Deer Mouse Preference for Seed of Commonly Planted Species, Indigenous Weed Seed, and Sacrifice Foods

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Highlight: Captive deer mice from pinyon-juniper, sagebrush-bitterbrush, and Jeffrey pine-ceanothus plant associations were fed a variety of shrub, grass, forb, and tree seeds. Mice ate or destroyed an amount of seed equal to approximately one-third their body weight daily. Seed of bitterbrush, singleleaf pinyon, balsamroot, and small burnet were the most preferred food items tested while seed of Utah juniper, smooth brome, fourwing saltbush, and big saltbush were least preferred. Planting valuable forage species whose seeds are not preferred by deer mice would appear to improve seeding success on sites where seed predation by deer mice is a problem.

Seed predation by the deer mouse (*Peromyscus maniculatus*) and other rodents has contributed to the failure of several seedings (Howard 1950; Spencer 1954; and Nord 1965). The deer mouse has been singled out as a major consumer of planted seed by Casebeer (1954), Kverno (1954), and Nelson et al. (1970).

Seeds are an important part of the deer mouse diet, especially in the fall and winter when insects and green vegetation are not available (Fitch 1954; Williams 1959; and Whitaker 1966). Seeds of forbs (Johnson 1961), grasses (Frischknecht 1965), and shrubs (Jameson 1952) are consumed at different times of the year, depending on seed availability and floristic composition. Seed size, odor, and nutrient content play an important role in food preference (Thompson 1953; Howard and Cole 1967; Lockard and Lockard 1971), but when food is scarce deer mice will take almost any food available. Deer mice are also opportunistic in their feeding habits and readily consume new foods (for example, planted seed) that appear on the site (Johnson 1961).

New methods of controlling deer mouse predation of planted seed should be developed. Recent restrictions on the use of poisons on federal lands (Evans 1974) and increased emphasis on the preservation of all nongame wildlife species make many control treatments unacceptable.

By understanding the food habits and preferences of the deer mouse we hope to develop techniques that reduce seed predation to an acceptable level and so improve stand establishment. Seed predation may be reduced if planted seed species are less preferred by the deer mouse than indigenous food or low-cost sacrifice foods. This paper presents information on deer mouse preference for seed species commonly planted on rangelands, indigenous weed seed, and possible sacrifice foods.

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Methods

Native deer mice were trapped in western Nevada and transferred to an animal holding room at the University of Nevada at Reno. There a series of feeding trials were run to determine deer mouse preference for various seeds and sacrifice foods.

Eight deer mice trapped in a sagebrush (*Artemisia tridentata*)-bitterbrush (*Purshia tridentata*) plant association were used in an initial feeding trial to provide baseline information on deer mouse preference for seed species commonly planted on rangelands. Seeds of 18 shrub, forb, and grass species were divided into two 9-species groups A and B (Table 1). Each seed group was provided separately to four mice in individual cages.

After the feeding trial, seed species from both seed groups were separated on the basis of deer mouse acceptance. Seed species that made up 10% or more of the deer mouse diet were grouped as primary seed species while those seed species consumed in lesser quantities were grouped as secondary seed species.

A second feeding trial was run to determine deer mouse seed preference within primary and secondary seed groups. Each seed

Table 1. Deer mouse food preference for commonly seeded species.

	Feeding trials[1]			
	1		2	
Common name	Seed group A % diet	Seed group B % diet	Primary seed % diet	Secondary seed % diet
Antelope bitterbrush	30.7[a]		26.0[a]	
Arrowleaf balsamroot	23.6[ab]		16.1[b]	
Small burnet		20.5[a]	14.3[b]	
Sainfoin	18.4[b]		8.7[c]	
Mountainmahogany	9.6[c]		9.3[c]	37.0[a]
Serviceberry		15.7[a]	10.2[c]	
Lewis flax		16.3[a]	4.7[d]	
Stiffhair wheatgrass	13.8[c]		4.5[d]	
Big bluegrass		17.2[a]	2.0[e]	
Russian wildrye		10.7[b]	3.5[e]	24.0[b]
Alfalfa		8.3[b]		19.2[c]
Green ephedra		3.5[c]		7.4[d]
Cicer milkvetch	2.4[d]			3.1[e]
Sheep fescue		3.0[c]		4.6[e]
Bulbous bluegrass	.0[e]			2.6[e]
Big saltbush		4.5[c]		1.3[f]
Fourwing saltbush	1.3[d]			.3[f]
Smooth brome	.1[e]			.7[f]

[1] Species in each column with dissimilar superscripts are significantly different ($p<0.1$).

