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FOOD HABITS AND FORAGE PREFERENCES OF BIGHORN SHEEP IN ALPINE AND SUBALPINE  
COMMUNITIES

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ABSTRACT: Relationships between Rocky Mountain bighorn sheep (Ovis canadensis canadensis) and their habitat were studied from June 1976 to October 1978 in the Pecos Wilderness, New Mexico. Food habits and forage preferences of bighorn sheep were determined for summer and autumn by direct observations of feeding of human-habituated, wild bighorn sheep. Year-round diet was determined by microhistological analysis of fecal samples. Food habits and forage preferences of bighorns from June to October were calculated for Kobresia, Trifolium, Geum, Potentilla, Salix, Vaccinium, Deschampsia, and Polygonum communities. Forbs were preferred over grasses and grasslike plants and woody plants. Forage preferences were not significantly different among bighorn ewes, yearlings, and immature rams. Diets selected varied among communities. Bighorn ate vegetation that was in early stages of phenological development, and abandoned stands as plants matured. Bighorn altered their feeding locations in response to phenological development among plant communities. Condition of this herd was excellent based on body weights, age-ratios, horn growth and levels of Protostongylus in lungs and feces. It is hypothesized that animals were

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in excellent condition, because they were able to eat a high quality diet by changing their distribution, forage preferences, and diet selection throughout summer.

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Todd (1972) summarized the literature on food habits of Rocky Mountain bighorn sheep (Ovis canadensis canadensis) and concluded that grasses and grasslike plants were the most important forage and that forbs were consumed voraciously when they became available. Recent research continues to support this statement (Constan 1972, Erickson 1972, Frisina 1974, Stewart 1975, Lauer and Peek 1976, Harrington 1978). However, few studies determined forage preferences of bighorn or how food habits changed within a season.

Knowledge of food habits and forage preferences of bighorn is necessary to understand their habitat requirements. Traditionally, it has been assumed that lack of suitable winter range is the limiting factor affecting bighorn populations (Smith 1954, Buechner 1955, Oldemeyer et al. 1971, Stelfox 1976, Hoefs and Brink 1978). However, the importance may be underestimated of other seasonal ranges in maintaining populations in good condition by providing high quality forage throughout the growing season.

Recent papers have pointed out the importance of summer forage in maintaining ungulate populations in good condition. Captive bighorn maintained on a diet collected year-round on winter ranges were smaller and less able to tolerate cold temperatures than were sheep maintained on a diet simulating a diet obtained from altitudinal migration to alpine summer range. The explanation was that migrating animals were able to eat forage in early stages of phenological development thus obtaining a diet high in protein and digestible energy throughout summer. Nonmigrating animals

survived on a lower quality forage (Hebert 1973). Mule deer (Odocoileus hemionus sitkensis) in Alaska that used a summer range with a wide variety of communities were larger than mule deer restricted to habitat with only a few communities. The larger animals used a succession of sites that were in early stages of phenological development and abandoned sites as plants matured. Thus they ate a higher quality diet throughout summer than did animals restricted to a less diverse habitat (Klein 1965).

This paper was developed from data collected during a 3-year study of habitat of bighorn sheep funded by the Santa Fe and Carson National Forests, USDA. J. A. Bailey, D. Hein, and C. A. Wasser reviewed the design of this study. R. A. Sleeper reviewed this manuscript.

#### DESCRIPTION OF STUDY AREA

The study area was within the Pecos Wilderness near the southernmost end of the Rocky Mountains in the Sangre de Cristo Mountains, New Mexico (105°35'W, 36°30'N). Elevation ranged from 2750 to 4031 m. Treeline varied from 3500 to 3700 m depending on slope and aspect.

#### METHODS

Direct observations of feeding, totaling 62,244 bites, were obtained on 150 occasions from human-habituated, wild bighorn. All observations of feeding were made from within 5 m of the sheep and most were recorded from within 1 m. An occasion was defined as at least 100 bites recorded for 1 animal feeding in 1 location. A location was defined as an area that was relatively homogeneous with respect to vegetative composition. Up to 5 occasions of feeding were recorded at 1 location. Feeding observations were obtained during 2 3-day periods per month from the periods June-October 1977 and June-September 1978. Weather conditions and inability to find

human-habituated sheep made it impossible to obtain feeding observations on some days. Bighorn were especially wary of humans following trapping and transplanting operations conducted by New Mexico Game and Fish Department in August 1977 and 1978.

