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SEASONAL AND GEOGRAPHIC DIFFERENCES IN THE DIET OF THE BARN OWL IN AN AGRO-ECOSYSTEM IN NORTHERN ITALY

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ABSTRACT.—We studied the dietary niche breadth of the Barn Owl (*Tyto alba*) in the Po plain of northern Italy. A total of 1266 pellets was collected during 2 yr in an agricultural area located between Mantova and Brescia. Bones of 4455 prey items were identified with small mammals, in particular rodents and Insectivora, the most important dietary component and birds (Passeriformes) comprising most of the remainder of the diet. Arthropods were occasionally eaten and amphibians and bats were rare in the diet. Two families of rodents (Microtidae and Muridae) were the most important dietary components. Members of the order Insectivora were complementary prey, showing an increase in winter when voles declined. In summer, a significant increase of birds was seen. Dietary composition and niche overlap were tested on diets of two pairs of owls. One pair ate mostly voles and the other pair ate birds more frequently. Nevertheless, niche overlap was high because of the similarity between the nest sites used by the two pairs.

KEY WORDS: *Barn Owl*; Tyto alba; *diet*; *seasonal variation*; *niche breadth.*

Diferencias estacionales y geográficas en la dieta de *Tyto alba* en un agroecosistemas del norte de Italia.

RESÚMEN.—Estudiamos la amplitud del nicho alimenticio de *Tyto alba* en el plano del Río Po en el norte de Italia. Un total de 1266 egagropilas fueron recolectadas durante 2 años en el área agrícola localizada entre Mantova y Brescia. Los huesos de 4455 presas fueron identificados como pequeños mamíferos en particular los roedores e insectos fueron los componentes mas importantes es la dieta. Las aves (Passeriformes) constituyeron el resto de esta. Los artropodos fueron ocasionalmente ingeridos y los anfibios y murciélagos rara ve. Dos familias de roedores (Microtidae y Muridae) fueron los componentes mas importantes. Los miembros del orden Insectívora constituyeron una presa complementaria mostrando un incremento en el invierno cuando los roedores declinaron. En el verano hubo un incremento de aves. La composición de la dieta y el traslape del nicho fueron probados en la dietas de dos parejas de lechuzas, una igirio mas que todo ratones, mientras que la otra comió aves con mas frecuencia. Sin embargo el traslape del nicho fue mayor debido a la similaridad de los sitios del nido utilizados por estas dos parejas.

[Traducción de César Márquez]

The Barn Owl (*Tyto alba*) is a widely-distributed owl with euryphagous feeding habits (Lovari et al. 1976, Contoli 1981, Galeotti 1992). Because 95% of the variability in its diet is due to environmental factors (Spitz 1981), analysis of its diet can provide information on the availability of small mammal prey species in a particular area, even when few pellets are available (Contoli 1981). Its specialization on mammal species decreases when the abundance of its main prey decreases (Herrera 1974) and it increases the diversity of its diet to new prey items of lower energy content. Consequently, changes in its diet can be used to reflect real changes in the small mammal fauna available to the owl (Marti 1986).

Moreover, analysis of Barn Owl diets can be used as a tool in the research for the management and protection of important habitats. Indeed, small mammals may represent a biological indicator of biocoenosis in terrestrial ecosystems because they occupy various trophic levels, and then their presence or absence gives information on degree of biotope alteration (Contoli 1975).

Many studies have examined the diet of Barn Owls in Italy (Contoli 1980, 1981, Contoli et al. 1983, Torre 1983, 1987, Pandolfi and Santolini 1987, 1988, Boldreghini et al. 1988, Bigini and Turini 1992, 1995), but few data are available on the diet of the species in the Po plain in northern Italy (Groppali 1987, Vicini and Malaguzzi 1988). The aim of our study was to provide new information on the niche breadth of the Barn Owl (*Tyto alba*) and to contribute to the knowledge of the presence and the distribution of its prey species in an area in the Po plain.

STUDY AREA AND METHODS

The study was conducted in a 3500 ha area located between Mantova and Brescia. Approximately 90–95% of the area was intensively cultivated with few patches of the original mixed woodland habitat (*Querco-Carpinetum*) remaining (Sestini 1963, Ingegnoli 1993, Pignatti 1994). Agricultural fields consisted of cereals, corn, sunflower (40%), vegetables and fodder (35%), and wheat (5%). The area also included the Chiese River and many canals, as well as woody areas, grasses, permanent pastures, buildings, and abandoned fields.

