

## DIETS OF BARN OWLS DIFFER IN THE SAME AGRICULTURAL REGION

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**ABSTRACT.**—We studied the diet of 20 Barn Owl (*Tyto alba*) pairs breeding in three habitats (alfalfa fields, date plantations, and villages) in the same agricultural region in the Jordan Valley, Israel. Small mammals, particularly three rodents (Levant voles [*Microtus socialis guentheri*], house mouse [*Mus* sp.], and Tristram's jird [*Meriones tristrami tristrami*]), comprised 73 to 88% of the 3,544 prey items taken by Barn Owls in the three habitats. Frequencies in number and biomass of the rodent species differed among habitats. The number of bird species, their frequencies, and biomass in the diet were higher in villages than in the other two habitats, and were related to the higher diversity of birds breeding in villages. The frequency of birds in the diet was negatively correlated with distance from the village to open fields. Differences in the diet of Barn Owls among the three habitats most likely reflected differences in the distribution and abundance of the prey items in each habitat. Received 28 June 2008. Accepted 11 December 2008.

The diet of Barn Owls (*Tyto alba*) is well known throughout the world because of their cosmopolitan distribution and ease of pellet analysis (Taylor 1994), a method that accurately represents what they consume (Raczynski and Ruprecht 1974). Long-term changes in the diet of Barn Owls are often the result of intensification of agriculture and landscape management (Love et al. 2000). Local variation in diet in different habitats has been described in Europe and the United States (Buckley and Goldsmith 1975, de Bruijn 1994, Taylor 1994, Rodríguez and Salvador 2007), and the diet of Barn Owls in Pakistan differed between districts (Mahmood-ul-Hasan et al. 2007a, b). Barn Owl's are among the most common species of owls in Israel (Shirihai 1996), but studies on their diet have either concentrated on one habitat in one area (Kahila 1992, Pokines and Peterhans 1997, Yom-Tov and Wool 1997, Tores and Yom-Tov 2003, Tores et al. 2005, Charter et al. 2007),

or in several areas (Dor 1947), but not in different habitats at a local scale.

Barn Owls occur in most agricultural regions and are mostly specialist predators of small mammals but vary in species hunted according to prey availability (Taylor 1994, Tores et al. 2005). Voles are often the most dominant prey in Barn Owl diets throughout most of the owl's range in the northern hemisphere, probably because of their relative high body mass and ease of capture (Taylor 1994). The Levant vole (*Microtus socialis guentheri*) is a major pest species of leafy crops in Israel (Moran 2003), and is found at especially high densities in alfalfa fields (Bodenheimer 1949). The house mouse (*Mus* sp.) and Tristram's jird (*Meriones tristrami tristrami*) are also common rodents, and are considered agricultural pests (Moran 2003). However, their densities differ between habitats (M. Charter, unpubl. data). In addition, the number of bird species has been shown to increase with vegetation layers and habitat diversity (Moller 1984) with more species in heterogeneous landscapes than in homogenous arable landscapes (Hanowski et al. 1997, Moreira et al. 2005).

We compared diets of Barn Owls breeding in three different types of habitats (villages, date plantations [*Phoenix daetylifera*], and alfalfa fields) in the same agricultural region to examine whether diets differed between different habitats within one relatively small agricultural area.

### METHODS

The study site (90 km<sup>2</sup>) was an agricultural region in the Beit She'an Valley, Israel (32°

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30' N, 35° 30' E), 150 to 250 m below sea level. The climate is arid with maximum and minimum mean daily temperatures (Mar–Jul 1999) of 32.3° C and 16.7° C, respectively, and average yearly rainfall of 267 mm (2001–2006).

Oral pellets and prey remains were collected from 20 nests at the end of the Barn Owl breeding season on 28 July 2006 in three habitats: alfalfa fields ( $n = 7$ ), date plantations ( $n = 6$ ), and inside villages ( $n = 7$ ). Nests in alfalfa fields and date plantations were separated by at least 1,000 m. Villages were surrounded by agricultural land within 1,000 m of date plantations and 500 m from alfalfa fields.

