# Forage Preference Exhibited by Sheep With Esophageal Fistulas

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Those concerned with the harvesting of range forage by grazing animals have puzzled for many years over the question: Do animals eat the plants and the parts of plants in the same proportion that they occur on the range? "Probably no," has been the answer, but so far no direct measurement of the consumed forage has been made. Once the forage passes the animal's mouth it is unavailable. Sampling before and after grazing and grazed and ungrazed plots depends upon the difference principle to measure the consumption. This has not been a satisfactory technique in all respects. Some workers have followed the animals and attempted to grab from the standing plant materials a sample similar to that taken by the animals. This too, has not been accepted as a completely satisfactory procedure. Since these aspects of range sampling are well known, a literature review of previous attempts to sample the eaten forage is not presented.

Introductory data on the use of sheep with esophageal fistulas to collect forage actually eaten by the animals are presented. A hole or fistula in the throat allows a sample of forage to be taken after it passes the mouth but before it reaches the stomach. Emphasis will be given to percentage botanical composition of fistula collected material in comparison with two methods commonly employed in field sampling. The forage collected by fistulas and by clipping square foot plots was sampled by a new technique.

Most of the data are expressed in terms of percentage botanical composition. Sample sizes and units of measurement were different with the various techniques. Percentages are used to place the data on a comparable basis. The amount a sheep can consume has an upper limit. Percentages divide that limit into component parts, which, for this experiment, is the primary concern.

Appreciation is expressed to

**Table 1. Average number of seed germinating per square inch of soil surface from 10 samples in each plot.**

| Species | PLOTS Soft Chess | Filaree | Bur Clover | Resident Annual |
|---|---|---|---|---|
| Soft chess | 17.0 | 6.2 | 12.8 | 10.3 |
| Filaree | 2.0 | 2.7 | 2.1 | 3.6 |
| Bur clover | 0.9 | 1.1 | 5.8 | 0.3 |
| Ripgut | 1.3 | 0.2 | 0.4 | 1.3 |
| Other grasses | 5.0 | 1.4 | 7.6 | 2.8 |
| Other weeds | 10.2 | 1.3 | 7.9 | 0.3 |
| All species | 36.4 | 12.9 | 36.6 | 18.6 |

Mr. Thomas Bedell who gave invaluable assistance in the sampling.

### Experimental Plots

Before the fall rains of 1956, four adjacent plots of annual type range on the Hopland Field Station in Mendocino County, California, were treated to change the composition of the vegetation and fenced. Each plot was 30 feet square. One was raked clean of mulch and seeded with filaree *(Erodium circutarium)*. Only a few plants of this species appeared but the manipulation of mulch resulted in a high proportion of the stand being broadleaf filaree *(Erodium botrys)*. This plot will be referred to as the filaree plot. A second plot was partly cleaned of mulch and seeded to soft chess *(Bromus mollis)*. This will be called the soft chess plot. The third plot had similar mulch treatment to the soft chess plot, but it was seeded with bur clover *(Medicago hispida)*. It is so named in the paper. The fourth plot had no mulch removed but all of the dry material was cut and spread evenly over the soil surface, so that it would not appear in the material consumed by sheep. This is the resident annual plot in later discussions.

Mulch treatment and seeding were done to obtain plots of different percentage botanical composition with the same species. The purpose was to determine animal preference in relation to relative abundance of species. After the manipulation, ten samples 1 inch square by ¼ inch deep were taken of the soil and seed. These were placed on moist filter paper in petri dishes to determine the quantity of viable seed. Table 1 shows the average number by species of seed which germinated. The first three species were the ones composing the major part of the vegetation. The species of fourth rank was ripgut *(Bromus rigidus)*. These four were the only common ones available to the animals during the winter and early spring. Many additional grasses and broadleaved species were present, but these seldom composed as much as 10 percent of the vegetation and 2 percent of the fistula samples.

The filaree and bur clover plots had a conspicuously high foliage cover of those species. The soft chess and resident annual plots contained high proportions of grasses. Differences between plots tended to disappear as the season progressed.

### Field and Laboratory Sampling

In the first week of February, March, April, May, and July of 1957 samples of the vegetation were taken by the point-plot method, by clipping square-foot plots, and by animals with esophageal fistulas. In February all plants were short, by May the vegetation was near maturity, and in July all plants were dry.

