

Gregory A. Green,¹ Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis, Oregon 97331

Richard E. Fitzner,² Battelle, Pacific Northwest Laboratories, P.O. Box 999, Richland, Washington 99352

Robert G. Anthony, U.S. Fish and Wildlife Service, Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis, Oregon 97331

and

Lee E. Rogers, Battelle, Pacific Northwest Laboratories, P.O. Box 999, Richland, Washington 99352

Comparative Diets of Burrowing Owls in Oregon and Washington

Abstract

We studied diets of breeding burrowing owls (*Speotyto cunicularia*) in the Columbia Basin of southcentral Washington and north-central Oregon during 1977-78 and 1980-81, respectively. Vertebrates, primarily rodents, comprised only 9.6 percent of the total prey numbers contained in 6,328 regurgitated pellets but 87.3 percent of the biomass in the two samples combined. Vertebrate prey use was twice as high in Washington (17.1%) as in Oregon (8.4%). We attributed this to differences in habitat, including soil type, and the effects of annual variations in rainfall on prey populations. Great Basin pocket mice (*Perognathus parvus*) dominated the vertebrate prey in both states and contributed the greatest overall biomass (35.0%). Orthopteran insects comprised the greatest invertebrate biomass (10.2%), while three families of beetles contributed 49.0 percent of the total individual prey, but only 1.3 percent of the biomass. Soil type influenced differences in vertebrate composition in Oregon. Mean dry mass of over 76 prey taxa ranged from <4 mg to >40 g, indicating this species has a broad range of prey size.

Introduction

Knowledge of a raptor's diet is an important component of an effective management plan. Because all raptors are carnivorous, management objectives should consider the prey base. However, raptor diets are often site-specific and contingent upon regional availability of potential prey (Jaksic and Marti 1981). Therefore, locally collected data can be misleading when applied to another site or general region. This is especially true for generalists with a broad foraging niche. Consequently, diet data should be collected locally to insure an accurate assessment of forage use and then compared to other regions to determine the uniqueness of the local diet.

Prey availability can also change within a region on an annual basis as the prey base is influenced by changing factors such as weather, population dynamics, vegetation growth, and human activities (especially agriculture). Therefore, data collected for only one year may provide a misleading view of raptor food habits and a misleading view of the region's potential prey base. Consequently, data should be collected for more than one year to assess annual variation.

We report on the diet of breeding burrowing owls (*Speotyto cunicularia*) in shrub-steppe habitats at two locations in the Columbia Basin from data collected over separate two-year periods. We compare our results among years, locations, and soil types within our study area to better quantify spatial and temporal variations in the owl's diet. We also compare our results with data collected from other large ecosystems (Colorado, California, and Chile) to gain a better perspective on the regional trophic ecology of the Columbia Basin relative to burrowing owl food habits.

Study Area and Methods

The studies were conducted in the shrub-steppe zone of northern Gilliam, Morrow, and Umatilla counties in northcentral Oregon and at the U.S. Department of Energy's (DOE) Hanford Site in north Benton County, southcentral Washington. The topography in both study areas ranges from flat to undulating, with elevations ranging from 75 m to 200 m. The average annual precipitation for both study areas is approximately 22 cm (Ruffner 1978), most of which falls during the winter and early spring. Summers are hot and dry with several days of maximum temperatures exceeding 40°C.

The natural vegetation of the study areas is included in the *Artemisia/Stipa* or *Artemisia/Roegneria* [= *Agropyron*] plant associations (Poulton

¹Present address: Ebasco Environmental, 10900 N.E. 8th, Bellevue, Washington 98004-4405.

²Deceased.

1955), but climax vegetation is rare because of edaphic conditions, fire, or livestock grazing. Cheatgrass (*Bromus tectorum*) is a major alien invader and dominates much of the study areas. Less disturbed grasslands were dominated by western needle-and-thread (*Stipa comata*) at the lower elevations (<100 m) and bluebunch wheatgrass (*Roegneria spicata* [= *Agropyron spicatum*]) at the higher elevations (>100 m). Important shrubs in both study sites included big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), gray rabbitbrush (*Chrysothamnus nauseosus*), and snakeweed (*Gutierrezia sarothrae*). Burrowing owl nest sites were found in cheatgrass-dominated grasslands, snakeweed shrublands, or sparse shrublands of tall sagebrush or bitterbrush which was associated with cheatgrass or sparse bluebunch wheatgrass.

