicides continues to rise and is seldom cost effective. Additionally, Alley (1979) does not feel that effective new, low cost herbicides will be available in the near future.

The presence of leafy spurge can reduce the carrying capacity of rangeland up to 75 percent (%) (Reilly and Kaufman 1979). Control measures must be utilized on land containing leafy spurge both to control spread of this species and return infested rangelands to their original production.

Chemical Control

Bowes and Molberg (1975) found that picloram (4-amino-3,5-trichloropicolinic acid) provided topgrowth control of leafy spurge for about 3 years. Alley (1979) reported that picloram (2 kg/ha) provided control of leafy spurge for as long as 5 years, however, many rangeland grass species were injured by the chemical. The estimated 1982 cost for picloram (2 kg/ha) is approximately $78 to $100/ha.

Dicamba (3,6-dichloro-o-anisic acid) controls leafy spurge topgrowth but reinfestation usually occurs within 2 years following application (Alley, 1979). Two,4-D[(2,4-dichlorophenoxy) acetic acid] will kill topgrowth and prevent seed production for a single season when applied at the rate of 2 kg/ha at the early bud stage (Alley 1979). This phenoxy herbicide must be applied twice a year for several years to reduce a leafy spurge infestation (Alley 1979).

Biological Control

Biological control of weeds involves the use of a living organism to reduce the density of the target weed to levels below the economic threshold (Harris 1979). The use of biological control agents may have future potential for leafy spurge control (Harris 1979).

Insects have been the major agents tested for biological control of weeds. Nobel et al. (1979) conducted an extensive survey in Eurasia and concluded that there are 17 insect species which possess potential as biological control agents for leafy spurge.

Two insects have been released in Montana to control leafy spurge. The spurge hawkmoth (*Hyles euphorbiae*) was released in 1978 (Story 1979a). This defoliating moth has repeatedly shown an inability to establish itself and no further work is planned.

A clear-winged moth, *Chamaesphecia tenthrediniformis*, was released in 1977 (Story 1979a). This root-mining moth has not been able to become established. Research continues with this insect since it may still have potential.

Oberea erythrocephala, a root boring beetle, was released in Oregon and Wyoming during 1980 (Story 1979b). This insect is considered an excellent candidate for potential control of leafy spurge (Harris 1979). *O. erythrocephala* attacked the leafy spurge plants of U.S. origin which were used for screening the insect in Europe. Feeding by the insect led to a sharp decline in the number of flowering stems the following year.

Plant pathogens have potential as biological control agents for leafy spurge. Research is currently being conducted to identify, screen and possibly release a pathogen which would control leafy spurge (Turner 1982).

Although the use of biological control methods have long range potential there are associated problems. The process of selecting, screening and releasing an agent is slow and costly. Harris (1979) estimated the cost for control of leafy spurge will involve 20 scientist years at a cost of $100,000/year for a total cost of $2 million.

Another area which complicates the leafy spurge problem is the diversity of taxonomic and biological plant types (Noble et al. 1979, Croizat 1945). As many as 12 different taxa have been associated with leafy spurge (Noble et al. 1979). This presents serious problems for researchers and managers as they review the literature for information about leafy spurge and to determine whether the results from another area are applicable to their leafy spurge problems. The range of biotypes and phenotypes is also creating unexpected problems in the development of host-specific biological control organisms and discrepancies in the literature as to the effectiveness of certain control measures.

The successful establishment of a biocontrol agent will not necessarily reduce the density of the host weed because monophagous insects do not normally have much impact on the population dynamics of their host plant (Harris 1979). Normally, host plants with some resistance to the insect survive and contribute viable seed for the next generation. The insect-plant relationship has a balance. The ultimate level of plant control may not approach the level desired after the insects have become established.

