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The harvest mouse (*Micromys minutus* Pallas, 1771) as prey: a literature review

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Abstract. The harvest mouse is a prey item for numerous vertebrates in various habitats, ranging from marshes and farmland, to urbanized areas. It has no specialised avian or mammalian predator and it always represents a low proportion of their diet, except in some wetlands where its frequency can exceed 40 % of total mammals taken by owls, which confirms the harvest mouse preference for this kind of habitat. Conversely, it is a much less important prey in farmlands. In Europe, barn owl (*Tyto alba*), long-eared owl (*Asio otus*), tawny owl (*Strix aluco*) and to a lesser extent little owl (*Athene noctua*) are the major avian predators of harvest mouse. Among carnivores, polecat (*Mustela putorius*) seems to be the main predator for the harvest mouse, but the scarcity of literature does not allow definitive conclusions. The influence of snow cover on the availability of harvest mice for raptors is pointed out, since this mouse tends to move above snow and therefore becomes easier prey than other rodents. Moreover, it seems that carnivores may be more efficient than raptors for hunting *Micromys* mice, probably because of their way of foraging amongst tall vegetation that makes them more likely to discover harvest mice.

Key words: rodent, predation, habitat, winter

Introduction

The harvest mouse is a tiny and elusive mammal, widespread in the Palaearctic and Indomalayan regions, from Spain and Great Britain to Japanese islands (Wilson & Reeder 2005). Whereas IUCN has assigned the status “least concern” to this species (Aplin et al. 2008), the harvest mouse has the growing attention of scientists and naturalists in some countries like Switzerland and Great Britain where its populations have declined during recent decades (Harris et al. 1995, Perrow & Jowitt 1995, Blant et al. 2012). Recently, several programs of biological conservation survey and species management have been planned in these countries in order to restore the populations of harvest mouse (Macdonald et al. 2001, Kean 2006). Among important parameters in such restoration projects, the risk of predation needs to be assessed to assure the viability of reintroduced individuals. A lot of scientific articles have been published since the beginning of the 2000s which specify feeding habits of avian raptors and carnivores, particularly in central Europe, and which allow assessment of the importance of the harvest mouse as prey. Moreover, a large dataset of harvest mouse predation by raptors and mammals in France offers

new information about the efficiency of each group of predators. It was thus interesting to re-assess the role of this little known species, almost forty years after Trout’s report (1978) which is still the only review.

Material and Methods

Search strategy

A search was conducted to find references addressing topics related to predation of the harvest mouse in Europe. Firstly with Google Scholar and then three main electronic databases that cover international literature in environmental science: Web of Science, ScienceDirect and SpringerLink. Additionally, an internet search was conducted to find grey literature (i.e. literature that has not been published in peer-reviewed journals). The terms used for each search are “micromys” added to “diet” or “feed” or “foraging”, and “diet” added to the predator’s name. Secondly, the literature mentioned in these articles was screened to identify new references. Then searches were made of some references in books at the library of the Museum National d’Histoire Naturelle (Paris). It should be noted that a great proportion of pellets and scats surveys are made by naturalist societies which often publish in regional revues that are not easy to find. The search

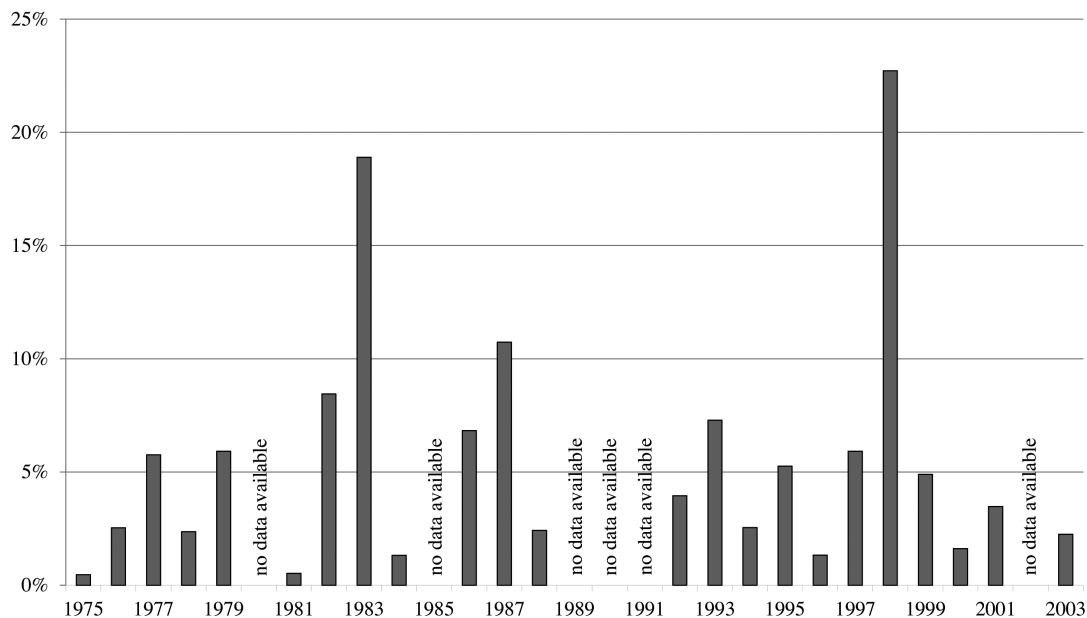


Fig. 1. Changes in the annual percentage of harvest mouse preyed by barn owl at Outines (Marne, France), from LPO dataset. See text page 127.

strategy did not have any language restriction but only papers published in English, French, Spanish, Italian and German could be used; others were only used when they contained a detailed abstract in English.

