Ornis Hungarica 2017. 25(2): 34–50.
DOI: 10.1515/orhu-2017-0014

DE GRUYTER OPEN

Food composition of the Little Owl *(Athene noctua)* in a farmland area of Central Hungary, with particular attention to arthropod diversity×

Dániel Hámori[1,2*], Győző Szél[3] & Dániel Winkler[1]

Received: August 21, 2017 – Accepted: October 06, 2017

Hámori, D., Szél, Gy. & Winkler, D. 2017. Food composition of the Little Owl *(Athene noctua)* in a farmland area of Central Hungary, with particular attention to arthropod diversity. – Ornis Hungarica 25(2): 34–50. DOI: 10.1515/orhu-2017-0014

×Presented at 1st Hungarian Owl Research Conference held in Pécs on 8th September, 2017

Abstract The feeding of Little Owl *(Athene noctua)* was studied in a farmland area of Kiskunság, Central Hungary. For the analyses, a total of 661 Little Owl pellets were collected between February and September 2005 from three locations, corresponding known Little Owl territories situated nearby the settlements Apaj, Kunpeszér and Ladánybene. The aim of the present study was to explore the diet composition of Little Owl and to give a detailed evaluation of the arthropod diversity based on the pellet analysis. The identified prey items represented 15 vertebrate and 39 invertebrate species/taxa. In terms of prey number, dominance of small mammals was observed in two sites (Apaj – 55%, Kunpeszér – 68%), while birds and mammals shared almost equal dominance (~25%) in Ladánybene. The most numerous mammal species was the Common Vole *(Microtus arvalis)*, while the Starling *(Sturnus vulgaris)* played key role among the birds. Contribution of amphibian Common Spadefoot *(Pelobates fuscus)* was considerable, while share of reptiles was marginal. Vertebrates also played a predominant role by contributing over 99% of the overall prey biomass in all study sites. Invertebrate prey dominance ranged from 24.8–30.0% while their contribution to the overall biomass was very low (0.14–0.34%). Large sized beetles *(Pentodon idiota, Melolontha hippocastani)* and orthopterans *(Tettigonia viridissima, Gryllotalpa gryllotalpa)* were preferred. Arthropod species richness and diversity were the highest in Kunpeszér, supposedly owing to the rich mosaic habitat structure.

Keywords: feeding ecology, diet, pellet analysis, Strigiformes, Coleoptera, farmland

Összefoglalás A kuvik *(Athene noctua)* táplálkozását Közép-Magyarország (Kiskunság) alföldi tanyavilágában vizsgáltuk. Az elemzésekhez 2005. február és szeptember között, összesen 661 köpetet gyűjtöttünk Apaj, Kunpeszér és Ladánybene települések közelében, amely területek egyben három aktuális kuvik revírnek feleltek meg. A kutatás fő célja a faj táplálékspektrumának feltárása, valamint a köpetelemzések alapján a vizsgált területek ízeltlábú-diverzitásának összehasonlító vizsgálata volt. A köpetekből azonosított zsákmányállatok 15 gerinces és 39 gerinctelen taxont képviseltek. Az egyedszámot tekintve két helyszínen a kisemlősök domináltak (Apaj – 55%, Kunpeszér – 68%), míg a harmadik helyszínen (Ladánybene) a kisemlősök és a madarak közel azonos arányban (~25%) voltak jelen. A leggyakoribb kisemlős zsákmánynak a mezei pocok *(Microtus arvalis)* bizonyult, míg a madarak közül a seregély *(Sturnus vulgaris)* fogyasztása volt jelentős. A barna ásóbéka *(Pelobates fuscus)* jelenléte a köpetanyagban figyelemre méltó, míg a hüllők részaránya nagyrészt elhanyagolható volt a vizsgált helyszíneken. A gerinces zsákmányállatok jelentőségét a magas, 99% feletti tömeg szerinti részarányuk is bizonyítja. A gerinctelenek egyedszám szerinti részaránya 24,8–30,0% volt, tömeg szerinti részesedésük azonban rendkívül csekély (0,14–0,34%). A kuvik a területen nagyrészt a nagyobb méretű bogarakat *(Pentodon idiota, Melolontha hippocastani)*, valamint egyenesszárnyúakat *(Tettigonia viridissima, Gryllotalpa gryllotalpa)* fogyasztotta. A köpetekből kimutatott rovarközösségek fajgazdagsága és diverzitása a kunpeszéri területen volt a legnagyobb, ami minden bizonnyal a változatos, mozaikos habitatstruktúrának is köszönhető.

Kulcsszavak: táplálkozásökológia, étrend, köpetelemzés, Strigiformes, Coleoptera, tanyasi élőhely

[1]University of Sopron, Institute of Wildlife Management and Vertebrate Zoology, 9400 Sopron, Bajcsy-Zsilinszky utca 4., Hungary, e-mail: hamoridanielkoe@gmail.com
[2]Hungarian Little Owl Protecting Public Benefit Association, 1082, Budapest, Szőlő utca 86. 2/12., Hungary
[3]Hungarian Natural History Museum, Department of Zoology, 1088 Budapest, Baross utca 13., Hungary
*corresponding author

Introduction

The Little Owl *(Athene noctua)* is one of the strictly protected owl species in Hungary. Despite its European population is estimated to be stable, decreasing trend has been observed in several countries (Cramp 1985, Van Nieuwenhuyse *et al.* 2008, BirdLife International 2016). Population trend in Hungary is not known, former data was mainly based on estimates provided by experts (Šálek *et al.* 2013). The breeding population is estimated between 1400 and 4000 pairs (Gorman 1995, Hadarics & Zalai 2008, Hámori 2014, BirdLife International 2016).

As a consequence of the experienced population decrease, Little Owl conservation and research have become a priority in most European countries (e.g. Zerunian *et al.* 1982, Genot 1994, Angelici *et al.* 1997). Apart from the knowledge on habitat preference, it is essential to perform detailed studies also on the feeding biology so as to develop the conservation strategies. It has already been revealed that population decline is due to the limited feeding possibilities and limited food availability (Genot & Van Nieuwenhuyse 2002, Zmihorski *et al.* 2006, Thorup *et al.* 2010). Inhabiting a large area and having a wide range of hunting techniques, the Little Owl generally feed on a wide variety of foods (Mikkola 1983, Cramp 1985, Schönn *et al.* 1991, Angelici *et al.* 1997). It mainly feeds on small mammals and invertebrates but occasionally also on amphibians, reptiles and fishes (Glutz von Blotzheim & Bauer 1980, Cramp 1985). European owl species feed almost exclusively on animal food, even occasional carrion-eating has been observed Milchev and Nikolay (2017). The Little Owl is, however, the only owl species feeding also on plant materials (Lanszki 2006, Van Nieuwenhuyse *et al.* 2008).

Based on pellet analyses from European and Middle East countries, the diet of Little Owl is mostly composed of insects, however, feeding behaviour can differ according to the habitat and geographical region (Herrera & Hiraldo 1976, Cramp 1985, Gorzel & Grzywaczewski 2003, Obuch & Kristin 2004, Van Nieuwenhuyse *et al.* 2008). On the diet composition and feeding habits, several studies carried out in Mediterranean region, Western Europe and Middle East have been published (e.g. Zerunian *et al.* 1982, Angelici *et al.* 1997, Gotta & Pigozzi 1997, Obuch & Kristin 2004, Alivizatos *et al.* 2005, Van Nieuwenhuyse *et al.* 2008). Otherwise, in Hungary, the Little Owl is one of the least studied species. Apart from a more detailed work also evaluating the arthropod diet of Little Owl (Lanszki 2006), studies from the Carpathian Basin mostly focus on the small mammal diet (Marián & Schmidt 1968, Molnár 1984, Andrési & Sódor 1986, Endes 1990).