Sheep and Leafy Spurge

While ranchers have been using sheep to graze leafy spurge for more than 30 years in Montana (Appendix A), there has been little scientific research conducted with sheep grazing leafy spurge. Johnston and Peake (1960) conducted an experiment which examined the effect of selective grazing by sheep on a mixed crested wheatgrass-leafy spurge pasture.

A 30 acre field was seeded with crested wheatgrass (*Agropyron cristatum* L.). Excellent stands of crested wheatgrass were established; however, the competition did not control the infestation. Twelve years later, when the pasture supported a uniform stand of crested wheatgrass, 45 ewes were placed on the pasture from May to September for a period of 5 years. At that time, the basal area of leafy spurge was reduced 98% while the basal area of crested wheatgrass increased 20%.

Selleck et al. (1962) found that seeding crested wheatgrass into a sparse stand of leafy spurge (less than 100 shoots/m^2) limited the rate of spread of leafy spurge. He also reported that crested wheatgrass seeded into dense stands of leafy spurge (greater than 100 shoots/m^2) was not able to reduce the density of leafy spurge.

Muenscher (1930) stated that large infestations of leafy spurge should be seeded with grass and pastured closely with sheep for at least 3 or more years. Bibbey (1952) reported that sheep effectively controlled leafy spurge and nearly eradicated the plant if grazing continued over a period of years.

Helgeson and Thompson (1939) grazed sheep on one acre pastures (mowed and unmowed) infested with leafy spurge. After 2 years of grazing the number of leafy spurge stalks was reduced 68 and 31% in the mowed and unmowed pastures, respectively. The total basal area of bluegrass increased 179 and 212% in the mowed and unmowed pastures, respectively. L. O. Baker (1981) found that grazing leafy spurge with sheep reduced the initial infestation 34% and led to a 10% increase in grass density after 6 years.

Wood (1945) seeded crested wheatgrass into a number of areas infested with leafy spurge. A study conducted in 1942 demonstrated that seeded plots contained 48% less leafy spurge stems than an unseeded check plot. However, all subsequent seedings failed to establish. In a second study an infested stubble field was seeded in the fall, 1943, and in July, 1945, there was a 90% reduction in number of leafy spurge plants. He also reported several cases where sheep were used to bring heavily infested pastures under control after 2 to 4 years of continuous grazing.

Bowes and Thomas (1978) studied the longevity of leafy spurge seeds following various control programs. Picloram (4-amino-3,5,6-trichloro-picolinic acid) was applied at 2 different locations and a third location was only grazed by sheep for 8 years. Seeds were recovered from soil, tested for viability and number of leafy spurge shoots/m^2 were recorded yearly at each location. During the first 3 to 4 years picloram was as effective as sheep grazing in reducing the density of leafy spurge, but the number of viable seeds in the soil increased from 3,500 to 11,000 in the picloram treatments in the next 4 years. The number of viable seeds in the grazed pastures went from 3,500 to 15 seeds/m^2 in the 8 year test period, the lowest seed density of all treatments.

There is a disagreement in the literature concerning the effect of leafy spurge on sheep. Muenscher (1930), Christensen et al. (1938), Wood (1945) and Baker (1981) state that sheep suffered no deleterious effects as a result of consuming leafy spurge. Bakke (1936) stated that neither sheep nor cattle will eat leafy spurge because of its acrid latex. He did indicate that sheep in an enclosed area will eat leafy spurge if starved and no harmful effects were noted. Helgeson and Thompson (1939) found that sheep suffered no ill effects from consuming leafy spurge with the exception of several lambs which scoured.

Alternatively, Johnston and Peake (1960) attributed the deaths of an unknown number of sheep to poisoning as a result of consuming relatively large leafy spurge plants. However, no losses were reported when sheep were placed in the pastures at an earlier date. Undocumented post-mortem examinations indicated that leafy spurge was responsible for the poisoning losses.

