J. Raptor Res. 39(4):429–438

A COMPARISON OF BREEDING SEASON FOOD HABITS OF BURROWING OWLS NESTING IN AGRICULTURAL AND NONAGRICULTURAL HABITAT IN IDAHO

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ABSTRACT.—Through analysis of regurgitated pellets and prey remains collected at nests between 2001–02, we characterized diet composition of western Burrowing Owls (*Athene cunicularia hypugaea*) in the Snake River Birds of Prey National Conservation Area (NCA) of southwestern Idaho. We hypothesized that diet differs between owls nesting in agricultural and nonagricultural habitat, because at least one important prey species, montane voles (*Microtus montanus*), occurs predominately in the former. From 859 pellets, we identified 7402 prey items representing 23 species, and identified 403 prey remains of 19 species. Invertebrates dominated the diet in numbers of prey, whereas rodents contributed the greatest biomass. Montane voles, which were not present in pellets in nonagricultural areas, represented the greatest percent biomass of pellets in agricultural areas. Invertebrates (predominately Gryllidae) also were more abundant in diets of owls nesting in agricultural habitat. Pellets of owls nesting in agricultural areas had greater species richness, whereas pellets from nonagricultural areas had greater species evenness and broader food-niche breadths. Finally, we estimated food-niche breadth of Burrowing Owls in the NCA to be broader than previously reported.

KEY WORDS: *Burrowing Owl*; Athene cunicularia; *agriculture*; *food habits*; *food-niche*; *Idaho.*

UNA COMPARACIÓN DE LOS HÁBITOS ALIMENTICIOS DE INDIVIDUOS NIDIFICANTES DE *ATHENE CUNICULARIA* EN AMBIENTES AGRICOLAS Y NO AGRICOLAS EN IDAHO

RESUMEN.—A través del análisis de egagrópilas y de restos de presas recolectados en nidos en 2001 y 2002, caracterizamos la composición de la dieta de *Athene cunicularia hypugaea* en el Área Nacional de Conservación de Aves de Presa Snake River, sudoeste de Idaho. Nos planteamos la hipótesis de que la dieta difiere entre las lechuzas que nidifican en ambientes agrícolas y no agrícolas, debido a que al menos una de las especies de presa importantes, *Microtus montanus,* se encuentra predominantemente en las áreas agrícolas. De un total de 859 egagrópilas, identificamos 7402 ítems de presas correspondientes a 23 especies, e identificamos 403 restos de presas provenientes de 19 especies. Los invertebrados dominaron la dieta en términos del número de presas, mientras que los roedores representaron la mayor biomasa. *Microtus montanus* no estuvo presente en las egagrópilas de las áreas no agrícolas y representó el mayor porcentaje de biomasa en las egagrópilas de las áreas agrícolas. Los invertebrados (predominantemente Gryllidae) también fueron abundantes en las dietas de las lechuzas que nidificaron en los ambientes agrícolas. Las egagrópilas de las lechuzas que nidificaron en las áreas agrícolas presentaron mayor riqueza de especies, mientras que las provenientes de las áreas no agrícolas presentaron mayor equidad y nichos alimenticios más amplios. Finalmente, estimamos que el nicho alimenticio de *A. c. hypugaea* en el área silvestre de conservación estudiada es más amplio de lo que había sido informado previamente.

[Traducción del equipo editorial]

Agricultural practices historically have provided many different types of wildlife habitat, including shelterbelts, hedgerows and fencerows, cultivated fields, and fields in rotation. Although some species nest, seek cover, and forage in these habitats, many wildlife populations have declined significantly in areas of agricultural conversion (Carlson 1985, Murphy 2003). In fact, there is mounting evidence that converting natural landscapes into agricultural use can affect a wide array of wildlife populations through erosion, exposure to herbicides and pesticides, and destruction of nesting and cover habitat (Carlson 1985, Jahn and Schenck 1991, Gervais et al. 2000). These effects may be

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amplified by the shift from small-scale farming practices to large-scale monoculture farming seen throughout the United States and Canada (Peterjohn 2003).

Western Burrowing Owls (*Athene cunicularia hypugaea*) are listed as Endangered in Canada and several western U.S. states, and their populations are declining in many areas (e.g., James and Espie 1997, Clayton and Schmutz 1999, Klute et al. 2003). These owls suffer deleterious effects from agricultural practices (James and Fox 1987, Haug et al. 1993, Bellocq 1997, Gervais et al. 2000) and, in Canada, often avoid agricultural fields (Haug and Oliphant 1990, Clayton and Schmutz 1999). However, throughout some portions of their western U.S. range, Burrowing Owls associate with agriculture (Rich 1986, DeSante et al. 2004, Moulton et al., in press), and they are the only raptor species that shows significant affinity for agriculture in southern Idaho (Leptich 1994). Rich (1986) suggested that proximity to montane voles (*Microtus montanus*) in farmlands could explain some of this habitat selection. Moulton et al. (in press) confirmed that owls did not nest in agricultural areas because of decreased nest predation or increased availability of nesting sites but noted that prey consumption was greater in agricultural areas.