Reviewing

Studies were selected that met the two following criteria: (1) provided results from empirical research, (2) only quantitative results (total number of prey with number of specimens for each prey species or percentage of each prey). For each study site, the harvest mice frequency is calculated with the total number of mammals preyed, which is not necessarily the same as the total amount of prey, especially for primarily insectivorous birds of prey.

Additional data

The small mammal inventory that was conducted in the Champagne-Ardenne region (France) by the Ligue pour la Protection des Oiseaux (LPO) since 1970s provided 671067 prey items of 24 micromammal species, from several predators. This huge dataset has been generously made available by the LPO to the author in order to analyse specifically the harvest mouse contribution.

Results

The harvest mouse, a prey item for numerous avian raptors

In the whole of Europe, avian predators for harvest mouse include owls, harriers, falcons, buzzards,

eagles, kites, shrikes, corvids, herons and even pheasants (Table 1); unfortunately, quantitative data are not available for each of these species. When it is present in their diet, the harvest mouse is always in low frequency and therefore surveys of avian raptor diet often do not quote *Micromys* as an item. Moreover, due to its low frequency in avian diet and to its small weight (6-8 g), harvest mouse usually represents a low biomass compared to other more frequent rodents like common vole (*Microtus arvalis*), bank vole (*Myodes glareolus*), field vole (*Microtus agrestis*) or wood mouse (*Apodemus sylvaticus*). Even when harvest mouse is an important prey by number, it never exceeds 10 % of the total biomass ingested by owls (Table 1). Caloric value of harvest mouse, equal to 23.78 kJ/g of dry weight, is rather high compared to other micromammals: 23.48 kJ/g for common vole, 21.68 kJ/g for wood mouse and 22.73 kJ/g for shrews (Soricidae) (Wijnandts 1984). However, according to this author, avian raptors seem to metabolize this energy with less efficiency than for other prey. For example, with long-eared owl, several tests tend to reveal that metabolizable energy coefficient, i.e. (kJ food intake – kJ rejecta)/kJ food intake, is the lowest for *Micromys* (0.61) compared to common vole (0.68), wood mouse (0.79) and shrews (0.62). Moreover, the weight percentage rejected in the pellets is high for the harvest mouse (25.4 %). As the compiling study is based on data gained with different methods from different people, their respective quality is not possible to judge. Due to the very delicate bones of

Table 1. European avian predators for the harvest mouse (*Micromys minutus*) according to the literature with available quantitative data. un. – unavailable data, * total prey (not only mammals) and unused for „Total“, ** on total prey (not only mammals).

	N	n	%n range	%n median	% Biomass Range	Most frequent mammal prey by number
	(total mammals)	(<i>Micromys minutus</i>)	(on total mammals)	(on total mammals)	(on total prey)	(in quoted literature)
barn owl <i>Tyto alba</i>	416832	9679	0.1-23.3	1.6	0.1-5.1	<i>Microtus arvalis</i>
long-eared owl <i>Astio otus</i>	100935	2464	0.09-27.6	3	0-5.4	<i>Microtus arvalis</i>
tawny owl <i>Strix aluco</i>	150432	1246	0.01-15.5	1.9	0-5.3	<i>Microtus arvalis</i> <i>Myodes glareolus</i>
common buzzard <i>Buteo buteo</i>	10603*	609	1.8**		un.	LPO Champagne-Ardennes (unpublished)
little owl <i>Athene noctua</i>	6114	343	0.7-42	6.8	1-9.3	<i>Microtus arvalis</i>
Tengmalm's owl <i>Aegolius funereus</i>	17448	298	0.04-3.3	2.3	0.9-1.2	<i>Microtus arvalis</i>
kestrel <i>Falco tinnunculus</i>	5458	174	0.3-2.5	2.4	0.1-1.1	<i>Microtus arvalis</i>

Agnelli & Lazzeretti 2009, Alivizatos et al. 2005, Bon et al. 1992, 1997, Bosé & Guidali 2001, Buckley 1977, Buckley & Goldsmith 1975, Cserkés 2007, De Bruijn 1994, Godin 1975, Gonzales Oreja et al. 1993, Gotta & Pigozzi 1997, Hetmański et al. 2008, Indelicato 2000, Janžekovič & Ficko 2000, Kalivoda 2001, Karanović 1991, Kitowski 2013, Latková 2008, Lustrat 2002, Meek 2011, Millán de la Pena et al. 2003, Milchev et al. 2006, Miltchev et al. 2004, Obuch 2011, Pailley & Pailley 2000, Petrovici et al. 2013, Plass 2004, Purger 1990, 2014, Rolland 2011, Ružić et al. 2009, Sándor 2009, Sommer et al. 2009, Spitzberger & Steiner 1975, Temme 2006, Uttendörfer 1952, Wazna et al. 2011, Wuntke & Ludwig 1998, Zabala 1973

