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Diet of the Pygmy Owl *(Glaucidium passerinum)* in eastern Central Europe

Potrava kulíška nejmenšího *(Glaucidium passerinum)* ve východní části střední Evropy

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ABSTRACT. The material includes 2,370 prey items from pellets collected in 1979-2000 during the breeding season (80.4 %) and the rest of the year (19.6%) on 63 localities in the Czech Republic, Slovakia and Poland. Mammals, including 11 species (924 ind.), composed 63.9 % of food in winter and 32.9 % in summer. The most common mammals were *Clethrionomys glareolus*, *Microtus agrestis* and *Microtus arvalis* (28.3 %, 44.3 % of the total weight). The remaining prey items composed of birds (1427 ind., 47 species.). Pygmy Owls regularly caught *Fringilla coelebs*, *Regulus* sp. and *Parus ater* (21.8 %, 14.3 % of the total weight). The Pygmy Owl hunts lizards only occasionally (19 ind.), rare may be insects. Cached prey weight 4-40g (99 %) mainly, mean body weight of prey was 19.2 g, but sometimes Pygmy Owl hunted prey larger than themselves. No marked difference were found in the food ecology of the Pygmy Owl in western and eastern Central Europe.

INTRODUCTION

Diet composition and food habits are the best known aspects in the ecology of owls (DEL HOYO et al. 1999). The reason is that they regularly regurgitate indigestible fragments of food in compact and durable pellets. There is much important diagnostic material in owls' pellets, due to weak gastric juice if compared to diurnal birds of prey (DEL HOYO et al. 1999).

The cold montane zone of Central Europe is inhabited by isolated and presumably post-glacial relict populations of Pygmy Owl. There are breeding birds strongly resident or short distance migrants (MIKKOLA & SACKL 1997). The mean weight of the Pygmy Owl is about 65 g, making it the smallest Palearctic owl. The Pygmy Owl is a diurnal bird with activity peaks at dawn and dusk, and locates its prey mainly by sight (MIKKOLA 1970). It is a food generalist, hunting mainly birds and mammals (MIKKOLA 1972, KELLOMÄKI 1977, SOLHEIM 1984, KORPIMÄKI & MARTI 1995).

The diet of the Pygmy Owls has been much studied, especially in Scandinavia and in the western part of Central Europe, mainly in Germany (review in SCHÖNN 1980, MIKKOLA 1983, GLUTZ & BAUER 1980, CRAMP & SIMMONS 1985). Most of these studies are from winter periods. The aim of the present study was to procure details about the Pygmy Owl diet in the eastern part of Central Europe. Earlier results from this part of Europe have been

published only in a few previous studies with scant material from 6 localities: from the Czech Republic in (a) FORMÁNEK & ANDRESKA 1964, (b) ŠUTERA & VONDRÁČEK 1985, from Slovakia in (c) KLAUS et al. 1982, (d) PAČENOVSKÝ 1990, and from Poland in (e) JĘDRZEJEWSKA & JĘDRZEJEWSKI 1993, 1998 (Table 1, Fig. 1).

Table 1 - Published studies of diet of the Pygmy Owl in the eastern Central Europe. All values in individuals. For legends see Introduction.

Tab. 1 - Publikované práce o potravě kulíška nejmenšího z východní části střední Evropy. Všechny hodnoty jsou uvedeny v kusech. Další údaje viz kapitola Úvod.

Country	Czech Republic		Slovakia		Poland
Authors	a	b	c	d	e
Sorex araneus	-	-	1	-	-
Sorex minutus	-	-	-	1	-
Sorex sp.	-	-	-	-	+
Neomys fodiens	-	-	1	-	-
Clethrionomys glareolus	-	1	5	4	+
Pitymys subterraneus	-	-	6	-	+
Microtus arvalis	18	8	-	2	-
Microtus agrestis	-	-	3	-	-
Microtus sp.	-	20	-	-	+
Apodemus sp.	-	-	-	1	+
Apodemus flavicollis	-	-	-	1	+
Sicista betulina	-	-	-	-	+
Mammalia total	**18**	**29**	**16**	**9**	+
Dendrocopos sp.	-	-	-	-	+
Motacilla alba	-	1	-	-	-
Anthus sp.	-	1	-	-	-
Prunella modularis	-	-	1	2	-
Sylvia curruca	-	-	-	1	-
Sylvia borin	-	-	-	1	-
Sylvia atricapilla	-	-	-	2	-
Sylvia sp.	-	-	-		+
Phylloscopus sibilatrix	-	-	-	2	-
Phylloscopus collybitta	-	-	-	1	-
Phylloscopus sp.	-	-	-	-	+
Regulus regulus	-	-	-	-	+
Regulus sp.	+	-	-	-	-
Muscicapa striata	-	-	-	2	-
Ficedula albicollis	-	-	-	1	+
Ficedula hypoleuca	-	-	-	-	+
Ficedula sp.	-	-	-	1	+
Erithacus rubecula	-	-	3	1	+
Phoenicurus phoenicurus	-	-	-	-	+
Phoenicurus ochruros	+	-	-	-	-
Turdus sp.	-	1	-	-	-
Aegithalos caudatus	+	-	-	-	-
Parus major	-	1	-	2	+
Parus ater	+	-	1	3	-
Parus caeruleus	-	1	-	2	+
Parus montanus	-	-	-	1	-
Parus sp.	-	2	4	1	+
Sitta europaea	-	-	-	2	+