Field points were taken in 8 groups of 50 hits each. A group of 50 was in an area no larger than 2 by 2 feet and the pins were taken until 50 hits had been obtained. In this way the sample size of hits was the same in each plot, and it measures the proportion of species on a coverage basis. No attempt was made to measure ground cover *per se* because it was high and because it probably had little influence on the nature of grazing. There was no grazing in the plots except during the short sampling period each month. The animals had essentially ungrazed forage available, and it was in large supply (Table 2). The 8 groups of hits were taken in a pattern near the sides of each plot because the sheep tended to graze near the fences. The hits were recorded in terms of their height above the soil surface according to a method described earlier (Heady, 1957). Each hit was also recorded as to whether it was on leaf, stem, or flower (including fruits).

At the same time 10 square-foot plots were clipped and the material composited in one bag. This material was quick frozen as soon as possible. It was later thoroughly mixed and sampled in the laboratory for percentage botanical composition in two ways. Ten sub-samples were taken at random from the whole pile of material. Each of these was placed in a tray approximately 5 by 30 inches and spread evenly. The tray had a series of

**Table 2. Average weight in grams of oven-dry material per square foot on each plot at five sampling dates.**

| Plot | Feb. 1 | March 5 | April 1 | May 2 | July 9 |
|---|---|---|---|---|---|
| Soft chess | 8.86 | 12.40 | 14.75 | 39.77 | 25.72 |
| Filaree | 6.05 | 10.68 | 10.12 | 30.68 | 20.20 |
| Bur clover | 8.70 | 10.42 | 14.01 | 38.03 | 23.25 |
| Resident annual | 13.07 | 14.63 | 15.90 | 39.40 | 21.69 |

25 notches on each side that served as stops when the tray was passed under a binocular microscope. One eyepiece of the scope had a cross-hair. When the tray and material was passed under the scope, the species nearest the cross-hair was considered a hit. Fifty hits were recorded from each sub-sample. In principle this is similar to taking points in the field. One major difference is in the position of the plants. Tall growing plants like the grasses were upright in the field but were horizontal under the scope. Prostrate species were horizontal in both field and under the scope. The hits with the scope were recorded as to species and also as to leaf, stem, or flower. Each of these sub-samples was then hand separated to species, oven dried at 100 degrees C. for 24 hours, and weighed. Thus percentage botanical composition was determined on the clipped material by laboratory points and by weight.

The microscope method was developed so that the green material from clipped plots and fistulas could be sampled by the same procedure. Preliminary samples on known compositions indicated that a total sample of 400 hits was necessary to obtain sample means for the major species within 10 percent of the population mean 19 times out of 20. Quick freezing was the most convenient way to preserve the samples.

### Fistula Material

Three sheep with esophageal fistulas were used to collect material in each plot at each time for determination of what the animals ate. The fistula is a hole in the esophagus which allows the eaten material to drop into a plastic bag that is secured below the fistula. The technique was perfected by Torell (1954). The sheep appear healthy and normal in their actions and food habits. One of the animals had had the fistula for four years at the time of this study. The important point of the study is that these sheep make possible a direct comparison of eaten and uneaten material.

The forage collected by the sheep was wet with saliva and matted into small cuds. It was preserved by freezing until sampling was done. Washing in cheese cloth and partial drying were required before the material could be spread out for study. The botanical composition and proportion of leaves, stems, and flowers in each fistula collection were determined by the microscope method described previously for the clipped material. Eight sub-samples with 50 hits each were taken from each fistula sample. Identification to species and plant part was easily accomplished; however, soft chess and ripgut were not always possible to distinguish. Hence, the all grass portion in the fistula analysis is more accurate than the part on soft chess.

### The Uneaten Forage

The uneaten forage presented to the sheep in the four plots was different in percentage botanical composition. Bur clover was about a third of the composition where it had been seeded, less than 10 percent on the other seeded plots and 1 percent or less where all the mulch had been left on the ground. Filaree was highest where all the mulch had been removed and lowest in the bur clover plot. All grasses were highest with the mulch and no seeding and lowest where the mulch was removed. Most of the "all grass" category was soft chess (Figure 1). Ripgut was under 5 percent of the composition except in late winter on the resident plot, when it reached a composition as high as 17 percent. Several other grass species were present, especially in the filaree and bur clover plots, but they did not account for more than a few percent of the composition at any time with a maximum of 9.6 percent in May on the bur clover plot.