Balčiauskienė et al. 2006, Bencová et al. 2006, Benedek & Sírba 2010, Canova 1989, Dolenc & Kis 2010, Dupal & Chernyshow 2013, Dziemian et al. 2012, Galeotti et al. 1997, Hetmański et al. 2008, Kafkaletou-Diez et al. 2008, Kopij et al. 2012, Nisteanu 2007, Petrovici et al. 2013, Pirovano et al. 2000, Roulin 1996, Rubolini et al. 2003, Stasiak et al. 2014, Ternois 1999, Tome 2000, 2009, Tulis 2011, Uttendörfer 1952, Wavrin et al. 1991, Wiącek et al. 2008, 2011

Balčiauskas et al. 2011, Balčiauskienė et al. 2006, Baudvin & Jouaire 2006, Capizzi 2000, Gryz et al. 2008, Grzędzicka et al. 2013, Kuhar et al. 2006, Lesiński et al. 2009, 2013, Lesiński & Stolarz 2012, Obuch 2011, Poláček et al. 2012, Romanowski et al. 2013, Romanowski & Zmihorski 2009, Roulin et al. 2008, Tishechkin 1997, Uttendörfer 1952, Wiącek et al. 2008, 2009, Zalewski 1994, Zmihorski & Osójca 2006

Alivizatos et al. 2005, Bon et al. 2001, Gotta & Pigozzi 1997, Lawicki & Raclawski 2006, Obuch 2011, Pocora et al. 2012, Romanowski et al. 2013, Schmitt & Hofer 2011, Šálek et al. 2010

Korpimäki 1986, 1988, Obuch 2011, Zárbynická et al. 2009

Boratynski & Kasprzyk 2005, Casagrande et al. 2008, Kečekšová & Noga 2008, Kitowski 2014, Shrub 1980, Skierczyński 2006, Zmihorski & Rejt 2007

red kite <i>Milvus milvus</i>	4230*	93	2.2**	un.	un.	LPO Champagne-Ardennes (unpublished)
Eurasian eagle owl <i>Bubo bubo</i>	30630	70	0.07-24.8	0.1	un.-0.5	Mikkola & Tornberg 2014, Obuch 2011, Obuch & Karaska 2010
Montagu's harrier <i>Circus pygargus</i>	2035	59	0.6-3	1.9	0.2-un.	Koks et al. 2007, Wiącek & Niedźwiedz 2005
Ural owl <i>Strix uralensis</i>	2604	37	0.4-12	0.8	0.1-3	Kociuba 2012, Obuch et al. 2013, Vrezec 2001
great grey shrike <i>Lanius excubitor</i>	663	29	4.4	un.	un.	Brzeziński et al. 2010
pygmy owl <i>Glaucidium passerinum</i>	3014	28	0.6-15	0.8	0	Halonen et al. 2007, Mikusek et al. 2001, Obuch 2011
hen harrier <i>Circus cyaneus</i>	297	23	1.8-14	7.5	un.	Schipper 1973, Toffoli 1994
short-eared owl <i>Asio flammeus</i>	1244	23	1-5.8	1.9	0.5-un.	Buckley 1973, Dupal & Chernyshow 2013, Noga & Dobry 2013, Szymański et al. 2010, Trnka & Obuch 2006, Uttendörfer 1952
Eurasian scops owl <i>Otus scops</i>	59	17	29	un.	un.	Bavoux et al. 2003
lesser spotted eagle <i>Aquila pomarina</i>	1601	4	0.2-1.9	0	0	Meyburg 1970, Zub et al. 2010
hawk owl <i>Surnia ulula</i>	732	4	0.6	un.	un.	Mikkola 1972
great gray owl <i>Strix nebulosa</i>	1517	3	0.7	un.	un.	Tishechkin 1997
imperial eagle <i>Aquila heliaca</i>	359	3	0.8	0.01	0.01	Demerdzhiev et al. 2014
greater spotted eagle <i>Aquila clanga</i>	322	2	0.6	un.	un.	Dombrowski 2010
marsh harrier <i>Circus aeruginosus</i>	151	2	1.3	0.5	0.5	Kitowski 2005
Total	742447	15209				

Table 2. Proportion of harvest mouse in the diet of the four main raptors. N – total mammal prey items, n – number of harvest mouse prey items in quoted literature (selection for n > 20), n% – percentage of harvest mouse prey items compared with total mammal prey items; Wet = wetland, Boc = bocage landscape, Wood = woodland, Urb = farmland, Farm = farmland, Urb = urbanized area, Mix = mixed habitats.