Table 1 - cont					
Certhia sp.	-	1	-	-	-
Certhia familiaris	+	-	1	1	+
Lanius collurio	-	-	-	-	+
Troglodytes troglodytes	+	-	2	2	+
Fringilla coelebs	+	1	4	3	+
Serinus serinus	-	-	-	-	+
Carduelis carduelis	+	-	-	-	+
Carduelis spinus	+	-	-	-	+
Carduelis cannabina	-	-	-	1	-
Carduelis chloris	-	1	-	2	+
Pyrrhula pyrrhula	-	-	1	-	+
Coccothr. coccothraustes	-	-	-	1	+
Passeriformes indet.	-	4	-	-	-
Aves total	+	**14**	**17**	**35**	+
Coleoptera sp.	+	-	-	-	-
Insecta total	+	-	-	-	+
Lacerta vivipara	-	-	1	-	-
Reptilia total	-	-	**1**	-	-
Total prey	**+18**	**43**	**34**	**44**	+

MATERIAL AND METHODS

The material includes unpublished data about Pygmy Owls' pellet analyses collected at nest and winter food-caches in the nest-holes and nest-boxes at 63 localities in the Czech Republic (4 areas), Slovakia (1 area) and Poland (2 areas) in 1979-2000.

Czech Republic

1) Šumava mountains (SU): 14° 00' E, 48° 50' N, 600-1000 m a. s. l., mountain forest with dominating spruce and peat-bogs, collected at 25 places during breeding (SU/s) and the rest of the year (SU/w) in 1982-1999 (B. Kloubec, M. Frencl, L. Mühlstein, P. Pavlík, R. Vacík etc.).

2) Lower parts of Southern Bohemia - Písek and Třeboň region (SB), 14° 80' E, 49° 20' N and 14° 50' E, 49° 00' N respectively, 400-600 m a. s. l., hills and lowlands, mixed forests and woods with spruce and pine as dominant, collected at 12 places during breeding (SB/s) and the rest of the year (SB/w) in 1979-1995 (B. Kloubec, J. Hlásek, F. Nosek, M. Šálek, R.Všetečka etc.).

3) Western Bohemia - Tachov region (WB), 12° 43' E, 49° 41' N, about 600 m a. s. l., forested hills mostly coniferous (spruce and pine dominant); pellets collected at two nests in the breeding season 1986 (B. Kloubec).

4) Czech-Moravian Highlands (CM), 16° 00'E, 49° 40' N, 600-800 m a. s. l., mountain with spruce forests dominant, collected in the breeding season at 5 nest-holes in 1993-2000 (J. Čejka, P. Eleder).

Slovakia

5) North-western Slovakia, Liptov and Orava region - Choč Mts., Nízke Tatry Mts. and Oravská Magura Mts (NS), 19° 20' E, 49° 10' N, 600–900 m a.s.l., collected at 7 places in the winter season at holes and nest-boxes in 1988-1996 (B. Murin, Š. Bílek, D. Karaska, M. Majda, J. Obuch).

Poland

6) Stolowe Mountains - Sudeten Mts. (ST), 16° 20'E, 50° 25' N, 500-750 m a. s. l., artificial

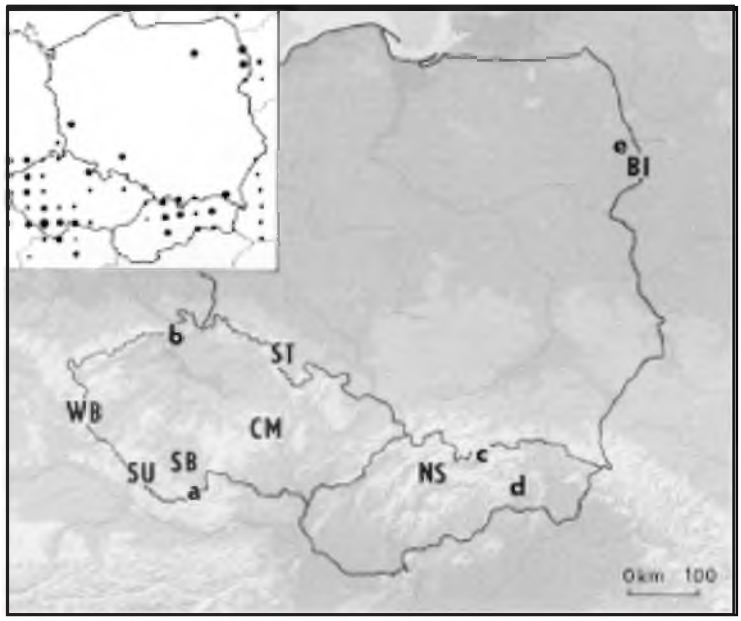

Fig. 1 - Study areas of diet of the Pygmy Owl in the eastern Central Europe (Czech Republic, Slovakia, Poland). Above left: distribution of Pygmy Owl in the eastern Central Europe (based on MIKKOLA & SACKL 1997). For legends see Introduction and Material and methods.

Obr. 1 - Místa výzkumu potravy kulíška nejmenšího ve východní části střední Evropy (Česká republika, Slovensko, Polsko). Vlevo nahoře: rozšíření kulíška nejmenšího ve východní části střední Evropy (podle MIKKOLA & SACKL 1997). Další údaje viz kapitola Úvod a Materiál a metodika.

spruce forests in bad condition with small mixture of deciduous trees, nests often not far from forest-wall and buildings, collected near 8 nest-holes (11 breedings) in 1997-2000 (R. Mikusek). Additionally 38 prey items had been collected in two territories in Walbrzyskie Mountains (Sudeten).