Bartik and Piskac (1981) stated that *Euphorbia esula* L. and other closely related species produce a poisonous white latex which affects almost all animal species. These authors added that drying does not remove the plant's toxicity. After ingestion an animal will experience gastroenteritis, violent vomiting, sometimes diarrhea with blood in the feces, feeble heartbeat and depression of the central nervous system.

Farnsworth et al. (1966, 1968) conducted a preliminary phytochemical and biological evaluation of *Euphorbia esula* L. An extract of leafy spurge at doses ranging from 5 to 400 mg/kg produced only a weak central nervous system depression in mice. Tertiary and quaternary alkaloids were present in the aerial parts of *Euphorbia esula* L.

Alkaloids are considered to be the toxic compound in many poisonous plants (Kingsbury 1964). Merck Veterinary Manual (1973) stated that the liver, intestines and nervous system were affected by ingestion of these poisonous plants. Analysis of blood samples has been used to evaluate effects of forage intake (Kirk and Davis 1970, Schaffer et al. 1981).

Helgeson and Thompson (1939) observed the grazing habits of sheep on spurge. They reported that sheep first ate all the blossoms and seeds, and later stripped the stems of the leaves. They reported that the sheep would alternatively graze leafy spurge and grass, eating the spurge rather "greedily" for a time and then shifting to grass. Johnston and Peake (1960) observed that sheep preferred younger leafy spurge plants and avoided more mature plants.

Johnston and Peake (1960) recommended that sheep distribution does not need to be controlled for the first 3 years of grazing since sheep will naturally congregate in areas infested with leafy spurge. After 3 years sheep should be moved to avoid overgrazing. L. O. Baker (1981) observed that sheep placed on leafy spurge required an adjustment period. Following this adjustment the sheep appeared to prefer the plant. Christensen et al. (1938) reported most of the lambs fed a leafy spurge silage did not consume much the first day. Neophobia is a recognized foraging strategy in the ruminant and adjustment periods prior to acceptance are not uncommon (McClymont 1967). After a few days all but 2 were eating enough to continue the test for 34 days without any apparent ill effects. Wood (1945) reported that sheep had a decided preference for leafy spurge over other herbage in a pasture, including crested wheatgrass which they had access to over the entire grazing season.

Helgeson and Thompson (1939) found that ewes and lambs grazing leafy spurge infested pastures maintained weights over a 3 month period comparable to those in uninfested pastures. Ewes averaged 4 and 7 lb gains while lambs averaged 28 and 40 lb gains on leafy spurge infested and uninfested pastures, respectively.

Christensen et al. (1938) conducted a study which determined the digestibility of leafy spurge silage. Three lots of silage were prepared: (1) leafy spurge alone; (2) leafy spurge plus phosphoric acid; and (3) leafy spurge plus molasses. The total digestible nutrients (TDN) for each silage was 45.2, 50.5 and 50.3%, respectively. The percent crude protein (CP) was 9.2, 9.5 and 9.4%, respectively. Lambs fed each of the silages lost an average of 3.4 lb per animal during a 10 day feeding trial. They contributed the loss in weight to the fact that the silages did not meet the minimum maintenance requirements for CP or TDN.

Past research has not quantified the intake of leafy spurge by sheep in a free-choice pasture situation. The literature has not examined the possibility of "preconditioning" sheep in order that they might consume a larger quantity of leafy spurge in a range situation. There are still conflicting reports whether leafy spurge is toxic to sheep and if so the literature has not identified what these effects are.

The objectives of this study were to: (1) Determine whether leafy spurge hay causes deleterious effects in sheep (external and internal); (2) Quantify [leafy spurge] consumption by sheep in a free-choice pasture; (3) Determine diet selection differences between sheep in pastures containing different levels of leafy spurge infestations; (4) Examine whether sheep have a decided preference for leafy spurge over other available forage; and (5) Determine whether preconditioning confined sheep with leafy spurge hay will influence subsequent diet selection of the free-ranging ewe.