If Burrowing Owl nesting distributions can be affected by prey, as Rich (1986) and Moulton et al. (in press) hypothesize, then diet composition may differ for owls occupying agricultural and nonagricultural areas. Thus, the objective of our study was to examine breeding season food habits of Burrowing Owls in the Snake River Birds of Prey National Conservation Area (NCA), where Burrowing Owls inhabit both agricultural and nonagricultural areas. Specifically, we tested the hypotheses that (1) diets of owls in agricultural areas contain more montane voles than those in nonagricultural habitats and (2) because of influences of agricultural practices, diet diversity and food-niche breadths differ. We predicted that Burrowing Owls nesting in agricultural habitats would have greater prey diversity and broader food-niche breadths than owls nesting in nonagricultural habitats. Finally, we compared our food-niche breadth estimates with those of a previous study (Marti et al. 1993) on raptor food habits in the NCA.

METHODS

We studied Burrowing Owls nesting within and near the NCA in southwestern Idaho during 2001–02. This area was once representative of a typical shrub-steppe community dominated by large expanses of big sagebrush (*Artemesia tridentata wyomingensis*; Hironaka et al. 1983) and other shrubs, and scattered perennial bunchgrasses. However, disturbances, such as range fires, military training, grazing, and off-road vehicle use, have helped convert much of the area to exotic annual grasslands dominated by cheatgrass (*Bromus tectorum*), tumble mustard (*Sisymbrium altissimum*), and other non-native species (Hironaka et al. 1983). Surrounding areas also contained scattered residential homes, paved and dirt roads, a military training area, and public lands managed by the Bureau of Land Management. Cattle and sheep graze much of the area, especially during winter. Irrigated agricultural fields (primarily alfalfa, sugar beets, and mint) constituted <5% of the NCA and were located primarily along its margins (USDI 1996). For the purpose of this study, we considered Burrowing Owl nests that were within 1 km of an irrigated agricultural field, to be in "agricultural" habitat (hereafter agricultural nests). Agricultural nests were located in the natural vegetation surrounding agriculture fields rather than in the irrigated portions where crops grew. However, adult owls frequently hunted within these fields and perched on fence posts adjacent to them (Moulton et al. in press). "Nonagricultural" habitat was the term we used to categorize nests that were greater than 3 km from irrigated fields (hereafter nonagricultural nests). Because this distance exceeded the typical foraging range of Burrowing Owls (Haug and Oliphant 1990, Rosenberg and Haley 2004), we are almost certain that owls from nonagricultural nests were not collecting prey from or near irrigated fields. Nonagricultural areas were generally disturbed shrublands and grasslands much like that in the agricultural areas, but there were no crops or irrigation nearby

Diet Composition. Regurgitated pellets are reliable indicators of the diet of Burrowing Owls (Marti 1974), although amphibians and reptiles can be underrepresented in pellets (Thomsen 1971, Haug 1985). Similarly, prey remains alone do not provide reliable information regarding overall diet composition, as many prey items consumed by Burrowing Owls are too small to cache (such as small insects). But, remains provide better information than pellets concerning amphibians and reptiles in the diet. Therefore, to determine diet composition, we both documented prey remains at nests and collected and analyzed regurgitated pellets.

Pellet Collection and Analysis. We collected regurgitated pellets from tunnel entrances, perches, and nearby mounds within 20 m of nest burrows every 3–10 d from hatching through 25 d post-hatch (May–June). For nests at which we collected more than 20 pellets (29 of 51 nests; 22 agricultural, 7 nonagricultural), we analyzed a random sample of 20 pellets per nest. For all other nests, we analyzed all collected pellets (11.2 ± 1.0 [SE] pellets per nest, range = 4–19).

We analyzed and quantified remains of each pellet using standard procedures (Marti 1987) and by comparing prey species to a museum collection at Boise State University. Skulls, jaws, dentition patterns, head capsules, pronota, elytra, legs, scales and other distinguishing body parts helped identify prey.

Prey Remains. Owls in this study nested in artificial burrows deployed for other studies (Smith and Belthoff 2001, Belthoff and Smith 2003, Brady 2004, Moulton et al. in press), which provided access to nest chambers, where we found most prey remains. We could therefore document cached and uneaten prey remains at all occupied nests and adjacent satellite burrows (non-nest burrows used by owls for roosting, cover, and caching prey). We quantified prey remains each time we excavated an artificial burrow (2–5 visits per nest) between hatching and 25 d post-hatch.