7) Białowieża Primeval Forest (BI), 52° 45'E, 23° 55' N, 160 m a. s. l. Two breeding places in 2000: old mixed pine-spruce forest and dry-ground forest mixture of spruce (R. Mikusek).

Breeding or summer season (s) covers the period between March and August - from courtship to family breaking up. During this time prey remains have been collected in the vicinity of nest-holes. The rest of the year we describe as a winter season (w).

The accurate number of pellets it is not known, because a significant part of the material was collected as loose fragments. Each part of the material collected in one day was treated in preparation and analyses as a whole. The pellets were dissected mechanically or dissolved in NaOH solution. After appropriate treatment, following bones were used for identification: maxilla and mandibula (in mammals and reptiles), bill, humerus, metacarpus and tarsometatarsus (in birds). If these bones were lacking in a sample, other limb bones were used, particulary in mammals. The abundance of a species in a sample was estimated as the number of its most numerous bone used for identification. When possible, also bone fragments were identified. Comparative skeletal samples served as most useful identification guide.

We did not include any invertebrates as prey to tables and resume, because in our examination we concluded that large part of the fragments found in pellets might originate as food from the stomach of the Pygmy Owls' prey. Numbers and percent shares in the results and discussion include only birds, which have been identified at species and genus level.

RESULTS

Material includes altogether 2,370 Pygmy Owl prey items (Table 2); 1,905 (80.4 %) of them originate from the breeding season and the remaining 465 (19,6 %) from the rest of the year. In the food were 60.2 % birds and 39.0 % mammals, the weight ratio favored mammals – 44 : 56.

The role of prey weight groups is shown in Fig. 2. The Pygmy Owl mainly catches prey weighing between 4 g *(Sorex minutus)* and 40 g (98.9 % of prey, 96.2 % of total weight). Prey weighing 21-40 g, composed as much as 35.2 % of the total prey by number (N = 762, 54.3 % by total weight of prey!), the majority of which were *M. agrestis, M. arvalis, C. glareolus* and to a lesser degree *Apodemus flavicollis*. About 95 % (N = 1,159) of the birds caught belonged to the 5-20 g weight group, and represented 68 % of the species (N = 32). Birds weighing more than 20 g made up only a marginal fraction of the total prey. The average body weight of prey was 19.2 g (N = 2,163).

Mammals. In the analyzed material 924 ind. were found belonging to 11 mammal species. Mammals dominated in the food composition during the winter season (63.9 %; 34.5-73.2 % in each location). The only place in which a higher number of mammals was caught during the summer season was in location SB. Three species, *Clethrionomys glareolus* (11.9 %, 15.8 % of total weight), *Microtus agrestis* (8.7 %, 16.2 %) and *Microtus arvalis* (7.8 %, 12.4 %), composed 28.3 % of the prey items (44.3 % of the total weight). *C. glareolus* was the only mammal found in all areas, where it made up 3.2-37.7 %. This was the animal most frequently captured by the Pygmy Owl over the winter season (27.5 %). Its role during the summer season was lower (8.0 %). Likewise, *M. arvalis* was considerably more common in winter (17.0 %) than in summer (5.5 %). The opposite situation occurred in *M. agrestis*, which was more common in summer (9.5 % ver. 5.4 %). It was the only

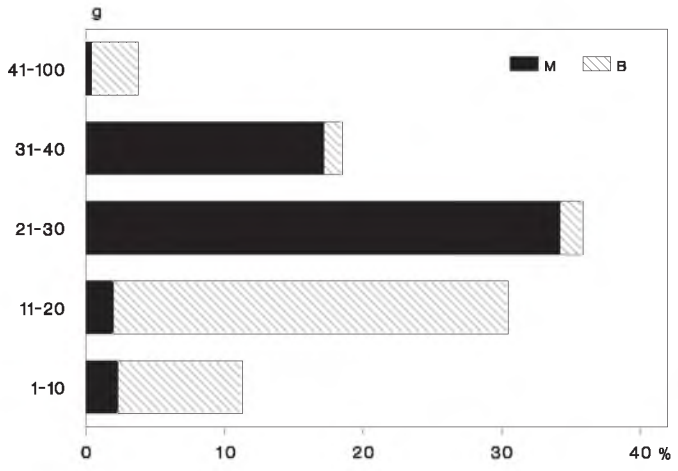

Fig. 2 - Prey weight categories in the diet of the Pygmy Owl. M - mammals, B - birds.
Obr. 2 - Váhové kategorie koŕisti kuliška nejmenšího. M - savci, B - ptáci.

Table 2 - Diet of the Pygmy Owl in the eastern Central Europe. All values in %. For legends see Material and methods.
Tab. 2 - Potrava kuliška nejmenšího z východní části střední Evropy. Všechny hodnoty jsou uvedeny v %. Další údaje viz kapitola Materiál a metodika.

