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Food Composition of the Little Owl *Athene noctua* in Farmland Areas of South East Poland

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ABSTRACT. The feeding ecology of the Little Owl (*Athene noctua*) was studied in farmlands of southeast Poland, which is dominated by monocultural farms. 3065 prey dissected from pellets were collected at 13 pellet stations between 1999 and 2001 through 7 seasons in total. Mammals were found to dominate both in total number (54.3% of caught prey) and total biomass (93.0% of caught prey) while insects comprised 43.0% of the number, but only 1.1% of the prey biomass. However, the proportion of insects reached up to 62% in certain seasons. Coleopteran beetles dominated the insect fraction representing 98.3% of the number and 87.9% of the insect biomass. Our study also illustrated that in some seasons, the prey composition included taxa related to intensive agricultural management. The food composition of the Little Owls from the examined Polish sites is more similar to Eastern and Southern populations than to Northern and Western populations of Little Owls in Europe.

KEY WORDS: Little Owl, diet, farmland, Poland

INTRODUCTION

Populations of the Little Owl *Athene noctua* have recently been decreasing in many European countries (MANEZ, 1994; VOGRIN, 1997; VORONETSKY, 1998; HEATH et al., 2000). The species has therefore become a high conservation priority, of increasing interest as a research subject, which in turn has resulted in the study of many aspects of its biology, ecology and distribution (ZERUNIAN et al., 1982; GENOT, 1994; ANGELICI et al., 1997).

Also in Poland, a drop in the number of little owls has been observed during the last 10 to 20 years, seemingly more evident in Western and Central Poland (TOMIALOJC & STAWARCZYK, 2003; ZMIHORSKI et al., 2006; GRZYWACZEWSKI, 2006a). Southeast Poland is slightly more densely populated by *A. noctua* (TOMIALOJC & STAWARCZYK, 2003), where it can be observed in towns and farms (KITOWSKI, 2000; 2002; KITOWSKI & GRZYWACZEWSKI, 2003; KITOWSKI & KISIEL, 2003; GRZYWACZEWSKI, 2006a). The obviously greater numbers of owls at sites in agricultural landscapes allows data collection from a large number of pellet stations for the study of food composition. In Central and East European countries, there is a lack of new data on the food for the Little Owl in contrast to Western Europe, the Mediterranean and Middle East, where several interesting studies were conducted (ZERUNIAN et al., 1982; GOTTA & PIGOZZI, 1997; ANGELICI et al., 1997; OBUCH & KRISTIN, 2004; ALIVIZATOS et al., 2005; VAN NIEUWENHUYSE et al., 2008). A good knowledge of the food ecology of Little Owls that also considers seasonal changes is needed for the development of appropriate conservation strategies. This is especially relevant because some authors (GENOT & VAN NIEUWENHUYSE, 2002; ZMIHORSKI et al., 2006) pointed out that the cause of the decline of Little Owls might be food related. New data on the food composition of Little Owls from Poland are largely lacking with the exception of two studies (BACIA, 1997; GRZYWACZEWSKI et al., 2007), where only the former considered seasonal changes in food. The aim of the presented research was to analyse the food composition of Little Owls and its seasonal changes, in farmland of southeast Poland dominated by large monoculture fields.

MATERIALS AND METHODS

Study area and methods

The study was carried out between 1999 and 2000 in the agricultural landscape of the southeast part of the Lublin region (the surroundings of the towns: Hrubieszow, Tomaszow Lubelski, within the triangle: 50°48'N, 23°55'E; 50°27'N, 24°00'E; 50°27'N, 23°25'E; SE Poland). Lands in this region used to be owned by the State from the Second World War till the early 90's. They were formed into state farms (in Polish: PGR – Panstwowe Gospodarstwo Rolne) or collective farms (in Polish: RSP – Rolnicza Spoldzielnia Produkcyjna). Presently, most of the state farms belong to private farmers or workers' associations. Infrastructure not owned by the new owners has progressively deteriorated. In order to collect pellets, the recesses, garrets, air channels, air holes, chimneys, and other niches in locations such as barns, cowsheds, dovecotes, granaries, corn hop bins, fertiliser store houses, sheds, and flat blocks were searched in 13 villages: Dutrow, Kornie, Przewodow, Mycow, Machnow Stary, Krzewica, Machnow Nowy, Kosciaszyn, Cichoborz II, Nowosiolki Kardynalskie, Dolhobyczow PGR, Szczepiatyn PGR and Zurawce PGR (elevation: 250-300m.a.sl.).