One 30-m transect was established that bisected each location where direct observations of feeding were obtained. Canopy cover was estimated for each species in 30 1x4-dm quadrats, and midpoints of percent classes 0-1, 2-5, 6-25, 26-50, 51-75, 76-95, 96-100 were recorded (Daubenmire 1959). Communities were identified from numerical analysis (Goldstein and Grigal 1972) of vegetation data describing 55 locations where 136 occasions of bighorn feeding were recorded. (See Johnson 1980 for detailed description of methods of obtaining direct observations of feeding and vegetation analysis). Forage preference was expressed as the ratio between percent bites of a species to percent that species contributed to vegetative canopy cover (Petrides 1975). A preference index of 1 indicated neither selection nor avoidance, whereas a value of greater than 1 indicated a selection and less than 1 an avoidance.

Composition of the year-round diet was estimated from microhistological analysis (Sparks and Malachuk 1968) of 485 fecal samples collected from June 1976-October 1978. Of this total, 419 samples were from animals of known age and sex (Johnson 1980).

## RESULTS

### Communities Used in Summer and Autumn

Ten communities were identified from vegetation describing 55 feeding sites used by bighorn in summer and autumn (Table 1). The communities were diverse, ranging from xeric to mesic. Some had little snow cover throughout

TABLE 1. Communities used by bighorn in summer identified from numerical classification of 55 stands, Pecos Wilderness, New Mexico, 1976-1978.

| Community                      | Number of Stands | Number of Pellets <sup>a</sup> | Percent canopy cover <sup>b,d</sup> |            |       | Percent ground cover <sup>b,d</sup> |                |        | Dominant vegetation <sup>e</sup> Species | Percent Canopy Cover <sup>b,d</sup> |
|--------------------------------|------------------|--------------------------------|-------------------------------------|------------|-------|-------------------------------------|----------------|--------|--|-------------------------------------|
|                                |                  |                                | Grasses                             | Grass-like | Forbs | Shrubs                              | Mosses/Lichens | Litter |  |                                     |
| <u>Kobresia</u>                | 4                | 187±150 <sup>d</sup>           | 1±0.4                               | 12±3       | 13±1  | 2±1                                 | 1±3            | 35±6   | 21±0                                     | 10±3<br>2±1                         |
| <u>Trifolium</u>               | 8                | 37±13                          | 5±2                                 | 3±2        | 33±4  | 4±2                                 | 10±3           | 25±6   | 23±5                                     | 14±2<br>3±1<br>2±2                  |
| <u>Geum</u>                    | 8                | 13±4                           | 6±2                                 | 4±1        | 37±4  | 5±2                                 | 10±1           | 38±4   | 18±4                                     | 12±2<br>4±2<br>3±0.4                |
| <u>Potentilla</u>              | 5                | 21±8                           | 8±3                                 | 5±1        | 27±4  | 17±3                                | 8±3            | 14±4   | 22±3                                     | 17±3<br>5±4<br>4±2                  |
| <u>Salix</u>                   | 3                | 7±5                            | 9±1                                 | 3±1        | 34±6  | 4±6                                 | 5±2            | 4±2    | 10±6                                     | 42±7<br>5±5<br>4±2<br>2±1           |
| <u>Vaccinium</u>               | 12               | 10±4                           | 7±1                                 | 3±1        | 24±2  | 14±1                                | 1±0.4          | 17±5   | 17±4                                     | 10±2<br>4±1<br>2±1                  |
| <u>Deschampsia</u>             | 7                | 14±4                           | 14±3                                | 5±2        | 24±6  | 2±1                                 | 1±0.5          | 10±2   | 21±6                                     | 13±3<br>5±3<br>5±1                  |
| <u>Polygonum</u>               | 6                | 4±2                            | 7±2                                 | 3±1        | 41±6  | 3±2                                 | 8±5            | 14±7   | 16±6                                     | 12±4<br>8±3<br>5±2                  |
| <u>Danthonia</u>               | 1                | 0                              | 26                                  | 3          | 9     | 7                                   | 0              | 15     | 26                                       | 19<br>4<br>4                        |
| <u>Potentilla diversifolia</u> | 1                | 5                              | 13                                  | 6          | 34    | 0                                   | 1              | 15     | 14                                       | 9<br>7<br>6                         |

<sup>a</sup> Number of pellets per 30 1 x 4-dm quadrats.<sup>b</sup> Estimated in 30 1 x 4-dm quadrats per transect.<sup>c</sup> Species included if greater than 2 percent ground cover.<sup>d</sup> Mean ± 1 standard error.

winter, and other communities were covered by snow through early July. Trifolium, Kobresia, Danthonia and portions of the Geum communities used in summer were part of the winter range also. Remaining communities were snow-covered throughout winter and were not included in winter range. Snow persisted until late May to late June on the Deschampsia, Salix, Vaccinium, and Polygonum communities and until early July on the Potentilla diversifolia community.