Table 2. Deer mouse preference for select seeded species, indigenous forb, grass, and tree seed and alpha-napthylthiourea (ANTU)-treated bitterbrush seed.

Food source Common name	Feeding trials[1] 3 Indigenous forb and grass seed	4 Tree seed and sacrifice food	5 ANTU-treated bitterbrush seed
Seeded species			
Antelope bitterbrush	31.5[a]	28.5[a]	10.2[b]
Arrowleaf balsamroot			11.7[h]
Small burnet		20.6[b]	11.5[b]
Mountainmahogany	22.8[b]		11.5[b]
Serviceberry			4.3[bc]
Russian wildrye	9.4[cd]	4.3[cde]	6.0[bc]
Cicer milkvetch	7.3[cde]	1.9[de]	.5[bc]
Big bluegrass	4.8[def]		
Fairway wheatgrass	4.1[ef]		
Sheep fescue	.6[f]		
Smooth brome	.1[f]		
Indigenous forb and grass species			
Prickly poppy	11.4[c]		
Lambsquarters	3.1[ef]		
Cheatgrass brome	2.9[ef]		
Coyote tobacco	2.0[ef]		
Tree seed			
Singleleaf pinyon		23.6[ab]	40.5[a]
Utah juniper		.4[e]	
Sacrifice foods			
Barley (rolled)		10.2[c]	
Lab Chow		8.5[cd]	
Wheat (hulled)		2.0[de]	

[1] Species in each column with dissimilar superscripts are significantly different ($p<0.1$).

group was provided separately to 12 mice: four each from sagebrush-bitterbrush, pinyon (*Pinus monophylla*)-juniper (*Juniperus osteosperma*), and Jeffrey pine (*Pinus jeffreyi*)-Ceanothus (*Ceanothus velutinus*) plant associations. For a continuum of food preference, seeds of mountainmahogany (*Cercocarpus ledifolius*) and stiffhair wheatgrass (*Agropyron trichophorum*) were included in both seed groups. Species in each seed group are identified in Table 1.

Third and fourth feeding trials were run to determine whether seed of weedy herbaceous species indigenous to disturbed rangelands or commercial sacrifice foods would reduce deer mouse consumption of desirable seed species (Table 2). Seeds of four indigenous weed species and eight commonly seeded species were provided to eight mice in the third trial. In the fourth trial, sacrifice foods (wheat (*Triticum sativum*), rolled barley (*Hordeum sativum*), and Lab Chow[1]), seeds of pinyon and juniper, and seeds of four commonly seeded species were provided to seven mice.

In the fifth and final feeding trial, we attempted to reduce deer mouse preference for bitterbrush seed by coating it (9% seed weight) with alpha-naphthylthiourea (ANTU)[2], a rodent pesticide-repellent (Passof et al. 1974). ANTU-treated bitterbrush seed and seed of seven previously tested seed species (Table 1) were provided to six mice in this trial.

In all feeding trials, mice were given 5 days to become accustomed to their new surroundings before the start of the test. Mice were provided with cotton nesting material and a surplus of water and Lab Chow. Lab Chow was removed from the cages during feeding trials in which it was not a test food.

Food choices were provided "cafeteria style" to each mouse in its individual cage. Seed or other food was placed in individual cubicles of a 12-cube ice tray. Food choices were kept separate and placement was made at random within the tray. We assumed that each mouse would make a large number of independent food selections during a feeding period and consumption of seed from any cubicle would reflect this independence. This assumption appeared reasonable from observations and because other food sources were taken before the preferred food was entirely consumed.

