Diets of the Black-tailed Hare in Steppe Vegetation

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Highlight: Thirteen species of plants were identified in fecal pellets of black-tailed hares collected from sagebrush and bitterbrush communities in southcentral Washington. Microscopic analysis of plant fragments indicated that yarrow was the most common food item in the diet, making up 25% of the overall diet. Other food items in decreasing order of importance were: turpentine cymopterus > hoary aster > needleandthread > and Jim Hill mustard. Preference indices indicated that needleandthread was the most preferred plant in the sagebrush community, while yarrow was the most preferred plant in the bitterbrush community. Although the communities were not similar in plant species frequency of occurrence and cover, the hare diets were quite similar in both communities, indicating that hares were actively seeking preferred foods.

Black-tailed hares (jackrabbits), *Lepus californicus*, are important herbivores on rangelands throughout the central and western United States (Hall and Kelson 1959). On many rangelands they can compete for forage with livestock and other wildlife. Hansen and Flinders (1969) have reviewed the known dietary habits of hares in North America. The objective of this investigation was to determine the dietary habits of black-tailed hares within sagebrush (*Artemisia tridentata*) and bitterbrush (*Purshia tridentata*) communities in southcentral Washington. The communities are utilized to some extent by mule deer (*Odocoileus hemionus*) and small mammals such as the ground squirrel (*Spermophilus townsendi*) but have not been grazed by livestock since 1943.

Study Area and Methods

The study area is on the Department of Energy's Hanford Reservation in southcentral Washington, on a broad plain that slopes gently toward the Columbia River. This area is characterized by gently undulating topography and the soils are mainly Rupert sands and Burbank loamy sands (Hajek 1966). The elevation is about 223 m with an average annual precipitation of 16 cm (Stone et al. 1972). Daubenmire (1970) described the two plant communities as *Artemisia tridentata/Poa sandbergii* and *Purshia tridentata/Stipa comata* associations. Both plant communities have been invaded by introduced annuals, especially cheatgrass (*Bromus tectorum*), which has become the dominant understory herb (Cline et al. 1977). The sagebrush community occupies approximately 546 km^2, while the bitterbrush community encompasses about 220 km^2 of the Hanford Reservation south and west of the Columbia River.

Fecal pellets were collected from two replicated sites located at random within the sagebrush and bitterbrush communities. Within each replicate two parallel transects (1 m × 50 m) were spaced 60 m apart. Each transect was subdivided into two lengths, 1 to 25 m and 25 to 50 m. All pellets were collected from these two subdivisions and designated as separate samples. This procedure was repeated for all transects, making a total of four samples for each replicate. Fecal pellets were dried at 70°C for 48 hours and ground through a Wiley mill (1-mm screen) to insure thorough mixing. All field sampling was conducted during April 1974. A total of 6,712 pellets and 2,871 pellets were included in the analyses for sagebrush and bitterbrush habitats, respectively. These analyses included a mixture of recent and old pellets from all seasons, dating back over a 10-year period as shown by radioactive dating (O'Farrell and Gilbert 1975; Uresk et al. 1975).

Fifteen microscope slides were prepared for each of the four samples from each site after the fecal contents had been washed over a 0.1-mm screen (Sparks and Malechek 1968). Slides were prepared with Hertwig's solution and Hoyer's solution (Baumgartner and Martin 1939) and dried for approximately 72 hours at 60°C.

Identification of plant fragments was made by microscopic examination of epidermal cell characteristics of vegetation in fecal material. Reference plant material prepared from specimens identified and collected from the study areas was used for comparisons. Twenty microscope fields were examined on each slide and all recognizable fragments recorded (Rogers and Uresk 1974). Fifteen slides were examined for each sample. Frequency of occurrence was determined by dividing the number of microscope views in which a given species occurred by the total number of views × 100 (Curtis and McIntosh 1950).