Biomass Estimation. We determined biomass of representative mammalian, avian, and amphibian prey using Smith and Murphy (1973) and Steenhof (1983). Biomass of invertebrate prey species was determined using our own estimates obtained from captured live specimens (Moulton 2003) and values reported in Smith and Murphy (1973) and Olenick (1990).

Statistical Analysis. Because we obtained prey remains from only two nonagricultural nests, we did not include data from prey remains in diversity calculations described below or in statistical comparisons; instead, pellet data provided all information used for these calculations and comparisons. We determined each prey type as a percent of total prey items per nest (percent number) and percent biomass per nest.

We determined food-niche breadth for agricultural and nonagricultural nests by calculating the reciprocal of Simpson's index (Simpson 1949). We calculated dietary evenness using the Alatalo (1981) modification of Hill's (1973) index: $F = (N_2 - 1)/(N_1 - 1)$.

To determine if differences in diets existed between owls nesting in each habitat, we compared percent number and percent biomass of each prey taxa (vertebrates), class (invertebrates), or order (invertebrates) per nest using Wilcoxon's ranked sums tests (Zar 1999). If there were differences between habitats in taxa/order of prey, we then compared species (vertebrates) or families (invertebrates) of that taxa/order. Because we made multiple comparisons of prey categories, we adjusted alpha levels using sequential Bonferroni corrections (Rice 1989).

To determine if diet diversity differed between agricultural and nonagricultural nests, we compared food-niche breadth (Simpson's index), species richness (number of species in the diet), and dietary evenness (Alatalo's index) using Wilcoxon's ranked sums tests. Statistical analyses were performed using JMPIN V.5 (SAS Institute, Inc., Cary, NC), and evaluated at an alpha level of 0.05 unless otherwise noted. Throughout, we present means with their standard errors.

RESULTS

Pellet Remains. We analyzed 602 regurgitated pellets from 34 agricultural nests and 257 pellets from 19 nonagricultural nests. From these, we identified 7402 prey items representing 23 different prey species.

Overall pellet composition. Invertebrates were the most frequent prey in pellets, representing 93% of prey items; however, they represented only 23% of biomass (Table 1). Conversely, vertebrates (rodents, birds, and herpetofauna) comprised 7% of prey items, but 77% of biomass.

Coleopterans (beetles) and Orthopterans (crickets, grasshoppers) were the most common invertebrates in pellets, constituting 47% and 32% of total prey, respectively (Table 1). Of Coleopterans, ground beetles (Carabidae) and darkling beetles (Tenebrionidae) were most common (33% and 22% of Coleopteran prey items, respectively). Orthopteran prey remains were predominately Gryllidae (crickets), which constituted 73% of Orthopteran prey items.

Rodents were the most common vertebrates in pellets and represented 97% of vertebrates detected and 73% of overall prey biomass (Table 1). Pocket mice (*Perognathus parvus*) and deer mice (*Peromyscus maniculatus*) were the most abundant rodents (37% and 25%, respectively), but montane voles represented the greatest biomass (18%).

Habitat variation. Invertebrates were the most frequent prey in pellets for both agricultural and nonagricultural nests, representing 95% and 90% of total prey items, respectively (Table 2). Vertebrate prey (mostly rodents) represented the greatest percent biomass in both agricultural (76%) and nonagricultural (79%) nests.

Coleopterans were the most common invertebrates in both habitats (Table 2). However, Arachnids contributed the greatest biomass (52%) of invertebrates in nonagricultural nests, and Orthopterans contributed the greatest biomass (52%) of invertebrates in agricultural nests. Of rodent species found in pellets, deer mice and pocket mice were most common in agricultural and nonagricultural nests, respectively. Pocket mice also contributed the greatest biomass of rodents at nonagricultural nests, but montane voles contributed the greatest biomass of rodents at agricultural nests. Only owls at agricultural nests preyed on montane voles (Table 2).

Agricultural and nonagricultural nests did not differ in percent biomass of vertebrates or invertebrates (Table 3). However, agricultural nests had a greater percent number of invertebrates, and nonagricultural nests had a greater percent number of vertebrates. Pellets from agricultural nests had greater percent number and percent biomass of montane voles (Table 4). Nonagricultural nests had greater percent number and biomass of pocket mice (Table 4). Among invertebrates, Arachnids and Orthopterans differed between habitats (Table 3). Solpugida (windscorpions) and Acrididae occurred in greater percent number and biomass in pellets of nonagricultural nests, while Gryllidae occurred in greater number and biomass in pellets at agricultural nests (Table 5).