Each mouse was provided with 0.5 g of selected foods the first day, 1 g the second day, and additional 1 g increments until the fifth day when 4 g of each food item were provided. At the end of each daily feeding (4 p.m. to 8 a.m.), the food tray was removed. Dropped or displaced seed was rare; when it occurred, the food items were replaced in their proper cubicles. Feces and other foreign matter were removed from the seed remnants.

Total seed consumed was determined for each seed species at the end of each feeding period by taking the difference between the weight of seed offered and the weight of whole seed remaining. Empty hulls were separated from whole seed; but, for several seed species, this was only possible for small samples. In the latter case, weight of whole seed remaining was determined by weighing the seeds and empty hulls together and correcting for the empty hulls with this equation:

$$W = \frac{A}{1+(B \cdot C)}$$

Where:

W is the weight of whole seeds,
A is the combined weight of whole seeds and empty hulls,
B is the ratio of the number of empty hulls to the number of whole seeds, and
C is the ratio of hull weight to the whole seed weight.

The value of B for each lot of remaining seeds and hulls was estimated by taking a sample from each lot and counting the number of whole seeds and estimating the number of hulls from remaining fragments. The value of C for each species was estimated by weighing a number of samples of hulls and whole seeds.

Amount of each seed species consumed during the 5-day feeding trial was expressed as a percentage (percent diet) of the total seed (all species) consumed. Percent diet was used instead of seed weight to make comparisons among seed species to nullify differences in total seed weight consumed by individual mice. Percentages were generally in the 0% to 30% range and as such were transformed to arc sine

$$\frac{\sqrt{\%\ \text{Diet}}}{100}$$

before statistical treatment (Snedecor 1956).

In each feeding trial except the second, differences in total seed consumption (% diet) were statistically analyzed with a one-way analysis of variance. Propriety of the analysis is dependent upon the assumption that food selections were made independent of each other. Hopefully, departures from this assumption will have minor effects on the analysis. In the second trial, differences in food consumption were run in a 3 by 10 factorial statistical test to delineate seed preference within seed groups and among mouse populations. Hartley's sequential method of testing (Snedecor 1956) was used to determine which food source pairs were significantly different (p 0.1) in preference in each separate feeding trial.

Results

Deer mice showed a definite preference for certain seed species within each feeding trial. Without exception, the numbers of species whose seeds were eaten decreased as the amount of seed offered increased. Most of the deer mouse diet

[1] Use of trade or firm names is for reader information only, and does not constitute endorsement by the U.S. Department of Agriculture or the Utah Division of Wildlife Resources of any commercial product or service.

[2] This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

(65–70%) was made up of only three or four food sources in each feeding trial. Deer mice, however, preferred some variety in their diet. Total consumption of the most preferred seed rarely occurred when increased amounts of seed were offered, although amounts of seed of individual species were well below the nightly food intake of the mice.

Deer mice consumed or destroyed an amount of seed equal to 30% to 40% of their body weight each night when more than that amount of seed was available. Total food intake decreased when less preferred seed species were provided. Deer mouse seed consumption or destruction over a 5-day period was 174% of body weight when preferred primary seed species were offered and 137% of body weight when less preferred secondary seed species were offered in the second feeding trial. Mice consumed or destroyed an intermediate amount of seed (162% of body weight) over a 5-day period when primary and secondary seed species were provided together in the first feeding trial.

Consumption of individual seed species varied among feeding trials, depending upon other food sources available. The proportion of mountainmahogany and Russian wildrye seed in the diet increased by 20% to 30% when offered with less preferred secondary seed species in the second feeding trial (Table 1).

Deer mice from pinyon-juniper, sagebrush-bitterbrush, and Jeffrey pine-ceanothus plant associations did not differ significantly (p 0.05) in their preference for seed species commonly planted on rangelands. The ranking of seed species according to deer mouse preference (Table 3) shows the general consistency in preference for seed species among deer mouse populations.

Deer mouse food preference was consistent among feeding trials with minor exceptions. Deer mouse preference for some seed species did vary when new food items were made available. For example, seed of big bluegrass (*Poa ampla*) was preferred over seed of Russian wildrye in the first trial, but not in the third trial (Table 1) when fairway wheatgrass (*Agropyron cristatum*) and a variety of weed seeds were provided.