Vegetational analyses included canopy cover provided by each species and frequency of occurrence. Two replicated sites were examined in each of the sagebrush and bitterbrush communities. Each replicate in the sagebrush community consisted of four parallel line transects 50 m long and 30 m apart while vegetational measurements were collected on two transects in the bitterbrush community. The canopy cover and frequency of occurrence methods of vegetational analysis developed by Daubenmire (1959) were used for herbaceous taxa. Canopy cover was estimated using the following cover-class categories: class 1 (1–5%), class 2 (6–15%), class 3 (16–25%), class 4 (26–50%), class 5 (51–75%), and class 6 (76–100%). Estimations were based on ocular examination of 50 (2 × 5 dm, 0.1 m^2) plots systematically spaced at 1-m intervals along each 50-m line transect. Canopy cover and frequency of occurrence values were summarized by line transects. All sampling was conducted in April which is the mid-growing season for the understory vegetation consisting primarily of winter and spring annuals.

The density of shrubs was determined by counting all shrubs rooted within a 10 × 50 m plot centrally located in each replicated study site.

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Each shrub was measured for long and short canopy diameter to determine canopy cover.

A nested factorial design was used for comparisons between plant communities and all statistical tests, unless otherwise noted, followed Snedecor and Cochran (1967).

Kulczynski's similarity indices (Oosting 1956) and Spearman's rank correlation coefficients (r_S) (Siegel 1956) were calculated for diet and plant communities to determine the degree of associations.

Preference indices were calculated by dividing the relative frequency in the diet by relative frequency in the habitat. Plant and dietary data collected in the field as frequency of occurrence were converted to percent relative frequency by species or as a percent of the total frequency of all species. All values were rounded to the nearest 0.1. The preference indices as used here are regarded only as a guide to food preferences rather than absolute values. Other methods of evaluating forage preferences of herbivores are presented by Krueger (1972).

Results

Vegetational Analyses

A total of 21 and 28 plant species were identified in the bitterbrush and sagebrush communities, respectively (Table 1). Sixteen species were common to both associations. Cheatgrass was the most abundant herbaceous plant in both communities. The bitterbrush community had fewer plant species, especially in the forb category.

Grasses provided about 40% of the canopy cover in the bitterbrush community and about 21% in the sagebrush community (Table 1). Forbs provided 14% and 16% cover for the bitterbrush and sagebrush communities, respectively. The total understory cover provided by herbaceous species was approximately 17 percentage units higher in the bitterbrush vegetation than that associated with the sagebrush ($\alpha \leq 0.01$). If cheatgrass

Table 1. Frequency of occurrence (% ± SE) and canopy cover (% ± SE) of plants in April 1974 within two plant communities used by black-tailed hares.