Disregarding plots, there was a change in composition through the season. The grasses tended to decrease in proportion of total weight while filaree tended to increase. The relative proportion of the clover by these two tended in the opposite direction. Perhaps this is because the grasses became taller and consequently were oversampled by the field points, as first hit only was recorded. The composition by laboratory points showed no such trends. Bur clover reached a high in composition in April by all methods (Figure 2).

### Comparison of Field Methods

The composition of the uneaten forage obtained by the different methods of sampling showed nearly constant relationships. For example, when seasons are disregarded, the weight method gave grasses less importance than the field points and these in turn less than the laboratory points. The same is true with one slight exception for soft chess. Since these are percentages, when one goes down another must go up. Filaree showed just the opposite trend by the different methods (Figure 1).

Another point of interest is that the percentage composition of the different species was not greatly different by the weight and field point methods. If these two methods prove on further study to show a constant relationship to each other, the long and tedious hand separation of samples may be unnecessary to estimate composition by weight. Total production by clipped samples is easy to obtain and so is percentage botanical composition in the field by the point procedure.

Although they are not shown in Figure 1, the compositions obtained by the fistulas are intermediate between the field and laboratory point methods when the data are averaged by plots

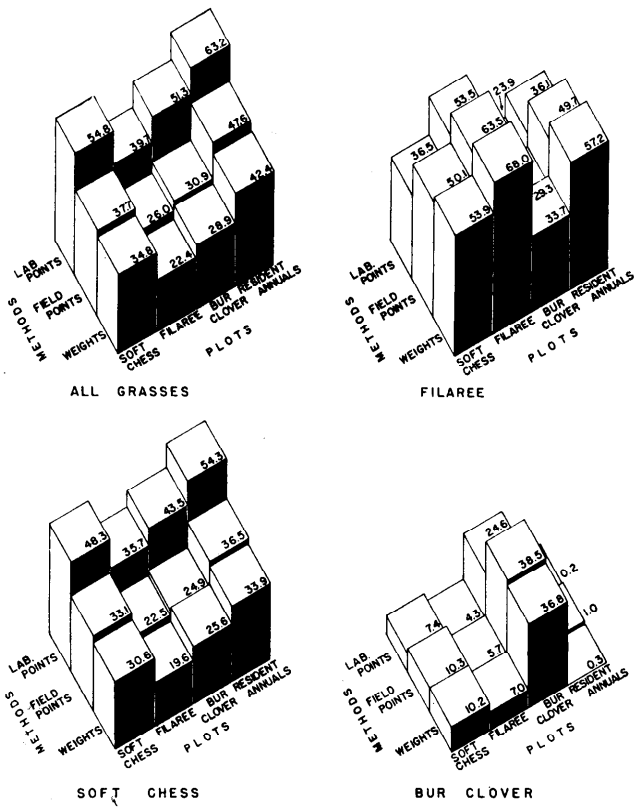


FIGURE 1. Percentage botanical composition of uneaten forage by three methods on four plots and averaged for the five sampling periods.

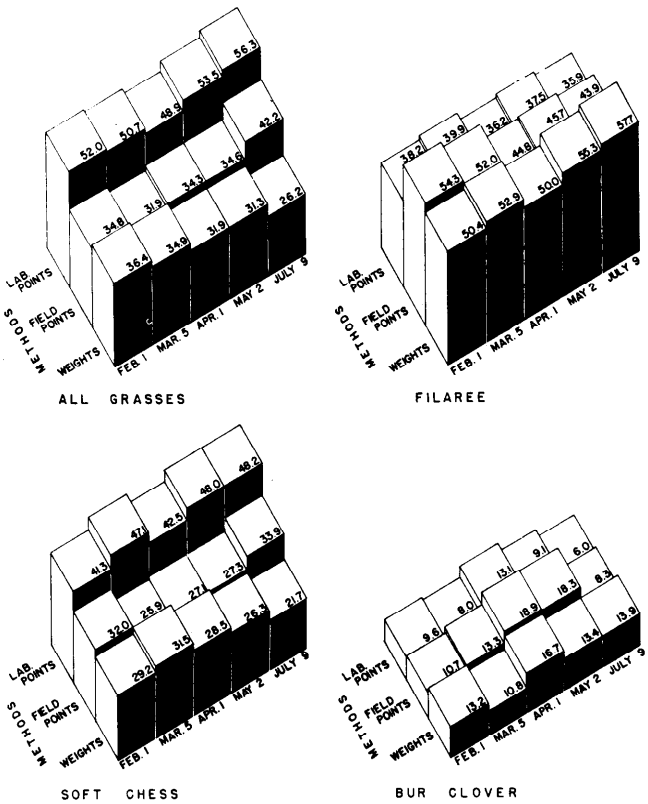


FIGURE 2. Percentage botanical composition of uneaten forage by three methods on five dates and averaged for the four plots.