The main goal of the present research was to explore the feeding habits of Little Owl in a farmland area in the Mid-Hungarian region (Kiskunság). Further aim was to give a detailed evaluation of the vertebrate prey and the arthropod diversity based on the pellet analyses, with relation to the habitat characteristics.

Material and methods

Study area

Our studies were carried out in the Upper-Kiskunság region (Mid-Hungary), in the administrative territories of the Kiskunság National Park and the Duna-Ipoly National Park. The study sites, corresponding three known Little Owl territories, are situated nearby the settlements Apaj, Kunpeszér and Ladánybene *(Figure 1)*. Brief description of the studied territories is provided hereinafter.

Apaj (N47.104754; E19.054062)

The Little Owl nest itself was found under the roof of a sheep barn. The territory has a mosaic structure, mainly characterized by sheep pastures and intensive agricultural fields, but enriched with an older pedunculate oak *(Quercus robur)* alley, a mixed, semi-open forest patch and the complex of buildings designed for sheep breeding and farming. Apart from the

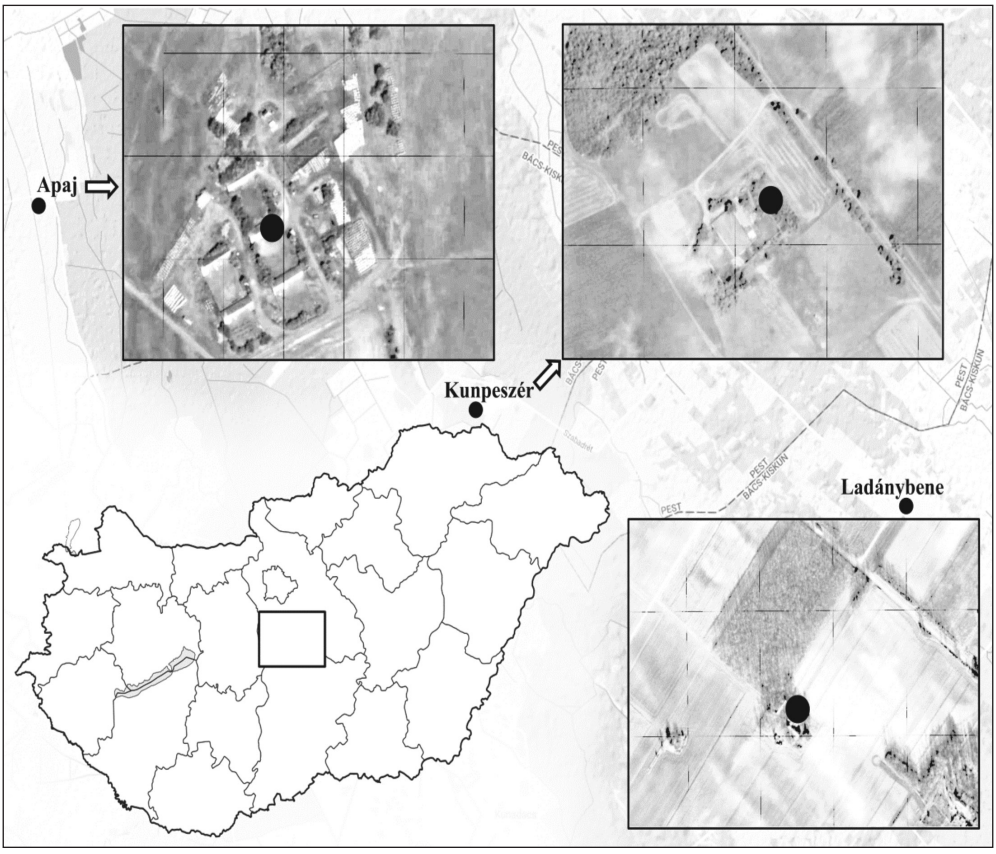

Figure 1. Map of the study area with the Little Owl territories
1. ábra A kutatási terület térképe a vizsgált kuvik territóriumokkal

pastures, mowed grasslands crossed by small canals, as well as small periodical water bodies and alkali fragments are also available.

Little Owl pellets were collected at the roosting place under the roof as well as from four stations regularly used for dropping pellets.

Successfully fledged young owls: 4

Kunpeszér (N47.080801; E19.245475)

The breeding took place in an artificial nest box installed on an old black locust *(Robinia pseudoacacia)* tree, surrounded by numerous farm buildings designed for cattle, sheep and geese. This site is characterized by high coverage of pastures and regularly mowed grasslands, while alkali patches with small temporary water bodies are less typical here. Apart from wayside black locust and poplar (*Populus* spp.) trees, scots pine *(Pinus sylvestris)* forest patches are also present, associated with a wide channel passing through the site.

Pellets were collected from the nest box, next to the clutch, and also from further two steady pellet-stations within the territory.

Number of successfully fledged young owls: 6

Ladánybene (N47.021768; E19.472589)

An artificial nest box installed on an old oak tree and occupied by the Little Owl is situated near to the settlement Ladánybene. A number of periodically occupied holiday properties are located within this site while animal husbandry is less prevalent. As a consequence just a few pastures and meadows have been maintained. More characteristic are, however, the abandoned fields with ruderal vegetation and plantations of black locust, poplar and black pine *(Pinus nigra)*.

Pellets were collected both from the nest box and from two regularly used pellet-stations.

Number of successfully fledged young owls: 6

Pellets of Little Owls were collected from February to September 2005. In each sites, prior to the first samplings, old pellet remnants had been removed. Each site was visited 5 times during the study period. The most important sampling parameters are summarized in *Table 1*.

Pellet analysis

A total of 661 Little Owl pellets were analysed. The pellets were dried and processed by standard methods (Schmidt 1967, Ruprecht *et al.* 1998). The remains were analysed by using a stereo microscope. Small mammals were assessed from skulls, mandibles and teeth following the works of Schmidt (1967), März (1987), Ujhelyi (1989) and Diesener and Reicholf (1997). Birds were determined on the basis of skulls and feathers (Brown *et al.* 1993). Insects were identified to species level and quantified by head capsules, elytra and other remains on the basis of the collection of the Hungarian Natural History Museum and following the keys in Laibner (2000), Móczár (1984), Müller-Motzfeld (2004), Rheinheimer and

Hassler (2010). Pellet material from all three sites was also tested for Annelida presence by detecting their chaetae. For determining biomass, weight of most of the prey species was derived from the literature (Dely 1967, 1978, Petrescu 1994, Fattorini *et al*. 1999, Grzywaczewski *et al*. 2006, Bihari *et al.* 2007, Kitowski & Pawlega 2010, Romanowski *et al.* 2013), while biometric data and specific equations were used to calculate the weight of the remaining species (Rogers *et al.* 1976, Jarošík 1989).

Data analysis

To assess and compare the arthropod diversities in the diet of Little Owl, three measures of diversity were given for each site: species richness, the Shannon index (Shannon & Weaver 1949) and equitability (Pielou 1966). To compare diversity values of two assemblages a modified *t*-test was used (Hutcheson 1970). Rényi diversity profiles (Tóthmérész 1997) were applied for partial diversity ranking of the arthropod communities as reflected in the owl pellets. To evaluate the similarities of species composition, Jaccard's similarity coefficient (Jaccard 1901) and the Bray-Curtis index (Bray & Curtis 1957) were calculated. All analyses were carried out with Past 2.17c (Hammer *et al.* 2001).

