

SHORT COMMUNICATIONS

Food habits of Mexican Spotted Owls in Arizona.—The Spotted Owl (*Strix occidentalis*) is most common in mature and old-growth coniferous forests throughout much of its range (Forsman et al. 1984, Laymon 1988, Ganey and Balda 1989a, Thomas et al. 1990). Proximate factors underlying habitat selection in Spotted Owls are understood poorly. Abundance and availability of food, however, may be a key factor influencing habitat selection in birds in general (Hilden 1965) and in owls in particular (Southern and Lowe 1968). In addition, prey abundance has been implicated as an important influence on reproduction in many owls (e.g., Rusch et al. 1972, Lundberg 1976, Wendland 1984).

In many areas, only two or three species of prey comprise 70–90% of prey biomass in Spotted Owl diets (Thomas et al. 1990:205–215). Understanding the ecology of these key species of prey could contribute greatly to understanding the ecology of the Spotted Owl. Despite this possibility, little is known about the diet of the Mexican subspecies of the Spotted Owl (*S. o. lucida*), which inhabits the southwestern United States and Mexico (Forsman et al. 1984). Previous reports suggest that Mexican Spotted Owls prey heavily on woodrats (*Neotoma* spp.) and also take other small mammals, birds, reptiles, and invertebrates (Ligon 1926, Marshall 1957, Kertell 1977, Wagner et al. 1982, Ganey et al. 1988, Duncan and Sidner 1990). These reports are based on small samples from restricted geographic areas, however, and may not reflect the full range of the diet in the southwest.

Information on food habits of the Mexican Spotted Owl was gathered at locations scattered throughout Arizona from 1984–1990. This is the first broad survey of food habits of Spotted Owls in the Southwest, and could aid in designing future studies on both feeding ecology of Mexican Spotted Owls and the prey populations on which they depend.

Methods.—Pellets and prey remains were collected beneath Spotted Owl roost and nest sites in habitats ranging from mid-elevation (1125 m) rocky canyons to high-elevation (2930 m) mixed-conifer forests. Remains were collected opportunistically whenever they were found. All remains collected during a visit to a site were treated as a single sample because remains of large vertebrates can appear in more than one pellet (Forsman et al. 1984). If some pellets appeared markedly older than others, however, I identified two samples as containing old and recent pellets, respectively (Forsman et al. 1984). Older pellets were dry, dusty, and partially disintegrated.

All prey remains collected were dated and grouped by five geographic regions: the San Francisco Peaks, approximately 3 km north of Flagstaff; Walnut Canyon, approximately 4 km southeast of Flagstaff; Black Mesa, on the Navajo Reservation in northeastern Arizona; the White Mountains of east-central Arizona; and southeastern Arizona (including the Santa Catalina, Santa Rita, Huachuca, and Chiricahua Mountains). Pellets were collected from three to 11 pairs of owls within each geographic area. Lumping of pellets from adjacent pairs may have masked variation in dietary composition among individual pairs (Laymon 1988), but was necessary because pellets collected from areas of overlap between adjacent pairs could not always be unambiguously assigned to a particular pair. Also, sample sizes were too small to characterize the diet adequately for most individual pairs.

Vertebrate prey were identified by comparison with specimens in the Northern Arizona University Museum of Vertebrates (NAUMV), using skeletal remains or feathers. The minimum number of individuals of each species was determined in each sample by counting skulls, right or left rami, or other identifiable skeletal remains (Forsman et al. 1984).

Invertebrates were identified and counted using mandibles, femurs, wings, or fragments of exoskeleton. In samples containing beetle legs, I estimated the minimum number of

individuals by counting all legs and dividing by six. Biomass of each species in the diet was estimated by multiplying the number of individuals by mean wet body mass. Body mass estimates were obtained from the literature (Steenhof 1983, Forsman et al. 1984, Severson and Hayward 1988) or from specimen records (NAUMV). A table of common and scientific names for all prey items, along with estimates of body mass and sources for those estimates, is available from the author.

