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Seasonal variability in the diet of the long-eared owl *Asio otus* in a mosaic of field and forest habitats in central Poland

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Abstract. The diet composition of long-eared owls in central Poland was studied in the years 2004-2010 using standard procedures entailing the analysis of pellets. A total of 2111 prey items were identified in the material analysed, and voles (*Microtus* spp.) were found to dominate in both the summer (April-September) and winter (October-March) seasons. Nevertheless, the owls consumed voles and all rodents significantly more often in winter, while taking birds and insects significantly more often in spring and summer. The food-niche breadth was thus greater in the summer period. Overall, the results confirm the dietary specialisation of long-eared owls toward predation on rodents of the genus *Microtus*.

Key words: Pellet analysis, rodents, winter, summer, food-niche breadth.

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I. INTRODUCTION

The long-eared owl *Asio otus* (LINNAEUS, 1758) is one of the most abundant owl species, in Poland in particular and in Central Europe in general (TOMIAŁOJĆ & STAWARCZYK 2003; KOWALSKI et al. 2007; KÖNIG & WEICK 2008). Although these birds display markedly territorial behaviour in their breeding season, they resort to a nomadic lifestyle during the rest of the year. Long-eared owls are regarded as dietary specialists with predation efforts in the northern part of their range that are largely directed against voles, i.e., *Microtus* spp. (GOSZCZYŃSKI 1981; MIKKOLA & WILLIS 1983; HOLT 1997; BIRRER 2009). It is nevertheless recognised that a far wider spectrum of prey is taken within the overall range of the species, extending to more than 400 species with body masses ranging between 1 and more than 500 g. Thus, in relation to the environment occupied, the diet of long-eared owls may be dominated by rodents of the genera *Apodemus*, *Arvicola*, *Mus*,

Tatera and *Gerbillus*, as well as by birds. Furthermore, North African populations live successfully by hunting reptiles and insects (BIRRER 2009; KHALEGHIZADEH et al. 2009). Certain publications have also referred to marked seasonal differences in diet (NILSSON 1981; BERTOLINO et al. 2001), which has not necessarily been confirmed by other studies (MARTI 1974; GOSZCZYŃSKI 1981). Among nearly 20 studies carried out on the food of long-eared owls in Poland, the decided majority have been based on owl pellets collected in the winter season only (e.g., CZARNECKI 1956; MICHALONEK & KOŚCIÓW 2005; ŻMIHORSKI 2005; CICHOCKI et al. 2008; HETMAŃSKI et al. 2008; WIĄCEK et al. 2008; WIĄCEK et al. 2011; DZIEMIAN et al. 2012) or solely in the breeding season (RUPRECHT & SZWAGRZAK 1987; ROMANOWSKI 1988; SAŁATA-PIŁACIŃSKA & TRYJANOWSKI 1998; JUSZKO 2005). Moreover, the material presented in the aforementioned studies was most often collected at only a few sites, which could influence the representativeness of samples. Among the available literature, only the studies of GOSZCZYŃSKI (1981) and ROMANOWSKI & ŻMIHORSKI (2008) address the issue of possible seasonal variability in food. The first of these studies was carried out in the extensive agrocoenoses of Poland's Wielkopolska region, and the second involved the country's Middle Vistula Valley.

Therefore, the work described here sought to fill the existing gaps in knowledge regarding both the diet and the foraging strategy adopted by long-eared owls within the scenario of the mosaic of field and forest habitats characteristic of central Poland.

II. STUDY AREA

The work was carried out in central Poland, within the vicinity of the village of Rogów, in Łódź voivodship (51°49′N, 19°53′E). The study area fell within UTM DC squares 14, 23, 24 and 33 and encompassed a 105 km^2 mosaic of field and forest habitats. The latter included 9 forest complexes of sizes ranging from 60-1000 ha, accounting for some 25% of the overall area (Fig. 1). The main forest-forming species is the Scots pine *Pinus sylvestris*, which accounts for 50% of the forest area, with also major contributions by oaks (*Quercus* spp.) and the beech *Fagus sylvatica*. The remaining part of the area is arable land (59%), orchards (5%), meadows (5%) and diffuse construction. The area is crossed by two small rivers; other bodies of water are solely of anthropogenic origin and do not play any major role in the landscape. Arable land of moderate fertility is used for the cultivation of cereals or rape but is very much fragmented, with the mean size of a farm plot not exceeding 1 ha (GRYZ et al. 2011). Long-eared owls were found nesting on the edges of forest complexes or in areas of planted trees in the middle of fields. The mean density of breeding pairs in the 2004-2008 period was 1.5 per 10 km^2 (GRYZ et al. 2013). In winter, it was possible to observe roving flocks of owls, occasionally formed by more than 20 individuals. Rodent monitoring carried out in 2006-2008 showed that population of common vole *Microtus arvalis* in the fields even in late summer did not exceed a few individuals per hectare. The striped field mouse *Apodemus agrarius* dominated among live-trapped rodents while common voles accounted for 2-4% (GRYZ et al. 2011; KRAUZE D. & GRYZ J. unpublished). However, as high as 80 ind. per ha densitied of common vole were recorded in the Rogów area in autumn of 1981 (GOSZCZYŃSKI 1985).