For all nests combined, food-niche breadth was

Table 1. Mean (±SE) percent number and percent biomass per nest of prey items detected in pellets collected at 53 Burrowing Owl nests in southwestern Idaho, 2001–02.

PREY CATEGORY	PERCENT NUMBER	PERCENT BIOMASS
Mammals	6.7 ± 0.7	72.9 ± 2.5
Spermophilus mollis	0.2 ± 0.1	10.2 ± 3.4
Thomomys townsendii	0.2 ± 0.1	12.4 ± 3.5
Perognathus parvus	2.5 ± 0.6	12.5 ± 2.5
Dipodomys ordii	0.6 ± 0.2	9.4 ± 2.4
Reithrodontomus megalotis	0.1 ± 0.1	0.3 ± 0.1
Peromyscus maniculatus	1.7 ± 0.4	11.1 ± 2.5
Mus musculus	0.2 ± 0.1	1.2 ± 0.5
Microtus montanus	0.9 ± 0.2	13.2 ± 2.8
Rodent—unidentified[a]	0.4 ± 0.1	2.7 ± 0.7
Birds—unidentified[b]	0.2 ± 0.1	2.2 ± 0.8
Reptiles and Amphibians[c]	<0.1 ± 0.1	1.9 ± 1.2
Arachnids	13.8 ± 1.9	6.3 ± 1.0
Scorpionida	5.8 ± 1.0	3.5 ± 0.9
Solpugida	8.0 ± 1.5	2.8 ± 0.5
Orthopterans	31.6 ± 3.2	9.6 ± 1.6
Acrididae	2.9 ± 0.6	0.7 ± 0.1
Gryllidae	23.2 ± 3.5	7.7 ± 1.7
Unknown Orthoptera	5.5 ± 0.9	1.2 ± 0.2
Dermapterans (Forficulidae)	0.4 ± 0.2	0.2 ± 0.1
Homopterans (Cicadidae)	0.1 ± 0.1	0.1 ± 0.1
Coleopterans	47.0 ± 2.6	6.8 ± 0.7
Carabidae	15.7 ± 2.2	1.9 ± 0.3
Scarabidae	7.5 ± 1.3	1.1 ± 0.2
Silphidae	8.0 ± 1.4	1.1 ± 0.2
Tenebrionidae	10.6 ± 1.9	2.3 ± 0.4
Coleoptera—unidentified	5.3 ± 1.2	0.5 ± 0.1
Total vertebrates	6.9 ± 0.7	77.0 ± 2.1
Total invertebrates	93.1 ± 0.7	23.0 ± 2.1

[a] Mouse species: likely *P. parvus*, *R. megalotis*, *P. maniculatus*, or *M. musculus*.
[b] Likely *Eremophila alpestris* or *Sturnella neglecta*.
[c] Includes *Bufo woodhousei*, *Phrynosoma platyrhinos*, and unknown snake species.

4.22 ± 0.22 (N = 53). Nonagricultural (N = 19) nests had greater species evenness than agricultural (N = 34) nests (0.76 ± 0.03 versus 0.60 ± 0.02; Z = 3.89, P < 0.001) and broader food-niche breadth (5.21 ± 0.33 versus 3.67 ± 0.25; Z = 3.24, P = 0.001). However, agricultural nests had higher species richness (11.82 ± 0.40 versus 9.79 ± 0.54; Z = −2.69, P = 0.007).

Prey Remains. We recorded cached and other uneaten prey remains at 43 nests (N = 41 agricultural, N = 2 nonagricultural) and documented 403 prey items representing 19 species (Table 6). Because we had so few nonagricultural nests, we made no comparisons between habitats and pooled data from all nests for descriptions of prey remains.

Although common in pellets, invertebrate prey remains were uncommon in nest burrows (N = 50 individual invertebrate prey items). The majority of prey remains in both percent number (87.6%) and percent biomass (99.7%) were vertebrates, most of which were rodents. Of rodent species, montane voles were most common by number (36%), and pocket gophers represented the greatest biomass (50%).

Although rare in pellets, we occasionally found herpetofauna (N = 38) and birds (N = 18) cached in burrows. Woodhouse's toads (*Bufo woodhousei*) were the most common (92%) herpetofauna in nest burrows. All toads were in nests adjacent to agricultural fields. Burrowing Owl nestlings were the most common (50%) cached avian prey item

Table 2. Mean (±SE) percent number and percent biomass per nest of prey items detected in pellets of Burrowing Owls nesting in agricultural (N = 34) and nonagricultural (N = 19) habitats of southwestern Idaho, 2001–02.