The opportunistic nature of the sampling limited the types of analyses I could conduct. Because sites were visited with differing frequencies in different years and seasons, unknown biases may exist within the data if there are interactions among region, season, and year. A preliminary log-linear analysis indicated that such interactions were present in the data, suggesting that in further comparisons all but one factor should be held constant.

Collections of ≥ 100 items per treatment were assumed necessary to characterize the diet for statistical comparisons (after Marti 1988). Sample sizes for most combinations of region, season, and year were inadequate by this criterion. Therefore, I view these data as useful primarily to describe some aspects of the feeding ecology of Spotted Owls, and have largely avoided statistical comparisons.

Results.—Between May 1984 and August 1990, I identified 1434 prey items from pellets or kills of 34 pairs of owls. The diet included at least 19 species of mammals, seven species of birds, two species of reptiles, and an unknown number of insect species. Vertebrates dominated the diet in all five regions, comprising 84–96% of total prey and 99% of prey biomass (Table 1). Mammals accounted for 73–96% of total prey and 91–99% of prey biomass. Owls consumed prey ranging in mass from beetles (Coleoptera) and moths (Lepidoptera) (ca 1 g) to adult cottontail rabbits (*Sylvilagus* spp.; ca 650 g). Mean prey mass ranged from 63–118 g in various regions.

Woodrats, white-footed mice (*Peromyscus* spp.), and voles (*Microtus* spp.) accounted for 61–83% of the total prey and 59–88% of total biomass in various regions (Table 1). Cottontails and pocket gophers (*Thomomys* spp.) accounted for another 3–14% of total prey and 7–36% of total biomass. Birds and reptiles contributed little to prey numbers or biomass except in Southeast Arizona. Insects were relatively common in the diet (3–16% of total prey) but contributed little to prey biomass. Diurnally active mammals such as squirrels and chipmunks (Sciuridae) accounted for <3% of total prey or biomass.

There appeared to be differences in the diet among regions within Arizona (Table 1), but after controlling for season and year, sample sizes were insufficient for statistical comparisons among regions. In general, woodrats and white-footed mice were common in the diet (>10% of total prey) in all regions. Voles were common in three regions, but were uncommon on Black Mesa, and did not appear in the diet in Southeast Arizona. Bats (Chiroptera), birds, and insects were most common in the diet in Southeast Arizona, and reptiles were observed in the diet only in that region.

I was able to compare dietary composition among years in only one region (Walnut Canyon, 1984–1987) and then only after combining prey categories to avoid low expected values. Dietary composition during the breeding season varied significantly among years (Table 2; $\chi^2 = 45.7$, $df = 12$, $P < 0.001$; $N = 4$ years and 655 items). The diet also appeared to vary among years on the San Francisco Peaks (Table 2), but sample sizes were too small for meaningful comparisons. Mammals comprised the majority of the diet in all regions in all years.

I could not compare dietary composition among seasons because most data (79%) were collected during the breeding season. In general, fewer bats and insects were taken during the nonbreeding season (1 September–28 February; Ganey and Balda 1989b) than during the breeding season, whereas the most common mammalian taxa were taken in relatively high numbers in both seasons.