Diets of burrowing owls were determined by analyzing regurgitated pellets. Pellets were collected from around each nest site and at nearby perches every 1-3 weeks during the nesting season (April-July) and soaked overnight in a 2-molar (8%) solution of NaOH (Degn 1978) to dissolve hair. After material was strained and dried, vertebrate and arthropod parts were separated from the pellet mass, identified to the lowest taxon possible, and the number of individuals counted. Head capsules, elytra, and jaws of arthropods, and skulls and dentaries of vertebrates were the main body parts used in identification. Fragments were identified by comparing to specimens in museum collections at Oregon State University and Battelle PNW Laboratories. All data were converted to biomass (dry weight) from Rogers *et al.* (1976), Gleason and Craig (1979), and specimens collected at the study sites.

Results and Discussion

We collected and analyzed a total of 6,328 pellets of which 769 were collected from 5 nest sites at the Washington site in 1977-78 and 5,559 from 65 nests at the Oregon study area in 1980-81. These samples comprised a total of 37,431 individual prey representing 35,269 g (dry) of biomass and included 14 species of small mammals, 3 species of birds, 2 reptiles, 1 amphibian, and at least 56 species of arthropods. Estimated biomass of each taxon ranged from 4 mg to 41.6 g. For both study sites and all years combined, arthropods made up 90.4 percent of the prey individuals

but only 12.7 percent of the biomass, while small vertebrates, mostly rodents, comprised the balance (Table 1).

A higher percentage of vertebrate prey numbers was found in diets in Washington (17.1%) than from Oregon (8.4%), which may have been a result of a higher availability of Orthoptera (Acrididae, Tettigonidae, and Gryllacrididae) prey at the Oregon study site. Grasshoppers, especially *Melanoplus* sp., were at or near epidemic proportions both years of the Oregon study and were preyed upon heavily by the owls probably to the near exclusion of other prey by late summer. Four species of small mammals were common among the vertebrate prey in Washington and six species in Oregon. Great Basin pocket mice (*Perognathus parvus*) dominated the vertebrate prey in both areas and contributed 35 percent of the total biomass. Other studies (O'Farrell *et al.* 1975, Green 1983) have found pocket mice at greater densities than all other small rodents on both areas. Differences in small mammal prey composition between the two areas reflected differences in prey species ranges and habitat types. Ord's kangaroo rat (*Dipodomys ordii*) does not occur on the Washington study area and consequently was found only in the Oregon owl diets. The sagebrush vole (*Lagurus curtatus*) was found in burrowing owl diets only on the loamy-soils in Washington, while montane voles (*Microtus montanus*) were found only in the diets of Oregon owls. These differences probably reflect habitat rather than range differences. The largest vertebrate prey were neonate Nuttall's cottontails (*Sylvilagus nuttallii*) and black-tailed jackrabbits (*Lepus californicus*) which together contributed > 10 percent of the biomass in Oregon. Northern pocket gophers (*Thomomys talpoides*) in the diets were generally juveniles.

The most common insect prey were the tenebrionid beetles *Conisattus nelsoni* (Washington) and *Blapstinus* sp. (Oregon) and the scarab beetle *Diplotaxis subangulata* (Oregon). These three species alone contributed over 28 percent of the total individuals. All three species are small (< 7 mg) and contributed < 0.3 percent of the total biomass. Active pursuit of these insects by burrowing owls may result in a negative energy gain to the owls, especially since adult burrowing owls carry single prey to their young. Owls were foraging primarily for their young during our study. We speculate that the adults and perhaps nestlings were passively feeding on these insects within the nest and roost

TABLE 1. Diet composition of burrowing owls in the Columbia Basin of southcentral Washington (1977-78) and northcentral Oregon (1980-81).