	Frequency of Occurrence		Cover	
	Sagebrush[1] Community	Bitterbrush community	Sagebrush[1] community	Bitterbrush community
Grasses				
Needleandthread (*Stipa comata*)	0.3 ± 0.3	0.5 ± 0.5	<0.1	<0.1
Sandberg bluegrass (*Poa sandbergii*)	21.5 ± 4.2	36.5 ± 6.9	1.7 ± 0.5	5.2 ± 2.0**
Cheatgrass (*Bromus tectorum*)	94.0 ± 1.5	98.0 ± 1.5	15.3 ± 0.9	34.9 ± 0.9**
Fescue (*Festuca spp.*)[2]	75.0 ± 6.1	1.0 ± 0.6**	4.0 ± 0.7	<0.1 **
Total grasses			21.0	40.1
Forbs				
Yarrow (*Achillea millefolium*)	1.0 ± 1.0		<0.1	<0.1
Turpentine cymopterus (*Cymopterus terebinthinus*)	0.8 ± 0.4		0.3 ± 0.2	
Hoary aster (*Aster canescens*)	3.3 ± 3.3		0.2 ± 0.2	
Jim Hill mustard (*Sisymbrium altissimum*)	1.0 ± 1.0		<0.1	
Matted cryptantha (*Cryptantha circumscissa*)	49.3 ± 4.6	15.0 ± 4.4**	1.8 ± 0.2	0.4 ± 0.1**
Blazing star (*Mentzelia albicaulis*)	0.5 ± 0.5		<0.1	
Carey's balsamroot (*Balsamorhiza careyana*)	0.8 ± 0.5		0.2 ± 0.1	
Wing-nut cryptantha (*Cryptantha pterocarya*)	11.8 ± 3.1	6.0 ± 2.5	0.6 ± 0.1	0.2 ± 0.1*
Spring draba (*Draba verna*)		72.0 ± 5.4		3.8 ± 0.8
Tansy mustard (*Descurainia pinnata*)	84.5 ± 5.0	4.0 ± 2.8**	8.0 ± 1.0	0.2 ± 0.1**
Pink Microsteris (*Microsteris gracilis*)	65.0 ± 5.0	48.5 ± 6.1	3.2 ± 0.5	2.5 ± 0.4
Threadleaf phacelia (*Phacelia linearis*)	6.5 ± 3.5	0.5 ± 0.5	<0.1	<0.1
Wallflower (*Erysimum asperum*)	2.7 ± 1.2		0.2 ± 0.2	
Russian thistle (*Salsola kali*)	4.5 ± 2.1	1.0 ± 1.0	0.1 ± 0.1	<0.1
Fiddleneck (*Amsinckia lycopsoides*)	1.0 ± 0.7	2.5 ± 0.5	<0.1	<0.1
Phlox (*Phlox longifolia*)	3.7 ± 1.9		0.7 ± 0.3	
Scurf-pea (*Psoralea lanceolata*)	<0.1	<0.1	<0.1	<0.1
Buckwheat (*Eriogonum spp.*)	3.0 ± 1.4	16.0 ± 4.7**	0.4 ± 0.2	2.7 ± 1.7
Pale comandra (*Comandra pallida*)	0.5 ± 0.3		<0.1	
Evening-primrose (*Oenothera pallida*)	0.5 ± 0.3		<0.1	
Star tulip (*Calochortus macrocarpus*)	1.5 ± 0.8		<0.1	
Willow-weed (*Epilobium paniculatum*)	0.3 ± 0.3	8.0 ± 1.4**	<0.1	0.2 ± 0.1
Brodiaea (*Brodiaea douglasii*)	0.7 ± 0.7		<0.1	
Jagged chickweed (*Holosteum umbellatum*)		29.0 ± 9.8		3.5 ± 1.6
Lomatium (*Lomatium spp.*)		0.5 ± 0.5		<0.1
Total forbs			15.7	13.5
Total herbaceous cover			36.7	53.6
Shrubs				
Big sagebrush (*Artemisia tridentata*)	36.0 ± 3.9	5.5 ± 1.3**	33.4 ± 1.6	9.0 ± 1.5**
Bitterbrush (*Purshia tridentata*)		23.0 ± 3.7		29.5 ± 2.4
Rabbitbrush (*Chrysothamnus nauseosus*)		1.5 ± 0.5		3.5 ± 0.5
Green rabbitbrush (*Chrysothamnus viscidiflorus*)	0.5 ± 0.3	1.5 ± 0.9	<0.1	1.1 ± 0.3**
Total			33.4	43.1

[1] Sagebrush community, n=8 (Cline et al., 1977) Bitterbrush, n=4.
[2] Annual species.
* Significantly different from sagebrush community $a \leq 0.05$.
** Significantly different from sagebrush community $a \leq 0.01$.

were excluded from the total understory cover, both sites had approximately the same amount of cover.