Chapter Two

METHODS AND MATERIALS

Winter Feeding Experiment

A feeding trial was conducted for 12 weeks at the Montana State Agricultural Experiment Station, Fort Ellis from January until April, 1981. Fifteen ewes of various ages and breeds were randomly selected from the flock located at the Montana State Agricultural Experiment Station, Red Bluff, and separated into 3 groups each containing 5 animals. The groups were maintained separately in 4 m by 5 m pens with separate feeders and automatic waterers. The leafy spurge hay, donated by the N-Bar Ranch, Grass Range, Montana, was cut and baled in mid-June, 1980 when the leafy spurge plants were in the bloom stage. Grass hay was obtained from the Montana Agricultural Experiment Station, Fort Ellis. The hay was cut in the seed set phenological stage in mid-June, 1981.

Botanical separations were performed with both hays using 3 random 0.45 kg samples of each to determine composition (Table 1).

Each animal was fed 1.82 kg hay/day based on National Research Council (1975) nutrient requirements of sheep for mature non-lactating ewes (2.4% of body weight in feed ration per day). Group I, the control, was fed entirely grass hay. Group II was initially fed grass hay containing 0.15 kg leafy spurge hay per day. Once a week, the amount of leafy spurge hay was increased 0.15 kg with a concurrent decrease in grass hay. The hay ration reached 100% leafy spurge hay after 10 weeks. To facilitate rumen adjustment, animals in group III were initially fed 0.91 kg leafy spurge hay/day. The ratio of leafy spurge hay was increased 0.22 kg/day. The total ratio reached 1.82 kg of leafy spurge hay per day after 1 week.

Table 1. Botanical Separation of the Leafy Spurge Hay and Grass Hay Used in Winter Feeding Experiment, 1981.

Species	% of Sample			
	1	2	3	Mean
Leafy Spurge Hay				
Euphorbia esula Leafy spurge	58	74	65	66
Dactylis glomerata Orchard-grass	18	8	14	13
Bromus inermus Smooth brome	12	4	8	8
Poa pratensis Kentucky bluegrass	6	2	4	4
Cirsium arvense Canada thistle	2	5	4	4
Unknown spp.	4	7	5	5
Grass Hay				
Bromus inermus Smooth brome	62	59	66	62
Poa pratensis Kentucky bluegrass	20	29	19	23
Agropyron cristatum Crested wheatgrass	14	6	5	8
Bromus tectorum Cheatgrass	1	3	5	3
Unknown spp.	3	3	5	4

Hay rations were weighed daily and fed by groups. Prior to feeding, orts from the previous day were removed from each pen and weighed.

Animals were weighed once a week in the morning on a platform type scale accurate to the nearest 0.45 kg.

Mineral supplement (10% calcium and 15% phosphorus) was provided for each group. The supplement was weighed and changed once a week to record intake.

Blood Analysis

In order to monitor internal physiology, blood samples were collected from each animal 5 times during the experiment and tested (Table 2). At the time of sampling, 2 blood aliquots were collected from the jugular vein using the "Corvac" integrated serum separator tube (Sherwood Medical, St. Louis, MO) and a "Venoject" liquid EDTA tube (Kimble-Terumo, Elkton, MD). A total of 23 individual blood tests (Table 3) were performed by the Montana State University Veterinary Research Laboratory at the beginning and end of the experiment.

Field Grazing Study

A field grazing study was conducted in central Montana on the Baxter Ranch located 6 miles south of Geyser, MT on flat to rolling terrain located near the Little Belt Mountains. The 27 ha study site was characteristic of the silty clay range site of the 38 to 48 cm precipitation zone in the foothill and mountain geographic region. The plant communities of this site were infested with leafy spurge (Figure 1).

Pastures were constructed using a natural leafy spurge infestation gradient. The rectangular area was divided into six 265 m by 152 m pastures (4.05 ha) arranged in a paired plot design. The north pasture of each pair was sprayed with 2.0 kg/ha 2,4-D ester [(2,4-dichlorophenoxy) acetic acid] in 167 liters of water per ha on May 18, 1981 with a pickup truck mounted skid sprayer to eliminate leafy spurge topgrowth for the entire experimental period from May until September, 1981.