Prey	Washington		Oregon		Total		Total No.
	(n = 769 pellets)		(n = 5,559 pellets)		(n = 6,328 pellets)		
	% No.	% Biomass	% No.	% Biomass	% No.	% Biomass	
Vertebrates	(17.1)	(89.9)	(8.4)	(86.7)	(9.6)	(87.3)	(3,592)
<i>Sylvilagus nuttallii</i>	<0.1	1.9	0.2	10.0	0.2	8.5	72
<i>Thomomys talpoides</i>	1.1	19.8	0.7	20.4	0.8	20.3	286
<i>Perognathus parvus</i>	10.5	44.9	5.1	32.7	5.8	35.0	2,167
<i>Dipodomys ordii</i>	0.0	0.0	0.4	8.7	0.4	7.1	136
<i>Peromyscus maniculatus</i>	1.6	6.2	1.6	9.8	1.6	9.1	604
<i>Lagurus curtatus</i>	1.4	6.1	0.0	0.0	0.2	1.2	69
<i>Microtus montanus</i>	0.0	0.0	0.3	4.6	0.3	3.8	105
Other vertebrates	2.5	11.1	0.1	0.5	0.3	2.5	153
Invertebrates	(82.9)	(10.1)	(91.6)	(3.3)	(90.4)	(12.7)	(33,839)
Scorpionida	3.7	1.0	0.5	0.2	1.0	0.4	360
Solpugida	1.0	0.1	0.5	<0.1	0.5	<0.1	201
Araneida	2.7	0.1	0.0	0.0	0.4	<0.1	137
Acrididae	0.8	0.1	8.7	2.5	7.6	2.0	2,856
Tettigonidae	8.5	6.5	12.1	3.3	11.6	3.9	4,345
Gryllacrididae	6.3	0.8	13.0	5.2	12.1	4.3	4,538
Carabidae	9.2	0.2	9.8	0.2	9.7	0.2	3,644
Silphidae	4.5	0.5	4.3	0.7	4.3	0.7	1,623
Scarabacidae	14.2	0.4	14.5	0.3	14.5	0.4	5,422
Tenebrionidae	27.5	0.4	24.3	0.8	24.8	0.7	9,269
Other invertebrates	4.5	<0.1	3.9	0.1	3.9	0.1	1,456
Total numbers and estimated biomass (g)	5,031	6,685	32,400	28,584	37,431	35,269	37,431

burrows. In support of this, over 80 hr of feeding observations by the senior author failed to note any direct feeding on these insects. The beetles are probably attracted to the cool moist burrows and nest litter contained within.

Large Orthoptera were the only invertebrates of which individual taxa contributed >1 percent of the total biomass. In Washington, the coulee cricket (*Apote notabilis*) was by far the most important invertebrate prey, contributing 6.5 percent of the biomass. Coulee crickets were also the largest insect prey averaging over 1 g (dry weight). The most important invertebrate prey in Oregon was the Jerusalem cricket (*Stenopelmatus fuscus*—5.2% of the biomass) followed by the migratory grasshopper (*Melanoplus sanguinipes*—2.5%), the coulee cricket (1.7%), and *Steiraxys* sp. (1.7%). Jerusalem crickets (*Stenopelmatus* spp.) have been reported to be important in the diet of other burrowing owl populations (Maser *et al.* 1971, Thomsen 1971, Gleason and Craig 1979, Brown *et al.* 1986). Other important invertebrate prey in-

cluded the burying beetle (Silphidae; *Nicrophorus* sp.—0.7% of the total biomass), several species of darkling beetles (Tenebrionidae; *Eleodes* spp.—0.6%), and scorpions (0.4%). Overall, the insect families Carabidae, Scarabacidae, and Tenebrionidae contributed over 30 prey species and 49 percent of the individuals consumed but only 1.3 percent of the total biomass.

Diets of burrowing owls elsewhere (reviewed by Gleason and Craig [1979]) have shown, as in this study, that these raptors feed predominantly on arthropods and small mammals. Our overall vertebrate:arthropod ratio (10:90%) is very similar to Marti's (1974) results (8:92%) from Colorado; however, prey species composition was quite different. Much higher percentages of vertebrates were found in burrowing owl diets in California (29.3%, Jaksic and Marti 1981; 31.4-41.2%, Thomsen 1971) and Chile (20.0%, Jaksic and Marti 1981). Jaksic and Marti (1981) surmised that the greater proportion of vertebrate prey at their California and Chile study sites

compared to the Colorado site reflected differential prey availability rather than differential selection.

We too attribute the differences between Oregon and Washington owl diets to differential prey availability, which in turn are affected by habitat differences (including soil type), annual variations in rainfall on summer estivation patterns of rodents, and the annual variation of insect populations. For instance, at the Oregon site in 1980, vertebrates comprised 12.6 percent of the diet even though grasshoppers (Acrididae—26.4%) were at epidemic population levels and the proportion of vertebrates in the diet had dramatically decreased from 49 percent in April to less than 5 percent in August (Green and Anthony 1989). In contrast, the composition of vertebrates and grasshoppers in the Oregon diet in 1981 decreased to 7.0 percent and 2.8 percent, respectively, with a corresponding increase in coleopteran prey from 23.3 percent to 62.7 percent; suggesting significant annual variations in diet. Furthermore, O'Farrell *et al.* (1975) determined that annual rainfall in the Columbia Basin and its effect on seed production governed the density and aboveground activity of Great Basin pocket mice. In their study, pocket mice had five-fold changes in population size and 30-day differences in above-ground activity between wet and dry years. Because the Oregon and Washington studies were not conducted during the same years, annual variation in rainfall may have contributed to differences in diet composition.