	SU		SB		WB	CM	NS	ST	BI	Total			
Period	s	w	s	w	s	s	w	s	s	s	w	s+w	weight
Sorex araneus	4.24	4.04	1.00	4.35	-	1.61	3.15	1.62	-	1.99	3.87	**2.36**	**1.26**
Sorex minutus	0.85	6.73	1.00	8.70	-	5.65	3.15	4.30	2.33	3.41	6.24	**3.97**	**0.84**
Clethrionomys glareolus	10.45	37.67	17.00	13.04	5.77	3.23	22.83	7.22	6.98	8.03	27.53	**11.86**	**15.76**
Arvicola terrestris	-	-	-	-	1.92	-	-	0.08	-	0.10	0.00	**0.08**	**0.40**
Pitymys subterraneus	0.85	-	-	-	-	-	4.72	0.41	2.33	0.47	1.29	**0.63**	**0.61**
Microtus arvalis	12.71	12.56	14.00	5.22	15.38	22.58	35.43	0.81	-	5.51	16.99	**7.76**	**12.39**
Microtus agrestis	13.28	5.83	12.00	7.83	11.54	6.45	2.36	8.77	-	9.50	5.38	**8.69**	**16.18**
Apodemus flavicollis	0.28	0.90	-	-	-	-	0.79	3.90	-	2.57	0.65	**2.19**	**3.50**
Apodemus sylvaticus	1.69	0.90	7.00	3.48	-	-	-	0.08	-	0.73	1.29	**0.84**	**0.90**
Micromys minutus	0.56	-	-	0.87	-	-	0.79	-	-	0.10	0.43	**0.17**	**0.07**
Muscardinus avellanarius	0.28	0.45	1.00	-	-	-	-	0.57	-	0.47	0.22	**0.42**	**0.34**
Mammalia total	**45.20**	**69.06**	**53.00**	**43.48**	**34.62**	**39.52**	**73.23**	**27.76**	**11.63**	**32.91**	**63.87**	**38.99**	**52.25**
Glaucidium passerinum	0.28	-	-	-	3.85	-	-	0.08	-	0.21	0.00	**0.17**	**0.63**
Dendrocopos major	-	-	-	-	-	-	-	0.16	-	0.10	0.00	**0.08**	**0.36**
Dendrocopos minor	-	0.45	-	-	-	-	-	-	-	0.00	0.22	**0.04**	**0.16**
Alaudidae indet.	-	-	-	-	-	-	-	0.08	-	0.05	0.00	**0.04**	**0.06**
Delichon urbica	-	-	-	-	1.92	-	-	-	-	0.05	0.00	**0.04**	**0.04**
Anthus trivialis	-	-	-	-	-	-	-	0.08	-	0.05	0.00	**0.04**	**0.05**
Anthus pratensis	-	-	-	-	-	-	-	0.32	-	0.21	0.00	**0.17**	**0.15**
Motacilla cinerea	-	-	-	-	-	-	-	0.24	-	0.16	0.00	**0.13**	**0.12**
Motacilla alba	-	-	-	-	-	-	-	0.24	-	0.16	0.00	**0.13**	**0.14**
Troglodytes troglodytes	1.69		2.00	6.09	3.85	-	-	3.41	-	2.73	1.51	**2.49**	**1.32**
Prunella modularis	1.98	0.90	-	-	-	3.23	-	1.46	-	1.52	0.43	**1.31**	**1.39**
Erithacus rubecula	4.24	-	4.00	8.70		1.61	-	3.81	9.30	3.78	2.15	**3.46**	**2.94**
Saxicola rubetra	0.56	-	-	-	-	-	-	1.14	-	0.84	0.00	**0.68**	**0.54**
Turdus merula	0.28	0.45	-	-	-	-	-	-	-	0.05	0.22	**0.08**	**0.45**
Turdus philomelos	0.56	0.45	-	-	-	-	-	0.41	2.33	0.42	0.22	**0.38**	**1.21**
Acroceph. schoenobaenus	-	-	-	0.87	-	-	-	-	-	0.00	0.22	**0.04**	**0.04**
Sylvia curruca	0.56	-	-	-	-	-	-	0.16	-	0.21	0.00	**0.17**	**0.11**
Sylvia communis	-	-	-	-	-	-	-	0.16	-	0.10	0.00	**0.08**	**0.07**
Sylvia borin	-	-	-	-	-	-	-	0.49	-	0.31	0.00	**0.25**	**0.27**
Sylvia atricapilla	1.98	0.45	2.00	0.87	-	1.61		2.11	-	1.94	0.43	**1.65**	**1.75**
Sylvia sp.	-	-	-	-	-	-	-	0.24	-	0.16	0.00	**0.13**	**0.13**

Table 2 - cont.