#### Forage Preferences and Food Habits

Variation in preferences and diet among age and sex classes. -- Diet and forage preference were not significantly different among age and sex classes of bighorn. Forage preferences of ewes, yearlings, and immature rams were not significantly different in Trifolium or Vaccinium communities or when occasions were combined across all communities (Table 2). Diets were not significantly different among ewes, yearlings, lambs, and rams for summers 1976-1978, autumns 1976-1978, early winter 1976-1977, and late winter 1977 (Johnson 1980:63, 146-148). Therefore, data were combined across age and sex classes for the remaining analysis of forage preferences and food habits.

Seasonal preferences and diet. -- Forage preferences changed throughout the year. In the period June to October, bighorn preferred forbs (1.18 mean preference index, n = 136) over grasses and grasslike plants (0.81, n = 136) and woody plants (0.87, n = 116) ( $p < 0.05$ ) except in July of both years when grass and grasslike plants were preferred more than or equally to forbs (Table 3).

Bighorn diet varied significantly throughout the year. Forbs dominated the diet from June to September, and grasses and grasslike plants were most

TABLE 2. Forage preferences of bighorn ewes, yearlings, and immature rams in 2 vegetative communities and across 8 communities, Pecos Wilderness, New Mexico, June-October 1977 and June-September 1978.

|  | Ewe <sup>a</sup>                                     |                 | Mean Rank |     | Total <sup>b</sup><br>Occurrences | $\chi^2$ | d.f. | Significance |
|--|--|-----------------|-----------|-----|-----------------------------------|----------|------|--------------|
|  | Grasses and grasslike plants preference <sup>c</sup> | Forb preference | Yearling  | Ram |                                   |          |      |              |
| <u>Trifolium community</u>                           |  |                 |           |     |                                   |          |      |              |
| Grasses and grasslike plants preference <sup>c</sup> | 13.8 (9)   | 9.2 (7)         | 12.4 (7)  |     | 23                                | 1.89     | 2    | 0.39         |
| Forb preference                                      | 9.7 (9)  | 16.4 (7)        | 10.6 (7)  |     | 23                                | 4.76     | 2    | 0.09         |
| Shrub preference                                     | 9.6 (8)  | 5.5 (6)         | 13.4 (5)  |     | 19                                | 5.3      | 2    | 0.07         |
| <u>Vaccinium community</u>                           |  |                 |           |     |                                   |          |      |              |
| Grasses and grasslike plants preference              | 10.6 (23)  | 11.0 (3)        |           |     | 26                                | 0.37     | 2    | 0.55         |
| Forb preference                                      | 13.4 (23)  | 14.2 (3)        |           |     | 26                                | 0.03     | 2    | 0.87         |
| Shrub preference                                     | 12.7 (23)  | 20.0 (3)        |           |     | 26                                | 2.47     | 2    | 0.12         |
| <u>Across all communities</u>                        |  |                 |           |     |                                   |          |      |              |
| Grasses and grasslike plant preference               | 69.7 (107)   | 61.3 (14)       | 66.9 (15) |     | 136                               | 0.59     | 2    | 0.74         |
| Forb preference                                      | 69.1 (107)   | 73.6 (14)       | 59.1 (15) |     | 136                               | 1.12     | 2    | 0.57         |
| Shrub preference                                     | 60.2 (91)  | 39.2 (13)       | 66.8 (12) |     | 116                               | 5.35     | 2    | 0.07         |

<sup>a</sup> Numbers in parentheses were occasions feeding was observed.

<sup>b</sup> Preference indexes were not calculated if a forage class was neither consumed nor sampled. Shrubs did not occur on all sites where occasions were recorded; therefore, shrub total is less than other totals.

<sup>c</sup> Corrected for ties; indexes within forage class were ranked across all age-sex classes from low (1) to high (total occasions) and a mean rank for each age-sex class was calculated.