The distribution of meadows and cultivated fields was mapped and their surface areas calculated with a digital planimeter from high-resolution aerial photos for a radius of 2km around each pellet station. In the first five villages, meadows covered more than 30% of the total area within a 2km radius, while in the other eight villages meadows were less than 30% of the total area within a 2km radius.

All villages were situated closely together (within 50km) in agricultural land. The infrastructure of the farms and their dwellings mostly formed "islands" surrounded by large field monocultures (fields with an average size of 25ha).

The food of Little Owls was studied in seven seasons, starting in summer 1999 until spring 2001. Prior to searching for pellets in the summer of 1999, all the places mentioned above were cleaned of "old pellets." The last collection of pellets of this study was performed on the day of the end of the astronomical winter 2001 (Tables 1 & 2). The overall number of pellets amounted to 608. The pellets were prepared for analysis by standard methods (Ruprecht et al., 1998). The number of vertebrate prey species was determined on the basis of skulls, mandibles, teeth and other important key remains following several authors (Bohme, 1977; Arnold & Burton, 1980; Pucek, 1984; Cuisin, 1989; Diesener & Reicholf, 1997) The following keys were used to note insects (Mroczkowski, 1954; Mroczkowski, 1955; Smreczynski, 1966; Stebnicka, 1978; Dahlgren, 1979; Stebnicka, 1991; Chinery, 1993; Warchalowski, 1993; Hurka, 1996; Burakowski et al., 1973; 1974). In some cases, we used our own collections of insects from the study area for comparisons with insect parts in the pellets. In the case of undetermined beetles Coleoptera n. det., the average biomass of specimens was estimated for the most numerous species or genus found in the analysed pellets. Some prey were grouped in different categories (for example as Aves n.det. Arvicolidae n.det., *Sylvaemus,* Muridae*, Pterostichus* n.det., Coleoptera n.det. itp. in Table 1), because sometimes a high degree of fragmentation did not allow them to be identified to the genus or species level. To estimate the prey biomass, data for invertebrate and vertebrate prey biomass were used as in Pucek (1984), Romanowski (1988), Kruuk (1989), Bacia (1997) and Jedrzejewska & Jedrzejewski (2001). In a few cases, independent weighing of captured insects was performed because data were not available from the literature. Biomass of the earthworm *Lumbricus terrestris* and their number on the basis of chaetae was calculated following Kruuk & Parish (1981). The breadth of food niches of owls was estimated with the formula by Levins (1968): $B=1/Sp_i^2$, where p_i is the proportion of the prey category i in the total biomass of the owl's diet.

Species richness (S) and Shannon-Wiener (H) indices were calculated to measure how similar the abundance of different prey categories was, while the evenness index calculated as E=H/log(S) measured the abundance of different prey categories. In the formula provided, H is the sum $[P_i \log(P_i)]$, S is the number of prey categories and P_i is the proportion of prey category i in the total number of prey (Krebs, 1997). The breadth of the food niche was calculated by the B index: $B=1/\Sigma p_i^2$ where p_i is the amount of the biomass of the i-th prey (Levins, 1968).

The means and standard deviation (SD) were provided for parametric data while non-parametric data were presented as medians and standard errors (SE) (Fowler & Cohen, 1992).

RESULTS

General Food Composition of Studied Little Owls

From all collected pellets, a total of 3065 prey items could be distinguished with a total biomass of 32800.07g (Table 1). Among the analysed prey, vertebrates were dominant and comprised 56.7% of the number of prey captured and 98.8% of its biomass (32393.3g) (Table 1). Amphibians were represented only by a single order and species (Table 1), while one order and two species of birds were found, the sparrows *Passer montanus* and *Passer domesticus*. Avian prey was strongly dominated by the house sparrow *P. domesticus* and they comprised as much as 80.0% of the number and 85.6% of the mass of all birds (Table 1).

Among the vertebrate prey, mammals were most common in both number and biomass (95.7% of prey number and 94.1% of prey biomass – see Table 1). Mammalian prey belonged to three orders (Insectivora, Chiroptera, Rodentia), four families and 15 species, and were dominated by rodents (52.7% of prey number and 91.9% of prey biomass – see Table 1).