Results

Overall food composition

The prey items identified from the 661 pellets represent 15 vertebrate species (1 amphibian, 2 reptile, 5 bird and 7 small mammal species) and 38 arthropod species. In addition, annelid presence was also detected, although their number was not assessed due to the limitations of methodology. Based on the identified prey number, dominance of small mammals can be observed in two sites (Apaj – 55.2% and Kunpeszér – 68.5%), while in Ladánybene, avian and small mammal preys shared equal dominance (~25%). Among small mammals, the most numerous species was the Common Vole *(Microtus arvalis)*, but also the Wood Mouse *(Apodemus sylvaticus)* and in Apaj and Kunpeszér also the House Mouse *(Mus musculus)* proved to be considerably abundant. Other rodent species include the Eurasian Harvest

Table 1. Summary of Little Owl pellet sampling parameters
1. táblázat A kuvik köpetminták gyűjtésének fontosabb adatai

Site	Location of pellet collection	Date of collection	Number of collected pellets
Apaj	Nest under a roof of a sheep barn and further pellet-stations	02.03.2005-09.01.2005	221
Kunpeszér	Artificial nest box and further pellet-stations	02.03.2005-09.01.2005	248
Ladánybene	Artificial nest box and further pellet-stations	02.03.2005-09.01.2005	192

Mouse *(Micromys minutus)* and the Brown Rat *(Rattus norvegicus)*, both occurred in low numbers. Apart from rodents, a few individuals of two species of Soricomorpha as Lesser White-toothed Shrew *(Crocidura suaveolens)* and Eurasian Pygmy Shrew *(Sorex minutus)* were also identified from the pellets. The contribution of birds in the diet varied depending on the site. Their highest proportion was found in Ladánybene, while they were completely absent from the pellets collected in Kunpeszér. Of the passerine bird species identified the Common Starling *(Sturnus vulgaris)* was the most dominant species, but also the House Sparrow *(Passer domesticus)* had a strong contribution in Ladánybene. Amphibians were represented by a single species, the Common Spadefoot *(Pelobates fuscus)*, occurring in all localities, with considerable contribution especially in Ladánybene. Reptiles were represented by two lacertid lizard species as Sand Lizard *(Lacerta agilis)* and Balkan Wall Lizard *(Podarcis taurica)* preyed only occasionally.

In terms of biomass, vertebrates play a predominant role by contributing over 99% of the overall prey biomass in all study sites. Within vertebrates, small mammals' contribution was the highest in Apaj (68.2%) and Kunpeszér (93.2%), while in Ladánybene, birds constituted nearly 55.9% of the total prey biomass. It is also noteworthy to mention the high contribution of amphibian species Common Spadefoot in Ladánybene, accounting for 16.3% of the total biomass.

Invertebrate prey dominance ranged from 24.8–30.0% in the studied sites. Despite of playing important role in Little Owl's food composition, their contribution to the overall biomass is only marginal (0.14–0.34%).

Arthropod preys consisted of relatively large insects like ground beetles (Carabidae), scarab beetles (Scarabaeidae) as well as crickets and bush-crickets (Orthoptera). The characteristic dominant beetle species in Apaj was *Pentodon idiota*, while the Chestnut Cockchafer *(Melolontha hippocastani)* occurred in high abundance in Ladánybene.

The most frequent orthopteran prey species, found in all studied localities, was the Great Green Bush-cricket *(Tettigonia viridissima)*, which proved to be markedly dominant in Kunpeszér, while the European Mole Cricket *(Gryllotalpa gryllotalpa)* showed a high contribution among the arthropods in Apaj.

Arthropod diversity in Little Owl's diet

The most important diversity characteristics for arthropod communities derived from Little Owl pellets are summarized in *Table 2*. Species richness, Shannon diversity and evenness indicated the highest arthropod diversity in the Kunpeszér study site. Species richness in Apaj was considerably lower, notwithstanding, Hutheson's modified *t*-test yielded no significant difference between the Shannon diversities (*t*-test, $t=1.617$, *ns*). The lowest arthropod species richness was found in Ladánybene, showing marked differences in diversity both from Apaj (*t*-test, $t=2.073$, $p<0.05$) and Kunpeszér (*t*-test, $t=3.256$, $p<0.01$).

These results are well reflected also in Rényi's diversity profiles *(Figure 2)*. The diversity profile of arthropod community found in Ladánybene clearly runs under the profiles of the two other locations, while the profiles of Apaj and Kunpeszér did not show clear separateness.

Table 2. Food composition of Little Owls in the study sites; *g* – grams, *N* – number of prey, *m* – pray biomass

2. táblázat A kuvik táplálék-összetétele a vizsgált élőhelyeken; *g* – gramm, *N* – zsákmányállatok száma, *m* – zsákmányállatok biomassza tömege

Taxa	weight (g)	Apaj		Kunpeszér		Ladánybene	
		% N	*% m*	*% N*	*% m*	*% N*	*% m*
VERTEBRATA total		***75.00***	***99.8035***	***75.13***	***99.66***	***70.00***	***99.8131***
***Class* AMPHIBIA**		**5.81**	**4.3478**	**5.58**	**5.5285**	**18.33**	**16.3781**
Pelobates fuscus	20.0	5.81	4.3478	5.58	5.5285	18.33	16.3781
REPTILIA		**1.16**	**0.8043**	**1.02**	**0.9298**	**2.50**	**1.6192**
Lacerta agilis	12.5					1.67	0.9306
Podarcis taurica	18.5	1.16	0.8043	1.02	0.9298	0.83	0.6886
***Class* AVES**		**12.79**	**26.4128**			**25.00**	**55.9088**
Motacilla alba	23.0	2.91	2.5000				
Sturnus vulgaris	82.0	6.98	21.3911			10.83	39.6796
Passer domesticus	28.0	1.74	1.8261			9.17	11.4646
Passer montanus	24.0					3.33	3.5734
Carduelis carduelis	16.0	1.16	0.6956			1.67	1.1911
***Class* MAMMALIA**		**55.23**	**68.2385**	**68.53**	**93.2058**	**24.17**	**25.9071**
Sorex minutus	5.0			1.02	0.2513		
Crocidura suaveolens	5.0	0.58	0.1087			5.00	1.1167
Microtus arvalis	32.0	23.26	27.8258	35.53	56.2903	10.83	15.4847
Apodemus sylvaticus	25.0	8.72	8.1521	19.29	23.8731	8.33	9.3057
Mus musculus	21.0	19.77	15.5216	12.18	12.6653		
Micromys minutus	5.0	1.74	0.3261	0.51	0.1256		
Rattus norvegicus	375.0	1.16	16.3042				
INVERTEBRATA total		***25.00***	***0.2348***	***24.87***	***0.3359***	***30.00***	***0.1869***
***Ordo* COLEOPTERA**		**18.02**	**0.0394**	**17.26**	**0.0686**	**28.33**	**0.1378**
***Fam.* Dytiscidae**		**0.58**	**0.0053**				
Dytiscus marginalis	0.246	0.58	0.0053				
***Fam.* Carabidae**		**3.49**	**0.0017**	**6.09**	**0.0208**	**5.83**	**0.0140**
Amara aenea	0.006			1.02	0.0003		
Anisodactylus binotatus	0.017					1.67	0.0013
Broscus cephalotes	0.095			1.02	0.0048		
Calathus fuscipes	0.023			0.51	0.0006		
Calosoma auropunctatum	0.135					0.83	0.0050
Calosoma sycophanta	0.184			1.52	0.0139		
Harpalus affinis	0.015	0.58	0.0003				
Harpalus distinguendus	0.013	2.33	0.0011	0.51	0.0003		
Harpalus hirtipes	0.010			0.51	0.0003		
Harpalus tardus	0.013	0.58	0.0003	1.02	0.0007		
Poecilus cupreus	0.017					0.83	0.0006