TABLE 3. Monthly variations in bighorn forage preferences determined from direct feeding observations, Pecos Wilderness, New Mexico, June-October 1977 and June-September 1978.

| Month                                  | 1977    |         |         |         | 1978    |         |         |         | Total Occasions <sup>a</sup> | F <sup>2</sup> | d. f. | Significance <sup>b</sup> |       |
|--|---------|---------|---------|---------|---------|---------|---------|---------|------------------------------|----------------|-------|---------------------------|-------|
|  | Jun     | Jul     | Aug     | Sep     | Oct     | Jun     | Jul     | Aug     |                              |                |       |                           | Sep   |
| Grasses and grasslike plant preference |         |         |         |         |         |         |         |         |                              |                |       |                           |       |
| Number occasions                       | 17      | 18      | 9       | 3       | 4       | 23      | 27      | 24      | 11                           | 136            | 19.5  | 3                         | 0.012 |
| Mean rank <sup>c</sup>                 | 51.1    | 101.5   | 54.1    | 72.8    | 78.4    | 67.3    | 70.5    | 65.7    | 52.3                         |                |       |                           |       |
| Calculated Indexes <sup>d</sup>        | 0.5±0.1 | 1.4±0.2 | 0.8±0.2 | 1.1±0.9 | 0.9±0.1 | 0.8±0.1 | 0.8±0.1 | 0.7±0.1 | 0.5±0.1                      |                |       |                           |       |
| Forb preference                        |         |         |         |         |         |         |         |         |                              |                |       |                           |       |
| Number occasions                       | 17      | 18      | 9       | 3       | 4       | 23      | 27      | 24      | 11                           | 136            | 19.2  | 8                         | 0.014 |
| Mean rank                              | 79.1    | 60.1    | 76.0    | 106.0   | 121.4   | 70.8    | 51.0    | 63.3    | 79.6                         |                |       |                           |       |
| Calculated Indexes                     | 1.5±0.2 | 1.0±0.3 | 1.4±0.3 | 1.6±0.4 | 2.0±0.2 | 1.1±0.1 | 0.9±0.1 | 1.0±0.1 | 1.3±0.1                      |                |       |                           |       |
| Shrub preference                       |         |         |         |         |         |         |         |         |                              |                |       |                           |       |
| Number occasions                       | 17      | 15      | 5       | 3       | 4       | 21      | 22      | 20      | 11                           | 116            | 19.5  | 0                         | 0.013 |
| Mean rank                              | 51.5    | 45.9    | 54.5    | 50.0    | 51.6    | 47.4    | 75.6    | 77.8    | 45.7                         |                |       |                           |       |
| Calculated Indexes                     | 0.6±0.4 | 0.4±0.2 | 0.5±0.2 | 0.4±0.1 | 0.4±0.2 | 0.8±0.4 | 1.6±0.6 | 1.0±0.2 | 0.7±0.4                      |                |       |                           |       |

<sup>a</sup> Preference indexes were not calculated if a forage class was neither consumed nor sampled. Shrubs did not occur on all sites where occasions were recorded, therefore shrub total is less than other totals.

<sup>b</sup> Corrected for ties.

<sup>c</sup> Indexes within a forage class were ranked across all months from low (1) to high (total occasions) and a monthly mean rank calculated.

<sup>d</sup> Mean ± 1 standard error.



prominent in October, as determined by direct feeding observations (Table 4). However, forbs and grasses and grasslike plants were equally important in the diet in summer as determined by microhistological analysis. Grasses and grasslike plants were the major forage and forbs were a minor portion of the diet during the rest of the year. Woody plants were of minor importance in the diet throughout the year, with the most consumed in late winter (Table 5).

Differences in results between the direct feeding observation and fecal analysis techniques were discussed by Johnson (1980). It was recommended that food habits determined by direct observations more accurately described dietary selection than data from fecal analysis. However, there are few populations of human-habituated sheep and the cost of hand-rearing study animals often is prohibitive, and is subject to other biases. Fecal analysis is a technique that is less costly in time and money, but results should be carefully reviewed.

Bighorn changed species proportions in their diets during the period June to October, and these changes were consistent between years for the major species in the diet. Trifolium dasyphyllum was the dominant forage in June, and Polygonum bistortoides provided up to a third of bighorn diets in July and August. In late summer, the composite family was the dominant forage. Senecio amplexans was the dominant species eaten. In October grasses dominated the diet (Table 4).