Two phyla, namely Annelida and Arthropoda, were represented in the invertebrate prey, totalling 406.8g altogether. Among the invertebrates, the highest numbers (99.4%) and biomass (95.6%) belonged to insects of which three orders with 13 families were identified: the order Orthoptera (families: Gryllotalpidae, Tettigoniidae), the order Coleoptera (families: Carabidae, Chrysomelidae, Curculionidae, Dynastidae, Dytiscidae, Elateridae, Geotrupidae, Scarabaeidae, Silphidae, Tenebrionidae) and the order Dermaptera (family Forficulidae).

Little Owls mostly caught beetles, which comprised as much as 98.3% in number and 87.9% of the biomass of all hunted insects (Table 1). Among the beetles, the mealworm *Tenebrio molitor* was especially frequent, contributing 29.1% (in number) and 48.9% (in biomass) of all beetles sampled in this study that could be identified to genus level.

The average mass of all prey caught by Little Owls in the study area was 10.63±11.06g per prey, ranging from 0.1-166g. The average prey biomass was not significantly different between the 13 sites where pellets were collected (ANOVA: $F_{11,\ 3053}=0.2197$, p=0.9964). However, highly significant differences were observed in the median mass of prey caught in the villages with less than 30% meadows within a radius of 2km from the pellet stations (8.0±0.236g, 0.1g-166g) as compared to villages with more than 30% meadows (19.0±0.314g, range: 0.1g-166g) (Mann-Whitney U-test: Z=-18.32, $n_1=2032$, $n_2=1033$, p<0.001).

Seasonal Changes of Food Composition

The median of prey mass ranged from 0.55±0.574g to 19±0.520g per study period and was significantly different between the seven study periods (Kruskal-Wallis ANOVA: H=156.1, df=6, P<0.00001) (Table 1). In certain seasons, the prey comprised species related to intensive agricultural management, as for example the synantropic mammals *Mus musculus* and *Rattus rattus* as well as insects related to storing and processing the harvest. The observed biomass distribution of all synantropic mammals deviated from the expected during the seasons (χ^2=1922.5, df=6, P<0.0001) and they were most often captured in spring 2000, when they comprised 13.7% of the number and 21.4% of the mass of all captured mammals (Table 1). In the same spring, Little Owls captured as much as 44.2% of the total mass (m=2331.5g) of this prey category from the entire study period. Also, the observed distribution of biomass of captured *Mus musculus* deviated from the expected distribution (χ^2=392.0, df=6, P<0.0001), because as much as 25.1% of this prey was captured in winter 2000. Altogether for the autumn-winter periods, *Mus musculus* comprised only 5.0% of 16993g biomass of all captured mammal species. However, during the spring-summer periods, *Mus musculus* contributed 9.3% of 8772g, a difference that was statistically significant: (χ^2=174.2, df=1, P=0.0001).

Also *Micromys minutus* played an essential role as food for Little Owls, mainly in the autumn-winter periods, comprising 5.3% of 16993g mammal prey biomass, whereas in the spring-summer period, this species contributed less than half, namely only 2.1% of 8772g. Also these differences were highly significant (χ^2=145.2, df=1, P<0.0001). Testing the significance for total prey biomass according to the different seasons found *M. minutus* was most important in spring (Table 1).

As shown above, among the insects, beetles were most numerous as food for Little Owls. Depending on the season, beetles composed an average of 98.5 ± 1.5% of the total number and 96.5±3.9% of total mass of captured insects, whereas in summer 2000 and winter 2001, they contributed 100% of insect food for Little Owls. One of the most numerous food components was *Tenebrio molitor*, comprising 62.5% in spring 2000 of all identified beetles. *T. molitor* was also caught in winter, when it contributed 29.5% of all (112) identified beetles. *T. molitor* contributed significantly more to beetle biomass in the spring-summer period than in autumn and winter (32.3% of 134g. *vs* 20.6% of 180g.) (χ^2=6.08, df=1, P=0.014).

Other beetles identified in this study as prey of Little Owls were related to cattle breeding as for example *Geotrupes vernalis, G. stercorarius* and *Copris lunaris*. Beetles typical for grasslands and meadows such as *Zabrus tenebrioides* were also found. In summary, they comprised as much as 12.7% of the 581 beetle individuals identified to the genus level in this study. Sometimes (for example in summer 2000), their proportions reached up to 29.5% of 61 identified beetles (Table 1).