Seed of bitterbrush and pinyon were clearly among the most preferred of the tested foods. From 26% to 32% of the deer mouse diet consisted of bitterbrush seed when the seed was available. The high preference of deer mice for bitterbrush seed may account for the extreme predation of planted bitterbrush seed under field conditions as reported by Brown and Martinsen (1959), Holmgren and Basile (1959), and Nord (1965).

Pine-nut consumption varied, ranging from 24% to 40% of the diet (Table 2). Increased amounts of pinyon nuts were consumed when untreated bitterbrush seed was not available. Utah juniper (*Juniper osteosperma*), smooth brome, (*Bromus inermis*), big saltbush (*Atriplex lentiformis*), and fourwing saltbush (*Atriplex canescens*) seeds were the least preferred of the tested foods.

With the possible exception of prickly poppy (*Argemone munita*), seeds of indigenous forbs were not preferred food items of deer mice. However, deer mice preferred seed of indigenous forbs as much or more than seed of smooth brome, big saltbush, fourwing saltbush, bulbous bluegrass (*Poa bulbosa*), sheep fescue (*Festuca ovina*), fairway wheatgrass, and cicer milkvetch (*Astragalus cicer*) (Table 2).

Sacrifice foods provided were usually intermediate in deer mouse preference (Table 2). Rolled barley, the most preferred sacrifice food (10% of the deer mouse diet), was preferred over seeds of cicer milkvetch and Russian wildrye (*Elymus junceus*).

ANTU-treated bitterbrush seed made up only 10% of the diet instead of 26% to 32% for untreated seed (Table 2). When treated bitterbrush seed and pinyon nuts were offered together, deer mice preferred pinyon nuts.

All tested foods are listed in Table 4 in estimated order of deer mouse food preference. The order in which foods appear is based on preference rankings within and among individual feeding trials. Seed from mountainmahogany (*Cercocarpus ledifolius*), Russian wildrye, or both occurred in all feeding trials and served as a baseline for comparisons among trials.

Table 3. Seed preference by deer mice from pinyon-juniper, sagebrush-bitterbrush, and Jeffrey pine-ceanothus plant associations.

Seed species	Preference ranking of seed species by deer mouse populations[1]		
	Pinyon-juniper	Sagebrush-bitterbrush	Jeffrey pine-ceanothus
Antelope bitterbrush	1	1	1
Arrowleaf balsamroot	2	3	2
Small burnet	3	2	3
Serviceberry	4	4	5
Sainfoin	5	5	6
Mountainmahogany	6	8	4
Lewis flax	7	6	8
Stiffhair wheatgrass	8	7	7
Russian wildrye	10	9	9
Big bluegrass	11	10	10
Alfalfa	9	11	11
Green ephedra	12	12	13
Cicer milkvetch	13	14	15
Bulbous bluegrass	15	13	12
Sheep fescue	14	15	14
Big saltbush	16	18	17
Smooth brome	17	17	18
Fourwing saltbush	18	16	16

[1] Ranking based on percent of deer mouse diet.

Table 4. Deer mouse food preference for seeded species, indigenous forb, grass and tree seed, and sacrifice foods.