Barn Owls within villages bred in human structures (Meyrom et al. 2008) other than nest boxes, mainly abandoned guard towers, while pairs in date plantations and alfalfa fields bred in nest boxes. All nests successfully fledged young and no significant difference was found in number of young per nest among the three habitats (Kruskal-Wallis ANOVA,  $F_{2,20} = 0.30$ ,  $P = 0.86$ ).

Pellets were soaked in water for 4 days; whole pellets were dissected individually while partial pellets were grouped together. Mandibles, skulls, and femurs of small mammals, and mandibles of invertebrates were separated and identified. Species identification was by comparison with specimens preserved in the collections of the Zoological Museum of Tel Aviv University and The Hebrew University of Jerusalem. Data are presented as the minimum number of individuals (MNI), percent frequency by number, and percent frequency by biomass. Body mass of rodents and birds were from Mendelsohn and Yom-Tov (1999) and Dunning (1993), respectively.

**Data Analyses.**—All tests were two-tailed except when testing the directional hypotheses that diet of pairs breeding in the villages would contain more species of birds, frequency of Levant voles would be highest in alfalfa fields, and Tristram's jirds would be highest in date plantations. Data were analyzed using one-way ANOVA, Bonferroni multiple comparison, and Kruskal-Wallis ANOVA. All percentages were Arcsine square-root transformed prior to analyses. Pearson correlation was used for analyzing correlations. Statistical

analyses were performed using Statistica 8.0 software (StatSoft, Bedford, UK).

## RESULTS

Whole pellets ( $n = 506$ ) were collected from pairs ( $n = 7$ ) in villages, 336 whole pellets from pairs ( $n = 6$ ) in date plantations, and 347 whole pellets from pairs ( $n = 7$ ) in alfalfa fields. Three-thousand, five hundred and forty-four prey items were identified from the pellets examined (Table 1).

**Small Mammals.**—Six mammalian species comprised 81.8 to 96.6% of all prey recorded from the three habitats. The percentage by number of rodents differed between habitats ( $F_{2,17} = 3.94$ ,  $P = 0.039$ ). Significantly fewer small mammals were found in pellets of pairs nesting in villages than in alfalfa fields ( $P < 0.05$ ), but no significant differences were found between date plantations and the other two habitats. The three most common mammal species were Levant vole, house mouse, and Tristram's jird, which together comprised 72.9 to 87.8% of total MNI in the three habitats (Table 1).

The percentage by number of Levant voles taken by pairs breeding in date plantations was significantly lower than in the other two habitats (Fig. 1). Tristram's jird, house mouse, black rat (*Rattus rattus*), blind mole rat (*Spalax leucodon ehrenbergi*), and shrews (*Crocidura* sp.) were found in similar frequencies in each habitat (Fig. 1).

Percent frequency of biomass differed among the three habitats ( $F_{2,17} = 16.71$ ,  $P < 0.001$ ) with Barn Owls breeding in villages having lower percent frequency biomass than in date plantations ( $P < 0.001$ ) and alfalfa fields ( $P < 0.001$ ). There were differences between percent frequency of biomass of Levant voles (one-tailed ANOVA;  $F_{2,17} = 8.11$ ,  $P = 0.002$ ) and Tristram's jird (one-tailed ANOVA;  $F_{2,17} = 7.47$ ,  $P = 0.003$ ) in the three habitats. No differences were found among house mice ( $F_{2,17} = 1.88$ ,  $P = 0.18$ ), black rats ( $F_{2,17} = 1.40$ ,  $P = 0.27$ ), blind mole rats ( $F_{2,17} = 3.02$ ,  $P = 0.076$ ), and shrews ( $F_{2,17} = 0.56$ ,  $P = 0.58$ ). Percent frequency of biomass of voles in date plantations was lower than in alfalfa fields ( $P = 0.005$ ) and villages ( $P = 0.014$ ). Percent frequency of biomass of Tristram's jird in date plantations was higher than in alfalfa fields ( $P < 0.004$ ); whereas no dif-

TABLE 1. Diet of Barn Owls breeding in villages ( $n = 7$ ), date plantations ( $n = 6$ ), and alfalfa fields ( $n = 7$ ) during the 2006 breeding season in the Beit She'an Valley, Israel. (MNI = Minimum number of individuals, PN = percentage by number, PFB = percent frequency biomass).