Three line transects for canopy cover estimation (Daubenmire 1959) were performed per pasture to determine plant species composition using twenty-five 20 cm by 50 cm frames per transect (Figure 1).

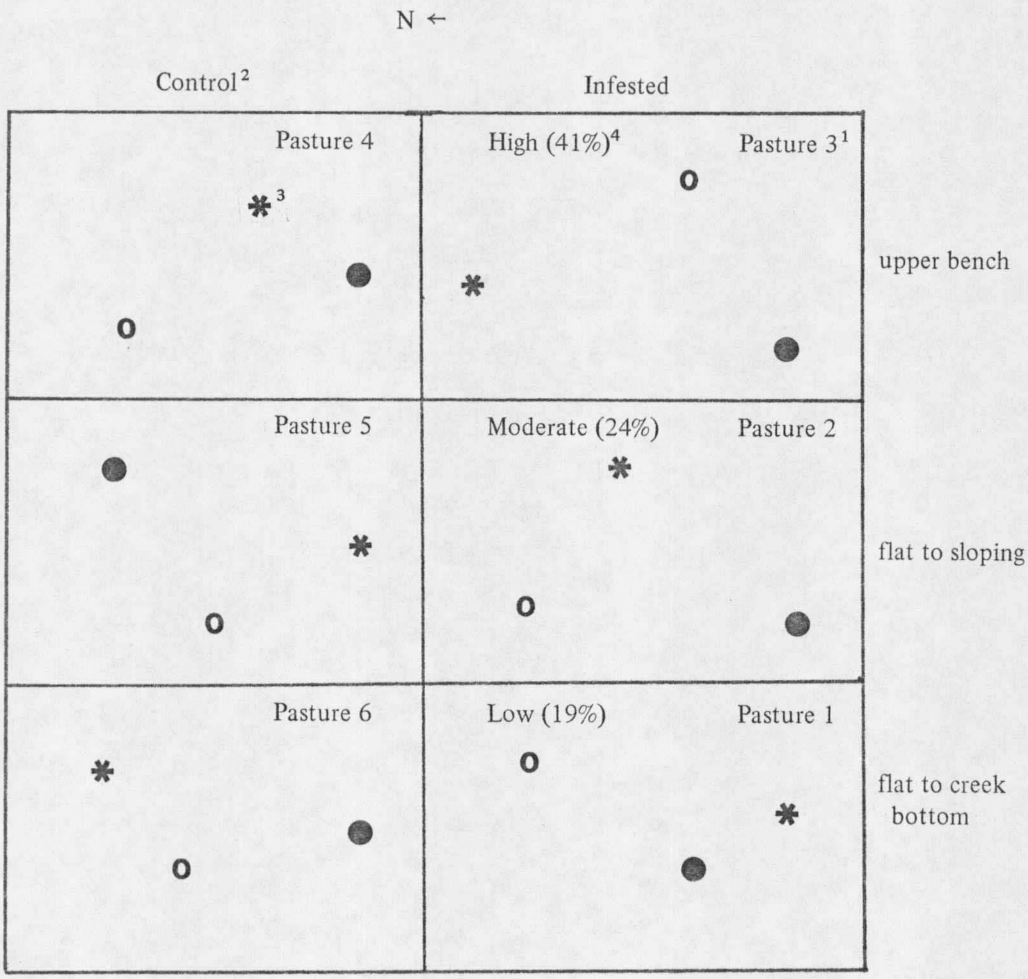
Table 2. Analysis Methods of Twenty-Three Blood Tests Performed at the Beginning and End of the Winter Feeding Experiment in Order to Monitor Physiological Condition of Each Animal in 3 Groups of Ewes Receiving a Grass, an Increasing Level of Leafy Spurge, or a Leafy Spurge Hay Ration.