	AGRICULTURAL		NONAGRICULTURAL	
PREY	PERCENT NO.	PERCENT BIOMASS	PERCENT NO.	PERCENT BIOMASS
Mammals	4.9 ± 0.8	70.7 ± 3.1	10.1 ± 1.1	76.9 ± 4.1
Spermophilus mollis	0.1 ± 0.1	5.3 ± 4.1	0.5 ± 0.2	0.2 ± 0.1
Thomomys townsendii	0.4 ± 0.1	1.9 ± 4.1	—	—
Perognathus parvus	0.7 ± 0.6	4.9 ± 2.6	5.6 ± 0.8	26.0 ± 3.4
Dipodomys ordii	0.4 ± 0.2	4.9 ± 2.8	1.2 ± 0.3	17.5 ± 3.8
Peromyscus maniculatus	1.4 ± 0.5	10.5 ± 3.1	2.1 ± 0.7	12.3 ± 4.2
Mus musculus	0.2 ± 0.1	1.9 ± 0.6	—	—
Microtus montanus	1.4 ± 0.3	20.6 ± 3.1	—	—
Birds—unidentified[a]	0.1 ± 0.1	2.3 ± 1.0	0.3 ± 0.1	2.0 ± 1.3
Reptiles and Amphibians[b]	0.1 ± 0.1	2.8 ± 1.5	0.1 ± 0.1	0.3 ± 2.0
Arachnida	6.7 ± 1.7	3.7 ± 1.1	26.5 ± 2.3	10.9 ± 1.4
Scorpionida	3.3 ± 1.1	2.0 ± 1.0	10.3 ± 1.5	6.0 ± 1.4
Solpugida	3.4 ± 1.6	1.7 ± 0.6	16.2 ± 2.1	4.9 ± 0.8
Orthoptera	40.0 ± 3.5	12.7 ± 1.9	16.7 ± 4.7	4.0 ± 2.6
Acrididae	1.8 ± 0.8	0.5 ± 0.2	4.9 ± 1.0	1.1 ± 0.2
Gryllidae	34.8 ± 3.5	11.4 ± 1.9	2.3 ± 4.7	1.0 ± 2.5
Coleoptera	47.6 ± 3.2	7.5 ± 0.8	46.1 ± 4.3	5.7 ± 0.1
Carabidae	21.4 ± 2.4	2.7 ± 0.4	5.5 ± 3.2	0.7 ± 0.5
Scarabidae	5.6 ± 1.5	1.0 ± 0.3	10.9 ± 2.0	1.3 ± 0.4
Silphidae	5.1 ± 1.7	0.9 ± 0.3	13.2 ± 2.3	1.4 ± 0.4
Tenebrionidae	11.1 ± 2.3	2.5 ± 0.6	9.6 ± 3.1	1.9 ± 0.7
Total vertebrates	5.0 ± 0.8	75.8 ± 2.6	10.3 ± 1.1	79.1 ± 3.5
Total invertebrates	95.0 ± 0.8	24.2 ± 2.6	89.7 ± 1.1	20.9 ± 3.5

[a] Likely *Eremophila alpestris* or *Sturnella neglecta*.

[b] Includes *Bufo woodhousei, Phrynosoma platyrhinos,* and unknown snake species.

we found. These Burrowing Owl nestlings all were individuals from nests other than the nest in which we found them. Whether they wandered into the nest on their own and subsequently starved or were killed or were taken directly from their nest is unknown. We suspect that adults tending nearby nests preyed upon these nestlings because they frequently were too young to have wandered into nests other than their own.

DISCUSSION

The NCA supports one of the highest densities of breeding raptors in the world (Marti et al. 1993), and many previous studies have examined food habits of nesting raptors there (e.g., Marks and Marks 1981, Marks and Doremus 1988, Marti 1988, Steenhof and Kochert 1988). However, dietary habits and trophic relationships of Burrowing Owls remain the least well-understood of raptors breeding in the NCA (Marti pers. comm.). Thus, our study filled an important knowledge gap in raptor ecology within the NCA. Our study found: (1) no one species dominated the vertebrate component of Burrowing Owl diets, unlike owls in other regions; (2) diets differed by habitat, most notably that montane voles and crickets were important prey for agricultural nests, but they were not part of the diet for nonagricultural nests; and (3) the food-niche breadth of Burrowing Owls in the NCA is broader than previously estimated.