TABLE 1
DIETARY COMPOSITION OF MEXICAN SPOTTED OWLS IN FIVE GEOGRAPHIC REGIONS IN ARIZONA, 1984-1990^a

Prey type ^b	Walnut Canyon		San Francisco Peaks		White Mountains		Black Mesa		Southeast Arizona	
	Prey (711)	Biomass (79,037)	Prey (276)	Biomass (17,455)	Prey (157)	Biomass (12,847)	Prey (89)	Biomass (10,492)	Prey (201)	Biomass (13,055)
<i>Neotoma</i>	33.1	50.0	18.5	49.1	17.8	36.6	57.3	81.7	22.4	57.9
<i>Peromyscus</i>	26.3	5.7	33.0	12.5	20.4	6.0	23.6	4.8	38.8	14.3
<i>Microtus</i>	14.3	4.5	27.2	15.0	37.6	16.1	2.2	0.7	0.0	0.0
<i>Sylvilagus</i>	8.4	29.6	1.1	6.7	5.1	24.3	1.1	3.7	2.0	11.9
<i>Thomomys</i>	6.0	6.1	5.1	9.1	5.7	7.9	3.4	3.2	0.5	0.9
Bats	1.7	0.2	0.0	0.0	0.0	0.0	2.2	0.3	5.5	1.5
Other mammals	3.0	2.3	3.3	4.4	5.7	6.0	5.6	4.1	3.5	4.6
Birds	2.5	1.5	2.9	3.1	3.8	3.1	1.1	0.6	7.5	7.7
Reptiles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.9
Insects	4.6	<0.1	9.1	<0.1	3.8	<0.1	3.4	<0.1	16.4	0.3
Average prey mass (g)	111		63		82		118		65	

^aAll values in columns are percentages and the total number of prey and total biomass (g) in parentheses.

^bNumbers of pairs represented: Walnut Canyon = 3; San Francisco Peaks = 7; White Mountains = 11; Black Mesa = 3; Southeast Arizona = 10.

TABLE 2
ANNUAL VARIATION IN THE DIET OF SPOTTED OWLS IN TWO REGIONS IN ARIZONA. VALUES REPRESENT % OF TOTAL PREY COLLECTED DURING THE BREEDING SEASON (1 MARCH–31 AUGUST)

Site	Year	N	Prey type				
			Neotoma	Peromyscus	Microtus	Other mammals	Other
Walnut Canyon	1984	116	42.2	25.0	10.3	12.9	9.5
	1985	249	21.7	28.1	20.1	19.3	10.8
	1986	188	41.0	27.1	10.1	19.7	2.1
	1987	102	32.4	24.5	13.7	24.5	4.9
San Francisco Peaks	1986	61	18.0	24.6	16.4	18.0	23.0
	1987	110	10.0	56.4	23.6	6.4	3.6
	1988	79	25.3	10.1	44.3	7.6	12.7

Discussion.—Small mammals dominate the diet of Spotted Owls in Arizona, with a few species comprising the bulk of the diet. This was also generally true in other areas where food habits of Spotted Owls were studied (e.g., Barrows 1980, Wagner et al. 1982, Forsman et al. 1984, Laymon 1988). In Arizona, the most common prey groups (woodrats, white-footed mice, and voles) were common in the diet in most regions, both seasons, and all years.

The range of average prey masses in Arizona (63–118 g; Table 1) fell within the range reported by Forsman et al. (1984) for Spotted Owls in different regions in Oregon (54–150 g). Barrows (1980) reported an average prey mass of > 100 g for Spotted Owls in California.

Spotted Owls prey heavily on woodrats in many areas (e.g., Barrows 1980, Wagner et al. 1982, Forsman et al. 1984). The relative abundance of woodrats in the diet appears to vary as a function of habitat, however. For example, Spotted Owls in Oregon preyed heavily on woodrats in xeric forests. In more mesic forests, where woodrats were uncommon, northern flying squirrels (*Glaucomys sabrinus*) comprised the bulk of the diet (Forsman et al. 1984, Thomas et al. 1990). Similar patterns occurred in Arizona. In northern Arizona, Spotted Owls ate fewer woodrats and more voles in mesic high elevation forest areas (San Francisco Peaks and White Mountains) than in more xeric areas dominated by rocky canyons (Walnut Canyon and Black Mesa). Most woodrats taken were probably either Mexican (*N. mexicana*) or white-throated (*N. albigula*) woodrats, based on distribution and habitat use of these species. These species are most abundant around rock outcrops and cliffs (Goodwin and Hungerford 1979, Hoffmeister 1986), habitats far more common in the Walnut Canyon and Black Mesa regions than in the San Francisco Peaks and White Mountains regions. In contrast, most voles taken were probably Mexican (*M. mexicanus*) or long-tailed (*M. longicaudus*) voles, species that are more abundant in the grassy understories of forests in the latter regions (Hoffmeister 1986). The importance of habitat as a factor contributing to variation in dietary composition was also suggested by the differences in the diets of owls in Walnut Canyon and on the San Francisco Peaks, two regions that were close geographically but very different in habitat composition.