Test	Analysis Method
SGOT (serum glutamic oxalo-acetic transaminase)	Worthington[1] Statzyme GOT reagent; Henry et al. (1960)
CPK (serum creatine phosphokinase)	Worthington[1] Statzyme CPK-n-1; Rosalki (1967)
LDH (lactate dehydrogenase)	Worthington[1] Statzyme LDH (L-P) reagent; Ames Pacer[2]
Alkaline Phosphatase	Worthington[1] Kinetic Alkaline Phosphatase reagent; Ames Pacer[2]
Glucose	Worthington[1] Statzyme Glucose reagent; Slein (1963)
BUN (bilary urea nitrogen)	Worthington[1] Statzyme BUN reagent; Talke and Schubert (1965)
Total protein	Buiret production @ 540 nm
Albumin	Bromcresol green @ 600 nm
Globulin	Total protein-albumin
Creatinine	Worthington[1] Creatinine reagent; Ames Pacer[2]
Cholesterol	Worthington[1] Cholesterol reagent; Ames Pacer[2]
Bilirubin	American Monitor[3] "525" Bilirubin reagent; Ames Pacer[2]
Calcium	Worthington[1] Calcium reagent; Connerty and Briggs (1966)
Phosphorus	Worthington[1] Ammonium Phosphomolybdate reagent; Ames Pacer[2]
Magnesium	Pierce Magnesium Rapid Stat reagent; spectrophotometric assay using Ames Pacer[2]
Sodium	Flame photometer; Instrumentation Laboratories
Potassium	Flame photometer; Instrumentation Laboratories
Chloride	Stanibo Chloride reagent
RBC (red blood cell)	Coulter Model Z_{BI}; Hialeah, FL
MCV (mean corpuscular vol.)	PCV (in ml/100 ml blood) × 10/RBC = MCV Coulter TM Model Z_{BI}; Hialeah, FL
HCT (hematocrit)	Packed cell volume (PCV) = volume percentage of erythrocytes in peripheral venous blood
WBC (white blood cell)	Coulter Model Z_{BI}; Hialeah, FL
HGB (hemoglobin)	Hemoglobinometer; Hialeah, FL

[1] Worthington Diagnostics, 488 Grandview Dr., South San Francisco, CA 94080.
[2] Ames, Division of Miles Laboratories, P.O. Box 70, Elkart, IN.
[3] American Monitor Corporation, P.O. Box 68505, Indianapolis, IN 46268.

Table 3. Blood Tests Performed on Confined Ewes and the Physiological Effects They May Indicate.

Blood Test	Indicative Of:
SGOT (serum glutamic oxalate transaminase)	liver; muscle
CPK (creatine pyrophosphokinase)	muscle deterioration—skeletal or cardiac
LDH (lactate dehydrogenase)	several tissues—not specific
Alkaine phosphatase	liver stasis
Glucose	energy balance; gastrointestinal
BUN (bilary urinary nitrogen)	kidney
Total protein	protein level; gastrointestinal; kidney
Albumin	liver; gastrointestinal
Globulin	immuno state; gastrointestinal; liver
Creatinine	kidney
Cholesterol	metabolize steroids; liver; thyroid
Bilirubin	liver; breakdown of red blood cells
Calcium	skeletal; kidney; calcium metabolism
Phosphorus	parathyroid; CA:PH ratio; kidney; phosphorus metabolism
Magnesium	level of magnesium; kidney; magnesium metabolism
Sodium	sodium levels; gastrointestinal
Potassium	potassium levels; gastrointestinal; potassium metabolism
Chloride	chloride levels; gastrointestinal blockage; kidney
RBC (red blood cell)	red blood cell count; ↓ anemia problem
MCV (mean corpuscular volume)	how large red blood cells are; ↓ iron deficiency-anemia; ↑ certain vitamin deficiencies; ↑ with regenerative anemia
HCT (hematocrit)	percent red blood cell in total blood count; ↓ anemia or polycythemia
WBC (white blood cell)	fight disease; illness; ↑ inflammation
HGB (hemoglobin)	protein respiratory pigment; ↓ anemia