In addition, differences in vertebrate prey composition between Washington and Oregon were influenced by differences in soil type. Edaphic factors such as depth, texture, and strength have been found to affect populations of small mammals (Best 1969, Kritzman 1974, Feldhammer 1979). Within the Washington and Oregon study sites, two basic soil types were present, loamy-sand and silty-loam. Within the loamy-sand sites pocket mice clearly dominated both the percent number and percent biomass of the mammalian prey at both sites (Table 2). While at the silty-loam sites in Oregon, deer mice (*P. maniculatus*), northern pocket gophers, and Great Basin pocket mice were found in nearly equal numbers, but pocket gophers provided most of the biomass (Table 2). In Washington, pocket gophers also dominated the biomass on silty-loam sites, although pocket mice represented 36 percent of the biomass. In terms of numbers at the Washington silty-loam sites,

pocket mice and sagebrush voles were most common. Consequently, dietary composition between Oregon and Washington at the loamy-sand sites were very similar, while at the silty-loam sites the dominance of deer mice in Oregon was replaced by sagebrush voles in Washington. Because sagebrush voles occur in the Columbia Basin of Oregon, their absences in the Oregon diets may be a result of habitat differences other than soil types between the Oregon and Washington sites.

TABLE 2. Composition of mammalian prey of burrowing owls nesting in loamy-sand and silty-loam soils in the Columbia Basin of Washington (1977-78) and Oregon (1980-81).

Prey Species	Loamy-sand Soil		Silty-loam Soil	
	% No.	% Biomass	% No.	% Biomass
Washington (n=333)				
<i>Perognathus parvus</i>	80.2	77.2	44.7	36.0
<i>Peromyscus maniculatus</i>	15.6	12.2	5.0	3.2
<i>Thomomys talpoides</i>	1.6	9.0	9.2	44.4
<i>Lagurus curtatus</i>	1.6	0.7	41.1	16.4
Other	1.0	0.9	0	0
Oregon (n=2,689)				
<i>Perognathus parvus</i>	66.4	41.1	26.4	10.5
<i>Peromyscus maniculatus</i>	16.6	11.7	31.1	14.0
<i>Thomomys talpoides</i>	5.0	15.5	28.8	57.1
<i>Dipodomys ordii</i>	4.7	10.7	6.1	3.9
<i>Microtus montanus</i>	3.9	6.2	4.0	4.0
Lagomorphs	2.8	14.5	1.3	4.0
Other	0.6	0.4	2.3	1.5

Feldhammer (1979) found a positive correlation between population densities of Great Basin pocket mice and the percentage of sand in the soil, which may aid their digging efforts, and a negative correlation between percent sand and deer mice densities and speculated that deer mice were avoiding the more arid, sandy soils. The same may be true for northern pocket gophers, although Miller (1964) found that this species occupied the widest range of soil types of the four species of pocket gophers he studied in Colorado.

The shift from vertebrate to orthopteran prey in 1980 and the subsequent shift to coleopteran prey by 1981 in Oregon indicates an opportunistic foraging behavior by burrowing owls. The presence

of a wide variety of prey taxa and sizes, including ichneumon wasps, blow fly pupae, juvenile muskrats (*Odonatra zibethicus*), and crayfish (*Pacifastacus* sp.) further exemplifies opportunistic foraging. The vast difference in mean prey size (<4 mg to >40 g) and the presence of items killed but not eaten (Great Basin spadefoot toad, [*Scaphiopus intermontanus*]) suggests burrowing owls will pursue any potential prey they can physically handle. Schlatter *et al.* (1980) drew the same conclusion based on their study of burrowing owl diets in central Chile.

Over 90 percent of the vertebrate prey and the major insects such as the Jerusalem cricket and burying beetle were nocturnal species. Their presence in the diet indicates that burrowing owls feed nocturnally. Studies by the senior author also revealed intense feeding activity during the crepuscular hours for predominantly ground-dwelling beetles and grasshoppers; little direct feeding activity was observed during the daylight hours.

Acknowledgments

We thank J. W. Badden, G. A. Bloomstrom, K. A. Engel, R. A. Grove, B. Halc, H. Jones, R. J.