Shrub cover averaged 33 and 43% in the sagebrush and bitterbrush communities, respectively (Table 1). The bitterbrush site had significantly ($\alpha \leq 0.01$) more total shrub cover than the sagebrush community, primarily due to the addition of sagebrush and rabbitbrush in the bitterbrush community. Bitterbrush has a different form than sagebrush, generally providing more cover per shrub. The average number of shrubs in the sagebrush site was 188/500 m^2 as compared to 90/500 m^2 in the bitterbrush community. Heights of sagebrush and bitterbrush were similar at both sites, averaging 85 and 88 cm, respectively. Rabbitbrush was much shorter in stature, ranging between 51 and 58 cm.

Pellet Composition

Thirteen plant species were identified in hare fecal pellets from both plant communities (Table 2). Yarrow was the most common species, comprising 48 and 71% frequency of occurrence in fecal samples from the bitterbrush and sagebrush sites, respectively. Needleandthread was the most common grass found in the diets. However, Sandberg bluegrass was abundant in diets from the bitterbrush area. Forbs provided the mainstay of the hare diets and were found approximately 22% more frequently in pellets from the sagebrush site. Rabbitbrush occurred more frequently in fecal pellets from the bitterbrush area. Although sagebrush also occurred in the bitterbrush site, it was only found in the pellets from the sagebrush community. The average composition of plant species in the hare fecal pellets based upon relative frequency consisted of 75% forbs, 14% grasses, 9% shrubs, and 1% unidentifiable material in the sagebrush community. Plant composition of fecal pellets in the bitterbrush community consisted of 69% forbs, 20% grasses, 10% shrubs, and 1% unidentifiable material.

When a plant species is scarce in the habitat but shows up frequently in the fecal pellets, it is assumed that this particular plant is actively sought by the foraging animal (Table 3). Needleandthread grass was the most highly preferred species in the sagebrush community. Other highly preferred forage plants in decreasing order include yarrow, turpentine cymopterus, Jim Hill mustard, rabbitbrush and hoary aster. Yarrow was the most highly preferred species in the bitterbrush community. Other highly sought after species in decreasing order include turpentine cymopterus, hoary aster, needleandthread, Jim Hill mustard, scurf-pea, and rabbitbrush. The hares were more actively seeking specific forage plants in the bitterbrush area than in the sagebrush community. This is reflected in the average preference indices of 104 and 63 of the respective communities. Cheatgrass was the most abundant plant in both study sites but did not appear in the fecal pellets, indicating that hares were selecting against this species.

The hare diets and preference indices were significantly more similar between plant communities than the vegetation when examining frequency and cover (Table 4). These data indicate that the hares are generally selecting for the same plants within both plant communities, although the communities are not necessarily similar in regard to frequency and cover values.

Table 2. Average botanical composition (%±SE) of fecal pellets collected from black-tailed hares.

Category	Sagebrush community[1]	Bitterbrush community[1]
Grasses		
Needleandthread	36.6 ± 2.3	28.9 ± 4.2
Sandberg bluegrass	0.4 ± 0.4	15.4 ± 1.2**
Forbs		
Yarrow	71.0 ± 2.6	48.1 ± 2.6**
Turpentine cymopterus	42.1 ± 3.3	40.4 ± 1.8
Hoary aster	35.8 ± 2.2	38.0 ± 2.2
Jim Hill mustard	33.8 ± 3.0	14.6 ± 2.6**
Matted cryptantha	11.4 ± 3.1	3.8 ± 1.5*
Scurf-pea	1.6 ± 0.9	7.1 ± 1.7**
Carey's balsamroot		0.3 ± 0.3
Wing-nut cryptantha		0.6 ± 0.5
Spring draba	0.4 ± 0.4	
Shrubs		
Big sagebrush	9.6 ± 0.9	
Rabbitbrush	13.0 ± 2.8	20.9 ± 3.4*
Unknowns	2.5 ± 0.3	1.8 ± 0.5

[1] Frequency of occurrence values, n = 8.
* Significantly different from sagebrush community $a \leq 0.05$.
** Significantly different from sagebrush community $a \leq 0.01$.