	<i>Tyto alba</i>			<i>Asio otus</i>			<i>Strix aluco</i>			<i>Athene noctua</i>			Habitat	
	N	n	n%	N	n	n%	N	n	n%	N	n	n%		
Austria	2670	39	1.5										Boc	Spitzenberger & Steiner 1975
Belarus				1517	30	2							Boc	Tishechkin 1997
Bulgaria	4842	66	1.4										Boc	Milchev et al. 2006
Bulgaria	23436	372	1.6										Boc	Miltshev et al. 2004
Czech republic				2701	40	1.5							Urb	Bencová et al. 2006
France	59109	233	0.4										Mix	Indelicato 2000
France	55515	783	1.4										Mix	Rolland 2011
France	6228	158	2.5										Boc	Millán de la Pena et al. 2003
France	52668	1495	2.8										Mix	Pailley & Pailley 2000
France				51734	28	0.05							Wood	Baudvin & Jouaire 2006
Germany	522	25	4.8										Farm	Wuntke & Ludwig 1998
Germany	794	77	9.7										Wet	Temme 2006
Great Britain	16481	226	1.4										Mix	Meek 2011
Greece				988	24	2.4							Farm	Kafkaletou-Diez et al. 2008
Greece										273	49	18	Wet	Alivizatos et al. 2005
Hungary	9693	152	1.6										Farm	Purger 2014
Hungary	23200	928	4										Boc	Cserkés 2007
Hungary	6131	313	5.1										Farm	Kalivoda 2001
Italy	4030	167	4.1										Farm	Bosè & Guidali 2001
Italy	4309	283	6.6										Farm	Bon et al. 1997
Italy	1233	100	8.1										Wet	Bon et al. 1992
Italy	200	24	12										Wet	Agnelli & Lazzaretto 2009
Italy										195	26	13	Farm	Bon et al. 2001
Italy	1472	270	23.3							348	78	25	Wet	Grotta & Pigozzi 1997
Italy				2511	132	5.3							Urb	Pirovano et al. 2000
Italy				2478	132	5.3							Farm	Rubolini et al. 2003
Italy				254	23, 88	9.4							Wet	Canova 1989
Italy				235	51, 94	22							Wet	Canova 1989

Italy		2247	620	27.6														Farm	Galeotti et al. 1997
Lithuania		4238	29	0.7		1211	24	2										Mix	Balčiauskas et al. 2011
Moldova		963	21, 19	2.2														Urb	Nistreanu 2007
Netherlands		1976	97	4.9														Boc	Wijnandts 1984
Netherlands	9605	37	0.4															Wet-Farm	De Bruijn 1994
Poland		3351	31	9														Urb	Dziemian et al. 2012
Poland		244	23	9.4														Farm	Wiacek et al. 2011
Poland		1277	26	2														Urb	Kopij et al. 2012
Poland																		Boc	Ważna et al. 2011
Poland	30044	430	1.4															Urb	Wiacek et al. 2008
Poland																		Farm	Romanowski et al. 2013
Poland																		Farm	Romanowski et al. 2013
Poland																		Farm	Kitowski & Pitucha 2007
Poland																		Boc	Lesiński et al. 2013
Poland																		Farm	Romanowski et al. 2013
Poland	1236	42	3.4															Farm	Kitowski 2013
Romania	1370	177	11.9															Wet	Sándor 2009
Romania		546	57	10.4														Urb	Benedek & Sirbu 2010
Romania																		Wet	Pocora et al. 2012
Serbia	2179	65	3															Farm	Ružić et al. 2009
Slovakia	9812	143	1.5															Boc	Latková 2008
Slovakia	49479	1028	2															Mix	Obuch 2011
Slovakia																		Farm	Tulis 2011
Slovakia																		Wet	Obuch 2011
Slovenia																		Mix	Tome 2000
Slovenia																		Farm	Tome 2009
Spain	1119	27	2.4															Farm	Zabala 1973
Total	377377	7660	2.8			114815	998	2.3											
Median				5.1		5474	311	15.6											

Micromys minutus, the portion of it in analyses maybe slightly underestimated in many studies except when these are based on crop or stomach analyses.

In the quoted literature, four raptors are the major predators of harvest mouse (Table 1): the barn owl (*Tyto alba*), the long-eared owl (*Asio otus*), the tawny owl (*Strix aluco*) and to a lesser extent the little owl (*Athene noctua*). Of 15209 specimens of harvest mice found in samples of the regurgitated pellets, 90 % were preyed upon by these owls and the barn owl is responsible for 64 % of the total. It seems that most of prey individuals are young animals: in a Great Britain survey, 74 % of the males were pubertal or prepubertal animals and 92 % of the females were low or nonparous specimens (Buckley 1977). These owls hunt out in the open but long-eared owls and tawny owls also hunt under tree canopies. Small mammals constitute their main food, with *M. arvalis* as the most important prey species and *M. minutus* as an occasional prey, rarely exceeding 5 % of the food intake. Nevertheless, it can constitute more than 20 % and exceptionally 42 % of the diet in particular conditions, related to the type of habitat where birds forage and to season. These owls can also breed in various urban environments, including suburban forests, cemeteries, city parks, roadsides and abandoned buildings (Petrovici et al. 2013) where the harvest mouse represents sometimes a prey as abundant as in the countryside (Table 2). The little owl (*A. noctua*) usually lives in open landscapes such as mixed farmland (bocage) and parks, but it is a fact that the number of individuals has declined in these appropriate habitats across Europe, due to new agricultural practices. Pocora et al. (2012) assume that marshes could offer new suitable hunting habitats for this owl, according to the huge percentage of harvest mouse hunted by the little owl in the Danube Delta, equal to 42 % of total mammal prey. Although mammals usually represent a small portion of its diet, the frequency of harvest mice is also very high in other wetlands such as rice fields and water meadows in the Sesia Natural Park (north Italy), reaching 24.8 % (Gotta & Pigozzi 1997) and 13 % (Bon et al. 2001) of total mammals preyed, or in the reedbeds and marshes of the Axios Delta (Greece), with 17.9 % (Alivizatos et al. 2005) and to a lesser extent in the Rhine alluvial marshes near Rheinberg (Germany), with 6.2 % (Schmitt & Hofer 2011).