Common name	Food categories[1]	Scientific name
Antelope bitterbrush	(C)	*Purshia tridentata*
Singleleaf pinyon	(T)	*Pinus monophylla*
Arrowleaf balsamroot	(C)	*Balsamorhiza sagittata*
Small burnet	(C)	*Sanquisorba minor*
Sainfoin	(C)	*Onobrychis viciaefolia*
Mountainmahogany	(C)	*Cercocarpus ledifolius*
Serviceberry	(C)	*Amelanchier alnifolia*
Barley (rolled)	(S)	*Hordeum sativum*
Lewis flax	(C)	*Linum lewisii*
Stiffhair wheatgrass	(C)	*Agropyron trichophorum*
Lab Chow	(S)	
Prickly poppy	(I)	*Argemone munita*
Big bluegrass	(C)	*Poa ampla*
Russian wildrye	(C)	*Elymus junceus*
Alfalfa	(C)	*Medicago sativa*
Green ephedra	(C)	*Ephedra viridis*
Wheat (hulled)	(S)	*Triticum sativum*
Cicer milkvetch	(C)	*Astragalus cicer*
Fairway wheatgrass	(C)	*Agropyron cristatum*
Lambsquarters	(I)	*Chenopodium album*
Cheatgrass brome	(I)	*Bromus tectorum*
Coyote tobacco	(I)	*Nicotiana attenuata*
Sheep fescue	(C)	*Festuca ovina*
Bulbous bluegrass	(C)	*Poa bulbosa*
Big saltbush	(C)	*Atriplex lentiformis*
Fourwing saltbush	(C)	*Atriplex canescens*
Smooth brome	(C)	*Bromus inermis*
Utah juniper	(T)	*Juniperus osteosperma*

[1] Food categories are: (C) commonly seeded species, (T) tree species, (S) sacrifice foods, or (I) indigenous herbaceous species.

Discussion

Deer mouse preference among seed species and sacrifice foods was very apparent and generally consistent among feeding trials and mouse populations. Amount of a particular seed species consumed was dependent upon the amount and kinds of food sources available. Seeds of less preferred species were taken in greater quantities when more preferred seeds were not available. The amount of food consumed per unit of body weight declined, however, when less preferred seed species were offered. Selecting seed species less preferred by deer mice should reduce the rate of predation of planted seed.

Predation of desired seed species should be further reduced if seed species are selected that are less preferred by deer mice than indigenous weed seed. Seeding in heavy stands of vegetation where indigenous seed sources may reduce predation of planted seed is not recommended because of plant competition and cover for deer mice. Predation of planted seed may be reduced, however, on prepared sites where indigenous weed seeds exist and cover is reduced.

Providing sacrifice foods may also lessen predation of desirable seeded species (Evans 1974). Rolled barley, Lab Chow or wheat could be obtained at minimal cost and mixed with the desired species, but only seed species that the deer mice prefer less than the sacrifice food would be protected. Seedling competition from rolled barley or Lab Chow would not occur because they are incapable of producing plants. Rodent populations could increase, however, because of the sacrifice food source and present a problem to emerging seedlings at a later date.

Treating bitterbrush seed with ANTU reduced its consumption by deer mice. Even a slight reduction in deer mouse preference for desirable seed species may be of great benefit if indigenous seed such as pinyon nuts are available to bear the brunt of deer mouse seed predation.

Although deer mice showed definite preferences among seed of commonly seeded species, indigenous species, and sacrifice foods in the laboratory, the findings may not agree entirely with deer mice preference under field conditions. Differences in nutritional requirements of deer mice from season to season may change seed preferences.

Seed consumption in the field may differ from predictions based on seed preference because all seeds are not equally available. Indigenous seed species are not as readily available to the deer mouse as newly seeded species, in most instances, but the presence of deer mice on the site prior to seeding is conclusive evidence that some indigenous food sources are available.

Planted seed may be consumed regardless of deer mouse preference if deer mouse populations are high or planted seed is exposed to predation for a long time. Planting seed species that are not preferred by deer mice in late winter or early spring when mouse populations are low and the length of the predation period is reduced should increase the number of seeds available for establishment.

Research is needed to document deer mouse seed consumption under field conditions as has recently been done for some granivorous birds (Goebel and Berry 1976). Information on deer mouse seed preference will aid in explaining any differences in seed consumption that may occur.

Conclusions

Differences in deer mouse food preference should be considered in making choices among equally adapted and productive species for seeding. We should plant desirable species whose seeds are not preferred by deer mice, especially those species whose seeds are less preferred than indigenous weed seed. Treating desirable seed species with a repellent or providing sacrifice foods may also be expedient when economically feasible. Smooth brome, fourwing saltbush, bulbous bluegrass, sheep fescue, fairway wheatgrass, and cicer milkvetch would appear to be good species for seeding when adapted to a site where seed predation by deer mice is a problem.

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