Seasonal changes in the food for the Little Owl were tested for mutual relationships of particular prey categories (Table 2). It was e.g. noticed that an increase of biomass of *Mus musculus* resulted in a significant reduction in biomass of the mammalian prey species *Microtus arvalis* and *Micromys minutus*. Simultaneously, a statistically significant growth in the biomass of insects was observed (Table 2). Similarly, an increase in the biomass of *Apodemus agrarius* reduced the biomass of Amphibia and Insectivora significantly (Table 2). Seasonal changes were also obvious from the breadth of food niche index B. B showed its greatest values in summer and its lowest in winter (Table 1). An increase in the proportion of *Microtus arvalis* in the total biomass of caught prey reduced the size of the food of Little Owls, while an increase of insects and *Mus musculus* in the biomass of caught prey expanded the food niche. Other food categories did not have any influence on the size of the food niche (Table 2). The estimated evenness E=0.68 for pooled data indicated that prey categories were not evenly distributed among the studied prey samples. The E index had its lowest value in both winters (Table 1) and its highest value in summer 1999.

DISCUSSION

Previous studies in the farmland of SE Poland showed that the hunting areas of Little Owls were on average about 20.2ha (Grzywaczewski, 2006b). The data presented here allow testing for correlations between particular prey categories and their seasonal changes, and thus provide deeper knowledge on foraging of Little Owls in monocultural farms of SE Poland.

Our study confirmed that Chiroptera was a rather rare component of the diet of Little Owls as only one specimen was found of the bat *Vespertilio murinus*, which is very rare in Poland (Woloszyn, 2001). This result fits with observations from other authors (Laiu & Murariu, 1997; Genot & Van Nieuwehuyse, 2002; Obuch & Kristin, 2004; Alivizatos et al., 2005) and is different to diets of other owls such as Tawny Owls *Strix aluco* or Barn Owls (Mikkola, 1983; Ruprecht, 1990; Bekasinski et al., 1996).

Despite the fact that the studied region is unusually poor in wetland areas, 4.4% of the number and 3.3% of the overall mass of hunted prey were *Micromys minutus*. This proportion clearly exceeds data from a nearby, more northern site in central Poland (Romanowski, 1988) where only 1.3% and 0.34%, respectively, were observed and from the Central Lublin region (Grzywaczewski et al., 2007) with 1.5% and 1.57%, respectively. In Southern Europe, for example in the rice fields of Northern Italy and wetlands in Greece, *M. minutus* contributed up to 24.8% and 9.3%, respectively (Gotta & Pigozzi, 1997) and 17.9% and 10.8%, respectively (Alivizatos et al., 2005).

During our study, only a small amount of *Lumbricus terrestris* appeared in the diet of studied owls, exclusively during autumn. As mentioned above, the study region is characterized by intense agricultural management such as multiple annual ploughing and intensive fertilization and pest control (GUS, 1975; 1988; 2008; Nowak & Nowak, 1996). These practices most likely cause low earthworm densities (Genot & Van Nieuwenhuyse, 2002).

TABLE 1

Food composition of Little Owls from south east Poland [g] – grams, n – number of prey, m –prey biomass