The other owls are casual hunters of harvest mice, since the total number of individuals preyed on by all of them represents less than 6 % of the total *Micromys* items hunted, as quoted in literature. Among these raptors, there is the Eurasian eagle owl (*Bubo bubo*),

the largest owl predator in Europe which mainly feeds on mammals weighing more than 200 g. In Finland, it has been shown that a high number of harvest mice in its diet may be an indication of food shortage or even starvation, when small prey specimens may be hunted as a last resort (Mikkola & Tornberg 2014). Thus, in 1990 and 2001 which were poor vole years, two eagle owls having nine harvest mice in their stomachs were discovered near the sea shore, where harvest mice live in the reed beds. Other owls live and hunt mostly in the forest: the pygmy owl (*Glaucidium passerinum*), the Tengmalm's owl (*Aegolius funereus*), the Ural owl (*Strix uralensis*), the great gray owl (*Strix nebulosa*) and the hawk owl (*Sturnia ulula*). Logically, as woody habitat is unsuitable for the harvest mouse, they constitute scarce prey for these owls with low percentages of prey (Table 2). For example, in Central Europe, in Slovakia (Choč Mts., Nízke Tatry Mts. and Oravská Mts.) and in the Czech Republic (Šumava Mountains), the harvest mouse is exceptionally hunted by pygmy owl (Mikusek et al. 2001, Obuch & Karaska 2010). In the same way, it is a rare prey for the hawk owl in Finland (Mikkola 1972) and the great gray owl in Belarus (Tishechkin 1997) which feed mainly on forest voles (*Myodes* sp.). However, in particular conditions, this proportion may considerably increase, reaching 11.8 % for a female Ural owl which was wintering in a small wood surrounded with wide grasslands, marshes and fields on Ljubljansko barje, in central Slovenia (Vrezec 2001). It is a fact that winter seems to make harvest mice more vulnerable to avian raptors. In Finland, the pygmy owl hoards prey in winter and it has been shown that the proportion of small mammals in the hoarded prey decreases dramatically after snow fall, except for the harvest mouse (Halonen et al. 2007). The reason is that it feeds and moves above the snow cover and therefore becomes more vulnerable to predation than voles and shrews, which move below the snow cover (Halonen et al. 2007). As for the scops owl (*Otus scops*) which is mainly insectivorous, it can surprisingly feed heavily on harvest mouse such as on Oléron Island (France), where five mice were brought back to the nest in 58 minutes; these serial catches may reveal the exploitation of a dense population of harvest mouse (Bavoux et al. 2003).

Low proportion of harvest mouse in the diet of some raptors is more surprising, particularly for birds hunting in suitable habitats for *Micromys*, such as harriers and short-eared owl (*Asio flammeus*). In reality, the low number of surveys of their feeding habits does not allow any reliable assessment. Among harriers, the

hen harrier (*Circus cyaneus*) is known for breeding mainly in reedbeds. Some surveys do not mention any *Micromys* in its diet (Marquiss 1980, Roulin 1996, Millon et al. 2002) but one tends to show that it is a significant resource for hen harrier in the Netherlands, for 13.2 % of its diet (Schipper 1973): when voles become too scarce, the hen harrier turns to prey upon birds and harvest mouse. According to the few articles found, it is difficult to determine the importance of harvest mice in Montagu's harrier (*Circus pygargus*) and marsh harrier (*C. aeruginosus*) feeding. Some authors do not quote any *Micromys* in the diet of the marsh harrier (Underhill-Day 1985, Witrowski 1989). Nevertheless, the dataset from LPO Champagne-Ardenne (France) points out that Montagu's harrier is able to significantly hunt for harvest mouse, since the proportion of *Micromys* in its diet reaches 3.5 % in this region. We could also highlight the lesser spotted eagle (*Aquila pomarina*) and the greater spotted eagle (*Aquila clanga*) which live closed to wetlands and which are known to hunt small mammals: the harvest mouse seems again to represent a small part of their diet (Meyburg 1970, Dombrowski 2010, Zub et al. 2010). Unexpected data come from Thrace region (Turkey), where the imperial eagle (*Aquila heliaca*) preys on *Micromys* in low numbers, its main prey usually being much larger (Demerdzhiev et al. 2014). Surprisingly, very few feeding-habit surveys were found about common generalist raptors like crows (Holyoak 1968), common buzzard (*Buteo buteo*) (Jędrzejewski et al. 1994, Graham et al. 1995, Selås et al. 2007) and kites (Sergio & Boto 1999). Although no quote of harvest mouse was found in the diet of these birds, the dataset from LPO Champagne-Ardenne (France) shows that harvest mice are part of the common buzzard and the red kite (*Milvus milvus*) diet, in respective proportions of 1.8 % and 2.2 % of the total prey. Moreover, Sleptsov (1947) points out that crows and also magpies (*Pica pica*) can heavily hunt for harvest mice in winter: the stomach contents of 15 magpies and 46 crows caught in Russia contained 24 and 88 *Micromys* remains, respectively. As for the kestrel (*Falco tinnunculus*), it feeds mainly on common vole but the harvest mouse is also a frequent prey, even in suburban areas (Žmihorski & Rejt 2007, Kečkéšová & Noga 2008). The great grey shrike (*Lanius excubitor*) is not a bird of prey but it has similar behaviour and feeding habits. This shrike feeds predominantly on orthopterans and beetles in southern Europe, where the abundance of invertebrates is high, but it also captures mammals and birds in northern and central Europe. Even if

