

Assessing Prey Selection of Barn Owls in Western Nebraska by Using Pellet Analysis and Small-mammal Trapping

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Abstract - Research on prey selection strategies is important for understanding the connections between predators and their prey communities. Studies on prey selection by *Tyto alba* (Scopoli) (Barn Owls) show contradictory results; some showed that Barn Owls are random samplers of small mammal communities, whereas others found that they take prey disproportionate to prey abundance. Here, we compared pellet analysis and small-mammal trapping data to assess patterns of prey selection by Barn Owls in western Nebraska. *Microtus* Schrank spp. (vole spp.) constituted 55.8% of the 1163 prey items. The proportions of several prey types in the diet were significantly different from the expected proportions based on trapping. *Microtus* spp. occurred more frequently in the diet, whereas *Peromyscus* Gloger spp. (deer mouse spp.) occurred less frequently in the diet than expected. This pattern may indicate Barn Owls actively select *Microtus* spp., possibly because they are twice as large as *Peromyscus* spp. and are, therefore, relatively more energetically rewarding. Alternatively, this pattern may suggest that *Microtus* spp. are more available to Barn Owls than are *Peromyscus* spp.

Introduction

Food-web structure and the patterns of interactions among predator and prey play a key role in setting the stability of ecosystems and their ability to provide ecosystem services (Beckerman et al. 1997, Estes et al. 2011, Fortin et al. 2005). A predator's diet reflects its connections to the community in which it lives, so documenting diets provides information on food-web structure. Searching predators may make decisions about where to forage, when to forage, and what to attack when they encounter potential prey (Stephens and Krebs 1986). There is extensive literature assessing the degree to which a predator makes decisions that can increase or maximize fitness, including decisions regarding how long to hunt in a patch and what prey to include in the diet (Charnov 1976). Although uncertainty remains about whether predators forage optimally (Sih and Christensen 2001), the degree to which many predators take prey disproportionate to their availability in the environment remains unclear. Such patterns may or may not reflect adaptive strategies but are important in understanding the connections between predators and their prey communities.

Tyto alba (Scopoli) (Barn Owls) are widely studied for their prey selection because of their global distribution, conservation status, susceptibility to rodenticides, and use as a biocontrol agent for rodents (Kross et al. 2016, Moore et al. 1998). Barn Owls may be unbiased samplers of the small mammal community upon which they principally prey, with several studies showing that prey in Barn Owl diets are proportional to their abundance in the prey community (Andrade et al. 2016, Bernard et al. 2010, Hawbecker 1945, Heisler et al. 2016, Hucks et al. 2015, Rifai et al. 1998). Moreover, Avenant (2005) demonstrated that Barn Owls are able to sample the small mammal community better than humans are able to sample by trapping. In addition, some diet studies suggest that Barn Owls show little pref-

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erence towards certain species and select a wide range of prey items that includes not only small mammals (including bats) but also birds, amphibians, arthropods, and fish, depending upon availability (Morton and Martin 1979).

In contrast, other studies suggest that Barn Owls take some prey species disproportionate to their abundance in the prey community. Typically, *Microtus* Schrank spp. (vole spp.) are the principal prey of Barn Owls in many temperate regions (Kopij 1998, Marti et al. 2020, Myers et al. 2009). This pattern is consistent with the results of studies showing that, given a choice, Barn Owls preferred *Microtus* spp. over other common rodents, such as *Peromyscus* Gloger spp. (deer mouse spp.), at least in a captive setting (Derting and Cranford 1989, Fast and Ambrose 1976). In the wild, Taylor (2009) found that Barn Owls showed a strong preference for *Microtus* spp. over mice in Scotland. Similarly, Gubanyi (1989) and Gubanyi et al. (1992) showed that *Microtus* spp. were taken as prey more often than expected based on their abundance, and *Peromyscus* spp. were taken less often than expected based on their abundance. Several additional studies showed evidence of selective predation by Barn Owls on *Microtus* spp., irrespective of their habitat and prey availability (Askew et al. 2007, Colvin 1985, Hindmarch and Elliott 2015, Marti 2010). This higher prevalence of *Microtus* spp. in the Barn Owl diet compared with other small rodents could result from them being more vulnerable or yielding higher energy intake per unit handling time compared with alternative prey (DeLong et al. 2013, Fast and Ambrose 1976, Stephens and Krebs 1986). Barn Owls hunt mainly using acoustic cues, so it is possible that *Microtus* spp. are louder and, therefore, more detectable than smaller alternative prey (Derting and Cranford 1989, Taylor 2009). In addition, some studies suggest that Barn Owl prey selection also may be influenced by body mass of the prey (Colvin 1985, Marti 2010, Taylor 2009). For example, Yom-Tov and Wool (1997) showed that, although Barn Owls might choose prey randomly, they prefer larger prey individuals over smaller ones. Such size-based prey selection might explain the Barn Owls' preference for *Microtus* spp., which are twice the size of *Peromyscus* spp. However, Dickman et al. (1991) and Trejo and Guthmann (2003) showed that Barn Owls have some preference towards smaller prey size.