Small, and N. E. Woodley for their field and laboratory assistance, and P. Johnson, E. Perkins, and G. Peters for their assistance in arthropod identification. We especially thank refuge managers J. Kurtz and G. Constantino for their initiation and support of part of this project. E. L. Bull and E. Yensen provided helpful comments on earlier drafts of the manuscript. This study was funded by the Umatilla National Wildlife Refuge and the U.S. Department of Energy under contract DE-AC06-76RLO-1830 with additional support from The Nature Conservancy and The Order of the Antelope. Part of this study was conducted under the auspices of the Oregon Cooperative Wildlife Research Unit; Oregon State University, Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and Wildlife Management Institute cooperating. We dedicate this paper to the memory of Dr. Richard E. Fitzner.

Literature Cited

- Best, R. 1969. Habitat, annual cycle, and food of burrowing owls in southwestern New Mexico. M.S. Thesis, New Mexico State Univ., Las Cruces. 34 p.
- Brown, B. A., J. O. Whitaker, T. W. French, and C. Maser. 1986. Note on the food habits of the screech owl and burrowing owl of southeastern Oregon. *Great Basin Nat.* 46:421-426.
- Degn, H. J. 1978. A new method of analyzing pellets from owls, etc. *Dansk. Orn. Foren. Tidsskr.* 72:143.
- Feldhammer, G. A. 1979. Vegetative and edaphic factors affecting abundance and distribution of small mammals in southeast Oregon. *Great Basin Nat.* 39:207-218.
- Gano, K. A., and W. H. Rickard. 1982. Small mammals of a bitterbrush-cheatgrass community. *Northw. Sci.* 56:1-7.
- Gleason, R. L., and T. H. Craig. 1979. Food habits of burrowing owls in southeastern Idaho. *Great Basin Nat.* 39:274-276.
- Green, G. A. 1983. Ecology of breeding burrowing owls in the Columbia Basin, Oregon. M.S. Thesis, Oregon State University, Corvallis. 51 p.
- Green, G. A., and R. G. Anthony. 1989. Nesting success and habitat relationships of burrowing owls in the Columbia Basin, Oregon. *Condor* 91:347-354.
- Henny, C. J., and L. J. Blus. 1981. Artificial burrows provide new insight into burrowing owls nesting biology. *Raptor Res.* 15:82-85.
- Jaksic, F. M., and C. D. Marti. 1981. Trophic ecology of *Athene* owls in mediterranean-type ecosystems: A comparative analysis. *Can. J. Zool.* 59:2331-2340.
- Kritzman, E. B. 1974. Ecological relationships of *Peromyscus maniculatus* and *Perognathus parvus* in eastern Washington. *J. Mammal.* 55:172-188.
- Marti, C. D. 1974. Feeding ecology of four sympatric owls. *Condor* 76:45-61.
- Maser, C., E. W. Hammer, and S. A. Anderson. 1971. Food habits of the burrowing owl in central Oregon. *Northw. Sci.* 45:19-26.
- Miller, R. M. 1964. Ecology and distribution of pocket gophers (Geomyidae) in Colorado. *Ecology* 54:256-272.
- O'Farrell, T. P., R. J. Olson, R. O. Gilbert, and J. D. Hedlund. 1975. A population of Great Basin pocket mice, *Perognathus parvus*, in the shrub-steppe of south-central Washington. *Ecol. Monogr.* 45:1-28.
- Poulton, C. E. 1955. Ecology of the non-forested vegetation in Umatilla and Morrow counties, Oregon. Ph.D. Thesis, Washington State Univ., Pullman. 166 p.
- Rogers, L. E., and R. E. Fitzner. 1980. Characterization of darkling beetles inhabiting radioecology study areas at the Hanford site in southcentral Washington. *Northw. Sci.* 54:202-206.
- Rogers, L. E., and J. D. Hedlund. 1980. A comparison of small mammal populations occupying three distinct shrub-steppe communities in eastern Oregon. *Northw. Sci.* 54:183-186.

Rogers, L. E., W. T. Hinds, and R. L. Buschbom. 1976. A general weight vs. length relationship for insects. *Annals of the Entomol. Soc. of Am.* 69:387-389.

Ruffner, J. A. 1978. *Climates of the United States, Vol. 2.* Gale Research Co. Book Tower, Detroit, Mich. 578 p.

Schlatter, R. P., J. L. Yanez, H. Nunez, and F. M. Jaksic. 1980. The diet of the burrowing owl in central Chile and its relation to prey size. *Auk* 97:616-619.

Thomsen, L. 1971. Behavior and ecology of burrowing owls on the Oakland Municipal Airport. *Condor* 73:177-192.

Received 10 August 1991

Accepted for publication 24 August 1992