Prey taxon	Village			Date plantation			Alfalfa field		
	MNI	PN	PFB	MNI	PN	PFB	MNI	PN	PFB
<b>Mammals</b>									
<i>Meriones</i>	258	20.8	35.5	415	36.5	66.3	352	30.2	49.1
<i>Microtus</i>	312	25.1	28.4	40	3.5	4.2	280	24.1	25.9
<i>Mus</i>	336	27.0	8.4	457	40.2	13.3	390	33.5	9.9
<i>Rattus</i>	35	2.8	8.8	24	2.1	7.0	17	1.5	4.3
<i>Spalax</i>	3	0.2	1.0	16	1.4	6.5	12	1.0	4.2
Unidentified rodent	4	0.3	0.0	6	0.5	0.0	11	0.9	0.0
<i>Soricidae</i>	69	5.6	0.9	76	6.7	1.1	62	5.3	0.8
Totals	1,017	81.8	83.1	1,034	90.9	98.5	1,124	96.6	94.3
<b>Birds</b>									
<i>Streptopelia</i>	21	1.7	3.8	2	0.2	0.4	11	0.9	2.0
<i>Passer</i>	148	11.9	7.3	2	0.2	0.1	3	0.3	0.2
<i>Coturnix</i>	0	0.0	0.0	0	0.0	0.0	4	0.3	0.7
<i>Galerida</i>	7	0.6	0.5	3	0.3	0.3	5	0.4	0.4
<i>Carduelis</i>	0	0.0	0.0	0	0.0	0.0	1	0.1	0.0
<i>Turdus</i>	4	0.3	0.8	2	0.2	0.5	7	0.6	1.4
<i>Columba</i>	5	0.4	3.2	0	0.0	0.0	1	0.1	0.6
<i>Sylvia</i>	10	0.8	0.4	0	0.0	0.0	2	0.2	0.1
<i>Emberiza</i>	0	0.0	0.0	0	0.0	0.0	2	0.2	0.1
<i>Pycnonotus</i>	5	0.4	0.4	0	0.0	0.0	2	0.2	0.2
<i>Nectarinia</i>	1	0.1	0.0	0	0.0	0.0	0	0.0	0.0
<i>Acocephalus</i>	1	0.1	0.0	0	0.0	0.0	0	0.0	0.0
<i>Upopa</i>	2	0.2	0.2	0	0.0	0.0	0	0.0	0.0
<i>Tyto</i> (nestling)	2	0.2	0.2	0	0.0	0.0	0	0.0	0.0
Unknown passerine	15	1.2		2	0.2		2	0.2	
Unknown	5	0.4		4	0.4		0	0.0	
Totals	226	18.2	16.9	15	1.3	1.3	40	3.4	5.7
<b>Invertebrates</b>									
<i>Gryllotalpa</i>	0	0.0	0.0	88	7.7	0.3	0	0.0	0.0
Total MNI	1,243			1,137			1,164		

ferences occurred between villages and the other two habitats.

*Birds.*—Significantly more birds occurred in the diet of Barn Owls breeding in villages than in the other two habitats (one-tailed ANOVA;  $F_{2,17} = 26.36$ ,  $P < 0.001$ ). Significantly more birds were found in pellets of pairs nesting in villages than in alfalfa fields ( $P < 0.05$ ) and date plantations ( $P < 0.05$ ). There was also a difference between percent frequency of biomass of birds in the diet (one-tailed ANOVA;  $F_{2,17} = 20.86$ ,  $P < 0.001$ ) with significantly lower biomass in date plantations ( $P < 0.001$ ) and alfalfa fields ( $P = 0.002$ ) than in villages. The number of bird species differed between locations (Kruskal-Wallis ANOVA;  $F_{2,17} = 12.44$ ,  $P = 0.002$ ) with Barn

Owl pairs breeding in villages preying on more species than those breeding in date plantations ( $P < 0.001$ ) and alfalfa fields ( $P = 0.007$ ). A positive correlation was found between the percent frequency of birds in the diet of Barn Owls in villages and the distance from the owl's nest to the nearest agricultural field (Fig. 2).