Burrowing Owl Diet in the NCA. Burrowing Owls are considered opportunistic predators (Gleason and Craig 1979, Green et al. 1993, Haug et al. 1993), and the wide variety of prey owls consumed in our study area is consistent with this notion. Similar to studies in Colorado (Marti 1974), Saskatchewan (Haug 1985), and the Idaho National Engineering Laboratory (INEEL) in Idaho (Gleason and Craig 1979), invertebrates represented approximately 90–95% of prey items in regurgitated pellets, but they constituted only 20–30% of biomass of prey. In contrast, Olenick (1990), in

Table 3. Mean (±SE) percent number and percent biomass per nest of vertebrate (taxa) and invertebrate (class/order) prey detected in pellets of Burrowing Owls nesting in agricultural ($N = 34$) and nonagricultural ($N = 19$) habitats of southwestern Idaho, 2001–02.

PREY CATEGORY	HABITAT			
	AGRICULTURAL	NONAGRICULTURAL	Z^a	P-VALUE
Percent Number				
Mammal	4.9 ± 0.8	10.1 ± 1.1	3.01	0.003*
Bird	0.1 ± 0.1	0.3 ± 0.1	0.22	0.823
Reptile and Amphibian	0.1 ± 0.1	0.1 ± 0.1	−0.38	0.701
Arachnid	6.7 ± 1.7	26.5 ± 2.3	4.98	<0.001*
Orthopteran	40.0 ± 3.5	16.7 ± 4.7	−3.61	<0.001*
Coleopteran	47.6 ± 3.2	46.1 ± 4.3	−0.29	0.774
Total vertebrates	5.0 ± 0.8	10.3 ± 1.1	3.05	0.002*
Total invertebrates	95.0 ± 0.8	89.7 ± 1.1	−3.05	0.002*
Percent Biomass				
Mammal	70.7 ± 3.1	76.9 ± 4.1	1.03	0.303
Bird	2.3 ± 1.0	2.0 ± 1.3	0.02	0.988
Reptile and Amphibian	2.8 ± 1.5	0.3 ± 2.0	−0.51	0.613
Arachnid	3.7 ± 1.1	10.9 ± 1.4	4.12	<0.001*
Orthopteran	12.7 ± 1.9	4.0 ± 2.6	−3.24	0.001*
Coleopteran	7.5 ± 0.8	5.7 ± 0.1	−0.99	0.321
Total vertebrates	75.8 ± 2.6	79.1 ± 3.5	0.96	0.340
Total invertebrates	24.2 ± 2.6	20.9 ± 3.5	−0.96	0.340

[a] Data were compared using Wilcoxon's ranked sums tests.
* Significant based on sequential Bonferroni corrections adjusted from an original alpha level of 0.05 for a total of 16 comparisons

Table 4. Mean (±SE) percent number and percent biomass per nest of rodent species detected in pellets of Burrowing Owls nesting in agricultural ($N = 34$) and nonagricultural ($N = 19$) habitats of southwestern Idaho, 2001–02.

PREY SPECIES	HABITAT			
	AGRICULTURAL	NONAGRICULTURAL	Z^a	P-VALUE
Percent Number				
Spermophilus mollis	0.1 ± 0.1	0.5 ± 0.2	1.83	0.067
Thomomys townsendii	0.4 ± 0.1	0.0 ± 0.1	−2.72	0.007
Perognathus parvus	0.7 ± 0.6	5.6 ± 0.8	4.23	<0.001*
Dipodomys ordii	0.4 ± 0.2	1.2 ± 0.3	1.67	0.095
Peromyscus maniculatus	1.4 ± 0.5	2.1 ± 0.7	−1.43	0.153
Mus musculus	0.2 ± 0.1	0.0 ± 0.1	−2.25	0.025
Microtus montanus	1.4 ± 0.3	0.0 ± 0.4	−4.32	<0.001*
Percent Biomass				
Spermophilus mollis	5.3 ± 4.1	0.2 ± 0.1	1.86	0.063
Thomomys townsendii	1.9 ± 4.1	0.0 ± 5.4	−2.72	0.007
Perognathus parvus	4.9 ± 2.6	26.0 ± 3.4	4.00	<0.001*
Dipodomys ordii	4.9 ± 2.8	17.5 ± 3.8	1.79	0.073
Peromyscus maniculatus	10.5 ± 3.1	12.3 ± 4.2	−1.05	0.294
Mus musculus	1.9 ± 0.6	0.0 ± 0.8	−2.25	0.025
Microtus montanus	20.6 ± 3.1	0.0 ± 4.2	−4.32	<0.001*

[a] Data were compared using Wilcoxon's ranked sums tests.
* Significant based on sequential Bonferroni corrections adjusted from an original alpha level of 0.05 for a total of 14 comparisons

Table 5. Mean (±SE) percent number and percent biomass per nest of Arachnid orders and Orthopteran families detected in pellets of Burrowing Owls nesting in agricultural (N = 34) and nonagricultural (N = 19) habitats of southwestern Idaho, 2001–02.