In this study, we evaluated prey selection in Barn Owls by using pellet analysis and determined whether prey selection was proportional to the availability of prey. We focused on a site in western Nebraska for which small-mammal community trapping data were available. We tested whether Barn Owl diets reflected prey availability by species, indicating a good sampler strategy, or whether diets were disproportionate to prey's relative abundance, suggesting either the existence of foraging strategies or differences in prey detectability. We then tested whether the overall distribution of prey body mass in the diet differed from the distribution of body mass in the prey community to determine whether Barn Owls could simply be selecting larger or smaller prey rather than targeting specific species.

Methods

Study Area

The study area was in western Nebraska (Keith County), in and surrounding the University of Nebraska–Lincoln's Cedar Point Biological Station (CPBS). Habitats around the station include mixed-grass prairie and dry and irrigated agricultural fields. *Bubo virginianus* (J.F. Gmelin) (Great Horned Owls), *Megascops asio* (Linnaeus) (Eastern Screech Owls), *Athene cunicularia* (Molina) (Burrowing Owls), *Asio otus* (Linnaeus) (Long-eared Owls), and Barn Owls occur in the area.

Pellet Sampling

We searched for Barn Owl nests and collected pellets from in and under the nests in May to July of 2016–2018 from 5 Barn Owl territories at CPBS and along State Highway 92. We autoclaved and cleaned the pellets, separating the skull and jaw bones. We identified individual prey by the skulls, and we matched jaws to skulls whenever possible, counting additional prey individuals for unmatched jaws (Marti 1973). We measured (in mm) skull length (maximum length) and width (maximum distance between zygomatic arches), as well as the length of both jaws, if available. We only included measurements from bones that were intact and whose dimensions were not altered by digestion.

We estimated the mass of prey items identified from pellets through a set of regressions linking bone measurements to wet mass of whole individuals. We estimated the mass (g) of *Microtus* spp. with the equation $y = a + b \cdot BL$, where BL is basilar length in mm (Pagels and Blem 1984). From a subset of *Microtus* spp. skulls in our sample, we determined that basilar length was 90% of total skull length and, therefore, estimated basilar length as $0.9 \times$ total skull length. For the samples missing skull length, we applied regression equations based on our data, using either $y = a + b \cdot x$ or $y = a + b \cdot z$, where y = skull length (mm) and x = jaw length (mm) or zygomatic width (mm), respectively. In the case of samples missing both skull and jaw length measurements (because of skull or jaw damage), we used the mean mass of the specimens of the appropriate species housed in the Division of Zoology in the University of Nebraska State Museum (UNSM). We estimated the body mass (g) of *Peromyscus* spp. with the regression equation $y = a + b \cdot ML$, where $a = -2.972$, $b = 4.146$, and ML is mandible length (mm), which is the jaw without incisors or the mandibular condyle (Hamilton 1980). We corrected our jaw lengths to mandible lengths with the correction factor of 0.728, which is the average proportion of mandible length to jaw length in a random sample of 10 jaws from our pellets. In the case of samples that lacked the jaw length, we applied the regression equation $y = a + b \cdot z$, where x = zygomatic width (mm) and y = jaw length (mm). For *Reithrodontomys* Giglioli spp. (harvest mouse spp.), we estimated mass using the same mass/mandible length equation as used for *Peromyscus* spp. but with $a = -1.769$ and $b = 2.958$ (Hamilton 1980).

We categorized some prey more broadly into the subfamily Neotominae if they could not be classified as either *Peromyscus* spp. or *Reithrodontomys* spp., which was the case when prey items were present only as jaws. We estimated the mass of these prey items using the same mass/mandible length equation, with values of a and b averaged across both *Peromyscus* spp. and *Reithrodontomys* spp.

We estimated the average mass of the other identified small mammal prey, *Blarina* Gray spp. (American short-tailed shrew spp.), *Sorex* Linnaeus spp. (red-toothed shrew spp.), *Geomys* Rafinesque spp. (eastern pocket gopher spp.), and *Dipodomys ordii* Woodhouse (Ord's Kangaroo Rat), as the average of locally collected specimen data provided by the UNSM.