#### DISCUSSION

The greater contribution of birds in the diet of Barn Owls nesting in villages and the higher diversity of bird species taken was most likely a result of greater cover and diversity of tree and plant species providing habitat for birds compared to the open, uniform alfalfa fields and date plantations. More birds are in

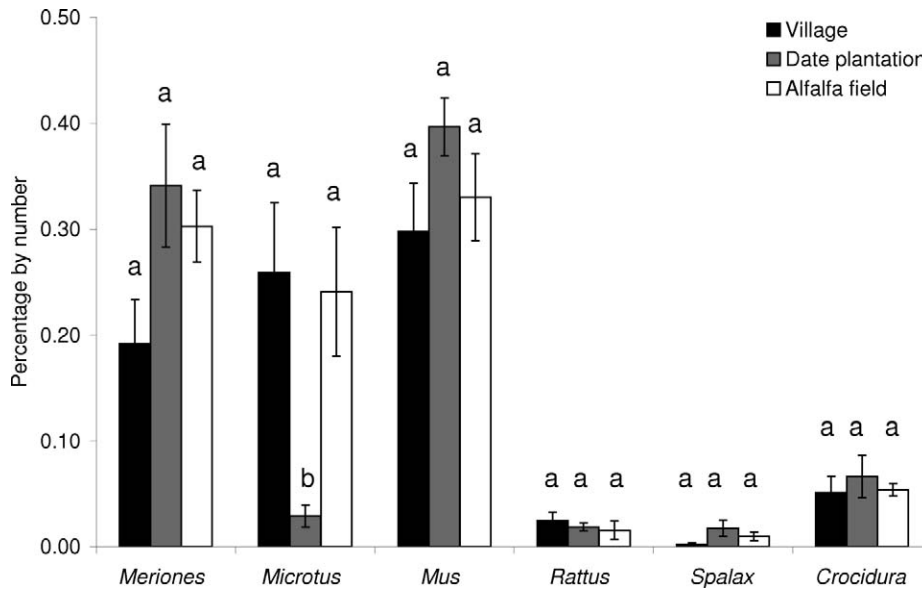


FIG. 1. Percentage by number of *Meriones* ( $F_{2,17} = 3.13, P = 0.070$ ), *Microtus* (one-tailed ANOVA;  $F_{2,17} = 7.87, P = 0.002$ ), *Mus* ( $F_{2,17} = 1.59, P = 0.23$ ), *Rattus* ( $F_{2,17} = 0.79, P = 0.47$ ), *Spalax* ( $F_{2,17} = 3.11, P = 0.070$ ), and *Crocidura* ( $F_{2,17} = 0.24, P = 0.79$ ) in diets of Barn Owls breeding in villages, date plantations, and alfalfa fields. Different letters indicate significant difference between nest types (Bonferroni multiple comparison,  $P < 0.05$ ). Nest types with no differences have the same letter.

villages while higher rodent densities are in alfalfa fields and date plantations than in villages (M. Charter, pers. obs.). The frequency of birds in the diet of Barn Owls breeding in villages increased with distance to the closest agricultural fields. Low frequency of birds in diets of Barn Owls breeding among fields and plantations has been recorded elsewhere in Israel (Kahila 1992, Tores et al. 2005).