Variations in preferences and diet among 8 communities. --Forage preferences of bighorn varied significantly among communities (Table 6). Generally, bighorn preferred 1 to several of the dominant species within a community, although not necessarily during the same month. Notable

Table 4. Bighorn diet, in percent bites, determined from direct feeding observations, Pecos Wilderness, New Mexico, June-October 1977 and June-September 1978.

|                                  | 1977  |       |       |      | 1978  |        |        |        | Totals |                 |
|----------------------------------|-------|-------|-------|------|-------|--------|--------|--------|--------|-----------------|
|                                  | Jun.  | Jul.  | Aug.  | Sep. | Oct.  | Jun.   | Jul.   | Aug.   |        | Sep.            |
| Total bites                      | 5,394 | 6,633 | 3,493 | 851  | 2,196 | 12,868 | 13,744 | 12,414 | 4,651  | 66,244          |
| Grasses and grasslike plants     | 18    | 33    | 17    | 14   | 66    | 14     | 26     | 16     | 12     | 24 <sup>b</sup> |
| <i>Carex</i> spp. <sup>a</sup>   | 7     | 12    | 2     | 8    | 4     | 4      | 5      | 3      | 3      | 3               |
| <i>Deschampsia caespitosa</i>    | 3     | 10    | 1     | 1    | 10    | 3      | 2      | 3      | 1      | 1               |
| <i>Kobresia macrocarpa</i>       | 7     |       | 5     |      |       | 2      | 14     |        |        |                 |
| other grasses and grasslike spp. | 1     | 11    | 9     | 5    | 52    | 5      | 5      | 10     | 8      | 8               |
| Forbs                            | 68    | 64    | 71    | 74   | 30    | 83     | 57     | 68     | 85     | 67              |
| <i>Erigeron</i> spp.             |       | 1     | 4     |      | 10    |        | 4      | 13     | 4      | 4               |
| <i>Geum rossii</i>               | 3     | 4     |       |      |       | 1      | 5      | 1      |        |                 |
| <i>Oreoxis alpina</i>            |       | 6     |       |      |       | 5      | 3      |        |        |                 |
| <i>Polygonum bistortoides</i>    | 2     | 31    | 12    | 4    |       | 1      | 14     | 20     | 4      | 4               |
| <i>Senecio amplexicens</i>       |       |       | 4     | 11   |       |        |        | 3      | 11     |                 |
| <i>Solidago ciliosa</i>          |       | 1     | 2     | 20   | 7     |        |        | 2      | 5      |                 |
| <i>Trifolium dasyphyllum</i>     | 37    | 2     | 16    | 1    | 1     | 62     | 9      | 4      | 16     | 16              |
| other forbs                      | 26    | 19    | 31    | 39   | 12    | 14     | 22     | 25     | 45     | 45              |
| Woody plants                     | 14    | 3     | 12    | 12   | 4     | 3      | 17     | 16     | 3      | 9               |
| <i>Salix nivalis</i>             | 7     |       | 7     |      |       |        | 9      |        |        |                 |
| <i>Salix planifolia</i>          |       |       |       |      |       |        |        |        |        |                 |
| <i>Vaccinium scoparium</i>       | 3     | 3     | 4     | 10   | 4     |        | 7      | 7      | 3      | 3               |
| other woody plants               | 4     |       | 1     | 2    |       | 3      | 1      |        |        |                 |

<sup>a</sup>A species is listed if it was at least 5 percent of the total bites recorded for some 2 months.<sup>b</sup>Mean percent diet.

Table 5. Bighorn seasonal diets determined by microhistological analysis of fecal samples, Pecos Wilderness, New Mexico, June 1976-October 1978.