The annual variation in the diet may indicate that Spotted Owls respond to changes in prey availability among years. Forsman et al. (1984) also noted annual variation in the diet in Oregon. In that study, as in Arizona, the major prey taxa were generally well represented

in all years, although relative rankings changed somewhat. Neither study was based on systematic sampling, however, and sampling bias may have contributed to the apparent annual variation (Forsman et al. 1984).

Analyses of food habits based on pellet analysis may be subject to bias. I probably underestimated the number of insects in the diet, because remains of such animals are less likely to be found in pellets than vertebrate remains. The proportion of insects in the diet would have to increase greatly in order for insects to contribute much to prey biomass, however.

Future studies of food habits of Spotted Owls should attempt to gather larger samples from individual pairs to examine variation among pairs. Systematic sampling of particular pairs across seasons and years could provide useful information on the extent of temporal variation in dietary composition. Studies that quantified abundance of small mammals would be particularly useful, as they would allow comparisons of use and availability of various taxa. Future studies should also examine habitat relationships of selected small mammals to provide insight into habitat features important to population levels of prey species. In Arizona, particular attention should be paid to factors influencing the distribution and abundance of woodrats, white-footed mice, and voles because of their abundance in the diet.

Because small mammals dominate the diet of Spotted Owls in Arizona, management activities that reduce small mammal populations in areas inhabited by Spotted Owls should be avoided. In most cases, this probably means that adequate amounts and types of downed wood should be maintained for hiding cover (Goodwin and Hungerford 1979). The effects of livestock grazing on herbaceous vegetation and vole abundance should also be evaluated where Spotted Owls occur.

Acknowledgments.—Thanks to D. Aubuchon, N. Dodd, G. Goodwin, C. LaRue, S. Nagiller, J. Stephenson, and J. Vahle for assistance in collecting pellets. L. and S. Ganey helped dissect pellets. G. Bateman, K. Dial, K. Paige, and especially N. Czaplewski helped identify mammalian remains. M. Hetz assisted with identification of insect remains. C. Barrows, W. Block, C. Marti, and K. Steenhof reviewed earlier drafts of this paper. This research was funded largely by the USDA Forest Service, Southwestern Region, through an agreement with the Arizona Game and Fish Department, Nongame Branch. Additional funding was provided by the National Wildlife Federation, the Arizona Wildlife Federation, and the Arizona Wildlife Foundation.

LITERATURE CITED

- BARROWS, C. W. 1980. Feeding ecology of the Spotted Owl in California. *Raptor Res.* 14: 73–78.
- DUNCAN, R. B. AND R. SIDNER. 1990. Bats in Spotted Owl pellets in southern Arizona. *Great Basin Nat.* 50:197–200.
- FORSMAN, E. D., E. C. MESLOW, AND H. M. WIGHT. 1984. Distribution and biology of the Spotted Owl in Oregon. *Wildl. Monogr.* 87.
- GANEY, J. L. AND R. P. BALDA. 1989a. Distribution and habitat use of Mexican Spotted Owls in Arizona. *Condor* 91:355–361.
- AND ———. 1989b. Home range characteristics of Spotted Owls in northern Arizona. *J. Wildl. Manage.* 53:1159–1165.
- , J. A. JOHNSON, R. P. BALDA, AND R. W. SKAGGS. 1988. Mexican Spotted Owl. Pp. 145–150 *in* Proc. Southwest raptor management symposium and workshop (R. L. Glineski, B. G. Pendleton, M. B. Moss, M. N. LeFranc, Jr., B. A. Millsap, and S. W. Hoffman, eds.). Natl. Wildl. Fed., Washington, D.C.