Barn Owl pairs in villages did not breed more than 225 m from agricultural fields where there were other Barn Owl pairs breeding in nest boxes placed in the fields. Fewer pairs bred inside villages with consequent possibly less competition and more potential avian prey available. Another possibility is that Barn Owls may have encountered more birds in villages while flying to and from

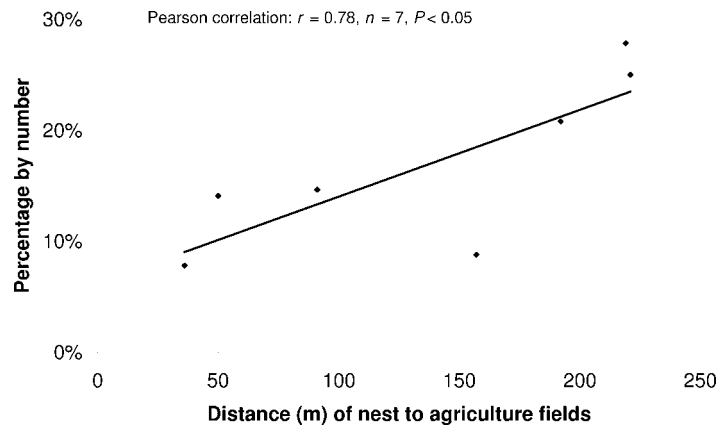


FIG. 2. Correlation between percentage by number of birds in the diets of Barn Owls breeding in villages and distance of the nest to agricultural fields.

nests, during which time passerines and doves are often flushed from roosts or nests.

Small mammals comprised the majority of prey specimens in the Barn Owl's diet in all three studied habitats similar to other studies throughout the world (Taylor 1994) and Israel (Kahila 1992, Pokines and Peterhans 1997, Yom-Tov and Wool 1997, Tores and Yom-Tov 2003, Tores et al. 2005, Charter et al. 2007). It has been suggested that Barn Owls in Mediterranean regions eat fewer rodents due to a reduction in diversity and abundance of small mammals (Herrera 1974). This does not hold in agricultural habitats where rodent pests may be abundant, as reflected in the diet of Barn Owls in this and other studies in Israel (Kahila 1992, Tores et al. 2005, Charter et al. 2007), and also in Syria (Shehab 2005).

The combined frequency of Levant vole, house mouse, and Tristram's jird in the Barn Owl's diet in the current study was similar to that in other studies near agriculture in Israel, where they comprised 89.0 to 93.9% of prey (Kahila 1992 Tores et al. 2005, Charter et al. 2007). All three are considered the main rodent pests of agriculture in Israel (Moran 2003). Barn Owl populations have consequently been deliberately increased through provision of nest boxes in a national biological pest control project (M. Charter, unpubl. data).

The Levant vole was found at a lower percent frequency in number and percent frequency of biomass in date plantations than in the other two habitats. Vole populations, possibly because of higher temperatures and dry conditions, are mostly restricted to alfalfa fields (all are irrigated), which is the main leafy crop in the region, and fewer voles are found in date plantations (Y. Motro and M. Charter, pers. obs.). Barn Owls switched to house mice and Tristram's jirds in date plantations where they occurred in higher abundance than alfalfa fields. Barn Owl pairs breeding in villages also hunted in alfalfa fields, as demonstrated by the percent of voles in their diet.