The area was subdivided in three zones, 3–5 km apart, representing three different vegetation types. Several buildings such as farms or complexes of houses were also present. It contained two Barn Owl nest sites and we collected pellets at six collection sites (two silos and four hay lofts) in the two nest areas. Zone 1 (2 km^2) was characterized by cultivated fields (corn, sunflower, wheat), waste herbaceous fields (*Convolvulus arvensis, Calystegia sepium, Malva* spp.), *Platanus acerifolia* and *Sambucus ebulus* on the edges of the ditches, and small woodlots of *Robinia pseudoacacia.* Wetlands were abundant along the Chiese River, many ditches, mole drains, and an artificial lake. This zone contained one nest site and two roosts. Zone 2 (1 km^2) was surrounded by sunflower fields, woodlands of *Robinia pseudoacacia, Populus alba* and *Crataegus monogyna* and included two roosts 300–400 m away from the river. Zone 3 (1 km^2) had more homogeneous vegetation with corn fields and meadows and it included one nest site. Zones 1 and 3, within the municipalities of Remedello and Acquafredda, differed in their vegetation. Zone 1 had grassland and pastures and the habitat was more varied. Zone 3 consisted almost completely of corn fields (ISTAT 1990).

We visited the sites every 2 wk, at the middle and at the end of every month, from January 1993–December 1994. A total of 1266 pellets was collected. Pellets were analyzed using the dry method (Contoli 1980) and bones of prey species were identified by using dichotomous keys for mammals (Chaline et al. 1974, Pucek 1981, Amori et al. 1984, 1993) and birds (Moreno 1985, 1986, 1987). Prey were enumerated based on the minimum number of individuals (Southern 1954). Pelvis fragments were also used to estimate the quantity of prey, because skulls were missing in some cases. A complete determination of avian remains was not always possible because diagnostic bones were lost and skulls were fragmented. Biomass was calculated based on average weights of prey obtained from the literature (Toschi and Lanza 1959, Toschi 1965, 1986, Brichetti 1976). For *Rattus,* we used the average mass given by Di Palma and Massa (1981).

We estimated the percent frequency and percent biomass for each prey species based on the total number of specimens found and the biomass value of each specimen. To determine seasonal variation in the diet, we calculated the frequency of the families and classes of prey in each season and tested the differences with a chi-square test using the average frequency values between the two years. Finally, we tested the correlation (Spearman correlation coefficient) between the seasonal trends of prey frequencies.

To determine niche breadth, we first tested the relative importance of the prey categories and the diversity of the diet using a Kruuk and Parish's diagram (1981). It is based on the comparison of the percent frequency on the X-axis and percent biomass on the Y-axis. The relation (X*Y/100) equaled the bulk of each prey category in the diet and all points with equal X*Y values were connected by a set of isopleths. For both frequency and biomass, the average values between the 2 yr were used. To have another measure of the trophic diversity, we also calculated the Shannon index (H′) (Margalef 1968) and the Levins' normalized (B) index (Levins 1968).

When comparing diets, we considered only the samples collected at the two sites that were located 4200 m apart in two areas with different vegetation. A total of 460 pellets was collected at Site 1 (N = 1756) and 449 were collected at Site 2 (N = 1579). Niche overlap between the two nest sites was tested using a Percentage similarity index (Pso, Schoener 1970) based on the equations:

$$H' = -\sum_i pi \ln p_i \qquad B = (1/R) \sum p_i^2$$

$$Pso = 1 - 0.5\left(\sum |p_{i1} - p_{i2}|\right)$$

where $p_i = n_i/N$ and R = dietary categories.

RESULTS AND DISCUSSION

We identified a total of 4455 prey items with a total biomass of 91 021.02 g (Table 1). Mammals (Rodentia, Insectivora, and Chiroptera) were the most important prey species in the diet (F = 90.46, B = 79 550.8 g, %B = 87.40). The two principal prey species (*Sorex araneus* and *Apodemus sylvaticus*)

Table 1. Number of specimens (*N*) and frequency (F) of prey in Barn Owl diets by season in the Po plain, Italy (pooled values for 1993 and 1994).