- GOODWIN, J. G., JR. AND C. R. HUNGERFORD. 1979. Rodent population densities and food habits in Arizona Ponderosa Pine forests. USDA For. Serv. Res. Pap. RM-214. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
- HILDEN, O. 1965. Habitat selection in birds: a review. *Ann. Zool. Fenn.* 2:53-73.
- HOFFMEISTER, D. F. 1986. Mammals of Arizona. Univ. of Arizona Press, Tucson, Arizona.
- KERTELL, K. 1977. The Spotted Owl at Zion National Park, Utah. *West. Birds* 8:147-150.
- LAYMON, S. A. 1988. Ecology of the Spotted Owl in the central Sierra Nevada, California. Ph.D. diss., Univ. of California, Berkeley, California.
- LIGON, J. S. 1926. Habits of the Spotted Owl (*Syrnium occidentale*). *Auk* 43:421-429.
- LUNDBERG, A. 1976. Breeding success and prey availability in a Ural Owl (*S. uralensis* Pall.) population in central Sweden. *Zoon.* 4:65-72.
- MARSHALL, J. T., JR. 1957. Birds of the pine-oak woodlands in southern Arizona and adjacent Mexico. *Pac. Coast Avif.* 32:78-79.
- MARTI, C. D. 1988. A long-term study of food-niche dynamics in the Common Barn Owl: comparisons within and between populations. *Can. J. Zool.* 66:1803-1812.
- RUSCH, D. H., E. C. MESLOW, P. D. DOERR, AND L. B. KEITH. 1972. Response of Great Horned Owl populations to changing prey densities. *J. Wildl. Manage.* 36:282-296.
- SEVERSON, K. E. AND B. J. HAYWARD. 1988. Rodent weights in modified pinyon-juniper woodlands of southwestern New Mexico. *Great Basin Nat.* 48:554-557.
- SOUTHERN, H. N. AND V. P. W. LOWE. 1968. The pattern of distribution of prey and predator in Tawny Owl territories. *J. Anim. Ecol.* 37:75-97.
- STEENHOF, K. 1983. Prey weights for computing percent biomass in raptor diets. *Raptor Res.* 17:15-27.
- THOMAS, J. W., E. D. FORSMAN, J. B. LINT, E. C. MESLOW, B. R. NOON, AND J. VERNER. 1990. A conservation strategy for the Northern Spotted Owl. Rep. of the Interagency Scientific Committee to address the conservation of the Northern Spotted Owl. U.S. Govt. Printing Off.:1990-791-171/20026.
- WAGNER, P. W., C. D. MARTI, AND T. C. BONER. 1982. Food of the Spotted Owl in Utah. *Raptor Res.* 16:27-28.
- WENDLAND, V. 1984. The influence of prey fluctuations on the breeding success of the Tawny Owl (*S. aluco*). *Ibis* 126:285-295.

JOSEPH L. GANEY, *Dept. of Biological Sciences, Northern Arizona Univ., Flagstaff, Arizona 86001.* (Present address: Rocky Mountain Forest and Range Experiment Station, 700 S. Knoles Drive, Flagstaff, Arizona 86001.) Received 26 Aug. 1991, accepted 18 Nov. 1991.

Wilson Bull., 104(2), 1992, pp. 326-333

Nestling growth rates of Short-eared Owls.—The Short-eared Owl (*Asio flammeus*) is a widely distributed ground-nesting species (Burton 1973). Nests are difficult to locate, and consequently few data are available concerning the owl's breeding biology (Clark 1975, Cramp 1985). Clark (1975) reported nestling growth for three captive Short-eared Owls from Manitoba, Canada. Hagen (1952) provided growth data for two nestling Short-eared Owls from Norway. Wijnandts (1984) reported growth models for Hagen's data and perhaps from some unpublished data. Unfortunately, it is unclear if the unpublished data were for masses or some other category; the numbers were not stated. Here we describe growth rates of wild nestling Short-eared Owls. To our knowledge, this is the first report of such data for North America.