Small-mammal Trapping

We compiled trapping data collected in mid-July to mid-August at CPBS (2012–2016) as a part of a long-term field parasitology course at the University of Nebraska–Lincoln (Genoways et al. 2008, Howell et al. 2016). During the course, we collected small mammals of several different species from different locations in Keith, Arthur, Garden, and Grant counties in western Nebraska: CPBS (41.21°N, 101.65°W; containing Great Plains grassland/woodland and wetland habitats), Grama Grass (41.19°N, 101.65°W; a fallow mixed-grass pasture), Double Tank (41.20°N, 101.64°W; mixed-grass habitat), Breen's Flyway (41.18°N, 101.36°W; containing riparian-wetland habitat on the edge of the North Platte River), Ackley Valley (41.33°N, 101.73°W; a short grass horse pasture), and Arapahoe Prairie (41.49°N,

101.86°W; short grass habitat) (Bailey 1982). We used Sherman™ live traps (H.B. Sherman Traps, Inc., Tallahassee, FL), Museum Special snap traps (Woodstream Corp., Lititz, PA), or pit-fall traps, baited with a mix of vanilla, peanut butter, and oatmeal, to collect specimens (Gardner 1996, Gardner and Jiménez-Ruiz 2009). We checked traps twice daily, in the early morning and late afternoon, and left traps open during the day to capture diurnal mammals, such as *Microtus* spp. and Sciuridae spp. We prepared standard voucher specimens for all trapped individuals, with weight and measurement data recorded at time of collection, and we deposited specimens in the mammal collection of UNSM (Gardner 1996).

Statistical Analyses

All statistical analyses were carried out using MATLAB 2019 (Mathworks, Natick, MA). We identified several prey items only to the subfamily Neotominae, which includes *Peromyscus* spp. and *Reithrodontomys* spp. To include these taxa in the analysis, we determined the proportions of Neotominae that were identified as *Peromyscus* and *Reithrodontomys* and allocated the more broadly categorized items to these 2 genera accordingly to correct for undersampling. We ran chi-square tests to compare the proportion of prey types in the diet to the relative abundance of prey types from the trapping sample at the level of genus. We considered only small mammals in our analyses as we did not have a community sample for other prey types or identifications for the avian prey items. We also compared the distribution of body masses between the trapping and prey item samples by using a 2-sample Kolmogorov–Smirnov test. For the test, we included only the species with masses <200 g and excluded the larger species that were trapped but never found in the Barn Owl diet (e.g., *Vulpes* Frisch spp., *Lepus* Linnaeus spp.).

Results

From all pellet material, we identified 1163 prey items, 11 of which were unidentified birds. Of the 1152 mammalian prey items (Table 1), the majority (649 prey items or 56.3%) were *Microtus* spp., including *Microtus ochrogaster* (Wagner) (Prairie Vole; 291 prey items) and *Microtus pennsylvanicus* (Ord) (Meadow Vole; 336 prey items). The mammals in the diet also included *Peromyscus* spp. (14.1%), *Reithrodontomys montanus* (Baird) (Plains Harvest Mouse) and/or *Reithrodontomys megalotis* (Baird) (Western Harvest Mouse) (21.2%), *Blarina brevicauda* (Say) (Northern Short-tailed Shrew) and/or *Blarina hylophaga* Elliot (Elliot's Short-tailed Shrew) (0.34%), *Sorex* spp. (3.1%), *Dipodomys ordii* (2.9%), and *Geomys* spp. (2.0%). Unidentified Neotominae constituted 13.1% of the prey items. We also found evidence of *Faxonius virilis* (Hagen) (Northern Crayfish) remains below 1 Barn Owl nest.

Mammal trapping yielded 592 individuals representing 14 species, including the 8 found in the owl pellets plus 6 other species not found in owl pellets: *Perognathus* Wied-Neuwied spp. (pocket mouse spp.), *Chaetodipus hispidus* (Baird) (Hispid Pocket Mouse), *Onychomys leucogaster* (Wied-Neuwied) (Northern Grasshopper Mouse), *Ictidomys* J.A. Allen spp. (lined ground squirrel spp.), *Sylvilagus audubonii* (Baird) (Desert Cottontail), and *Zapus hudsonius* (Zimmermann) (Meadow Jumping Mouse) (Table 1). In contrast to the pellet samples, the most abundant prey type in the trapping samples was *Peromyscus* spp.