[1] each pasture = 4.05 ha
[2] control pastures sprayed with 2 kg/ha 2,4-D
[3] transect number
● = 1
✱ = 2
O = 3
[4] figures in parentheses expressed percentage of vegetation composition of leafy spurge

Figure 1. The Study Area Contained 3 Pastures With Increasing Levels of Leafy Spurge, and 3 Paired Control Pastures Without Leafy Spurge Topgrowth. This figure shows the approximate locations of the Daubenmire vegetation analysis transects.

Esophageal Fistula Collections

Thirty-eight ewes were obtained from the Montana Agricultural Research Station, Red Bluff, MT. Esophageal fistulas (Harris et al. 1977) were placed in 14 ewes on May 5 to 8, 1981 using a cannula design from Denny (1981). Two of the fistulated animals were maintained as replacement ewes.

Four fistulated sheep were placed in each infested, unsprayed pasture with 2 unfistulated ewes for a stocking rate of 1.3 ha/AUM (animal unit month). Six unfistulated ewes were placed in each sprayed pasture on June 15, 1981. Two of the 4 fistulated sheep in each infested pasture had previous experience with leafy spurge since they were utilized in the winter feeding trial. The other fistulated sheep in each treatment pasture had no previous experience with leafy spurge. None of the ewes in the control pasture had previous experience with leafy spurge. Individual animals were weighed once a week in the morning using a platform-type scale accurate to the nearest 0.45 kg.

Forage samples were collected from each fistulated animal in a screen-bottomed canvas collection bag every 10 to 12 days. Samples were collected from a single group per sampling day. On the morning of collection the animals were placed in a confinement pen located inside their respective pasture. Cannulas were replaced with collection bags and the sheep were allowed to graze normally for 20-25 minutes. The collection bags were removed and the cannulas were replaced. Individual samples were immediately frozen to await analysis.

Botanical analysis of fistula contents. Samples were thawed and placed on a tray. Contents were analyzed for percent forb, grass, shrub and leafy spurge by the microscopic point technique (Harker et al. 1964). Fifty points were read and recorded for each sample.

Preference index. A preference index (Allison et al. 1977, Van Dyne and Heady 1965) was constructed to compare the amount of leafy spurge consumed to the abundance of that species in each pasture according to the following ratio:

$$\text{Preference Index} = \frac{\text{\% composition of leafy spurge in diet}}{\text{\% composition of leafy spurge in pasture}}$$

The preference index interpretation is presented in Table 4.

Table 4. Preference Index Ranges and Interpretation.

Preference Index	Interpretation
> 1.8	definite preference
1.3 - 1.79	some preference
0.8 - 1.29	same in diet as available
0.3 - 0.79	some avoidance
< 0.29	avoidance

Statistical Analysis

One-way analysis of variance tests were conducted for esophageal fistula collections, weight gains, composition of pastures and blood tests. Analyses which resulted in significant f-statistics were tested for differences in means at the p = .05 level using the least significant difference (lsd) test of significance (Steel and Torrie 1960).

Chapter Three

RESULTS AND DISCUSSION

Winter Feeding Experiment

All 3 groups of sheep consumed their assigned hay ration. There was a relationship between the amount of leafy spurge hay in the diet and the amount of weight gain per group. The control group gained an average of 2.5 kg while groups II and III lost 2.5 and 4.2 kg per animal, respectively (Table 5). While animals in groups II and III lost weight during the experiment, the loss of 2.5 and 4.2 kg (3.5 to 7.0% of body weight) per animal is not a significant loss for mature unbred ewes over a 3 month period during the winter (Cook and Harris 1968, Bishop et al. 1975). Hay containing leafy spurge was palatable to sheep, and did not cause any visual deleterious effects.