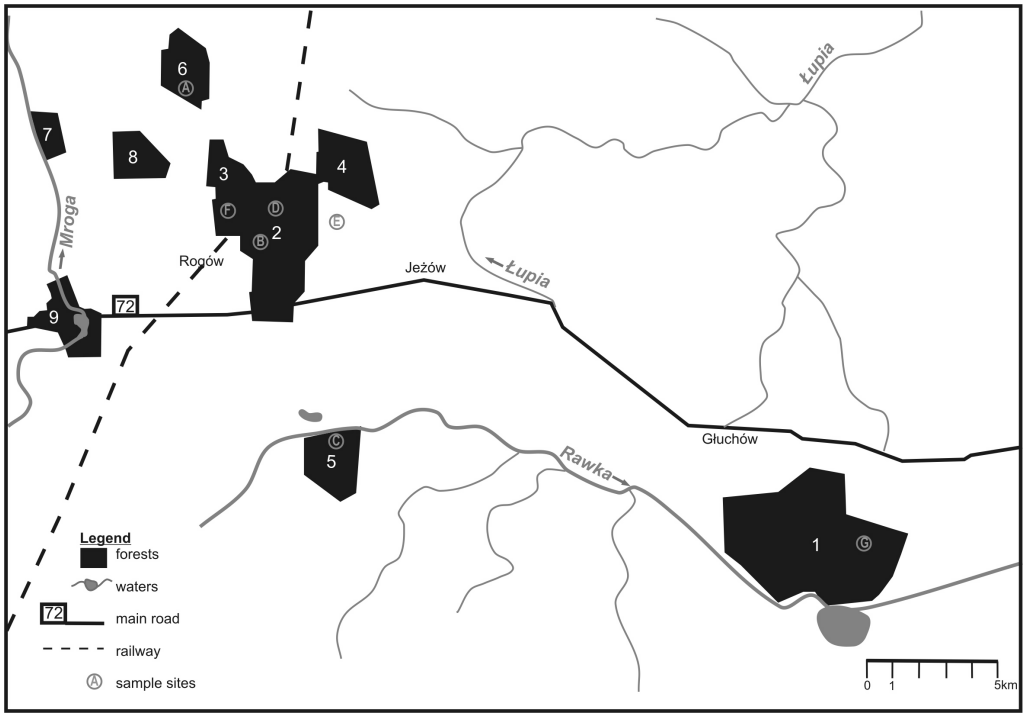

Fig. 1. Distribution of forest complexes in the study area and sites of pellet collection: 1 – Głuchów (968.5 ha); 2 – Zimna Woda i Wilczy Dół (449.5 ha); 3 – Doliska (202.3 ha); 4 – Górki (206.98 ha); 5 – Popień (168.3 ha); 6 – Zacywilki (166.4 ha); 7 – Kołacin (60.0 ha); 8 – Jasień (134.1 ha); 9 – Rogów (170 ha); A – winter 2005/2006, 2007; B – winter 2008; C – winter 2009; D – summer 2004, 2006; E – summer 2004, 2005, 2007; F – summer 2008; G – summer 2010.