Phylloscopus sibilatrix	-	-	-	-	-	-	-	0.73	-	0.47	0.00	**0.38**	**0.16**
Phylloscopus trochilus	2.26	-	5.00	3.48	5.77	3.23	-	0.97	-	1.68	0.86	**1.52**	**0.81**
Phylloscopus collybitta	1.13	-	-	-	-	0.81	-	1.22	2.33	1.10	0.00	**0.89**	**0.38**
Regulus regulus	0.56	-	-	-	-	-	-	-	-	0.10	0.00	**0.08**	**0.02**
Regulus sp.	5.93	8.07	8.00	7.83	3.85	13.71	7.87	7.95	4.65	7.77	7.96	**7.81**	**2.08**
Muscicapa striata	-	-	-	1.74	1.92	-	-	0.49	2.33	0.42	0.43	**0.42**	**0.34**
Ficedula parva	-	-	-	-	-	-	-	0.08	-	0.05	0.00	**0.04**	**0.02**
Aegithalos caudatus	0.85	-	-	-	-	-	0.79	0.32	2.33	0.42	0.22	**0.38**	**0.20**
Parus palustris	2.26	2.24	-	-	-	1.61	0.79	5.11	-	3.83	1.29	**3.33**	**2.13**
Parus montanus	-	-	-	-	-	-	-	0.08	-	0.05	0.00	**0.04**	**0.02**
Parus cristatus	0.56	0.45	1.00	-	1.92	0.81	-	1.46	-	1.21	0.22	**1.01**	**0.65**
Parus ater	5.08	5.38	1.00	1.74	0.00	10.48	7.09	4.38	9.30	4.72	4.95	**4.77**	**2.54**
Parus caeruleus	1.69	3.14	1.00	2.61	3.85	1.61	3.15	0.32	-	0.79	3.01	**1.22**	**0.72**
Parus major	2.54	1.35	2.00	2.61	3.85	3.23	-	3.08	11.63	3.15	1.29	**2.78**	**2.96**
Parus sp.	-	-	-	-	-	-	-	0.16	-	0.10	0.00	**0.08**	**0.06**
Sitta europaea	-	0.45		1.74	-	-	-	0.57	-	0.37	0.65	**0.42**	**0.45**
Certhia familiaris	0.28	-	-	0.87	1.92	1.61	0.79	-	-	0.21	0.43	**0.25**	**0.16**
Certhia sp.	0.28	-	-	-	-	-	-	2.27	2.33	1.57	0.00	**1.27**	**0.65**
Lanius collurio	-	-	-	-	-	-	-	0.16	-	0.10	0.00	**0.08**	**0.13**
Passer montanus	-	-	-	-	1.92	-	-	-	-	0.05	0.00	**0.04**	**0.07**
Fringilla coelebs	7.34	3.14	8.00	11.30	19.23	4.84	2.36	10.96	18.60	10.13	4.95	**9.11**	**9.69**
Fringilla montifringilla	-	-	-	-	-	-	-	0.16	-	0.10	0.00	**0.08**	**0.10**
Carduelis chloris	0.56	-		1.74	-	-	-	-	-	0.10	0.43	**0.17**	**0.22**
Carduelis carduelis	0.28	-	-	-	-	-	0.79	0.41	-	0.31	0.22	**0.30**	**0.25**
Carduelis spinus	1.13	0.90		1.74	1.92	5.65	-	2.68	2.33	2.41	0.86	**2.11**	**1.46**
Carduelis cannabina	-	-	-	-	-	-	-	0.57	-	0.37	0.00	**0.30**	**0.31**
Loxia curvirostra	0.28	-	1.00			0.81	-	0.00	-	0.16	0.00	**0.13**	**0.24**
Pyrrhula pyrrhula	-	0.90	-	0.87	-	-	-	0.81	-	0.52	0.65	**0.55**	**0.96**
Coccothr. coccothraustes	-	-	-	-	-	-	0.79	0.00	4.65	0.10	0.22	**0.13**	**0.34**
Emberiza citrinella	0.56	0.45	-	-	-	-	-	0.73	-	0.58	0.22	**0.51**	**0.81**
Passeriformes indet.	7.63	0.45	12.00	0.87	9.62	5.65	2.36	11.12	16.28	10.24	1.08	**8.44**	**6.64**
Aves total	**53.39**	**29.60**	**47.00**	**55.65**	**65.38**	**60.48**	**26.77**	**71.43**	**88.37**	**66.30**	**35.27**	**60.21**	**47.50**
Lacerta vivipara	0.85	1.35	-	0.87	-	-	-	0.81	-	0.68	0.86	**0.72**	**0.24**
Lacerta sp.	0.56	-	-	-	-	-	-	-	-	0.11	0.00	**0.08**	**0.01**
Reptilia total	**1.41**	**1.35**	**0.00**	**0.87**	**0.00**	**0.00**	**0.00**	**0.81**	**0.00**	**0.79**	**0.86**	**0.80**	**0.25**
Total individuals (100 %)	**354**	**223**	**100**	**115**	**52**	**124**	**127**	**1232**	**43**	**1905**	**465**	**2370**	
Diversity index H'	4.15	3.23	3.52	3.97	3.59	3.65	2.92	4.31	3.47	4.36	3.57	4.28	

mammal species dominating in ST (8.8 %), where the diet was composed primarily of birds. The role of *C. glareolus*, *M. agrestis* and *M. arvalis* among mammals were respectively 30.4% , 22.3 % and 19.9 % (total 72.6 %).

Insectivorous mammals *S. araneus* and *S. minutus* composed 6.3 % of the prey (2.1 % of total weight) and 16.2 % of the overall number of mammals. *S. minutus* was found almost twice as often as *S. araneus* during both summer and winter seasons. In locations SU and SB, where food composition was examined in both seasons, *S. minutus* was found more often during winter than summer. Mice composed almost 3.0 % of the Pygmy Owl prey composition (4.4 % of total weight, 7.8 % in mammals). However, in location SB during the summer season *Apodemus sylvaticus* composed 7.0 % (14.0 % in mammals). Much more seldom were *Pitymys subterraneus*, *Muscardinus avellanarius*, and exceptionally *Micromys minutus* (4 ind.) and *Arvicola terrestris* (2 ind.). Altogether these made up 1.3 % prey composition (3.4 % in mammals).

Birds. In the collected bone material remains of 1,427 birds of 47 species were found. Birds composed 60.2 % of the total number of prey and 26.8-88.4 % in each location. During the winter season they composed a considerably smaller percentage – 35.3 % (26.7-55.6 % at each locality), than in the summer period (66,3 %).