Table 5. Weight (kg) Gain or Loss for 3 Groups of 5 Ewes Fed Different Hay Rations During a 3 Month Winter Feeding Experiment, 1981.

Group (hay ration)	Animal Number 1	2	3	4	5	Mean[1]
I-control (grass)	−1.8	+4.5	+2.7	+3.2	+3.6	+2.5[a]
II (increasing level of leafy spurge)	−3.6	−3.2	−3.2	−1.8	−0.5	−2.5[b]
III (leafy spurge)	−3.2	−2.7	−4.5	−5.4	−5.0	−4.2[c]

[1] Means followed by a different letter are significantly different at $p \leq .05$.

There were differences in mineral consumption between the 3 treatment groups (Appendix B). However, mineral consumption for all 3 groups was within the range suggested by the National Research Council (1975) requirements for sheep.

<u>Hay quality</u>. The leafy spurge hay contained 20% less protein than the grass hay (Table 6). The protein content of the leafy spurge hay was 9.1%. This is considered an adequate protein level for mature nonlactating ewes (National Research Council 1975).

The crude fiber content was used to estimate the amount of net energy (Mcal/kg) available in each hay (Table 6). Even though the leafy spurge hay contained 13% less energy than the grass hay it was considered adequate for maintenance.

Table 6. The Approximate Analysis of Hay Used in the Winter Feeding Experiment, 1981.

Hay Type	Crude Protein	Ash	Crude Fiber	Phosphorus	Calcium	Ether Extract-able	Net Energy* (Mcal/kg)
	----------	----------	----------	%	----------	----------	
Leafy spurge	9.1	6.9	39.1	0.22	0.85	2.8	1.09
Grass	11.4	6.9	32.3	0.23	0.30	0.8	1.25
Maintenance† requirements for 60 kg ewe	8.9	NA	NA	0.26	0.28	NA	1.60‡

*Estimated from NE = 1.991 – 0.023 (% CF) (Chandler 1978).
†National Research Council (1975).
‡Estimated from National Research Council (1975) tabular values.

The phosphorus content of both hays (Table 6) was slightly lower than the amount recommended by the National Research Council (1975). The leafy spurge hay contained almost 3 times more calcium than the grass hay. This is not unusual since grass hay is commonly low in calcium (Morrison 1958).

The ether extractable fraction was 3.5 times higher in the leafy spurge hay than the grass hay. This was possibly due to the latex content of leafy spurge. The latex contains volatile oils and resinous compounds (Batik and Piskač 1981, Esau 1977) which are determined by the ether extract analysis.

The results of the hay analysis indicated that the leafy spurge hay and the grass hay compared in this study were neither isocaloric nor isonitrogenous. If the leafy spurge hay ratio had been increased to provide each animal with a similar net energy intake, the weight difference amoung groups would probably have been reduced substantially or eliminated.

Blood Analysis

The results of the blood analyses indicated no harmful internal physiological effects resulting from sheep consumption of leafy spurge hay.

Protein. Total protein (Figure 2) analysis indicated differences between groups receiving different rations but all values were in the normal range for sheep. There appears to be a relationship between the amount of leafy spurge hay in the diet and the protein level occurring in the blood. This observation agrees with the hay analysis which indicated the leafy spurge hay provided 20% less protein than the grass hay.

Trends in blood constituents, including total protein, are a function of physiological and environmental factors. These factors may include age of the animal, time of year, breed, species and physiological state such as lactation and gestation (Kirk and Davis 1970, Schaffer et al. 1981). The dynamic fluctuation of total protein content reflected in Figure 2 illustrates these responses.

All hemoglobin (HGB) (Appendix C) values were in the normal range with no differences between groups. An indicator of blood protein level these blood hemoglobin levels agree with results of the total protein analysis.