the main prey items are voles, shrikes often hunt for shrews and harvest mice. These seem to be small enough to be easily killed, and may become the main mammalian alternative prey if *Microtus* voles become scarce (Brzeziński et al. 2010). In south-west Finland, harvest mice are the most numerous prey items of shrikes in midwinter, when snow cover is thick, whereas the larger *Microtus* voles dominate in autumn and late winter. In December and January, harvest mouse can reach more than 50 % of all vertebrate prey of the great grey shrike when *Microtus* voles decrease to less than 20 % (Karlsson 2007). In the Champagne-Ardenne region, a great grey shrike has been seen impaling a harvest mouse upon a broken willow stalk. Moreover, three species of shrikes (*Lanius collurio*, *L. excubitor*, *L. sphenocercus*) have been reported to hunt for *Micromys* in Russia and Germany (Sleptsov 1947).

In spite of their attraction to wetlands and marshes, herons have provided very few data of predation upon harvest mouse. They are known to be predominantly fish and amphibian eaters, but small mammals are a part of their diet too. The only reference concerns the night heron (*Nycticorax nycticorax*) in the River Po region (Italy) which consumes an important proportion of harvest mice among a small number of mammals ingested: 4 *Micromys* for a total of 16 mammals (Fasola et al. 1981). Conversely, Jakubas & Mioduszevska (2005) found no remnants of harvest mouse in 1194 pellets of grey heron (*Ardea cinerea*) in large wetlands of northern Poland. No data was found about the Eurasian bittern (*Botaurus stellaris*) which yet shows a strong preference for reedbeds where the harvest mouse also lives. As for the common pheasant (*Phasianus colchicus*), it is able to eat young harvest mice, as observed by Sleptsov (1947) in cereal crops during autumn. Nowadays, in Europe, pheasants are widespread and common in the countryside due to frequent releases for hunting game (Hume 2014), and it may become a new predator for harvest mice in suitable habitats like marshy, reedy places and hedgerows.

A prey item for mammals

Surveys of diet for European carnivores are much scarcer than for avian raptors. These latter present the advantage of regurgitating pellets easy to find and to study, whereas for mammals it is necessary to examine scats, stomachs and guts. Nevertheless, this review yields some literature that reveals a great variety of mammal predators, mainly wild ones like red fox (*Vulpes vulpes*), stone marten (*Martes foina*), polecat (*Mustela putorius*), feral mink (*Mustela*

Table 3. European mammalian predators for the harvest mouse (*Micromys minutus*) according to the literature with available quantitative data. N – total mammal prey items, n – number of harvest mouse prey items in quoted literature, n% – percentage of harvest mouse prey items compared with total mammal prey items, * on total prey (not only mammals) and unused for „Total“.

	N	n	n% range	n% median	
domestic cat	6225	181	0.3 - 3.2	1.3	Borkenhagen 1978, Nelson et al. 2005, Woods et al. 2003
wild cat <i>Felis sylvestris</i>	2323*	66*	2.8*		LPO Champagne-Ardennes (unpublished)
red fox <i>Vulpes vulpes</i>	1405 + 5832*	18 + 92*	2.4-5.4	2.5	LPO Champagne-Ardennes (unpublished), Meisener et al. 2014, Prigioni & Tacchi 1991, Stiebling 1998
stone marten <i>Martes foina</i>	486 + 1012*	16 + 32*	2-3.9	3.2	Baghli & Engel 2001, 2002, Bakaloudis et al. 2012, Lanski & Széles 2006, LPO Champagne-Ardennes (unpublished)
pine marten <i>Martes martes</i>	5621*	141*	2.5*		LPO Champagne-Ardennes (unpublished)
polecat <i>Mustela putorius</i>	186	12	0.2-13	4.8	Baghli & Engel 2002, Baghli et al. 2005, Malecha & Antczak 2013
American mink <i>Mustela vison</i>	1198	6	0.4-1.2	0.8	Chanin & Linn 1980, Zschille et al. 2014
Total	9500	233			