Taxa	weight (g)	Apaj		Kunpeszér		Ladánybene	
		% N	*% m*	*% N*	*% m*	*% N*	*% m*
Zabrus spinipes	0.063					2.50	0.0070
***Fam.* Histeridae**		**1.16**	**0.0001**				
Margarinotus purpurascens	0.001	1.16	0.0001				
***Fam.* Silphidae**				**1.02**	**0.0019**	**0.83**	**0.0014**
Silpha carinata	0.037			1.02	0.0019	0.83	0.0014
***Fam.* Lucanidae**				**1.52**	**0.0106**		
Dorcus parallelipipedus	0.140			1.52	0.0106		
***Fam.* Geotrupidae**		**0.58**	**0.0022**	**0.51**	**0.0003**		
Geotrupes spiniger	0.100	0.58	0.0022				
Odonteus armiger	0.012			0.51	0.0003		
***Fam.* Scarabaeidae**		**10.47**	**0.0292**	**5.08**	**0.0325**	**20.83**	**0.1222**
Aphodius prodromus	0.002	1.74	0.0001				
Copris lunaris	0.089	1.74	0.0058	1.52	0.0067	0.83	0.0033
Oryctes nasicornis	0.226			1.52	0.0170	1.67	0.0168
Pentodon idiota	0.089	6.98	0.0232				
Melolontha hippocastani	0.126					16.67	0.0938
Anomala vitis	0.044			0.51	0.0011		
Cetonia aurata	0.051			0.51	0.0013	0.83	0.0019
Protaetia speciosissima	0.172			0.51	0.0043	0.83	0.0064
Protaetia cuprea	0.083			0.51	0.0021		
***Fam.* Elateridae**				**1.02**	**0.0014**		
Agrypnus murinus	0.028			0.51	0.0007		
Melanotus punctolineatus	0.028			0.51	0.0007		
***Fam.* Cerambycidae**				**0.51**	**0.0008**		
Plagionotus floralis	0.031			0.51	0.0008		
***Fam.* Chrysomelidae**		**0.58**	**0.0001**	**1.02**	**0.0001**		
Gonioctena fornicata	0.002	0.58	0.0001				
Oulema melanopa	0.002			1.02	0.0001		
***Fam.* Curculionidae**		**0.58**	**0.0002**	**0.51**	**0.0003**	**0.83**	**0.0003**
Otiorhynchus ligustici	0.013			0.51	0.0003		
Psallidium maxillosum	0.007	0.58	0.0002			0.83	0.0003
***Fam.* Tenebrionidae**		**0.58**	**0.0007**				
Tenebrio molitor	0.034	0.58	0.0007				
***Ordo* ORTHOPTERA**		**6.98**	**0.1954**	**7.61**	**0.2673**	**1.67**	**0.0490**
Gryllotalpa gryllotalpa	0.563	3.49	0.0734			0.83	0.0210
Gryllus campestris	0.081	0.58	0.0018	0.51	0.0020		
Tettigonia viridissima	0.754	2.91	0.1202	7.11	0.2653	0.83	0.0281
***Phylum* ANNELIDA**		+		+		+	

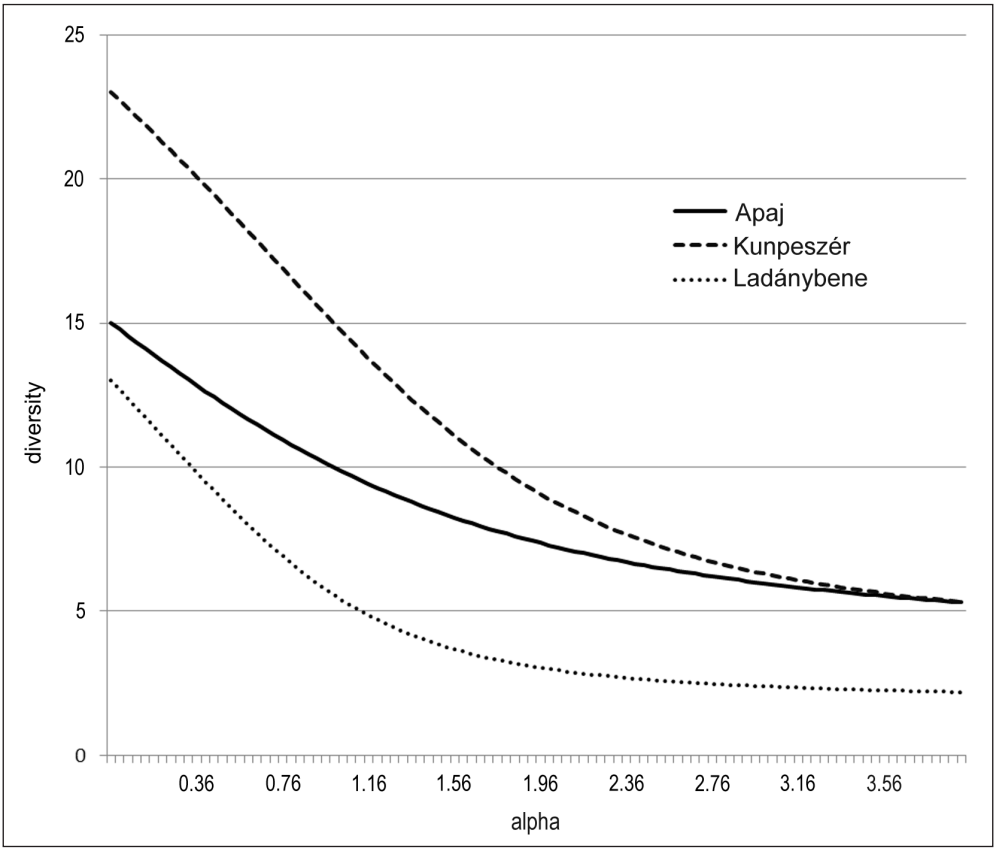

Figure 2. Comparison of arthropod diversities based on Little Owl pellets using Rényi's diversity profiles

2. ábra A kuvik köpetek alapján kimutatott ízeltlábúak diverzitási profiljai

Table 2. Characteristics of arthropod communities of the studies sites on the basis of Little Owl pellets

2. táblázat A vizsgált revírek ízeltlábú-közösségeinek karakterisztikái a kuvik köpetek alapján

	Apaj	**Kunpeszér**	**Ladánybene**
Species richness (*S*)	15	23	13
Shannon diversity (*H*)	2.316	2.727	1.751
Equitability (*J*)	0.855	0.871	0.683

Table 3. Pairwise comparison of arthropod communities as found in Little Owl pellets using the Jaccard's similarity coefficient (normal letters) and the Bray-Curtis index (italicized letters)

3. táblázat A kuvik köpetek alapján vett rovarközösségek hasonlósága (Jaccard-féle fajazonossági index – normál betű; Bray-Curtis hasonlósági index – dőlt betű)

	Apaj	**Kunpeszér**	**Ladánybene**
Apaj		*0.38*	*0.16*
Kunpeszér	0.31		*0.57*
Ladánybene	0.24	0.36	

Based on the Jaccard index of community composition *(Table 3)*, the highest similarity (0.36) was observed between Kunpeszér and Ladánybene with 6 common arthropod species, while the lowest similarity (0.24) was found between the arthropod assemblages in Apaj and Ladánybene (4 common species). These results are confirmed by the Bray-Curtis index of similarity which takes into account also the arthropod abundance.