III. MATERIAL AND METHODS

Fieldwork was carried out over 7 years, from 2004 to 2010. Sites of pellets collection were found in the course of field work connected with owl inventory as well as studies on birds of prey in the area in question. Pellets were collected in the vicinity of nests, near perches and in the places where winter flocks of birds were observed to concentrate. The material collected was assigned to either the spring-summer (April-September) or autumn-winter (October-March) season, thereafter referred to as summer and winter. In winter, material was collected in three places, most of pellets were collected from November 2005 to April 2006 in a sample site in Zacywilki forest where also some pellets were collected the following year. In summer most of the material was collected in the area of small forest complexes where all recorded long-eared owls nested. In contrast to winter material, summer material was quite evenly distributed between samples (Fig. 1). The pellet analysis followed standard procedures (RACZYŃSKI & RUPRECHT 1974; YALDEN & MORRIS 1990; GRYZ & KRAUZE 2007). Pellets or parts thereof were soaked in water for 12 hours and then processed by the separation of fractions into bones, hides, feathers, invertebrate remains and plant material present *ad hoc*. The numbers of mammals were es-

tablished by reference to the numbers of right and left mandibles. The numbers of birds reflected the skulls or sterna counted. Pelvic bones were taken into account in the case of frogs (*Rana* spp.). Bone fragments of mammals were identified using the key from PUCEK (1981) or more detailed studies (RUPRECHT 1979; BALČIAUSKIENĖ et al. 2002). In certain cases, the microscopic hair analysis was also performed (DZIURDZIK 1973; TEERINK 1991). Bone fragments from birds were again identified using a key (MORENO 1985; UJHELYI 1992), and ENGELMANN et al. (1985) was implemented for identifications of amphibians and reptiles. The comparative collections of the Department of Forest Zoology and Wildlife Management at Warsaw University of Life Sciences (SGGW) were also utilised for identifications of remains. In cases in which the state of preservation was too poor to allow species to be identified, the identification of remains was then attempted at the level of the genus, family or order.

Dietary composition is referred to in terms of the percentage shares accounted for by specimens of given taxa or the biomass thereof, as set against the total number of prey items and the overall biomass consumed, respectively. Data for the body masses of prey items were derived from the subject literature (SZCZEPSKI & KOZŁOWSKI 1953; PUCEK 1981; JĘDRZEJEWSKA & JĘDRZEJEWSKI 1998) or were estimated through the capture of rodents in the course of fieldwork (GRYZ J. unpublished). The frequencies of occurrence of given groups in different seasons were compared using a chi-square test applying both the Yates and Bonferroni corrections (with $p<0.01$). The statistical analyses were performed using the *Statgraphics 4.1 plus* programme. Simpson's formula was used to determine the breadth of the food niche in the winter and summer half-years, as follows: $D=1/\sum pi^2$, where *pi* represents the proportion of the overall diet accounted for by a given prey category (WEINER 2003). The six categories of prey decided upon were voles, other rodents, shrews, birds, poikilothermic vertebrates (amphibians and reptiles) and insects.

IV. RESULTS

From the material collected, 2111 prey items, with a total estimated mass in excess of 40 kg, were identified. More than 1500 of the items represented the composition of the diet in winter. In winter diet of long-eared owls there were 9 prey species recorded, while in summer diet 10. Voles (*Microtus* spp.) occupied the dominant share in terms of both items of prey and total biomass consumed (Table 1). In the winter period, voles represented 87.4% of all prey items, whereas the proportion was significantly lower in summer, at 72.3% (chi-square test, $\chi^2=65.09$, df=1, $p<0.0001$). Mice (Muridae) were much more rarely represented, though their share was similar in both seasons ($\chi^2=3.35$, df=1, $p=0.07$).

Rodents associated with a forest environment, i.e., the yellow-necked mouse *Apodemus flavicollis* and bank vole *Myodes glareolus*, accounted for less than 3% of the prey items, and their shares were similar in the two seasons ($\chi^2=0.55$, df=1, $p=0.55$). Rodents accounted for 98% in winter, but in summer the share was significantly lower, though still at the level of 86.0% of prey items and 89.4% of consumed biomass ($\chi^2=120.13$, df=1, $p<0.0001$). The share of the diet accounted for by birds differed significantly between winter, when it was at 1.6%, and summer, when it was 6.6% ($\chi^2=37.87$, df=1, $p<0.0001$). The share of insects in the summer and winter diets was even more disparate, at 6% and just

Table 1

Composition of the diet of the long-eared owl *Asio otus* in winter (X-III) and summer (IV-IX) season. The percentage shares set against the total number of prey items or the overall biomass consumed. N – number of individuals, D – Simpson index for the food-niche breadth