Microtus spp. and *Reithrodontomys* spp. occurred significantly more in the diet than expected from their frequencies in the trapping samples, whereas *Peromyscus* spp. and *Dipodomys* spp. occurred less frequently in the diet than expected (Table 1). We also found a significant difference between the distributions of the estimated mass of prey items in the diet and the mass of individuals collected by trapping ($k = 0.24$, $P \leq 0.001$; Fig. 1).

Table 1. Total number of individuals and percentage of small mammals in trapping samples and Barn Owl pellet samples in western Nebraska. There were an additional 11 bird skulls of unidentified species found in the pellets. The pellet sample numbers include unidentified Neotominae allocated to *Peromyscus* spp. (41 individuals) and *Reithrodontomys* spp. (91 individuals) based on their proportions in the identified portion of the prey items. Differences in the frequency of prey types between potential prey and actual prey were analyzed at the genus level through chi-squared (χ^2) tests.

Prey Items	Trapping sample	%	Pellet sample	%	χ^2	P
<i>Microtus</i> Schrank spp.	53	8.95	649	56.33	370.02	<0.001
<i>M. pennsylvanicus</i> Ord			336			
<i>M. ochrogaster</i> Wagner			291			
<i>Peromyscus</i> Gloger spp.	283	47.80	163	14.14	227.39	<0.001
<i>Dipodomys ordii</i> Woodhouse	49	8.27	33	2.86	24.97	<0.001
<i>Blarina</i> Gray spp.	2	0.33	4	0.34	15.64	NA
<i>Geomys</i> Rafinesque spp.	20	3.37	23	1.99	2.96	0.08
<i>Reithrodontomys</i> Giglioli spp.	51	8.61	244	21.18	45.13	<0.001
<i>Sorex</i> Linnaeus spp.	12	2.02	36	3.12	1.85	0.17
<i>Perognathus</i> Wied-Neuwied spp.	37	6.25	–	–		
<i>Chaetodipus hispidus</i> Baird	18	3.04	–	–		
<i>Onychomys leucogaster</i> Wied-Neuwied	31	5.23	–	–		
<i>Ictidomys</i> J. A. Allen spp.	5	0.84	–	–		
<i>Sylvilagus audubonii</i> Baird	7	1.18	–	–		
<i>Zapus hudsonius</i> Zimmermann	24	4.05	–	–		
Total	592		1152			

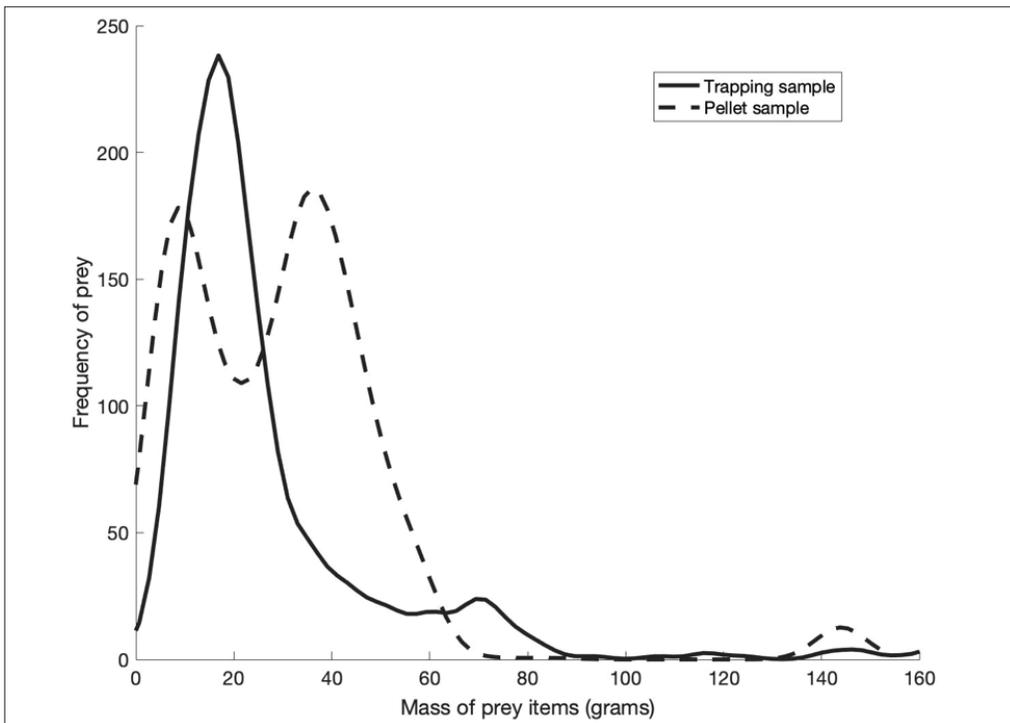


Figure 1. Mass distribution of prey items using trapping data versus estimated mass distribution of prey items in the diet of Barn Owls in western Nebraska. The diet distribution is significantly shifted towards the right of the trapping sample ($k = 0.25$, $P < 0.001$).