vison), pine marten (*Martes martes*), wild cat (*Felis sylvestris*) and even golden jackal (*Canis aureus*). Sleptsov (1947) and Teagle (1964) also mention weasel (*Mustela nivalis*) as a serious predator of harvest mice. Furthermore, two domestic mammals are able to hunt for harvest mice: the domestic cat and the dog. All these wild species are likely to live in suitable habitat for *Micromys* but this represents a low proportion of their diet (Table 3). The only exception quoted in literature concerns the polecat for which the harvest mouse can reach 12.9 % of total mammals consumed in summer. Many authors regard the polecat as a generalist feeder (Blandford 1987, Hanski et al. 1991, Prigioni & De Marinis 1995), as an amphibian specialist (Jędrzejewski et al. 1989, Weber 1989, Jędrzejewski et al. 1993, Lodé 1996) or even a lagomorph specialist (Blandford 1987, Lodé 1997). In fact, its diet composition is strongly affected by habitat and in wetlands polecats principally feed on rodents and anurans (Lodé 1996, Malecha & Antczak 2013). Moreover, no effect of winter was found for polecat and stone marten as for avian raptors; the share of *Micromys* is even higher in summer in their scats (Baghli & Engel 2002, Baghli et al. 2005).

Predation upon harvest mouse is not clear concerning two others mustelids known to live in wetlands. In Poland, no *Micromys* were found in annual diet of otter (*Lutra lutra*) and feral mink in river valleys of Białowieża, although simultaneous live trapping revealed that it lives there with significant populations, up to 11 % of community of micromammals (Jędrzejewska et al. 2001). In the Mazurian and

Brodnicza lakelands (Poland), in spring, remnants of harvest mouse occur in 0.9 % of mink scats (Brzeziński & Żurowski 1992). In Devon (Great Britain), Wise et al. (1981) showed that mammals comprised only 1.2 % of the diet of otters and 29.5 % of that of mink, but harvest mouse was found only in scats of mink on rare occasions. Conversely, in the Słońsk Reserve (West Poland), in autumn-winter, only the harvest mouse occurs in mink scats with high frequency (10 %), which nevertheless makes less than 2 % of the biomass consumed (Bartoszewicz & Zalewski 2003). Red fox is a generalist predator which mainly preys on voles in western and northern Europe (Dell'Arte et al. 2007); harvest mouse never heavily occurs in its scats. No quantitative data were found in literature about harvest mice consumption by stoat (*Mustela erminea*) and pine marten. Nevertheless, some authors report that in Poland, pine marten occasionally feeds on *Micromys* in the Turew region (Goszczwinski 1976) and in Białowieża Forest (Zalewski 2007), whereas LPO dataset in Champagne-Ardenne region (France) reveals a significant share of harvest mouse in the diet of this mustelid (2.5 % of total prey). In western Finland, stoat (and also weasel) mainly feed on *Microtus* vole, but this mustelid is able to shift to alternative prey such as harvest mouse, house mouse (*Mus musculus*), bank vole (*Myodes glareolus*) and water vole (*Arvicola terrestris*) (Korpimäki et al. 1991). Others authors showed that *Micromys* mice may serve as alternative prey to many predators of rodents when abundant enough (Hanski & Henttonen 1996, Pekkarinen & Heikkilä 1997).

As for the golden jackal, its distribution overlaps that of the harvest mouse in south-eastern Europe. It lives in semi-arid areas but also in shrublands, marshlands and cultivated areas. Its variable diet, resulting from opportunistic feeding habits leads the golden jackal to feed partially on *Micromys* in Hungary and Greece (Lanski et al. 2010).

Due to their abundance in many ecosystems, domestic and feral cats are major predators of wildlife. In Great Britain, Woods et al. (2003) demonstrated that mammals make up 69 % of the 14370 prey items brought home by 986 cats; among them, the harvest mouse represents 1.8 % of the prey. It is conceivable that predation by superabundant and well-fed predators such as domestic cats could lead to the decline of species, if only on a local or temporary basis. Thus, Baker et al. (2003) recorded a negative relationship between numbers of wood mice and the numbers of cats visiting suburban gardens. In an anecdotal way, it has been reported that hunting dogs can eat some harvest mice when they find an occupied nest during their search for game (Darinot F., pers. observ.).

And what about other vertebrate predators?

Snakes are real predators of *Micromys* and particularly for nestlings. In Great Britain, Prestt (1971) showed that 91 % of the prey of adult adders (*Vipera berus*) were mammals, including wood mice (*A. sylvaticus*), harvest mice, common shrews (*Sorex araneus*), pygmy shrews (*Sorex minutus*), water shrews (*Neomys fodiens*), and field voles (*M. agrestis*). In Japan, it has been shown that snakes directly attack the nests of harvest mice and consume the young mice in the nests (Hata 2011). In Lavours marsh (France), both grass-snake (*Natrix natrix*) and green whip snake (*Hierophis viridiflavus*) were found in trap boxes set on stacks at 60 cm above ground level, that were used for *Micromys* surveys in reedbeds: no doubt nestlings may offer a good feeding resource for these species (Darinot F., pers. observ.).