and disregarding dates. For this reason comparisons of fistula samples are restricted to the laboratory points. Since the three methods show the same trends on a sampling basis with the fistulas, the same conclusions would be reached regardless of which pair is selected for comparisons. This by no means indicates that the animals ate the forage in the same proportion that it was presented to them, as will be shown in later sections.

### What the Animals Ate

The diet of the animals changed markedly through the growing season. During the winter over half of their diet was grass, 36 to 45 percent filaree, and 2 to 10 percent bur clover. In May a preference was shown for bur clover with a corresponding decrease in filaree and grass. In July after all plants were mature and dry the animals selected filaree for over 75 percent of their diet and about 11 percent of bur clover and grass. These relationships are based on the fistula samples only, with all sheep combined and all plots combined. The same preferences were shown in each plot where the proportion of the different forages on the ground was quite different. For example, the selectivity for bur clover in May and filaree in July was great, irrespective of whether these species were high or low in percentage botanical composition (Figure 3).

Bur clover is usually considered a plant of high palatability. Yet during February, March and April the animals took less of it than was presented to them. This was most striking on the bur clover plot in February, when 37 percent of the cover, 38 percent of the weight, and 30 percent by the laboratory points was bur clover; yet only 4.6 percent of the material eaten was this species. On the other hand, in May in the resident plot 30 percent of the diet was bur clover when the other methods showed it to be 1 percent or less of the plant material in the field. This indicates that sheep exhibit very strong preferences for certain species at different times during the growing season.

The animals to some extent consumed more grass, filaree, and bur clover in the plot where each of these was highest in composition. This was to be expected because all of these plants are readily consumed when they are young. However, much variation existed in the selectivity for any element of the forage between plots. For example, in April grass appeared in the diet to a greater extent than it was on the ground in two plots, less in a third, and the same in the fourth plot. At the same time filaree was selected to a greater extent than it occurred on three plots and less on one.