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#### LITERATURE CITED

- CHARTER, M., I. IZHAKI, L. SHAPIRA, AND Y. LESHEM. 2007. Diets of urban breeding Barn Owls, *Tyto Alba* in Tel Aviv, Israel. *Wilson Journal of Ornithology* 119:484–485.
- BODENHEIMER, P. S. 1949. Problems of vole populations in the Middle East. Report on the population dynamics of the Levant vole (*Microtus guentheri*). The Research Council of Israel, Jerusalem.
- BUCKLEY, J. AND J. GOLDSMITH. 1975. The prey of Barn Owl (*Tyto alba*) in east Norfolk. *Mammal Review* 5:13–16.
- DE BRUIJN, O. 1994. Population ecology and conservation of the Barn Owl, *Tyto alba* in farmland habitats in Liemers and Achterhoek (The Netherlands). *Ardea* 82:1–109.
- DOR, M. 1947. The Barn Owl diet. *Teva va-Arez* 7: 337–344; 414–419.
- DUNNING, I. B. 1993. CRC handbook of avian body masses. CRC Press, Boca Raton, Florida, USA.
- HANOWSKI, J. M., G. J. NIEMI, AND D. C. CHRISTIAN. 1997. Influence of within-plantation heterogeneity and surrounding landscape composition on avian communities in hybrid poplar plantations. *Conservation Biology* 11:936–944.
- HERRERA, C. M. 1974. Trophic diversity of the Barn Owl *Tyto alba* in continental western Europe. *Ornis Scandinavia* 5:181–191.
- KAHILA, G. 1992. The Barn Owl as a biological rodent control in agricultural areas. Thesis. The Hebrew University of Jerusalem, Israel.
- LOVE, R. A., C. WEBBON, AND D. E. GLUE. 2000. Changes in the food of British Barn Owls (*Tyto alba*) between 1974 and 1997. *Mammal Review* 30:107–129.
- MAHMOOD-UL-HASSAN, M., M. A. BEG, AND M. MUSH-TAQ-UL-HASSAN. 2007a. Locality related changes in the diet of the Barn Owl (*Tyto alba stertens*) in agroecosystems in central Punjab, Pakistan. *Wilson Journal of Ornithology* 119:479–483.
- MAHMOOD-UL-HASSAN, M., M. A. BEG, M. MUSHTAQ-UL-HASSAN, H. ALI MIRZA, AND M. SIDDIQUE. 2007b. Nesting and diet of the Barn Owl (*Tyto alba*) in Pakistan. *Journal of Raptor Research* 41: 122–129.
- MENDELSSOHN, H. AND Y. YOM-TOV. 1999. Mammalia of Israel. The Israel Academy of Science and Humanities, Jerusalem, Israel.
- MEYROM, K., Y. LESHEM, AND M. CHARTER. 2008. Barn owl (*Tyto alba*) breeding success in man-made structures in the Jordan Rift Valley, Israel. *Sandgrouse* 30:134–137.
- MOLLER, A. P. 1984. Community structure of birds in agricultural areas in summer and winter in Denmark. *Holarctic Ecology* 7:413–418.
- MORAN, S. 2003. Checklist of vertebrate damage to agriculture in Israel, updated for 1993–2001. *Phytoparasitica* 31:2.

- MOREIRA, F., P. BEJA, R. MORGADO, L. REINO, L. GORDINHO, A. DELGADO, AND R. BORRALHO. 2005. Effects of field management and landscape context on grassland wintering birds in southern Portugal. *Agriculture, Ecosystems and Environment* 109:59–74.
- POKINES, J. T. AND J. K. PETERHANS. 1997. Barn Owls *Tyto alba* taphonomy in the Negev Desert, Israel. *Israel Journal of Zoology* 43:19–27.
- RACZYNSKI, J. AND A. L. RUPRECHT. 1974. The effect of digestion on the osteological composition of owl pellets. *Acta Ornithologica* 14:25–37.
- RODRÍGUEZ, C. AND J. P. SALVADOR. 2007. Habitat associations of small mammals in farmed landscapes: implications for agri-environmental schemes. *Animal Biology* 57:301–314.
- SHEHAB, H. A. 2005. Food of the Barn Owl *Tyto alba* in southern Syria. *Acta Zoologica Cracoviensia* 48:35–42.
- SHIRIHAI, H. 1996. *The birds of Israel*. Academic Press, London, United Kingdom.
- TAYLOR, I. 1994. *Barn Owls: predator-prey relationships and conservation*. University Press, Cambridge, United Kingdom.
- TORES, M. AND Y. YOM-TOV. 2003. The diet of the Barn Owl (*Tyto alba*) in the Negev Desert. *Israel Journal of Zoology* 49:233–236.
- TORES, M., Y. MOTRO, U. MOTRO, AND Y. YOM-TOV. 2005. The Barn Owl—a selective opportunist predator. *Israel Journal of Zoology* 51:349–360.
- YOM-TOV, Y. AND D. WOOL. 1997. Do the contents of Barn Owl pellets accurately represent the proportion of prey species in the field? *Condor* 99:972–976.