	DEC.–FEB.		MAR.–MAY		JUNE–AUG.		SEPT.–NOV.	
PREY	*N*	F (%)	*N*	F (%)	*N*	F (%)	*N*	F (%)
Mammals								
Talpa europaea	0	0.00	1	0.20	2	0.08	2	0.27
Soricinae	125	14.99	78	15.73	212*	8.92*	106	14.17
Sorex araneus	118	14.15	69	13.91	175*	7.36*	91	12.17
Crocidurinae	249**	29.86**	128	25.81	484	20.36	148	19.79
Crocidura leucodon	84	10.07	41	8.27	226	9.51	69	9.22
Crocidura suaveolens	161**	19.30**	78	15.73	245	10.31	77	10.29
Microtidae	180*	21.58*	134	27.02	702	29.53	207	27.67
Microtus arvalis	119*	14.27*	102	20.56	483	20.32	138	18.45
Microtus savii	46	5.52	25	5.04	156	6.56	54	7.22
Muridae	196	23.50	113	22.78	631	26.55	196	26.20
Apodemus sylvaticus	125	14.99	76	15.32	456	19.18	118	15.78
Mus domesticus	9	1.08	6	1.21	30	1.26	13	1.74
Micromys minutus	33	3.96	20	4.03	81	3.41	33	4.41
Rattus sp.	14	1.68	3	0.60	15	0.63	13	1.74
Other mammals	64	7.67	50	10.05	235	9.88	74	9.89
Birds	61	7.31	23	4.64	252**	10.60**	58	7.75
Passer domesticus	31	3.72	13	2.62	114**	4.80**	28	3.74
Passer montanus	8	0.96	1	0.20	25**	1.05**	11	1.47
Other birds	2	0.24	1	0.20	17	71	2	0.26
Unidentified birds	20	2.40	8	1.61	96**	4.04**	17	2.27
Rana sp.	0	0.00	1	0.20	0	0.00	0	0.00
Arthropoda	0	0.00	1	0.20	21	89	8	1.07

* Frequencies lower than expected.

** Frequencies higher than expected.

were not habitat specialists. However, some prey species such as *Crocidura suaveolens, Crocidura leucodon, Micromys minutus* and *Microtus arvalis* were associated with open and cultivated habitats while others including *Neomys fodiens, Neomys anomalus* and *Arvicola terrestris* and *Mus musculus* and *Rattus* spp. were associated with canals and ditches and human habitations, respectively. Burrowing and arboreal species such as *Talpa europaea* and *Muscardinus avellanarius* were taken rarely, while forest specialists such as *Clethrionomys glareolus* and *Apodemus flavicollis* were not found in the diet. Surprisingly, we had a record of a *Suncus etruscus,* a species which is seldom reported in Lombardy (Ottolini and Aceto 1996).

Our sample included species related not only to various ecosystems but also to various trophic levels with rodents being first-order consumers and shrews, moles, and rats being higher-level consumers. Moreover, we observed a high diversity and abundance of insectivorous mammals which indicated that the study area had not been affected by chemical fertilizers (Contoli 1981). Every species that occurred in the study area occurred in the diet indicating that Barn Owls had large hunting territories and had both crepuscular or nocturnal foraging habits.

Birds represented a minor component in the diet (F = 8.84, B = 11 396.22 g, %B = 12.52). The principal prey species were *Passer domesticus* and *Passer montanus* which were very common in the study area. Arthropods (Classes Chilopoda and Insecta) and amphibians were only occasionally found.

Barn Owls specialize in eating small mammals throughout their range and the variety of small prey taken appears to vary with availability and environmental and geographical features. In North America, Clark and Bunck (1991) found an inverse correlation between shrew abundance and precipitation. In wetter habitats, shrews were more common in the diet while, in drier areas, rodents were

more common. Unlike Herrera (1974) who found a low diversity of mammalian prey in the diet of Barn Owls in the southern Mediterranean, we found an inverse correlation between latitude and diet diversity. In other studies in Africa (Heim de Balsac 1965, Goodman 1986) and South America (Jaksic and Yáñez 1979), rodents were the principal component of the diet of the Barn Owl. Apparently, the presence of shrews in the diet is variable and depends on environmental and geographical features. Birds, amphibians, arthropods, fish, and bats have been reported as prey in some areas when preferred small mammalian prey species declined. Very narrow Barn Owl diets have been reported by Lenton (1984) for Malaysia and by Morton and Martin (1979) for Australia. In both cases, the Barn Owls colonized areas where the small mammal fauna consisted of few species such as *Rattus* spp. and *Mus musculus.*

Mammals were the most important component of the diet in all seasons, always exceeding 80%. In spring, they reached their greatest frequency. There were significant seasonal differences of prey frequencies ($\chi^2_{15} = 113.79$, $P < 0.01$). In winter, Crocidurinae, mainly *Crocidura suaveolens,* occurred significantly more often and Microtidae, mainly *Microtus arvalis,* occurred less than expected. In summer, Soricinae decreased in frequency and birds, mostly *Passer* spp., increased significantly. Other mammals found in the diet included *Neomys fodiens, Neomys anomalus, Suncus etruscus, Microtus multiplex, Arvicola terrestris, Muscardinus avellanarius and Pipistrellus pipistrellus.* Other birds found in <3% of the sample included *Hirundo rustica, Riparia riparia, Melanocorypha calandra, Alauda arvensis, Sturnus vulgaris, Motacilla flava, Hippolais polyglotta, Carduelis carduelis and Carduelis chloris.*

The predation on small mammals that we observed may have been a reflection the reproductive cycles of the prey species (Torre 1983, Boldreghini et al. 1988, Bigini and Turini 1992, 1995). We recorded the highest predation rates when juvenile dispersal occurred (February–March for Insectivora, summer for Microtidae, and autumn for Muridae). It is possible that the increase in summer vegetation may have also contributed to the decline in small-sized insectivores which became difficult to find. Our analysis confirmed the inverse trends for frequency of Crocidurinae and Muridae ($r = -0.84$, $P < 0.001$). As for birds, our data confirmed that their capture fluctuated in accordance to the availability of mammals.