|                                     | Season            |         |         |         |                |         |                |                |                |                |         |         |         |         |
|-------------------------------------|-------------------|---------|---------|---------|----------------|---------|----------------|----------------|----------------|----------------|---------|---------|---------|---------|
|                                     | 1976-1977         |         |         |         |                |         | 1977-1978      |                |                |                |         |         | 1978    |         |
|                                     | Jun-Aug           | Sep-Oct | Nov-Jan | Feb-Apr | May            | Jun-Aug | Sep-Oct        | Nov-Jan        | Feb-Apr        | May            | Jun-Aug | Sep-Oct | Jun-Aug | Sep-Oct |
| Number samples                      | 16                | 12      | 10      | 10      | 1 <sup>a</sup> | 16      | 12             | 1 <sup>a</sup> | 1 <sup>a</sup> | 1 <sup>a</sup> | 16      | 12      | 16      | 11      |
| Grasses and grasslike plants        | 51+5 <sup>c</sup> | 64+4    | 83+3    | 84+2    | 74             | 43+5    | 64+5           | 83             | 75             | 47             | 44+6    | 64+5    | 44+6    | 57+6    |
| <i>Carex-Kobresia</i> <sup>b</sup>  | 29+4              | 22+4    | 50+5    | 69+8    | 18             | 28+4    | 25+2           | 77             | 70             | 10             | 23+5    | 26+5    | 23+5    | 26+5    |
| <i>Danthonia</i> spp.               | 2+1               | 5+2     | 12+4    | 19+10   | 45             | 2+1     | 10+2           | 0              | 2              | 10             | 3+1     | 1+1     | 3+1     | 1+1     |
| <i>Deschampsia caespitosa</i>       | 6+3               | 18+3    | 8+3     | 1+1     | 2              | 4+2     | 10+3           | 2              | 0              | 10             | 5+2     | 9+3     | 5+2     | 9+3     |
| <i>Festuca</i> spp.                 | 11+2              | 10+2    | 18+3    | 5+2     | 6              | 3+1     | 15+3           | 3              | 0              | 0              | 8+2     | 12+4    | 8+2     | 12+4    |
| Forbs                               | 47+5              | 34+4    | 15+3    | 6+2     | 26             | 53+4    | 25+4           | 5              | 5              | 41             | 50+6    | 36+6    | 50+6    | 36+6    |
| <i>Potentilla-Geum</i> <sup>b</sup> | 30+5              | 10+3    | 2+2     | 1+1     | 23             | 29+4    | 11+2           | 1              | 3              | 31             | 17+1    | 11+3    | 17+1    | 11+3    |
| <i>Trifolium</i> spp.               | 5+2               | 9+3     | 1+1     | 1+1     | 2              | 8+3     | t <sup>d</sup> | 2              | 0              | 4              | 23+6    | 3+1     | 23+6    | 3+1     |
| Woody plants                        | 3+1               | 2+1     | 2+1     | 11+2    | 0              | 4+2     | 11+2           | 12             | 20             | 12             | 6+2     | 7+2     | 6+2     | 7+2     |

<sup>a</sup> Composite samples.

<sup>b</sup> Technicians cannot distinguish between these genera.

<sup>c</sup> Mean  $\pm$  1 standard error.

<sup>d</sup> Less than 0.5 percent.

TABLE 6. Mean ranks of forage preferences of bighorn determined by direct feeding observations in 8 communities, Peons Wilderness, New Mexico June-October 1977 and June-September 1978.

|   | Communities <sup>a</sup> |          |         |         |         |         |         |          | Total Occasions <sup>b</sup> | $\chi^2$ | d.f. | Significance <sup>c</sup> |
|---|--------------------------|----------|---------|---------|---------|---------|---------|----------|------------------------------|----------|------|---------------------------|
|   | 1                        | 2        | 3       | 4       | 5       | 6       | 7       | 8        |                              |          |      |                           |
| <b>Grasses and grasslike plant preference</b> |                          |          |         |         |         |         |         |          |                              |          |      |                           |
| Number occasions                              | 12                       | 23       | 14      | 12      | 12      | 27      | 23      | 13       | 136                          | 20.2     | 7    | 0.0051                    |
| Mean rank                                     | 93.5                     | 63.7     | 85.3    | 53.4    | 38.0    | 60.4    | 77.2    | 78.3     |                              |          |      |                           |
| Calculated index <sup>d</sup>                 | 1.1±0.1                  | 0.6±0.1  | 1.0±0.2 | 0.6±0.2 | 0.4±0.1 | 0.7±0.1 | 0.9±0.1 | 1.0±0.2  |                              |          |      |                           |
| <b>Forb preference</b>                        |                          |          |         |         |         |         |         |          |                              |          |      |                           |
| Number occasions                              | 12                       | 23       | 14      | 12      | 12      | 27      | 23      | 13       | 136                          | 42.9     | 7    | 0.0001                    |
| Mean rank                                     | 29.0                     | 57.1     | 51.6    | 106.7   | 34.8    | 85.4    | 80.8    | 59.3     |                              |          |      |                           |
| Calculated index <sup>d</sup>                 | 0.5±0.1                  | 1.1±0.03 | 1.0±0.1 | 1.8±0.2 | 0.7±0.2 | 1.3±0.1 | 1.7±0.3 | 1.1±0.04 |                              |          |      |                           |
| <b>Shrub preference</b>                       |                          |          |         |         |         |         |         |          |                              |          |      |                           |
| Number occasions                              | 8                        | 19       | 12      | 12      | 12      | 27      | 21      | 8        | 116                          | 21.0     | 7    | 0.0038                    |
| Mean rank                                     | 74.1                     | 40.4     | 67.6    | 38.9    | 66.9    | 64.0    | 58.6    | 51.3     |                              |          |      |                           |
| Calculated index <sup>d</sup>                 | 1.2±0.5                  | 0.5±0.2  | 0.8±0.3 | 0.3±0.1 | 1.4±0.1 | 0.9±0.2 | 0.8±0.2 | 0.8±0.4  |                              |          |      |                           |