Fringilla coelebs and *Regulus sp.* were found at all locations. *Parus ater*, *Carduelis spinus*, *Parus caeruleus* and *Parus major* were found at all but one location. In the majority of locations *Certhia familiaris*, *Erithacus rubecula*, *Parus cristatus*, *Phylloscopus trochilus*, *Troglodytes troglodytes* and *Sylvia atricapilla* were also found. The aforementioned birds made up 38.3 % of the total prey in frequency and 27.8 % in weight.

The most often found species was *Fringilla coelebs* - 9.1 % (2.4-19.2 % at each locality, 9.7 % of total weight), *Regulus sp.* was found less frequently - 8.0 % (3.9-13.7 %, 2.1 % of total weight). The role of *Parus ater* was 4.8 % (0-10.5 %, 2.5 % of total weight). These last three species composed 21.8 % of prey items (17.0-32.6 % on each place) and 14.3 % of total weight. Among identify birds their percentage was 42 % (*F. coelebs* 17.6 %, *Regulus sp.* 15.2 %, *P. ater* 9.2 % by number, 35.2 % of total birds weight). Paridae was the most commonly caught bird family - 14.5 % of prey (9.1 % of total weight), making 25.6 % among birds (22.2 % of total weight).

Five other species, *Erithacus rubecula*, *Parus palustris*, *Parus major*, *Troglodytes troglodytes* and *Carduelis spinus*, each composed 2.3-3.8 % of prey, together making up 15.5 % of total prey (10.8 % of total weight) and 27.4 % among birds (26.6 % of total weight). None of the remaining species composed more than 1.8 % of total prey by number (3.2 % of total weight).

There were three species of genus *Phylloscopus* among them, which altogether composed 3 % of prey (5.4 % of birds). In this material the following larger prey items were also found: *T. philomelos*, *T. merula*, *C. coccothraustes* and *Dendrocopos major*, some of which were adult birds. In four cases *G. passerinum* was found.

The main part of birdo (38.1 %) was composed of high-nesting birds although these composed only 12.8 % of total bird species (N = 6). Some of the most often-caught species were found to be *F. coelebs*, *R. regulus* and *C. spinus*. Hole-nesters composed 27.1 % of the prey, a rate similar to that of their frequency among species (23.4 %, N = 11). Low-nesting birds were the most numerous by species (34 %, N = 16), but composed only 19.2 % of the

total food. Ground-nesting species (25.5 %, N = 12) composed 15.4 % of prey. Two species, *Fringilla montifringilla* and *Delichon urbica*, were recognized as accidental prey. Thirty species of birds (63.8 %) were associated with forests and the remaining 9 species (19.1%) were characteristic for open areas. The latter were caught occasionally, making up 1.2 % of all Pygmy Owl food. The birds from this group appeared mainly in ST, where patches of different environments are characteristic.

Reptiles. 19 examples of reptiles are confirmed in 3 locations, where they composed 0.8 % of prey. Almost all (at least 17 ind.) were *Lacerta vivipara*.

The effect of longitude on the summer diet composition was found significant (Monte Carlo permutation test, $P < 0.01$; Fig. 3). As diagram shows, the greatest difference was detected between Białowieża region and other areas. Birds play the key role in the diet of Pygmy Owl in the Białowieża forest. Species characteristic for this area are *Parus major*, *Fringilla coelebs*, *Erithacus rubecula* and *Parus ater*. Among mammals, the main differences between diet composition in other regions consist in the proportion of the Soricidae and *Microtus*, but these differences are not clearly accountable. This is because the proportion of the Soricidae is not correlated with that of *Microtus* in the prey. Only one bird species, *Phylloscopus collybita*, shows negative correlation with increasing longitude towards east. Thus, the uniform pattern was not found in Czech Republic, but in comparison with eastern Poland the proportion of bird prey is lower.

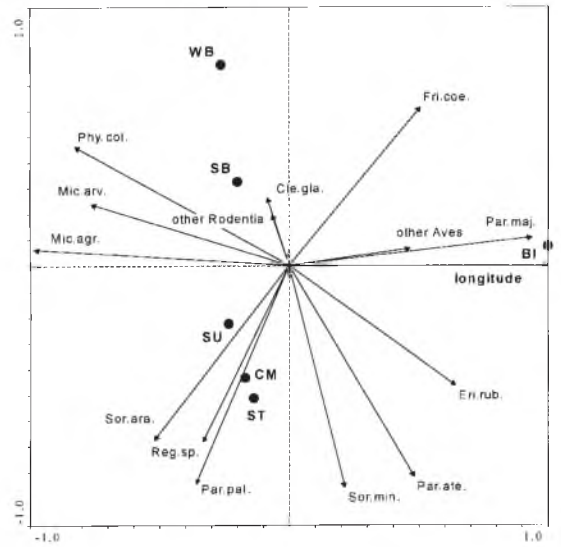

Fig. 3 - The effect of longitude on the summer diet composition of Pygmy Owls. The multivariate RDA analysis (canonical axes I and II account for 70.0 % of variability in the data, Monte Carlo P-test, $P < 0.01$). The picture includes only those species representation in diet varies between regions at least as much as for 3 %. For legend see Table 2.

Obr. 3 - Vliv zeměpisné délky na skladbu potravy kuliška nejmenšího v letním období. Multivariantní RDA analýza (osy odpovídají 70 % variabilitě údajů, Monte Carlo P-test, $P < 0.01$). Uvedeny jsou pouze druhy mající v jednotlivých oblastech zastoupení větší než 3 %. Legenda viz tab. 2.