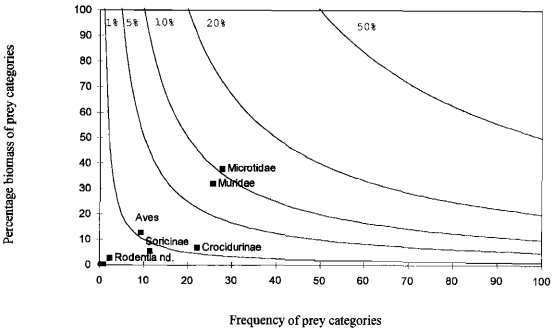

Figure 1. Kruuk and Parish's diagram of the estimated bulk of prey categories in the diet of Barn Owls in the Po plain, Italy. Isopleths connect points of equal relative bulk in the Barn Owl diet.

Our analysis of niche breadth confirmed the euryphagous habits and the wide trophic niche of the Barn Owl. The Kruuk and Parish diagram (Fig. 1) revealed that Microtidae and Muridae were principal prey (hyperbola of 10%), while all the other prey categories had only a marginal role (hyperbola of 1%) and none of them represented more than 50% of the diet. Both the indexes of niche breadth had high values ($H' = 1.648$, $B = 0.58$). The Shannon index was higher than previously reported by other authors in other regions (e.g., 1.13 [Lovari et al. 1976]; 1.37 [Amori and Pasqualucci 1987]; 1.39 [Petretti 1977]). Our index was was very similar to indexes of 1.67 reported by Groppali (1987) and 1.63 reported by Vicini and Malaguzzi (1988) in the Po plain and to the average value of 1.7 calculated for Italy by Contoli (1988). These results confirmed the presence of a diversified small mammal population with various trophic levels represented which could reflect a complex trophic relationship and an apparently mature and stable ecosystem (Margaleff 1975).

At site 1, Microtidae, in particular *Microtus arvalis,* were twice as abundant as in Site 2 and Muridae and birds were more frequent in the diet than expected in Site 2 (Table 2). These differences could have been due to the differences in vegetation between the two sites. Site 1 was located in an area with various kinds of agriculture with fields and woodlands on the edges of canals. The area surrounding Site 2 had less habitat diversity which may explain the absence of Microtidae in the diet and the occurrence of Muridae in the diet. At Site 2, the decrease of Microtidae forced Barn Owls to

Table 2. Number of specimens (*N*) and frequency (F) of prey in the diets of Barn Owls at two nests sites (pooled values for 1993 and 1994).

	SITE 1		SITE 2	
	N	F	*N*	F
Mammals	1678*	95.56%*	1310*	82.96%*
Insectivora	581	33.09%	523	33.12%
Talpidae	1	0.06%	3	0.19%
Soricinae	192	10.93%	170	10.77%
Crocidurinae	376	21.41%	336	21.28%
Rodentia	1096	62.41%	786	49.78%
Microtidae	638*	36.33%*	303*	19.19%*
Microtus arvalis	529*	30.13%*	142*	8.99%*
Muridae	413*	23.52%*	449*	28.44%*
Apodemus sylvaticus	283*	16.12%*	321*	20.33%*
Gliridae	4	0.23%	1	0.06%
Chiroptera	0	0.00%	1	0.06%
Birds	65*	3.70%*	260*	16.47%*
Passer domesticus	27*	1.54%*	125*	7.92%*
Passer montanus	8*	0.46%*	25*	1.58%*
Other birds	2	0.12%	15	0.94%
Unidentified birds	28*	1.59%*	95*	6.02%*

* Frequencies significantly different between the two sites.

increase their predation on the other available species, in particular birds ($\chi^2_4 = 233.4$, $P < 0.01$). The increase in predation on complementary prey categories was confirmed by both indexes of niche breadth, that were higher in Site 2 ($H' = 1.686$, $B = 0.623$) than in Site 1 ($H' = 1.51$, $B = 0.29$).

The Percentage similarity index (Pso = 0.73) indicated a high niche overlap in the diets of Barn Owl at the two sites. This finding was expected because the two sites had similar climatic, environmental, and anthropogenic features. The diversity of birds and Microtidae in the diet at both sites was a reflection of the adaptability of Barn Owls to differing prey availabilities.

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