Prey category	m [g]	summer 1999		autumn 1999		winter 2000		spring 2000		summer 2000		autumn 2000		winter 2001		Total	
		%n	%m	%n	%m	%n	%m	%n	%m	%n	%m	%n	%m	n%	%m	n%	%m
Pelobates fuscus	20	2.1	3.78	0.6	1.32	0.4	0.71	2.8	6.66			0.9	1.37	0.6	0.75	1.14	2.13
Amphibia	**-**	**2.1**	**3.78**	**0.6**	**1.32**	**0.4**	**0.71**	**2.8**	**6.66**			**0.9**	**1.37**	**0.6**	**0.75**	**1.14**	**2.13**
Passer domesticus	32	1.0	2.68	1.6	5.62	1.5	4.16	1.0	4.0					0.8	1.8	1.04	3.12
Passer montanus	23	0.2	0.48	0.2	0.51	0.4	0.82									0.16	0.35
Aves n.det	18	0.2	0.38	0.2	0.39	0.1	0.21									0.10	0.16
Aves	**-**	**1.4**	**3.54**	**2.0**	**6.52**	**2.0**	**5.19**	**1.0**	**4.0**					**0.8**		**1.3**	**3.63**
Sorex araneus	8	1.0	0.7	0.2	0.18	0.1	0.09	0.7	0.67	1.5	1.63	0.9	0.55	0.6	0.3	0.59	0.44
Sorex minutus	3.5	0.2	0.07			0.3	0.08	1.0	0.44					0.6	0.13	0.36	0.12
Crocidura leucodon	8	0.5	0.34			0.4	0.28	0.7	0.67	1.1	1.2	0.4	0.27	1.4	0.75	0.59	0.44
Insectivora	**-**	**1.7**	**1.11**	**0.2**	**0.18**	**0.8**	**0.45**	**2.4**	**1.78**	**2.6**	**2.83**	**1.3**	**0.82**	**2.6**	**1.18**	**1.54**	**1.00**
Vespertilio murinus	14	0.2	0.29													0.03	0.04
Chiroptera	**-**	**0.2**	**0.29**													**0.03**	**0.04**
Clethrionomys glareolus	17					0.1	0.2									0.03	0.05
Microtus subterraneus	17	1.0	1.43	0.6	1.12	0.5	0.8	0.7	1.42	0.8	1.73	1.3	1.75	0.3	0.32	0.69	1.1
Microtus œconomus	26	0.7	1.64	0.2	0.57	0.4	0.92	0.5	1.6	0.4	1.33			0.3	0.49	0.39	0.95
Microtus agrestis	23					0.3	0.54									0.07	0.14
Microtus arvalis	19	**20.1**	**34.27**	**14.7**	**30.05**	**21.3**	**35.10**	**13.8**	**30.84**	**13.2**	**33.92**	**31.7**	**46.93**	**36.4**	**45.84**	**20.49**	36.40
Arvicolidae n.det.	23	11.1	23.16	5.7	14.14	7.8	15.51	6.0	16.28	10.5	32.85	6.6	11.84	10.4	15.92	8.06	17.32
Mus musculus	15.5	4.2	5.85	3.0	4.77	3.7	4.95	4.1	7.61	4.1	8.7	2.0	2.13	2.8	2.9	3.49	5.1
Rattus norvegicus	166							0.7	13.82							0.13	2.02
Micromys minutus	8	4.4	3.19	6.1	5.45	4.0	2.74	0.7	0.67			10.1	6.30	8.2	4.34	4.40	3.3
Apodemus agrarius	17	3.0	4.28	11.5	20.91	9.7	14.28	1.6	3.18	2.3	5.2	10.1	13.41	10.5	11.76	6.98	11.1
Apodemus flavicollis	31	0.2	0.65	0.2	0.68	0.3	0.73							0.3	0.58	0.16	0.47
Apodemus silvaticus	20	1.0	1.68	0.2	0.44	0.9	1.66	0.5	1.25					1.4	1.87	0.65	1.22
Sylvaemus n.det.	23	2.5	5.31	1.4	3.54	1.8	3.27	1.0	2.87	1.1	3.52	2.2	3.95	2.5	3.87	1.73	3.72
Muridae n.det.	18	5.6	9.06	4.5	8.70	7.6	11.93	2.7	5.62	3.0	7.34	7.5	10.5	6.8	8.08	5.42	9.11
Rodentia	**-**	**53.8**	**90.52**	**48.1**	**90.36**	**58.4**	**92.61**	**32.3**	**85.18**	**35.4**	**94.59**	**71.5**	**96.81**	**79.9**	**95.97**	**52.69**	**91.94**
Mammalia	**-**	**55.7**	**91.87**	**48.3**	**90.53**	**59.2**	**93.07**	**34.7**	**86.94**	**38.0**	**97.44**	**72.8**	**97.63**	**82.5**	**97.14**	**54.26**	**92.98**
Vertebrata	**-**	**59.2**	**99.24**	**50.9**	**98.55**	**61.6**	**98.98**	**38.5**	**97.60**	**38.0**	**97.44**	**73.7**	**99.00**	**839**	**99.70**	**56.70**	**98.80**
Lumbricus terrestris	2.5			0.6	0.16							2.0	0.34			0.23	0.05
Myriapoda n.det.	0.01											0.4	+			0.03	+
Gryllotalpa gryllotalpa	2.0					0.4	0.07	0.4	0.08			0.4	0.07			0.20	0.04
Tettigoniidae n.det.	0.7	0.2	0.01													0.03	+
Orthoptera	-	0.2	0.01			0.4	0.07	0.4	0.08			0.4	0.07			0.23	0.04
Forficula auricularia	0.07	0.7	+	2.0	0.01	0.4	+									0.49	+
Dermaptera	**0.07**	**0.7**	**+**	**2.0**	**0.01**	**0.4**	**+**									**0.49**	**+**
Dytiscus marginalis	0.6	0.7	0.04	1.0	0.07	0.3	0.01					3.1	0.14	1.1	0.04	0.69	0.04
Carabus granulatus	0.54	0.2	0.01	0.6	0.04	0.3	0.01	1.0	0.07	0.8	0.06	0.9	0.04	0.3	0.01	0.55	0.03
Carabus cancellatus	0.58					0.1	0.01	0.2	0.01					0.3	0.01	0.10	0.01
Amara aenea	0.01	0.2	+	0.2	+											0.07	+