The average size of pellets in the Sudeten range was 23.0 x 10.4 mm (6.9-41.2 x 4.8-20.0, N = 680), in the Czech Republic 24.9 x 11.5 mm (11-38 x 7-15 mm; N = 70). In one pellet an average of 1.37 prey was found (N = 920). Among the 450 pellets from ST terrain the remains of as many as five prey were found in one pellet in 0.9 % cases, 4 prey in 2.9 %, 3 in 12.1 %, 2 in 35.5 % and 1 in 44.5 %. Almost all bones of prey in Pygmy Owl pellets are broken, and there are no complete skulls. In 2.6 % of cases no bones were found at all in the pellets from ST; these were likely the pellets of owlets. 67 % of pellets contained only bird remains, 7 % of mammals and 26 % both components.

DISCUSSION

To date 73 species of birds and 26 species of mammals have been recorded as constituents of the Pygmy Owl diet (GLUTZ & BAUER 1980, SCHÖNN 1980). In our material we did not discover any new prey species. The wide food spectrum of the Pygmy Owl is likely an adaptation to the weak environments it inhabits, where there is a need to exploit all available prey (KELLOMÄKI 1977). For this reason they hunt for and kill all prey species that happen to be available at the moment (MIKKOLA 1983, SOLHEIM 1984a). The large role of birds in our material (60.2 %) is of particular interest. An explanation for this might be the fact that there are fewer rodents and more birds in the south. The role of small mammals in the food composition in good vole-years is greater than in other years (MIKKOLA 1972, KORPIMÄKI & MARTI 1995). Nevertheless, the Pygmy Owl stays in its territories even during bad vole-years and simply hunts for alternative food. The Pygmy Owl also demonstrates many evolutionary adaptations for hunting birds. Daytime activity with peaks at dusk and dawn corresponds with the activity of most of the small birds (for example MIKKOLA 1983). Analogous species of nocturnal owls catch birds only occasionally (DEL HOYO et al. 1999). Exceptionally late egg-laying can be explained by a synchronization with the passerine breeding season (KELLOMÄKI 1977). Despite the fact that the Pygmy Owl is described as a sit-and-wait raptor (MIKKOLA 1983, KULLBERG 1995), it also employs many hunting techniques such as active by searching the crowns of trees and penetration of nest holes where small passerines can be found (LIKHACHEV 1957, SCHERZINGER 1974, MIKKOLA 1983, KULLBERG 1995). During the winter season the Pygmy Owl follows the birds on which it feeds (MIKKOLA 1983). The role of birds as food increases particularly in poor rodent years (MIKKOLA 1972, KELLOMÄKI 1977, SOLHEIM 1984B, CRAMP & SIMMONS 1985). This reflects - but not to a significant degree - the number of eggs laid and breeding success, which is 20 % lower than in good vole years. However, there is no difference in the relationship between the number of fledglings leaving the nest and number of eggs laid in vole and other years (HAAPALA et al. 1994, 1995 - self counting). According to KELLOMÄKI (1977), the role of birds in food increases during the breeding season as a result of vegetation growth and consequently decreased access to mammals. According to the same author, averages for food composition in Europe are 46 % birds and 52 % mammals, and according to MIKKOLA (1983) 44 % birds and 54 % mammals. Results from Finland from the years 1962-1973 give an average of 38.2 % birds. Their role in each year in Finland ranges from 16.3 % in vole years to 82.1 % in years of scarcity (SCHÖNN 1980, GLUTZ & BAUER 1980). KELLOMÄKI (ex MIKKOLA 1983) believes that this is dependent on variations in numbers of small mammals which applies mainly to North Europe, where such variations are cyclical.

In our material, where over 80 % of the pellets were collected during the breeding season, the ratio throughout the year was approximately 60:40 in favor of birds. In the winter season mammals dominated, making up 64 % of the collected food. In this same period birds were hunted less frequently (35.3 %). In the summer period birds dominated - 66 % (47.0-88.4 %) and mammals composed merely 33 % (11.6-53.0 %) of the total food.

As the research in ST shows, variations in proportions of mammals to birds are lower than in Finland, with a 25 % difference between years, and between pairs in the same year (Mikusek - unpubl. data.). This is most likely a result of significantly lower variation in the number of mammals in Central Europe. As the Pygmy Owl requires a sufficient amount of light for hunting, it hunts 24 hours a day in the north only, with a peak between 9:00 pm and 1:00 am, which corresponds with the activity of *C. glareolus* (MIKKOLA 1970). In Central Europe the Pygmy Owl remains active between 4.00 a.m. and 10.00 p.m. (SCHÖNN 1980, MIKUSEK unpubl. data), throughout the breeding season. As a result its access to nocturnal mammals is limited in this part of Europe.