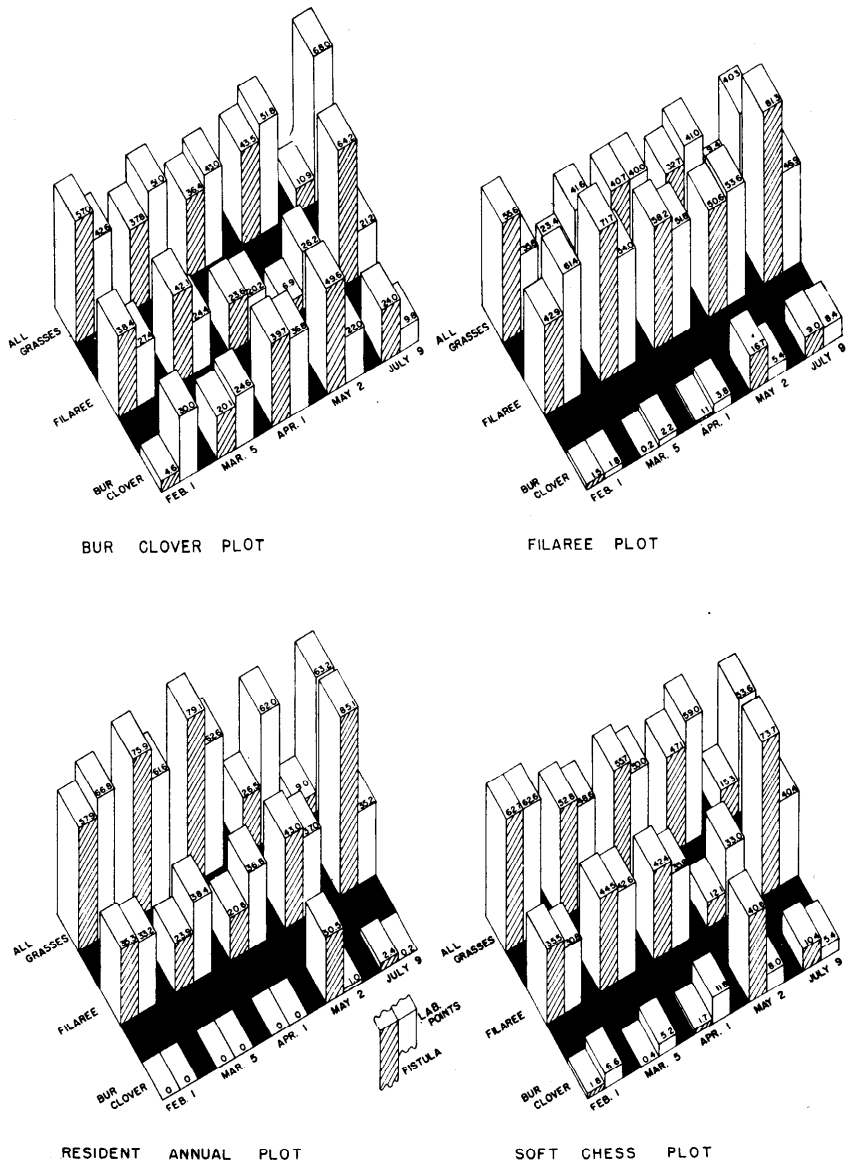


FIGURE 3. Percentage botanical composition of eaten and uneaten forage presented to three sheep with esophageal fistulas.

Still another element of variation existed between sheep. The average percentage of grass in the diet of the 3 animals over all seasons and plots was 47.4 for the lowest and 49.4 for the highest. When averaged for plots within dates, the extremes were 31.0 and 41.6 percent. On a between plot within date basis they were 42.0 and 63.2 percent. Similar variation was shown between sheep for filaree and bur clover.

Thus, the change in selectivity for a species with season or stage of maturity is clearly shown. A positive relationship between relative amount of a forage species present and consumed is indicated. The individual sheep preference for a species varied greatly on a short time basis but may be little different over a whole season. More data are needed on the last point particularly.

### Preference in Relation to Height of Plant Material

Height of plant materials was measured by determining the height of the hits above the soil surface with the point plot method. It is not maximum height of plants but indicates the height of bulk, or in another sense, height of foliage cover.

Generally the height of materials was greatest on the resident plot and lowest on the filaree plot. This was true with the three major species, soft chess, filaree, and bur clover, with few exceptions. The heights in the other two plots were intermediate and very close to each other on a plot basis. On a species basis soft chess was the tallest and filaree the lowest. Bur clover was as tall as the soft chess from February to April but afterwards was little different in height from the filaree (Figure 4).

During the whole season all species as well as the three major ones were between 0.05 and 0.15 foot in height from February to April. Growth was rapid during April and by May the vegetation had reached an average height of 0.3 to 0.4 foot. The averages for all species were somewhat higher than the averages for the three major species because of the scattered tall species such as ripgut, slender oat (*Avena barbata*), and a few broadleaved herbs.

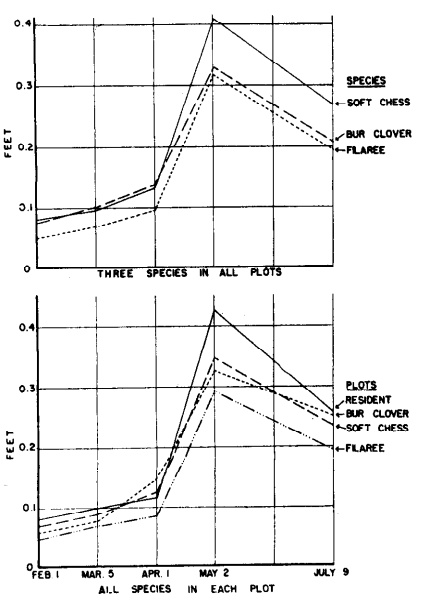


FIGURE 4. Average height of plant materials for three species in all plots and for all species in each plot between February 1 and July 9, 1957.

Since there was little change in the relationship between the heights of plant materials between species over all plots during the growing season, or between plots, ignoring species, during the growing season, there is little basis for the conclusion that height of plant materials made any difference in the diet of the animals. Again it should be noted that the animals were sampling ungrazed plants at each date and that all of the plant material was well within their reach. The amount of forage in each plot of 900 square feet was very much more than the animals could consume during the 15 to 20 minutes it took them to collect a sample (Table 2). Where forage is scarce and the plants tall, height may be a factor in forage preference.