Discussion

As literature data report, the Little Owl is a dietary generalist predator whose diet composition is linked to the abundance of potential prey species available (Cramp 1985, Schönn *et al.*1991, Laiu & Murariu 1997, Van Nieuwenhuyse *et al.* 2008, Šálek *et al.* 2010). This fact is well reflected in marked differences in food composition of Little Owls occurring in distinct geographical regions (Obuch & Kristin 2004, Charter *et al.* 2006, Van Nieuwenhuyse *et al.* 2008, Kayahan & Tabur 2016) or inhabiting different environments and habitats within the same geographical area (Van Nieuwenhuyse *et al.* 2008). Seasonal variation in diet composition is also a known and well documented phenomenon (e.g. Hounsome *et al.* 2004, Alivizatos *et al.* 2006, Lanszki 2006, Romanowski *et al.* 2013). In general, from central Europe towards to the South-European region, the role of small mammals in the diet of Little Owl gets less important in contrast with the insects becoming predominant in the Mediterranean region (Libois 1977, Zerunian *et al.* 1982, Mánez 1983, Mikkola 1983, Simeonov 1983, Schönn *et al.* 1991, Ille 1992, Angelici *et al.* 1997, Genot & Van Nieuwenhuyse 2002, Arcidiacono *et al.* 2007, Tomé *et al.* 2008, Kayahan & Tabur 2016). In Hungary, previous studies have shown a dominant contribution of insects (in terms of prey number) during the breeding season (Schmidt 1967, 1998, Lanszki 2006). In contrast, our result showed that vertebrate prey heavily dominated not only the overall biomass, but also the number of individuals (70–75%), in accordance with the results of Polish (Romanowski 1988, Kitowski & Pawlega 2010) and Bulgarian (Georgiev 2005) studies. This phenomenon can be considered unusual also because the climate of our study area is extremely hot and semi-arid, thereby showing a moderate similarity with Mediterranean conditions, supposedly providing high abundance and availability of arthropod invertebrates. Nevertheless, there are rare examples of vertebrate dominance in the diet of Little Owls also in the Mediterranean region (Goutner & Alivizatos 2003).

Among vertebrates the key role of Common Vole was also confirmed by our results, in accordance with other Hungarian (Greschik 1911, 1924, Schmidt 1967, Marián & Schmidt 1968, Lanszki 2006) and other studies from the central European region (Romanowski 1988, Ille 1992, Genot & Bersuder 1995, Laiu & Murariu 1997, Schmid 2003, Grzywaczewski *et al.* 2006, Romanowski & Żmihorski 2006, Šálek *et al.* 2010, Romanowski *et al.* 2013). House Mouse proved to be also numerous in sites where farm buildings are redundant (Apaj and Kunpeszér). In such environments, synanthropic small mammals can have a considerable contribution in the diet (Marián & Schmidt 1968, Romanowski *et al.* 2013, Chenchouni 2014). It has also been observed that Little Owls hunt for these preys inside the buildings (Genot & Van Nieuwenhuyse 2002).

Usually, birds do not play a key role in the diet of Little Owls (Libois 1977, Laursen 1981, Simeonov 1983, Cramp 1985, Lanszki 2006, Šálek *et al.* 2010, Romanowski *et al.* 2013). Nonetheless, a few studies reported high seasonal frequency of bird occurrence in springtime and autumn (Hounsome *et al.* 2004), in autumn and winter (Mikkola 1983) or during the wintertime (Hell 1964). While in our study site in Kunpeszér birds were completely absent in the Little Owl pellets, their contribution was remarkable in Apaj, and especially in Ladánybene, reaching 25% in terms of number and 55.9% of the overall biomass. Avian prey in the latter sites was strongly dominated by the Common Starling. The forest patches provide optimal night roosts for starlings where they can be easily caught by Little Owls. Other bird prey items include the House Sparrow or the White Wagtail *(Motacilla alba)* are clearly linked to the farm buildings in these sites and are often falling prey to the Little Owls (Marián & Schmidt 1968, Grzywaczewski *et al.* 2006, Shao & Liu 2008, Kitowski & Pawlega 2010, Pocora *et al.* 2012). The absence of birds in pellets collected in Kunpeszér might be explained by the site characteristics, as neither the sparse Black Locust trees nor the dense pine plantations can provide night roosts preferred by Common Starlings.

Amphibian presence in the diet of Little Owl is usually scarce (Lanszki 2006, Romanowski *et al.* 2013, Chenchouni 2014) or completely absent (Laiu & Murariu 2000, Hounsome *et al.* 2010, Šálek *et al.* 2010) depending their availability and the habitat. Although occasional reports on presumed higher proportions of amphibian prey are available (Uttendörfer 1939, Festetics 1955), this phenomenon has rarely been observed. For that reason, the occurrence of the Common Spadefoot in all studied site with remarkable contribution merits a special mention. In Ladánybene this species constituted in 18.3% of all prey and represented 16.4% of the total biomass. The Common Spadefoot is a species with nocturnal activity, occurring in high abundance in the study area. It is, therefore, not a coincidence that Little Owls prefer this easily obtainable prey over the fast-moving small mammals or the less profitable arthropod prey items.

Reptiles play relevant role in Little Owl's food composition mostly in the Mediterranean (Zerunian *et al.* 1982, Angelici *et al.* 1997, Mastrorilli *et al.* 2001, Arcidiacono *et al.* 2007) and in the desert areas in Asia (Al-Melhim *et al*. 1997, Obuch & Kristin 2004, Shao *et al.* 2007). In Central Europe reptiles are less abundant, which is well reflected also in the diet composition of Little Owls (Greschik 1911, Schmidt & Marián 1968, Laiu & Murariu 2000). In our study area two lacertid lizard species were found in the pellets but with marginal contribution.

From the pellet analyses we can draw the conclusion that in contrast with the only detailed study carried out in Hungary (Lanszki 2006), arthropod preys do not play a crucial role in our study area. As stated by Schmidt (1998), utilization of this food source can be limited depending on the habitat, but researches are lacking to assess this assertion. Notwithstanding, as the relatively high species richness observed in the pellets from the study area suggested that relevance of invertebrates, especially of insects is obvious. In agreement with our result, most studies from the region of Central Europe report the domination of coleopteran beetles in the arthropod fraction over the other orders (Genot & Bersuder 1995, Fattorini *et al.* 1999, 2001, Grzywaczewski *et al.* 2006, Lanszki 2006, Kitowski & Pawlega 2010, Šálek *et al.* 2010, Romanowski *et al.* 2013). Within Coleoptera,

the preferred prey items are usually large ground beetles (Carabidae) and scarab beetles (Scarabaeidae) of higher prey item's mass (e.g. Ille 1996, Schmid 2003, Grzywaczewski *et al.* 2006, Lanszki 2006, Šálek *et al.* 2010). Such species in our study area include the Chestnut Cockchafer, as well as protected species like the Forest Caterpillar Hunter *(Calosoma syhophanta)* or the European Rhinoceros Beetle *(Oryctes nasicornis)*. Common characteristics of the majority of prey insects are the nocturnal or intermediate activity and the ground-dwelling life from suitable for the hunting habits of the Little Owl (Grzywaczewski *et al.* 2006, Lanszki 2006, Šálek *et al.* 2010). Orthopterans also showed a considerable contribution among the arthropod groups, especially in Apaj and Kunpeszér, which can be explained by the great extent of mowed meadows and grasslands. In Ladánybene, the abandoned fields with mostly tall and dense ruderal vegetation can heavily decrease the availability of the otherwise abundant orthopterans, therefore the hunting efficiency is low in such habitats (Hoste-Danyłow *et al.* 2010). The Great Green Bush-cricket proved to be the most preferred species. Due to its large size, crepuscular and nocturnal stridulating and flying activity it is frequently captured by Little Owls with high efficiency (Ille 1992). Similar relatively high proportion of Orthoptera as detected in Kunpeszér (7.6% in terms of prey numbers) is quite unusual in Central Europe, while often observed in the Middle East (Obuch & Kristin 2004) and in the Mediterranean region (Goutner & Alivizatos 2003, Tomé *et al.* 2008, Kayahan & Tabur 2016), where an absolute predominance of this group was also experienced.

Although the main habitat characteristics of the studied sites show no distinct differences, the particularities in mosaic structure mentioned in the site descriptions are reflected also in the arthropod communities, as derived from the Little Owl pellet analyses. The highest species richness, diversity and evenness, found in Kunpeszér, are presumably associated with the rich mosaic habitat structure of a relatively small area, where the trophic niche of the Little Owls is usually wider (Van Nieuwenhuyse *et al.* 2008). Primary reason of the low arthropod diversity observed in the Ladánybene site is due to the extreme dominance of the Chestnut Cockchafer. This socially foraging species is habitually occurring in forest edges in large quantities and thus easily available for Little Owls (Merkl & Vig 2009). The fact that the owls effectively feed on this prey can therefore bias the diversity results. As it was previously revealed, there is not necessarily an evident relationship between the actual prey diversity and that calculated on the basis of Little Owl pellets, owing to the opportunistic feeding (Lanszki 2006).