<sup>a</sup> Communities: 1 = Kobresia; 2 = Trifolium; 3 = Gum; 4 = Potentilla; 5 = Salix; 6 = Vaccinium; 7 = Deschampsia; 8 = Polygonum.

<sup>b</sup> Preference indexes were not calculated if a forage class was neither consumed nor sampled, shrubs did not occur on all sites where occasions were recorded; therefore, the shrub total is less than the other totals.

<sup>c</sup> Corrected for ties.

<sup>d</sup> Within a forage class, indexes were ranked across all communities from low (1) to high (Total Occasions) and a mean rank for each community calculated.

<sup>e</sup> Mean ± standard error.

exceptions were the low preference for P. fruticosa (0.3) in the Potentilla community and for G. rossii (0.3) in the Geum community. Within a community used during several months, forage preferences changed as summer progressed (Johnson 1980:80-92).

Diets of bighorn from June to October varied among communities (Table 7). Those species contributing the most to the diet in each community were usually the most abundant species within that community. However, in the Geum and Potentilla communities, G. rossii and P. fruticosa were each 8 percent of the bites recorded in the respective communities. In those communities used all 5 months, June through October, bighorn ate a greater variety of species than in communities used only 2 or 3 months (Table 7). Within a community grazed during 3 or more months, food habits of bighorn changed as summer progressed (Johnson 1980:154-161).

#### DISCUSSION

Bighorn distribution changed among communities as summer progressed. They ate species that were in early stages of phenological development and avoided plants that were past flowering. Plants in xeric communities flowered earlier in summer than did plants in mesic communities. Xeric communities were used early in summer but were abandoned as plants matured and snow melted, exposing vegetation on the more mesic sites. Thus by utilizing various communities and various species within communities, bighorn maintained a diet high in protein, phosphorus, and digestible energy. Highest levels of protein, phosphorus, and digestible energy are in plants in early stages of phenological development and decline as plants mature (Klein 1965, Johnston et al. 1968, Hebert 1973, Keiss and Schoonveld 1974, P-R Proj., W-41-R-23, Colorado Div. of Wildlife, Fort Collins, Keiss 1977).

Table 7. Bighorn food habits in 8 communities determined by direct feeding observations in summer and autumn. Species included contributed at least 5 percent of total bites recorded in some 2 months during the periods June-October 1977 and June-September 1978, Pecos Wilderness, New Mexico.