Prey (g)	Winter			Summer		
	N	% of occurence	% of biomass	N	% of occurence	% of biomass
Microtus arvalis (19)	1265	80.2	78.7	319	59.7	59.9
Microtus oeconomus (26)	11	0.7	0.9	21	3.9	5.4
Microtus spp. (20)	101	6.4	6.6	46	8.6	9.1
Microtus subterraneus (10)	1	0.1	0.0	0	0.0	0.0
∑Microtus	1378	87.4	86.3	386	72.3	74.3
Myodes glareolus (18)	17	1.1	1.0	7	1.3	1.2
Apodemus agrarius (20)	54	3.4	3.5	30	5.6	5.9
Apodemus flavicollis (30)	20	1.3	2.0	8	1.5	2.4
Apodemus sylvaticus (25)	13	0.8	1.1	4	0.7	1.0
Apodemus spp. (21)	50	3.2	3.4	11	2.1	2.3
Mus musculus (17)	11	0.7	0.6	10	1.9	1.7
Micromys minutus (15)	0	0.0	0.0	1	0.2	0.1
Muridae indet. (20)	3	0.2	0.2	2	0.4	0.4
∑Rodentia	1546	98.0	98.1	459	86.0	89.4
Sorex araneus (9)	4	0.3	0.1	3	0.6	0.3
Sorex minutus (5)	0	0.0	0.0	3	0.6	0.1
∑Sorex	4	0.3	0.1	6	1.2	0.4
Passer domesticus (29)	2	0.1	0.2	0	0.0	0.0
Passer montanus (21)	1	0.1	0.1	2	0.4	0.4
Passer spp. (24)	2	0.1	0.2	2	0.4	0.5
Parus major (20)	5	0.3	0.3	0	0.0	0.0
Cyanistes caeruleus (12)	0	0.0	0.0	1	0.2	0.1
Certhia sp. (10)	1	0.1	0.0	0	0.0	0.0
Sitta europaea (25)	2	0.1	0.2	0	0.0	0.0
Sturnus vulgaris (80)	0	0.0	0.0	1	0.2	0.8
Phoenicurus phoenicurus (16)	0	0.0	0.0	1	0.2	0.2
Small bird indet. (22)	12	0.8	0.9	25	4.7	5.4
Medium bird indet. (74)	0	0.0	0.0	3	0.6	2.2
∑Aves	25	1.6	1.8	35	6.6	9.6
Rana spp. (20)	0	0.0	0.0	1	0.2	0.2
Lacerta spp. (12)	0	0.0	0.0	1	0.2	0.1
Insecta (1)	2	0.1	0.0	32	6.0	0.3
Total (N/%)	1577	100	100	534	100	100
D		1.3			1.8	

0.1%, respectively. Indeed, the share of insects in terms of consumed biomass was found to be so low that they may not be considered to be an important component of the long-eared owl diet (Table 1). The food-niche breadth was greater in the warm half-year (for which the Simpson index was 1.82) than in the winter period (1.29).

V. DISCUSSION

The presented results confirm the hypothesis that long-eared owls specialise in hunting common voles, particularly given the relatively low population densities achieved by this species in the study area. However, there was no confirmation of the conclusion arrived at by ROMANOWSKI and ŻMIHORSKI (2008) regarding the greater share of voles in the diet in the warm half-year, with relatively more mice being taken in winter, which was in line with data from Moscow, where higher snow cover resulted in lower proportion of voles in a diet (SHARIKOV & MAKAROVA 2014). These differences could reasonably be accounted for by the meteorological conditions prevalent in the study area, with most of the winter seasons in the study period characterised by non-persistent, interrupted snow-cover that did not exceed 10-20 cm in depth. Nevertheless, the higher shares of birds, poikilothermic vertebrates and insects in the summer diet is understandable and does reflect the real availability and accessibility of prey. Among the invertebrates, the remains of chafer-beetles of the genus *Melolontha* were found most often. These beetles are periodically very abundant within the study area (data from the Rogów Forest District) and are especially active at dusk. Although no such increase in the role played by these groups was noted in the study by ROMANOWSKI and ŻMIHORSKI (2008), a higher proportion of birds in the summer diet was reported in Slovenia (TOME 1994) but an opposite pattern was observed in a desert in Israel (CHARTER et al. 2012). The fact that GOSZCZYŃSKI (1981) reported no seasonal differences in diet is most likely a reflection of the relatively high population density of common voles reached in the study area, allowing owls to hunt for them equally intensively in both winter and summer. The reported population densities of voles in Wielkopolska were decidedly higher than those noted in the Rogów area (GOSZCZYŃSKI 1981).

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