Similarity measures showed a fair distinctiveness between the studied sites based on the pellet analyses Correspondingly, this was also experienced by Shao and Liu (2008) when comparing diet composition of Little Owls inhabiting sites of similar habitat types. The low number of common species is likely to be related to the varied distribution of certain habitat elements. Hence, insects connected to water bodies or waterside habitats *(Dytiscus marginalis, Anisodactylus binotatus)*, to sandy areas *(Broscus cephalotes, Harpalus hirtipes, Anomala vitis)*, to salt affected soils *(Geotrupes spiniger, Pentodon idiota)* or to forest patches (Forest Caterpillar Hunter, *Protaetia aeruginosa,* Rhinoceros Beetle, Chestnut Cockchafer) occurred exclusively or with higher abundance in a given site with suitable habitat characteristics.

The share of earthworms (Lumbricidae) in the diet of Little Owl has been regarded as marginal (Laursen 1981, Romanowski 1988, Grzywaczewski *et al.* 2006), considerable (Petrescu 1994, Blache 2001) or significant (Juillard 1984, Bacia 1998, Hounsome *et al.* 2004, Tomé *et al.* 2008, Schipper *et al.* 2012). In the pellets from the study sites, earthworm chaetae were present with a high frequency, albeit their number and biomass have not been calculated due to the not fully developed methodology.

In contrast with the findings of Lanszki (2006), plant materials were not detected in the Little Owl pellets from our study area.

As supported by our results, the Little Owl can be considered a typical generalist predator in the Kiskunság region. The identified 54 prey taxa represent a wide range of food types within a relatively small area and provide important information not only on the feeding ecology but also for the conservation of Little Owl.

Acknowledgement

We are deeply indebted to György Traser and József Lanszki for their helpful comments and advices, the members of the Hungarian Little Owl Protecting Public Benefit Association for their help in the field work. Anonymous reviewers provided helpful comments that improved the manuscript. This article was made in frame of the „EFOP-3.6.1-16-2016-00018 – Improving the role of research+development+innovation in the higher education through institutional developments assisting intelligent specialization in Sopron and Szombathely".

References

Alivizatos, H., Goutner, V. & Zogaris, S. 2005. Contribution to the study of the diet of four owl species (Aves, Strigiformes) from mainland and inland areas of Greece. – Belgian Journal of Zoology 135: 109–118.

Alivizatos, H., Goutner, V., Athanasiadis, A. & Poirazidis, K. 2006. Comparative temporal prey use by Barn Owl *(Tyto alba)* and Little Owl *(Athene noctua)* in the Evros Delta, northeastern Greece. – Journal of Biological Research 6: 177–186.

Al-Melhim, W. N, Amr, Z. S., Disi, A. M. & Bader, K. 1997. On the diet of the Little Owl, *Athene noctua*, in the Safawi Area, Eastern Jordan. – Zoology in the Middle East 15: 19–28. DOI: 10.1080/09397140.1997.10637734

Andrési, P. & Sódor, M. 1986. Adatok fészkelő bagolyfajaink táplálkozásökológiájához [Foraging ecology of some owls]. – A Magyar Madártani Egyesület II. Tudományos Ülése, Szeged, pp. 293–300. (in Hungarian)

Angelici, F. M., Latella, L., Luiselli, L. & Riga, F. 1997. The summer diet of the Little Owl *(Athene noctua)* on the Island of Astipalaia (Dodecanese, Greece). – Journal of Raptor Research 3: 280–282.

Arcidiacono, G., Donati, C. & Mastrorilli, M. 2007. Dieta della Civetta *Athene noctua* in habitat naturali e antropizzati: una revisione bibliografica [Diet of the Little Owl *Athene noctua* in rural and urban areas: a bibliographical review]. – Studi Trentini di scienze naturali, Acta Biologica 83: 243–247. (in Italian)

Bacia, D. 1998. Territorial behaviour and food composition of two pairs of the Little Owl *Athene noctua* Scopoli, 1796, nesting at a distance of only 40 m apart. – Verslagen en Technische Gegevens, Institute for Systematics and Population Biology 75: 1–21.

Bihari, Z., Csorba, G. & Heltai, M. (eds.) 2007. Magyarország emlőseinek atlasza [The Atlas of Hungarian Mammals]. – Kossuth Kiadó, Budapest (in Hungarian)

BirdLife International 2016. *Athene noctua*. – The IUCN Red List of Threatened Species 2016: e.T22689328A86869477. DOI: 10.2305/IUCN.UK.2016-3.RLTS.T22689328A86869477.en

Blache, S. 2001. Study of the diet of young Little Owl (*Athene noctua* Scop.) in a very intensive agricultural habitat in southeast of France. – Ciconia 25: 77–94.