Discussion

Barn Owl diets have been extensively studied throughout the world (Bernard et al. 2010, Glue 1972, Heisler et al. 2016, Marti 1973), but it remains unclear if Barn Owls generally take prey types in proportion to their abundance in the prey community. Gubanyi (1989) and Gubanyi et al. (1992) recorded ~17 mammal species in the diets of Barn Owls in western Nebraska, with most of the prey being *Microtus* spp., *Reithrodontomys* spp., and *Peromyscus* spp. In addition, Bonner and Geluso (2010) recorded 12 species of mammals in the diets of Barn Owls at Crescent Lake National Wildlife Refuge in northwestern Nebraska, with most of the diets composed of *Microtus* spp., *Dipodomys* spp., and *Peromyscus* spp. Huebschman et al. (2000) found 11 mammal species in Barn Owl pellets collected from 24 counties in Nebraska from 1980–1998, and they found that *Microtus* spp. and *Peromyscus* spp. constituted the principle prey items. Our data on diet for western Nebraska indicate a similar array of prey types, with *Microtus* spp. constituting most of the diet.

In our study, the proportions of some species differed significantly between the pellet and trapping samples. For example, *Microtus* spp. and *Reithrodontomys* spp. occurred more frequently in the diet than expected from trapping results, whereas *Peromyscus* spp. and *Dipodomys* spp. occurred less frequently in the diet than expected, which is a pattern similar to some previous findings (Gubanyi 1989, Gubanyi et al. 1992, Pearson and Pearson 1947). Although covering a wide range of habitats and using multiple trapping techniques, the trapping data may not exactly represent the foraging habitats used by Barn Owls in our study area or may not be a perfectly random sample of the prey base. A mismatch between pellets and trapping also could arise through incomplete spatial overlap of owl hunting and trapping areas, differences in years between the samples, and differences in seasonal timing of pellet and trapping collection. However, a large portion (45%) of our pellet data was collected in 2016, a year in which trapping data was also collected, and both trapping data and pellets came from a broadly overlapping region during the breeding season for the owls, indicating reasonable support for the comparison. Furthermore, the dramatic differences between prey and trapping frequencies for *Microtus* spp. (56.3% in diet versus 9.0% in traps) and *Peromyscus* spp. (14.1% in diet versus 47.8% in traps) suggest that, even given some potential error in sampling, Barn Owls showed non-random consumption of potential mammalian prey.

Marti (1973) showed that Barn Owls prefer larger prey species over smaller ones, whereas Dickman et al. (1991) found the opposite. Our genus-level differences between prey items and potential prey also reflect that the body mass distribution of the diet is significantly shifted to the right of the body mass distribution of trapped mammals, indicating selection of larger prey (Fig. 1). This result reflects that the most abundant prey, *Microtus* spp., are about twice the size of *Peromyscus* spp. This bias toward relatively larger prey species in the diet might reflect the possibility that *Microtus* spp. are a more energetically profitable option than the smaller *Peromyscus* spp., suggesting that Barn Owls in western Nebraska forage in a way that is consistent with an optimal foraging strategy (DeLong et al. 2013, Derting and Cranford 1989). Alternatively, Barn Owls might be detecting *Microtus* spp. more often as they might be louder or more vulnerable and hence more available to Barn Owls than are *Peromyscus* spp. Individuals of *Peromyscus* spp. and *Microtus* spp. also live in different habitats, so *Microtus* spp. may be more detectable or their locations may be more predictable given a potentially acoustics-focused hunting method by the owls.

Raptor diets are likely influenced by prey abundance, seasonal vegetation changes, habitat modification, prey behavior, and prey reproductive patterns (Rosenblatt et al. 2015, Taylor 2009), all of which should be considered when trying to understand prey selection.

Overall, our results support the idea that Barn Owls select a wide range of prey items but are biased toward certain species (here, *Microtus* spp.) despite the availability of other prey types. We suggest that, given the equivocal evidence for Barn Owls either being random samplers of the prey community or displaying selective foraging behaviors, future work should consider the conditions under which some degree of prey selectivity would arise for Barn Owls, or for raptors more generally.

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