Table 3. Preference indices of black-tailed hares by food items within two plant communities.

Plant taxa	Sagebrush community[1]	Bitterbrush community
Grasses		
Needleandthread	142	131
Sandberg bluegrass	<1	<1
Forbs		
Yarrow	137	219
Turpentine cymopterus	82	184
Hoary aster	20	173
Jim Hill mustard	66	66
Matted cryptantha	<1	<1
Scurf-pea	6	32
Carey's balsamroot		1
Wing-nut cryptantha		<1
Draba	2	
Shrubs		
Big sagebrush	<1	
Rabbitbrush	50	24
Average	63	104

[1] Preference index values were calculated as: (relative frequency of a species in the diet ÷ relative frequency of the same species in the community).

Discussion

Selectivity in foraging by the black-tailed hare has been reported by several investigators and is influenced by the phenological stages of plant growth (Hayden 1966; Sparks 1968; Hansen and Flinders 1969; Flinders 1971; and Flinders and Hansen 1972). Grasses were important food items during

Table 4. Average similarity indices (%) and rank-order correlation coefficients (r_s) of hare diets, preference indices (PI), frequency of occurrence and cover when comparing the two plant communities.

	Sagebrush community vs bitterbrush community	
Category	%	r_s
Diets	48	0.80**
PI	44	0.77**
Frequency	21	0.20
Cover	18	0.04

** Significant at $\alpha < 0.01$.

early spring and summer, while forbs were important during the summer and shrubs important in winter (Hayden 1966; Sparks 1968). Hares exhibited a preference for green succulent plants at all seasons. Selectivity may also be influenced by the amount of available energy stored in certain plants (Church et al. 1972).

Stewart and Hull (1949) maintain that hares strongly influence the development and maintenance of cheatgrass cover. Hares feeding heavily on perennial grasses prevented these grasses from invading cheatgrass communities. On areas where hares were purposefully excluded, perennial grass increased as rapidly as cheatgrass, but perennial grasses disappeared when grazed by both hares and cattle. Hares sometimes girdle main stems of sagebrush and rabbitbrush, and may thus destroy the plant.

Although hares were not especially abundant in these study areas, it does seem possible their selective feeding habits could be influential in keeping perennial grasses such as needleandthread from increasing in abundance in the absence of livestock grazing. Mule deer are the only big game animal known to graze this area during the past 30 years, and they generally concentrate in the bitterbrush community during the winter months. Deer densities are estimated at approximately .23/km^2 on the Hanford Reservation south and west of the Columbia River and their influence on the plant communities has been slight (Uresk, unpublished data).

The rank-order correlation coefficients for the food items found in the fecal pellets of the hares and preference indices were significantly correlated when comparing both plant communities. This indicates that hares are selecting and preferring the same food items at both sites. Preference indices of food items selected by the hares were high. Seven plants were highly preferred and sought out in much greater quantities relative to their percent frequency in the communities. The low similarity indices and nonsignificant correlation coefficients show that the plant communities are not related when considering frequency of occurrence and canopy cover of plants. Thus, the hares are actively seeking out certain food items they prefer.

The sagebrush and bitterbrush communities today are much like those that existed prior to 1943, when the Hanford Reservation was established (Cline et al. 1977). The major change in plant species composition has been the introduction of cheatgrass, which has been important to this area for more than half century (St. John and Jones 1928).

There is a need for additional dietary information concerning other important herbivores within the confines of the Hanford Reservation and other large nuclear facilities. Dietary analyses of the black-tailed hare and other herbivores when related to availability of forage plants in the habitats would provide information useful in selecting plants to revegetate shallow burial sites for low-level radioactive wastes from nuclear energy facilities. It is especially important to select plants not consumed by herbivores that have the ability to be self-maintained, yet prevent soil erosion. It is also important to select plants for revegetation that are not preferentially selected by wild herbivores because it is prudent to keep food chain transfers of radionuclides to a level low as possible.

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