|                                   | Community                       |  |   |                    |                   |  |  |                               |  |  |  |  |
|-----------------------------------|---------------------------------|--|---|--------------------|-------------------|--|--|-------------------------------|--|--|--|--|
|                                   | Kobresia                        | Trifolium                                | Geum                                    | Potentilla         | Salix             | Vaccinium  | Deschampsia  | Polygonum                     |  |  |  |  |
| Number occasions                  | 12                              | 23                                       | 14                                      | 12                 | 12                | 7  | 25   | 20                            |  |  |  |  |
| Months utilized                   | June(4) <sup>a</sup><br>July(6) | June(19)<br>July(1)<br>Aug(2)<br>Sept(1) | June(4)<br>July(6)<br>Aug(2)<br>Sept(2) | June(0)<br>July(1) | July(6)<br>Aug(6) | June(4)<br>July(7)<br>Aug(10)<br>Sept(8)<br>Oct(2) | June(1)<br>July(11)<br>Aug(6)<br>Sept(3)<br>Oct(4) | July(6)<br>Aug(12)<br>Sept(2) |  |  |  |  |
| Grasses and grass-<br>like plants | 59±0 <sup>b</sup>               | 12±2                                     | 20±4                                    | 12±4               | 4±2               | 19±1   | 35±4   | 16±2                          |  |  |  |  |
| Forbs                             | 26±7                            | 87±3                                     | 70±6                                    | 79±9               | 18±6              | 67±5   | 59±4   | 80±2                          |  |  |  |  |
| Woody plants                      | 15±3                            | 7±0.5                                    | 10±5                                    | 9±5                | 73±7              | 15±3   | 6±1  | 2±1                           |  |  |  |  |
| Carex spp.                        | 0±4                             | 2±2                                      | 7±2                                     | 3±3                | 1±0.3             | 6±3  | 9±2  | 2±1                           |  |  |  |  |
| Deschampsia<br>caespitosa         | 1±0.4                           | 1±0.4                                    | 6±3                                     | 2±1                | 1±0.3             | 3±1  | 11±3   | 5±1                           |  |  |  |  |
| Kobresia macroparva               | 49±10                           | 3±1                                      | 2±1                                     | 1±1                | 4±1               | 8±2  | 6±2  | 9±2                           |  |  |  |  |
| Eriogonum spp.                    | 0                               | 0  | 0                                       | 0                  | 0                 | 0  | 0  | 0                             |  |  |  |  |
| Geum rossii                       | 6±2                             | 0  | 8±3                                     | 2±1                | 1±1               | 1±0.1  | 2±1  | 2±1                           |  |  |  |  |
| Oreoxis alpina                    | 4±2                             | 4±1                                      | 2±1                                     | 9±6                | 0                 | 0  | 0  | 0                             |  |  |  |  |
| Polygonum<br>bistortifolius       | 1±0.4                           | 0  | 10±3                                    | 2±1                | 4±2               | 12±2   | 27±5   | 26±5                          |  |  |  |  |
| Semecio amplexans                 | 0                               | 0  | 0                                       | 0                  | 0                 | 4±2  | 0  | 13±5                          |  |  |  |  |
| Solidago ciliata                  | 3±2                             | 0  | 1±1                                     | 0                  | 0                 | 3±2  | 3±1  | 1±1                           |  |  |  |  |
| Trifolium<br>dasyphyllum          | 1±1                             | 63±4                                     | 23±8                                    | 41±11              | 3±1               | 0  | 0  | 1±1                           |  |  |  |  |
| Salix nivalls                     | 12±8                            | 0  | 5±5                                     | 0                  | 0                 | 1±1  | 0  | 0                             |  |  |  |  |
| Salix planifolia                  | 0                               | 0  | 0                                       | 0                  | 72±7              | 0  | 0  | 0                             |  |  |  |  |
| Vaccinium<br>scopulorum           | 0                               | 0  | 3±2                                     | 1±1                | 0                 | 13±9   | 5±1  | 2±1                           |  |  |  |  |
| Number bites                      | 4,073                           | 12,659                                   | 8,901                                   | 4,019              | 3,583             | 10,339   | 8,796  | 9,864                         |  |  |  |  |
| Number species                    | 11                              | 11                                       | 19                                      | 13                 | 6                 | 33   | 28   | 12                            |  |  |  |  |

<sup>a</sup>Number of occasions feeding observations obtained in month.

<sup>b</sup>Percent mean ± 1 standard error.

<sup>c</sup>Less than 0.5 percent.

<sup>d</sup>G. rossii was not 5 percent of the bites for some 2 months, but it was included because it was a major species over much of the range.

<sup>e</sup>Number of species greater than 5 percent of the total bites for some age-sex class for some 1 month.

This population of bighorn was in excellent condition as measured by body weight, horn growth of rams, lamb:ewe and yearling:ewe ratios, and Protostrongylus numbers in feces and lungs. Ewes weighed up to 90 kg. Horns of 2-year old rams were greater than 1/2 curl by end of summer and mean weights of 5 2 1/2-year old rams was 81 kg. Lamb:ewe and yearling:ewe ratios were 0.86 and 0.89 in 1976; 0.67 and 0.40 in 1977, and 0.62 and 0.32 in 1978. Ratios of yearlings:ewes were depressed in 1977 and 1978 because of a disproportionate number of lambs and yearlings captured during trapping operations in 1977 and 1978. Three ewes and 2 lambs were necropsied in 1976, and all animals were in excellent condition with few Protostongylus nodules in the lungs (Lange 1980). Protostrongylus was present in low levels in feces (Lange 1980). We believe the excellent condition of this herd was directly attributable to availability and selection of high quality forage throughout summer.

This information has important management implications. On sites considered for release of bighorn sheep, potential summer range should be critically examined. A mosaic of slopes and aspects should exist that will support a variety of communities providing forage in various stages of phenological development throughout summer. This will permit animals to obtain a high quality diet and will increase the probability of a successful establishment of a self-sustaining population of bighorn.

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