### Preference for flowers and fruit, leaves, and stems

The hits by all the methods were recorded by flower and fruit, leaves, and stems. This allows a percentage breakdown of the hits for each species according to plant parts. Since the clipped material and the fistula collections were sampled with the same apparatus, these two give comparisons of the plant parts presented to the sheep and those actually eaten. In Figure 5 percentages are shown for the three major species in all the plots combined for the sampling dates of May and July. Stems and flowers were insufficient previous to May to make analysis of the data on a basis of plant parts worth while.

Generally speaking the sheep ate the parts of soft chess in about the same proportions that they were available. Flowers were slightly preferred in May. Observations in the California annual type have indicated that soft chess seeds are often selected by sheep. It is speculated that this preference did not show up because the forage was ungrazed when the animals were placed in the plots. If grazing were more competitive and other palatable parts of the forage had been removed, the animals probably would have shown a preference for the soft chess seed.

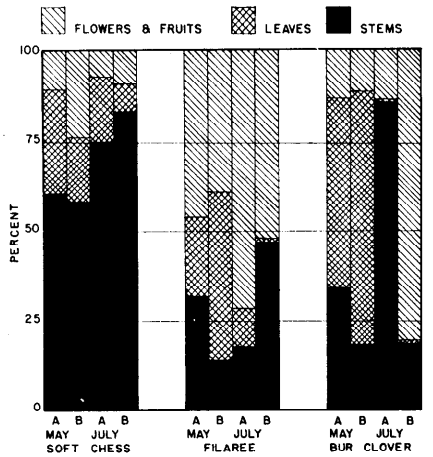


FIGURE 5. The proportion of flowers and fruit, leaves and stems for three species presented to the sheep (A) and eaten by them (B).

The high proportion of filaree flowers and fruit in the forage, and to a slightly less extent in the diet, is probably in part due to the nature of the plant. Filaree in a dense stand of the California annual type is usually a short plant with an abundance of seed. The seed is large and has a long awn, so that the bulk of the whole fruit is large in relation to the rest of the plant. It is upright and therefore readily available. When the seeds shatter the awn twists much as the awn of *Stipa*, and for a short time after plant maturity it tends to be twisted around other plants. The small proportion of leaves with both sampling methods in July reflects the fact that they shatter into small fragments and disappear shortly after maturity. The animals selected more filaree leaves in May and more stems in July than was presented to them in the forage.

The graph indicates the very leafy nature of bur clover. In May there was evidently a preference for leaves over stems. This was the time when bur clover was very highly preferred. By July the leaves had disappeared and composed less than 1 percent in both the material presented to the animals and that eaten. July was the time when bur clover fruit was preferred. This has been observed many times in the California annual type, and it is common to see both sheep and cattle actually licking the burs off the ground.

Where animals are on ranges with a high proportion of either filaree or bur clover after plant maturity, they maintain condition very well. This is probably because there is a high proportion of seeds of these two species in their diet.

### Summary

Sheep with esophageal fistulas were used to determine the percentage botanical composition of consumed forage. The forage presented to the animals was sampled by points in the field, points with a microscope on clipped plants, and by weight. The fistula-collected material was sampled with the microscope technique. Samples were taken with three animals and with the field methods on four plots of different botanical composition during the growing season of 1957.

The forage presented to the sheep was principally soft chess, filaree, and bur clover. The percentage of grass was least by the weight method, slightly more by the points and considerably more by the laboratory points. The proportion by different methods showed similar trends between plots for the primary species. Therefore, the methods sampled the trends in adequate manner even though the absolute values were different between techniques.

Animals showed high preference for bur clover leaves in May, and for seed in July. Bur clover was avoided during the winter. They selected filaree in July in a much higher ratio than it was present in the forage. Where a species was high in com-

position, they tended to take more of it. Preference was not related to height of the plant materials. Much variability existed between sheep in the preference for plant species on a short time basis, but over the whole season very little difference appeared in the diets of different animals.

Preference for bur clover seed in the early summer is frequently given as the reason that animals maintain condition on dry annual ranges. This study indicates that the seed of filaree is also an important element in sustaining animal condition into the dry season.

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