According to DEL HOYO et al. (1999) the majority of species of genus *Glaucidium* regularly hunt prey larger than themselves. There are six species of genus Turdidae (including *T. viscivorus*, body mass 120 g!), *C. coccothraustes*, *Dendrocopus major* among the largest Pygmy Owl prey noted (MIKKOLA 1983). According to KELLOMÄKI (1977), only a larger female is capable of hunting adults of these species. In our material, the largest prey was *Turdus merula* (about 100g), and the smallest vertebrates were *Sorex minutus*, *Lacerta vivipara* and *R. regulus*. The main group of Pygmy Owl prey (89 %) weighed 4-30 g. Larger prey was also caught in chance attacks with the exception of *Microtus agrestis*, with an average weight of 35 g. This was one of the dominant mammals found and, with regards to weight, composed more of the food than *C. glareolus* and *Microtus arvalis*. According to CRAMP & SIMMONS (1985) *M. agrestis* and *C. glareolus* are hunted more often by the Pygmy Owl than they occur in proportion to their environment. The average mass of prey in our material (19.2 g) is about 30 % of the mass of the Pygmy Owl. For example, *Glaucidium nanum* from S. America, having a similar body weight, captures prey weighing an average of 34.2 g (JIMENEZ & JAKSIC 1989). The presence of four Pygmy Owl specimens in the food composition in three areas (SU, ST and WB) is of great interest. Perhaps these were young birds, which perished in the nest and were eaten by the members of their families. But it cannot be ruled out either that they could have been young birds hunted from other broods.

Based on analysis of food composition, Pygmy Owl hunting grounds can be determined indirectly. In our material, the owls exploited species residing in open areas (such as clear-cuts and stands of young trees) as well as meadows beyond forests (for example by taking *Lanius collurio*, *Saxicolia rubetra*, *Anthus pratensis*).

Lizards have been detected in 70 % species of genus *Glaucidium* (DEL HOYO et al. 1999), including the Pygmy Owl. In our material reptiles were found in 19 cases (0.8 %). *Lacerta vivipara* composed about 1 % of prey from SU, SB and ST. Similar results were found in other areas of Europe (GLUTZ & BAUER 1980, CRAMP & SIMMONS 1985 etc.).

Collection of Pygmy Owl pellets in the breeding season is relatively simple due to regular cleaning of the nest-hole by the female when nestlings are present, and thanks to spitting out of pellets by adults in a few established places in the vicinity of the nest trees. The average size of pellets in this material (24 x 11 mm) is similar to the majority of data from Eu-

rope (for example MÄRZ 1964; BERGMAN & GANSO 1965, SCHERZINGER 1974, PUKINSKIJ 1977). MIKKOLA (1983) gives 28 x 12 mm as the average dimensions of pellets from the winter season.

The ratio of 1.4 prey per pellet agrees with the majority of other publications (MIKKOLA 1970, KELLOMÄKI 1977 etc.). Only in data from Białowieża (JĘDRZEJEWSKA & JĘDRZEJEWSKI 1993) a large difference was found, where the average was 2.3 prey per pellet, probably because in that material each pellet was treated independently, increasing the final sum of prey items. We did not use this material for comparison for this reason.

Cases of insects caught by the Pygmy Owl are very rare. In our pellet material were found Coleoptera and Hymenoptera in almost all area (for example 1 *Carabus hortensis*, 1 *Carabus* sp., 1 Chrisomelidae indet., 1 *Athous* sp., 1 *Vespa crabro*, 2 Hymenoptera indet. in SU and SB). We assume on the basis of exact analyzes that most insects found here originated from the stomachs of Pygmy Owl' prey. During long observations Pygmy Owls were never seen hunting for invertebrates in ST (MIKUSEK unpubl. data).

In closing it is important to emphasize that comparisons of food composition between different regions brings many difficulties. According to KORPIMÄKI & MARTI (1995) diet composition cannot be extrapolated even to a neighboring area (!). MIKKOLA (1983) suggests a lack of selection in the choice of prey species, which are caught according to their availability. Another very important problem is that the Pygmy Owl doesn't consume its prey as a whole, but tears it apart before feeding. For this reason remains of an individual prey animal, particularly a big one, might be found in several pellets. A few other difficulties (decapitation, food-storing etc.) incite the need to approach analyses of results of pellet diagnostics with great care (MIKUSEK unpubl. data).

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SOUHRN

Z východní části střední Evropy bylo o potravě kuliška nejmenšího doposud publikováno velmi málo údajů (tab. 1, obr. 1). Práce popisuje výsledky rozborů vývržků kuliška z hnízdních teritorií z letního a méně i ze zimního období. Materiál byl sbírán v letech 1979-2000 na 63 lokalitách v 7 oblastech České republiky, Slovenska a Polska (obr. 1). Celkem bylo determinováno 2 370 kusů kořisti (tab. 2). V potravě bylo zjištěno 11 druhů savců a 47 druhů ptáků. Savci tvořili 40,0 % kusů zjištěné potravy (52,3 % biomasy), jejich zastoupení se v průběhu roku výrazně měnilo (32,9 % v letním období, 63,9 % v zimním období). Nejčastěji lovenými savci byli norník rudý, hraboš mokřadní a hraboš polní (72,6 % savců), běžně, ale méně často byli loveni též hmyzožravci (rejsek malý, rejsek obecný) a myšice křovinná. Nejčastějšími ptáky v potravě kuliška byla pěnkava lesní, králíček a sýkora uhelníček (42,0 % ptáků), dále červenka obecná, sýkora babka, sýkora koňadra, střízlík obecný a čížek lesní. Jako vzácná složka potravy byly zjištěny ještěrky (celkem 19 ex.). Výjimečně byly ve vývržcích zjištěny i zbytky hmyzu (blanokřídlí, brouci), není však jisté, zda se jednalo o hmyz ulovený kuliškem. Nejčastější váha lovené kořisti se pohybovala v rozmezí 4-40 g (průměrně 19,2 g), největší druhy kořisti (např. drozdovití) přesahovaly hmotnost kuliška. Nebyly zjištěny žádné významné rozdíly v potravní ekologii kuliška mezi západní a východní částí střední Evropy.

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