Bray, J. R. & Curtis, J. T. 1957. An ordination of the upland forest communities of Southern Wisconsin. – Ecological Monographs 27: 325–349. DOI: 10.2307/1942268
Charter, M., Leshem, Y., Izhaki, I., Guershon, M. & Kiat, Y. 2006. The diet of the Little Owl, *Athene noctua*, in Israel. – Zoology in the Middle East 39(1): 31–40. DOI: 10.1080/09397140.2006.10638180
Chenchouni, H. 2014. Diet of the Little Owl *(Athene noctua)* during the pre-reproductive period in a semi-arid Mediterranean region. – Zoology and Ecology 24(4): 314–323. DOI: 10.1080/21658005.2014.965919
Cramp S. (ed.) 1985. Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic, Vol. 4. – Oxford University Press, Oxford
Dely, O. Gy. 1967. Kétéltűek – Amphibia. – Magyarország Állatvilága (Fauna Hungariae) 20(3): 1–80. (in Hungarian)
Dely, O. Gy. 1978. Hüllők – Reptilia. – Magyarország Állatvilága (Fauna Hungariae) 20(4): 1–128. (in Hungarian)
Diesener, G. & Reicholf, J. 1997. Amphibians and Reptilians. – Warsaw, Swiat Ksiazki, Poland
Endes, M. 1990. Kuvik *(Athene noctua)* ürgefogyasztása [Little Owl *(Athene noctua)* feeding on Ground Squirrel]. – Calandrella 4(1): 85. (in Hungarian)
Fattorini, S., Manganaro, A. & Salvati, L. 2001. Insect identification in pellet analysis: implications for the foraging behaviour of raptors. – Buteo 12: 61–66.
Fattorini, S., Manganaro, A., Piattella, E. & Salvati, L. 1999. Role of the beetles in Raptor diets from a Mediterranean urban area. – Fragmenta Entomologica 31: 57–69.
Festetics, A. 1955. Megfigyelések a gyöngybagoly és kuvik életéről [Observations on the life of Barn Owl and Little Owl]. – Aquila 59–62: 401–403.
Genot, J-C. 1994. Breeding biology of the Little Owl *Athene noctua* in France. – In: Meyburg B-U. & Chancellor R. D. (eds.) Raptor Conservation. – WWGBP/The Pica Press. Berlin, pp. 511–520.
Genot, J-C. & Bersuder, D. 1995. Le regime alimentaire de la Chouette cheveche *Athene noctua* Alsace-Lorraine [The diet of the Little Owl *Athene noctua* in Alsace-Lorraine]. – Ciconia 19: 35–51. (in French)
Genot, J-C. & Van Nieuwenhuyse, D. 2002. Little Owl *Athene noctua.* – Birds of Western Palearctic Update 4: 35–63.
Georgiev, D. G. 2005. Food niche of *Athene noctua* (Scopoli, 1769) and *Tyto alba* (Scopoli, 1769) (Aves, Strigiformes) co-existing in one region of the Upper Tracian Valley (South Bulgaria). – Animalia 41: 115–122.
Glutz Von Blotzheim, U. & Bauer, K. 1980. Handbuch der Vögel Mitteleuropas, Band 9 [Handbook of the birds of Central Europe, Vol. 9.]. – Aula-Verlag, Wiesbaden
Gorman, G. 1995. The status of owls (Strigiformes) in Hungary. – Buteo 7: 95–108.
Gorzel, M. & Grzywaczewski, G. 2003. Feed of Little Owl (*Athene noctua* Scop. 1769) in agricultural landscape of the Lublin area. – Acta Agrophysica 1(3): 433–440.
Gotta, A. & Pigozzi, G. 1997. Trophic niche of the Barn Owl and Little Owl in a rice field habitat in northern Italy. – Italian Journal of Zoology 64: 55–59. DOI: 10.1080/11250009709356172
Goutner, V. & Alivizatos, H. 2003. Diet of the Barn Owl *Tyto alba* and Little Owl *Athene noctua* in wetlands of northeastern Greece. – Belgian Journal of Zoology 133: 15–22.
Greschik, J. 1911. Hazai ragadozó madarak gyomor- és köpettartalom vizsgálatai II. Baglyok [Stomach and pellet analyses of our native birds of prey II. Owls]. – Aquila 18: 156–158. (in Hungarian)
Greschik, J. 1924. Gyomor- és köpettartalom vizsgálatok. Adatok hazánk apró emlőseinek faunájához [Stomach and pellet analyses. Data on the native small mammal fauna]. – Aquila 30–31: 243–263. (in Hungarian)
Grzywaczewski, G., Kitowski, I. & Scibior, L. 2006. Diet of Little Owl *Athene noctua* during breeding in the central part of Lublin region. – Acta Zoologica Sinica 52(6): 1155–1161.
Hadarics, T. & Zalai, T. 2008. Magyarország madarainak névjegyzéke – Nomenclator Avium Hungariae – An annotated list of the birds of Hungary. – MME, Budapest, p. 148. (in Hungarian)
Hammer, Ř., Harper, D. A. T. & Ryan, P. D. 2001. PAST: Paleontological statistics software package for education and data analysis. – Palaeontologia Electronica 4(1): 1–9.
Hell, P. 1964. Prispevok k poznaniu potravy niektorych dravcov a sov v mimoriadne krutej zime 1962–1963 [Contribution to knowledge on diet of some raptors and owls in extremely cold winter 1962–1963]. – Zoologicke Listy 13: 207–220. (in Slovak)
Herrera, C. M. & Hiraldo, F. 1976. Food-niche and trophic relationships among European owls. – Ornis Scandinavica 7: 29–41.
Hoste-Danyłow, A., Romanowski, J. & Żmihorski, M. 2010. Effects of management on invertebrates and birds in extensively used grassland of Poland. – Agriculture, Ecosystems and Environment 139: 129–133. DOI: 10.1016/j.agee.2010.07.009

Hounsome, T., O'Mahony, D. & Delahay, R. 2004. The diet of Little Owls *Athene noctua* in Gloucestershire, England. – Bird Study 51(3): 282–284. DOI: 10.1080/00063650409461366

Hutcheson, K. 1970. A test for comparing diversities based on the Shannon formula. – Journal of Theoretical Biology 29: 151–154. DOI: 10.1016/0022-5193(70)90124-4

Ille, R. 1992. Zur Biologie und Ökologie des Steinkauzes *(Athene noctua)* im Marchfeld: Aktuelle Situation und mögliche Schutzmanahmen [Contributions to the biology and ecology of Little Owl *(Athene noctua)* in Marchfeld: actual situation and possible preservation]. – Egretta 35: 49–57. (in German)

Ille, R. 1996. Zur Biologie und Ökologie zweier Steinkauzpopulationen in Ostösterreich [On the biology and ecology of two little owl populations in eastern Austria]. – Abhandlungen der Zoologisch-Botanischen Gesellschaft 129: 17–31.

Jaccard, P. 1901. Étude comparative de la distribution florale dans une portion des Alpes et des Jura [Comparative study of floral distribution in a portion of the Alps and Jura]. – Bulletin de la Société Vaudoise des Sciences Naturelles 37: 547–579. (in French) DOI: 10.5169/seals-266450

Jarošík, V. 1989. Mass vs. length relationship for carabid beetles (Col., Carabidae). – Pedobiologia 33: 87–90.

Juillard, M. 1984. La chouette chevêche [The Little Owl]. – Nos Oiseaux, Prangins (in French)

Kayahan, A. & Tabur, M. A. 2016. Diet composition of Little Owl (*Athene noctua* Scopoli, 1769) in Turkey. – Pakistan Journal of Zoology 48(4): 943–948.

Kitowski, I. & Pawlega, K. 2010. Food composition of the Little Owl *Athene noctua* in farmland areas of South East Poland. – Belgian Journal of Zoology 140(2): 203–211.

Laibner, S. 2000. Elateridae of the Czech and Slovak Republic. – Česke a Slovenské Republiky, Kabourek, Zlín

Laiu, L. & Murariu, D. 1997. Diet of the Little Owl *(Athene noctua)* during summer in a sub-Carpathian depression of Moldovia – Romania. – Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 37: 319–326.

Laiu, L. & Murariu, D. 2000. Food of the Little Owl (*Athene noctua* Scop., 1769) (Aves: Strigiformes) in the surroundings of Bucharest (Romania). – Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 42: 185–193.

Lanszki, J. 2006. A kuvik *(Athene noctua)* táplálék-összetétele egy Somogy megyei külvárosi élőhelyen [Seasonal diet composition of Little Owl *(Athene noctua)* in a suburban habitat, Somogy county]. – Natura Somogyiensis 9: 315–324. (in Hungarian)

Laursen, J. T. 1981. Kirkeuglens *Athene noctua* fødevalg i Østjylland [Prey of the Little Owl *Athene noctua* in East Jutland]. – Dansk Ornitologisk Forenings Tidsskrift 75: 105–110. (in Danish)

Libois, R. 1977. Contribution à l'étude du régime alimentaire de la Chouette chevêche *(Athene noctua)* en Belgique [Contribution to the knowledge on the diet of Little Owl *(Athene noctua)* in Belgium]. – Aves 14: 165–177. (in French)

Mánez, M. 1983. Espectro alimentacio del Mochuelo común *(Athene noctua)* en Espána [The diet spectrum of Little Owl *(Athene noctua)* in Spain]. – Alytes 1: 275–290. (in Spanish)

Marián, M. & Schmidt, E. 1968. Adatok a kuvik (*Athene noctua* (Scop.)) gerinces táplálékának ismeretéhez Magyarországon [Contribution to the knowledge on the vertebrate diet of Little Owl]. – Móra Ferenc Múzeum Évkönyve 1966–67, Szeged, pp. 271–275. (in Hungarian)

März, R. 1987. Gewöll- und Rupfungskunde [Handbook of bird pellets and droppings]. – Akademie Verlag, Berlin. (in German)

Mastrorilli, M., Sacchi, R. & Gentilli, A. 2001. Importanza dell'erpetofauna nella dieta degli Strigiformi italiani [Importance of the herpetofauna in the diet of Strigiformes in Italy]. – Pianura 13: 339–342. (in Italian)

Merkl, O. & Vig, K. 2009. Bogarak a pannon régióban [Beetles in the Pannonian Region]. – Vas Megyei Múzeumok Igazgatósága, B. K. L. Kiadó és a Magyar Természettudományi Múzeum, Szombathely (in Hungarian)