TABLE 1

Food composition of Little Owls from south east Poland [g] – grams, n – number of prey, m –prey biomass

Prey category	m [g]	summer 1999		autumn 1999		winter 2000		spring 2000		summer 2000		autumn 2000		winter 2001		Total	
		%n	%m	%n	%m	%n	%m	%n	%m	%n	%m	%n	%m	n%	%m	n%	%m
Pterostichus niger	0.05	3.3	0.01	0.2	+			0.9	0.01	1.1	0.02	0.9	0.01	0.8	0.01	0.91	0.01
Pterostichus vulgaris	0.1	3.5	0.03					0.7	0.01					0.3		0.65	0.01
Harpalus aeneus	0.06			0.2	+	0.1	+	0.4	+							0.13	+
Zabrus tenebrioides	0.25	0.2	+		0.01	0.1										0.07	+
Silpha obscura	0.06									0.4	+					0.03	+
Necrophorus humator	0.21	0.5	0.01													0.07	+
Necrophorus vespilloides	0.20	0.7	0.01	0.2	+			0.5	0.01							0.23	+
Geotrupes vernalis	0.5			0.4	0.02	1.6	0.07			1.1	0.08	0.4	0.02			0.59	+
Geotrupes stercorarius	0.7	0.7	0.04	2.5	0.18	0.5	0.03	1.8	0.15	5.6	0.53	0.9	0.05	0.6	0.03	1.57	0.1
Oryctes nasicornis	0.8							0.7	0.07	0.4	0.04					0.16	+
Melolontha melolontha	0.55	0.5	0.02	0.2	0.01	0.3	0.01	1.0	0.07	0.8	0.06					0.42	0.02
Cetonia aurata	0.5	0.5	0.02			0.1	0.01									0.10	+
Copris lunaris	0.7					0.1	0.01	0.9	0.07							0.20	0.01
Agrypnus murinus	0.28							0.2	0.01							0.03	+
Tenebrio molitor	0.6	4.4	0.24	5.3	0.34	3.4	0.18	13.0	0.91	5.6	0.46	1.3	0.06	2.3	0.09	5.51	0.31
Leptinotarsa decemlineata	0.15	0.7	0.01	0.2	+	0.1		0.5	0.01							0.26	+
Hypera zoilus	0.15	0.5	+	0.4	0.01	0.8	0.01	0.4	0.01	1.1	0.02	1.3	0.02	1.1	0.01	0.72	0.01
Agabus n.det.	0.18											0.4	0.01			0.03	+
Amara n.det.	0.015			1.2	0.02	0.3	+	0.4	0.01			0.9	0.01	0.3		0.42	0.01
Pterostichus n.det.	0.05	11.2	0.05	4.1	0.02	1.9	0.01	7.8	0.05	4.9	0.04	2.2	0.01	2.8	0.01	5.02	0.03
Harpalus n.det.	0.06	0.2	+	1.0	0.01	0.3		0.4	+	1.1	0.01					0.42	+
Carabidae n.det.	0.23	7.2	0.15	27.4	0.68	22.0	0.44	25.7	0.69	33.8	1.06	8.4	0.15	4.0	0.06	19.35	0.42
Carabidae larvae n.det.	0.2											1.3	0.02	1.1	0.01	0.23	+
Dytiscidae	0.6	0.2	0.01													0.03	+
Staphyllinidae n.det.	0.06			0.6	+			0.2	+	0.8	0.01	0.4	+			0.23	+
Elateridae n.det.	0.05	0.7	+					0.2	+							0.13	+
Curculionidae n.det.	0.15	0.5	+							0.4	0.01					0.10	+
Coleoptera n.det.	0.32	3.3	0.1	1.0	0.03	5.3	0.15	4.2	0.16	4.1	0.18	2.2	0.05	1.1	0.02	3.30	0.1
Coleoptera		**39.9**	**0.75**	**46.7**	**1.44**	**37.6**	**0.95**	**61.1**	**2.38**	**62.0**	**2.58**	**24.6**	**0.59**	**16.1**	**0.3**	**42.32**	**1.00**
Insecta		**40.1**	**0.76**	**48.4**	**1.45**	**38.5**	**1.20**	**61.9**	**2.4**	**62.0**	**2.58**	**24.9**	**0.66**	**16.1**	**0.3**	**43.03**	**1.15**
Total number of prey		428		490		733		565		266		229		354		3065	
Total biomass of prey [g]			4767.69		4552.95		8452.25		4804.75		1960.68		2915.03		5346.72		32800.07
B Levins index			5.22		5.82		5.33		6.31		8.07		3.71		3.83		5.25
Shannon-Wiener H index		4.21		3.72		3.70		3.87		3.50		3.64		3.42		4.02	
Evenness E index		0.780		0.720		0.695		0.737		0.744		0.756		0.698		0.684	
Median prey biomass ± SE [g]		15.5±0.473		8.0±0.437		17.0±0.351		0.6±0.683		0.55±0.574		17.0±0.520		19.0±0.410		15.0±0.199	