	Habitat			
Prey Order/Family	Agricultural	Nonagricultural	Z^a	P-VALUE
Percent Number				
Arachnida				
Scorpiones	3.3 ± 1.1	10.3 ± 1.5	2.22	0.026
Solpugida	3.4 ± 1.6	16.2 ± 2.1	4.04	<0.001*
Orthoptera				
Acrididae	1.8 ± 0.8	4.9 ± 1.0	2.81	0.005*
Gryllidae	34.8 ± 3.5	2.3 ± 4.7	−5.43	<0.001*
Percent Biomass				
Arachnida				
Scorpiones	2.0 ± 1.0	6.0 ± 1.4	1.72	0.086
Solpugida	1.7 ± 0.6	4.9 ± 0.8	3.68	<0.001*
Orthoptera				
Acrididae	0.5 ± 0.2	1.1 ± 0.2	2.38	0.017*
Gryllidae	11.4 ± 1.9	1.0 ± 2.5	−5.26	<0.001*

[a] Data were compared using Wilcoxon's ranked sums tests.
* Significant based on sequential Bonferroni corrections adjusted from an original alpha level of 0.05 for a total of four comparisons each for Arachnida and Orthoptera.

southeastern Idaho, reported that invertebrates represent only 60% of the number of prey items and less than 3% of the biomass, and owls in the Imperial Valley, California, feed almost exclusively on invertebrates (York et al. 2002).

Although invertebrates generally constitute a large percentage of prey Burrowing Owls consume, the orders and families that are most common in the diet vary among regions. For example, Coleopterans were the most abundant invertebrate species in our study, as well as in Colorado (Marti 1974), Washington (Green et al. 1993), and Oregon (Green et al. 1993), whereas Jerusalem crickets (*Stenopelmatus* spp.) were the most important invertebrate prey species, in terms of biomass, for Burrowing Owls in Oregon (Green et al. 1993), California (Thomsen 1971), and southeastern Idaho (Gleason and Craig 1979).

Vertebrates accounted for most of the biomass in our study, but no one vertebrate species dominated the diet. Percent biomass of montane voles (17%), pocket mice (16%), pocket gophers (16%), and deer mice (14%) were similar. In contrast, *Microtus* sp. were the predominant vertebrate prey item in Montana (Holt et al. 2001) and represented 80% of biomass in owl diets in southeastern Idaho (Olenick 1990), and pocket mice dominated rodent prey in Oregon (97%; Green 1983). This lack of a dominant vertebrate prey may indicate a diverse prey base in our study area (Moulton et al. in press).

Agricultural versus Nonagricultural Nests. Comparisons of pellet remains from Burrowing Owl nests in agricultural and nonagricultural areas revealed different prey composition, species richness, species evenness, and food-niche breadth. Although both habitats had similar biomass of vertebrates, nonagricultural areas had greater numbers of rodent prey. In contrast, owls nesting adjacent to agricultural fields in southeastern Idaho had a higher proportion of rodents in their diet than those nesting in more natural areas (Gleason 1978). Agricultural nests had a higher proportion of invertebrates than nonagricultural nests, which resulted from the high numbers of crickets present in pellets from agricultural nests. Crickets were rare in pellets of owls nesting in nonagricultural habitats. Moulton et al. (in press) reported greater prey consumption by Burrowing Owls nesting near agricultural fields in the NCA; this difference primarily resulted from greater invertebrate prey in agricultural habitats. While some have suggested

Table 6. Percent number, percent biomass, and total number of cached and other uneaten prey remains documented at 43 Burrowing Owl nests in southwestern Idaho, 2001–02.

PREY CATEGORY	PERCENT NO.	PERCENT BIOMASS	TOTAL NO.
Mammals	73.70	87.67	297
Sylvilagus nuttallii	0.25	1.03	1
Thomomys townsendii	10.91	44.73	44
Dipodomys ordii	11.41	13.01	46
Perognathus parvus	2.48	0.77	10
Mus musculus	2.98	1.17	12
Mouse species[a]	18.86	5.86	76
Microtus montanus	26.80	21.10	108
Birds	4.47	8.09	18
Eremophila alpestris	0.25	0.09	1
Sturnus vulgaris	0.74	1.22	3
Sturnella neglecta	0.50	0.41	2
Passerine sp.[b]	0.25	0.15	1
Athene cunicularia—juv.	2.23	4.16	9
A. cunicularia—adult	0.25	1.03	1
Raptor sp.[c]	0.25	1.03	1
Amphibians	8.68	3.60	35
Bufo woodhousei	8.68	3.60	35
Reptiles	0.74	0.29	3
Pituophis catenifer	0.74	0.29	3
Scolopendromorpha	0.50	0.00	2
Arachnids	10.92	0.34	44
Scorpiones	10.67	0.33	43
Solpugida	0.25	0.01	1
Orthopterans	0.50	0.01	2
Acrididae	0.25	0.00	1
Gryllidae	0.25	0.00	1
Total vertebrates	87.59	99.65	353
Total invertebrates	12.41	0.35	50
Total			403