Mikkola, H. 1983. Owls of Europe. – T & AD Poyser, Calton

Milchev, B. & Spassov, N. 2017. First evidence for carrion–feeding of Eurasian Eagle-owl *(Bubo bubo)* in Bulgaria. – Ornis Hungarica 25(1): 58–69. DOI: 10.1515/orhu-2017-0005

Móczár, L. (ed.) 1984. Állathatározó I-II. 3. átdolgozott kiadás [Animal identification I-II.]. – Tankönyvkiadó, Budapest (in Hungarian)

Molnár, I. 1984. Bagolytáplálkozási adatok a Dunántúlról [Data on the diet of owls from the Transdanubia]. – Madártani Tájékoztató júl–dec.: 106–110. (in Hungarian)

Müller-Motzfeld, G. (ed.) 2004. Die Käfer Mitteleuropas, Band 2: Adephaga 1, Carabidae (Laufkäfer) [Beetles of Central Europe, Vol. 2: Adephaga 1, Carabidae (ground beetles)]. – Spektrum, Akademischer Verlag, Elsevier, Heidelberg-Berlin (in German)

Obuch, J. & Kristin, A. 2004. Prey composition of the Little Owl *Athene noctua* in an arid zone (Egypt, Syria, Iran). – Folia Zoologica 53: 65–79.

Petrescu, A. 1994. Contributions à la connaissance de la nourriture de la chouette *Athene noctua* (Aves, Strigiformes) [Contribution to the knowledge on the diet of Little Owl *Athene noctua* (Aves, Strigiformes)]. – Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 34: 391–400. (in French)

Pielou, E. C. 1966. The measurement of diversity in different types of biological collection. – Journal of Theory Biology 13: 131–144. DOI: 10.1016/0022-5193(66)90013-0

Pocora, V., Popovici, M., Manci, C. O. & Iorgu, I. St. 2012. Feeding of the Little Owl during nesting season in the Danube Delta (Romania). – Analele Științifice ale Universității „Alexandru Ioan Cuza" din Iași, s. Biologie animală Tom 58: 107–114.

Rheinheimer, J. & Hassler, M. 2010. Die Rüsselkäfer Baden-Württembergs [Weevils of Baden-Württemberg]. – Verlag Regionalkultur, Baden-Württemberg (in German)

Rogers, L. E., Hinds, W. T. & Buschbom, R. L. 1976. A general weight vs length relationship for insects. – Annals of the Entomological Society of America 69: 387–389. DOI: 10.1093/aesa/69.2.387

Romanowski, J. 1988. Trophic ecology of *Asio otus* (L.) and *Athene noctua* (Scop.) in the suburbs of Warsaw. – Polish Ecological Studies 14: 223–234.

Romanowski, J. & Żmihorski, M. 2006. The Little Owl *Athene noctua* diet in Central Poland. – Notatki Ornitologiczne 47: 203–206.

Romanowski, J., Altenburg, D. & Zmihorski, M. 2013. Seasonal variation in the diet of Little Owl, *Athene noctua* in agricultural landscape of Central Poland. – North-Western Journal of Zoology 9(2): 310–318.

Ruprecht, A. L., Szwagrzak, A. & Koúciów, R. 1998. Skład pokarmu sów Puszczy Nadnoteckiej [Analysis of owl pellets from the Puszcza Notecka forest complex (W Poland)]. – Badania Fizjograficzne nad Polską Zachodnią Seria C, 45: 82–103. (in Polish)

Šálek, M., Chrenkova, M. & Kipson, M. 2013. High population density of Little Owl *(Athene noctua)* in Hortobágy National Park, Hungary, Central Europe. – Polish Journal of Ecology 61(1):165–169.

Šálek, M., Riegert, J. & Křivan, V. 2010. The impact of vegetation characteristics and prey availability on breeding habitat use and diet of Little Owls *Athene noctua* in Central European farmland. – Bird Study 57(4): 495–503. DOI: 10.1080/00063657.2010.494717

Schipper, A. M., Wijnhoven, S., Baveco, H. & van den Brink, N. W. 2012. Contaminant exposure in relation to spatio-temporal variation in diet composition: a case study of the Little Owl *(Athene noctua)*. – Environmental Pollution 163:109–116. DOI: 10.1016/j.envpol.2011.12.020

Schmid, P. 2003. Gewöllanalyse bei einer Population des Steinkauzes *Athene noctua* im Grossen Moos, einer intensiv genutzten Agrarlandschaft des schweizerischen Mittellandes [Pellet analysis in a population of the Little Owl *Athene noctua* in an intensively cultivated landscape (Grosses Moss) in Switzerland]. – Ornithologische Beobachter 100: 117–126. (in German)

Schmidt, E. 1967. Bagolyköpet vizsgálatok [Owl pellet analyses]. – A Magyar Madártani Intézet kiadványa, Budapest (in Hungarian)

Schmidt, E. 1998. Kuvik [Little Owl]. – In: Haraszthy, L. (ed.) Magyarország madarai [Birds of Hungary]. – Mezőgazda Kiadó, Budapest, pp. 218–219. (in Hungarian)

Schönn, S., Scherzinger, W., Exo, K. M. & Ille, R. 1991. Der Steinkauz [Little Owl]. – Die Neue Brehm-Bücherei, Vol. 606. – A. Ziemsen Verlag, Wittenberg Lutherstadt, Germany (in German)

Shannon, C. E. & Weaver, W. 1949. The Mathematical Theory of Communication. – University of Illionis Press, Urbana, pp. 1–117.

Shao, M. & Liu, N. 2008. The diet of the Little Owl *(Athene noctua)* in the desert habitats of Northwestern China. – Journal of Raptor Research 42(1): 61–64. DOI: 10.3356/JRR-05-17.1

Shao, M., Hounsome, T. & Liu, N. 2007. The summer diet of the Little Owl *(Athene noctua)* in the desert of north-west China. – Journal of Arid Environments 68: 683–687. DOI: 10.1016/j.jaridenv.2006.08.010

Simeonov, S. D. 1983. New data on the diet of the Little Owl (*Athene noctua* [Scop.]) in Bulgaria. – Ekologiya Sofiya 11: 53–60.

Thorup, K., Sunde, P., Jacobsen, L. B. & Rahbek, C. 2010. Breeding season food limitation drives population decline of Little Owl *Athene noctua* in Denmark. – Ibis 152: 803–814. DOI: 10.1111/j.1474-919X.2010.01046.x

Tomé, R., Catry, P., Bloise, C. & Korpimäki, E. 2008. Breeding density and success, and diet composition of Little Owls *Athene noctua* in steppe-like habitats in Portugal. – Ornis Fennica 85: 22–32.

Tóthmérész, B. 1997. Diverzitási rendezések [Diversity orderings]. – Scientia, Budapest (in Hungarian)

Ujhelyi, P. 1989. A magyarországi vadonélő emlősállatok határozója [Identification of wild mammals in Hungary]. – Magyar Madártani Egyesület, Budapest (in Hungarian)

Uttendörfer, O. 1939. Die Ernährung der deutschen Raubvögel und Eulen und ihre Bedeutung in der heimischen Natur [The diet of German birds of prey and owls and their importance in the nature]. – Neumann-Neudamm, Berlin (in German)

Van Nieuwenhuyse, D., Genot, J. & Johnson, D. 2008. The Little Owl: Conservation, Ecology and Behavior of *Athene noctua*. – Cambridge, New York, Cambridge University Press

Zerunian, S., Franzini, G. & Sciscione, L. 1982. Little Owls and their prey in Mediterranean habitat. – Bolletino di Zoologia 49: 195–206.

Zmihorski, M., Altenburg-Bacia, D., Romanowski, J., Kowalski, M. & Osojca, G. 2006. Long-term decline of Little Owl (*Athene noctua* Scop., 1769) in central Poland. – Polish Journal of Ecology 54: 321–324.