TABLE 2.

Correlation coefficients among food components and Levins (1968) B index. P<0.05*, P<0.01**, P<0.001***

	Amphibia	***Passer sp***	**Aves**	**Insectivora**	***M. arvalis***	***Microtus* spp**	***M. musculus***	***M. minutus***	***A. agrarius***	**Rodentia**	**Insecta**	**B**
Amphibia	-	-0.506 n=5	-0.104 n=5	0.520 n=5	-0.411 n=6	-0.344 n=6	0.749 n=6	-0.680 n=6	-0.869* n=6	-0.744 n=6	0.573 n=6	0.505 n=6
Passer sp.		-	0.869 n=5	-0.960* n=5	-0.532 n=5	-0.576 n=5	-0.01 n=5	0.291 n=5	0.668 n=5	-0.04 n=5	0.165 n=5	0.359 n=5
Aves			-	-0.879* n=5	-0.866 n=5	-0.901* n=5	-0.388 n=5	0.096 n=5	0.471 n=5	-0.458 n=5	0.549 n=5	0.770 n=5
Insectivora				-	0.230 n=7	0.278 n=7	0.367 n=7	-0.452 n=6	-0.789* n=6	0.05 n=7	0.234 n=7	0.201 n=7
M. arvalis						0,994*** n=7	-0.767* n=7	0.548 n=6	0.145 n=7	0.796 n=7	-0.701 n=7	-0.756* n=7
Microtus spp.							-0.717 n=7	0.505 n=6	0.059 n=7	0.788 n=7	-0.666 n=7	-0.720 n=7
M. musculus							-	-0.862* n=6	-0.624 n=7	0.560 n=7	0.888** n=7	0.944** n=7
M. minutus								-	0.710 n=6	0.766 n=6	-0.652 n=6	-0.662 N=6
A. agrarius									-	0.328 n=7	-0.394 n=7	-0.385 n=7
Rodentia										-	-0.514 n=7	-0.395 n=7
Insecta											-	0.920** n=7
B index											-	

However, on the other hand, the data above fit with the view point of other researchers, who show that owls as generalist predators reveal an adaptability to local sources for their diet. Consequently, a high proportion of earthworms in Great Britain and in the North and West parts of Europe (Libois, 1977; Altringham et al., 1994; Genot & Van Nieuwenhuyse, 2002, Hounsone et al., 2004) varies considerably from the prevalence of Arthropoda and Reptilia in the Mediterranean and desert areas of Asia (Al-Melhim et al., 1997; Obuch & Kristin, 2004; Shao et al., 2007). The studied Little Owls in SE Poland reflect this NW-SE gradient of diet changes to some extent. Although an unusually small quantity of earthworms was observed in their prey, no reptiles were discovered, despite the fact that they are so characteristic for south-eastern breeding sites of the species (Obuch & Kristin, 2004).

In our study area, we found a positive correlation between the prey biomasses of *Mus musculus* and insects. It illustrates the importance of farm buildings including grain warehouses, barns etc. and grassy areas among them for hunting, and corresponds with the observed negative correlations between the prey biomass of *M. musculus* and *Microtus arvalis* as well as between *M. musculus* and *Micromys minutus*. It shows that Little Owls trade off hunting between farm buildings and nearby fields and meadows. In spring, Little Owls select large numbers of *Micromys minutus* (Table 1) dwelling in meadows, sedges (*Carex* sp.) and buildings (Pucek, 1984), where they become alternative prey to *M. musculus*, which is also found in buildings. In summer, owls abandon the vicinity of buildings and prey in open fields and meadows, where they cannot acquire large amounts of *M. minutus*.