[a] Likely *P. parvus, R. megalotis, P. maniculatus*, or *M. musculus*.
[b] Likely *Eremophila alpestris* or *Sturnella neglecta*.
[c] Small juvenile hawk or Prairie Falcon (*Falco mexicanus*).

that Burrowing Owls associate with irrigated agriculture because of the high abundance of montane voles (Gleason 1978, Rich 1986), presence of high numbers of invertebrate prey in the diet of owls in agricultural habitat may indicate an overlooked importance of invertebrate prey to breeding Burrowing Owls in these areas.

Agricultural nests also had greater species richness than nonagricultural nests. Common rodent species in agricultural habitats, such as montane voles, were not in pellets of nonagricultural nests and likely were not available in that habitat type. However, nonagricultural nests had greater species evenness than agricultural nests. This greater species evenness likely contributed to our finding that diets of owls nesting in nonagricultural areas had a broader food-niche (i.e., greater diversity), as Simpson's diversity index can be greatly influenced by species evenness.

Narrower food-niche breadths of Burrowing Owls nesting near agricultural fields may indicate a more specialized diet. As MacArthur and Pianka (1966) proposed, one expects a species to specialize when prey availability is high (i.e., a productive environment), and thus search time is low. A species will generalize in unproductive environments where search times are high. Therefore, if owls in agricultural areas exhibit more specialized diets relative to owls in nonagricultural areas, we propose that owls nesting in agricultural areas are experiencing greater prey availability. This is consistent with suggestions by previous researchers (Gleason 1978, Rich 1986, Moulton et al. in press) that Burrowing Owls associate with agriculture because of increased prey. However, further research is needed to determine if the narrower food-niche breadth of owls in agricultural areas results from greater prey availability, where owls can be selective, or lower prey diversity.

Food-niche Breadth of Burrowing Owls in the NCA. Prior to our study, Burrowing Owls in the NCA were thought to have a very narrow food-niche breadth compared to other raptor species breeding there. Marti et al. (1993) estimated food-niche breadth of Burrowing Owls to be only 2.43, which was the narrowest food-niche breadth of all 12 raptor species studied. In contrast, food-niche breadth of Burrowing Owls in our study was 4.22 $\pm$ 0.22, which ranks Burrowing Owls seventh in terms of food-niche breadth (first being the broadest). This disparity may be explained in part by smaller sample sizes in Marti et al. (1993) combined with different levels of identification; that is, the 1993 study identified invertebrate prey to order, whereas we identified invertebrates to family when possible. Because this difference in prey level identification would only affect the food-niche breadth estimates of a species whose diet has a large invertebrate component, only Burrowing Owl estimates likely would be affected.

Compared to other raptors breeding within the NCA, our study estimated food-niche breadths of Burrowing Owls to be similar to Golden Eagles (*Aquila chrysaetos*; 4.07) and Long-eared Owls (*Asio otus;* 4.79; Marti et al. 1993). However, Burrowing Owl diet composition is more similar to American Kestrels (*Falco sparverius*), which also frequently prey on invertebrates (Marti et al. 1993). In fact, Burrowing Owls and American Kestrels are the only two raptor species in the NCA for which invertebrate prey comprises >1% of the diet (in terms of biomass: 23% and 5%, respectively).

ACKNOWLEDGMENTS

We thank T. Booms, K. Donohue, C. Eaton, J. Egbert, G. Fairhurst, K. Hasselblad, S. Lysne, R. Medeck, J. Rausch, J. Soules, M. Troxler, and J. Urbanic for assistance with fieldwork. Financial and logistical support was provided through an EPA STAR Fellowship to C. Moulton, grants from the Bureau of Land Management and Idaho Department of Fish and Game, and the Department of Biology and Raptor Research Center at Boise State University. J. Clark, J. Doremus, and J. Sullivan facilitated our work in the Snake River Birds of Prey National Conservation Area, and M. Fuller, Director of the Raptor Research Center, was helpful in numerous ways Finally, we thank J. Bednarz, C.S. Houston, J. Munger, T. Rich, and I. Robertson for helpful comments on previous versions of our manuscript.

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Received 1 December 2003; accepted 3 July 2005