The analysis of Little Owls' food during spring and summer pointed to a considerable proportion (54.4%) of insects. This percentage is much higher than in Central Poland (Romanowski, 1988) with 25% but is rather similar to the results from the central part of the Lublin region located about 90km NW from the studied places, where insects comprised 60.5% of prey from April to July (Grzywaczewski et al., 2007). However, insects form a much higher proportion of Little Owls' diets in Southern Europe, the Middle East or desert areas of Central Asia (Zerunian et al., 1982; Gotta & Pigozzi, 1997; Angelici et al., 1997; Obuch & Kristin, 2004; Shao et al., 2007). This gradient in the percentage of insects as prey items from Central to Southern Europe can be explained by a lower availability of microtines in the Mediterranean (Mikkola, 1983; Angelici et al., 1997; Obuch & Kristin, 2004). Also the proportion of Dermaptera is much lower in our study area than for example in Italy and Greece where they can be an essential food element (in terms of percentage of prey number) (Zerunian et al., 1982; Manganaro et al., 2001; Alivizatos et al., 2005).

Our study confirmed that, similar to other sites in Central Europe (Laiu & Murariu, 1997; Ille & Grinschgl, 2001), *Microtus arvalis* are very important prey items for Little Owls. This can be very profitable for the owls in "vole years" – on the other hand, it can cause poor breeding results in those years when vole populations decline (Genot & Van Nieuwenhuyse, 2002). One would expect that most *M. arvalis* should be caught in spring, the time of reproduction and rearing of the young, which was confirmed by Grzywaczewski et al. (2007) for other parts of southeast Poland. However, in other studies, most *M.*

arvalis in terms of biomass were caught in winter, which is a critical time for all owls including the Little Owl (MIKKOLA, 1983; GENOT & VAN NIEUWENHUYSE, 2002). Our results correspond with the latter data because the highest contribution of *M. arvalis* to prey biomass was found during winters, when other food resources are depleted.

Significant amounts of insects were found in Little Owls' winter diets. This can probably be explained by the fact that Little Owls hunt inside buildings where loose grain is stored that provides good habitats for certain insects such as *Tenebrio molitor*. Hunting inside buildings is undoubtedly attractive for Little Owls for at least three reasons. Firstly, there is no snow, which, similarly to high and dense vegetation, strongly reduces hunting efficiency (EXO, 1992). Secondly, owls avoid exposure to wind and low temperatures, which would require additional energy when hunting in the natural environment. Thirdly, hunting inside buildings offers easily accessible perches such as stored agricultural facilities, tools etc., providing owls with exquisite opportunities for their basic hunting technique, namely attacking from perches (MANEZ, 1994; GENOT & VAN NIEUWENHUYSE, 2002). These arguments are supported by the finding that hunting efficiency is low in high snow and during winter temperatures due to restricted food resources, causing winter mortality of owls (MARTI & WAGNER, 1985; EXO, 1992; MASSEMIN & HANDRICH, 1997). A second group of beetles found in the food of studied Little Owls whose presence can be explained by intense agricultural management are *Geotrupes vernalis*, *G. stercorarius* and *Copris lunaris* (WEGOREK, 1966; SANDNER, 1989). Their appearance is related to intensive cattle breeding and cow excrements in grazed and trampled areas providing easy access for Little Owls to this prey category.

The prey biomass of Little Owls differed significantly between the seasons, which can be explained by changes in availability and abundance of prey resources. Thus, Little Owls in the study area show a strong ability to adapt their diet according to available prey. This is in agreement with the results of other studies (ALTRINGHAM et al., 1994; GENOT & VAN NIEUWENHUYSE, 2002). There were no differences in biomass of prey between the studied sites, probably because the distances between them were too small (ALIVIZATOS et al., 2005). Our studies showed an evenness index of 0.68 for all collected data indicating an unequal distribution of prey categories. However, the categories are still more evenly distributed than in Greece (ALIVIZATOS et al., 2005), where the evenness index was between 0.12 and 0.58.

In conclusion, the food composition of the studied Little Owl populations in South-Eastern Poland conforms with gradients in food compositions between northern and southern as well as eastern and western European populations of Little Owls. This study also showed that prey items of Little Owls in South-Eastern Poland are closely related to intense agricultural management. Due to this, changes in agricultural practice might affect the prey and also the population size of Little Owls. However, seasonal changes in the diet components showed that Little Owls seem to be able to adapt to the prey available.

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