Comparison of mammal and avian predation

It seems that carnivores are more efficient than birds of prey for hunting harvest mouse. Indeed, in the Champagne-Ardenne region (France), remnants of *Micromys* represent 2.2 % of total mammal prey in faeces and stomachs of foxes, wild cats, pine martens and stone martens (of 13663 prey items), *versus* 1.2 % in pellets and crops of ten diurnal and nocturnal raptors (of 626340 prey items). In order to eliminate small samples that favour over-valuated frequencies of harvest mouse items, only faeces/stomach and pellet

studies with total number of mammal prey higher than median value have been conserved (respectively equal to 337 and 43 prey items). The difference between these two percentages is significant (Mann-Whitney test for two unequal sample variance, $z = 5.998$ for $p < 0.001$) which means that faeces and stomachs contain more harvest mouse remnants than pellets and crops. Why are carnivores more efficient in foraging for harvest mouse? Trout (1978) assumes that the affinity of the mouse for dense cover vegetation reduces its availability for avian raptors. Conversely, carnivores that forage amongst tall vegetation may be more likely to encounter harvest mice.

Discussion

Critical view of data sets

Available data on *Micromys* prey items in the diet of raptors should be analysed regarding the size of pellet samples for each species of raptor, i.e. relative to the sampling effort. Numbers of pellets are often unspecified in studies or they are submitted aggregated in the form of sets, which is not useful to determine a sampling effort. However, total number of prey is generally provided and this gives a good estimation of the sampling value. Thus, we assume that median percentage of harvest mouse in the diet of barn owl, tawny owl, long-eared owl, eagle owl, common buzzard, Tengmalm's owl, little owl and kestrel is probably reliable due to the high number of total prey for each species (Table 1). Conversely, we should question the low proportion of harvest mice in the diet of avian raptors hunting in suitable habitats such as harriers and short-eared owl, due to the weakness of the prey sample: consequently, new surveys should be conducted to specify their feeding habits with a distinctive effort in wetlands. Secondly, the range of sampling area should be considered for analysing the proportion of harvest mouse in the diet of raptors. Large sampling areas, such as on a regional scale, lead to a smoothing of the average frequency of *Micromys* in predator diet because of a greater diversity of habitats, more or less suitable for the harvest mouse. For example, the average percentage of *Micromys* in the diet of barn owl equals to 1.4 % in the Rhône-Alpes region (France) for 55515 mammal prey on 43698 km² (Rolland 2011), into which it reaches 3 % in the Dombes plain, for 7183 mammal prey in a 1000 km² rich wetlands area (Aulagnier et al. 1980), into which it peaks at 24.2 % at Birieux, a small village surrounded by large ponds and reedbeds, for 434 mammal prey (Aulagnier et al. 1980). This remark particularly applies to some local surveys, for

which the huge proportions of harvest mouse should be interpreted as a response of the mouse to a very suitable habitat. It is the case in the Danube Delta, where *Micromys* represents 42 % of mammal prey in the diet of little owl, with a survey that relies on a single site, the Letea village (Pocora et al. 2012). It also concerns the surveys conducted on Oléron island with 29 % of the diet of the Eurasian scops owl (Bavoux et al. 2003), in the Sesia Natural Park with 23.3 % of the diet of little owl (Gotta & Pigozzi 1997) and in the Monticchie Nature Reserve with 22.1 % of the diet of long-eared owl (Canova 1989). A lesser consideration should be devoted to bias due to annual fluctuations of harvest mouse population. Important density fluctuations have been observed in Russia (Sleptsov 1947) and in western Europe (Piechocki 1958, Migula et al. 1970, Trout 1978). In Britain, Trout (1978) has shown that annual densities may vary from 17 to 233 individuals/ha. Whereas these surveys were conducted with nests count or trapping, new results are given by owl pellets in the Champagne-Ardenne region (France), thanks to the Ligue pour la Protection des Oiseaux (LPO) (unpublished). This survey was conducted over 23 years between 1975 and 2003 in the village of Outines (Marne department) and yielded 565 *Micromys* items for 11690 mammal preyed by barn owl. In this single village, fluctuation of the percentage of harvest mouse in the diet of barn owl is significant over three decades (Fig. 1), ranging from 0.5 % to 22.7 %. Consequently, it is obvious that surveys of avian raptors diet habits, conducted in a restricted area, should rely on multiannual sampling or on an important amount of pellets which may correspond to several years of bird foraging.

Availability of prey

The proportion of remains of different mammal prey in pellets reflects their availability for raptors, which is linked with their population density in the birds' foraging areas and with their exposure to predation. This European review has shown that there is no specialised predator on harvest mouse, and moreover, that this species is almost always an occasional prey item. However, when main prey become scarce, i.e. their availability decreases, raptors are forced to hunt other prey such as the harvest mouse if present. Several authors describe this behaviour when the main mammal population density falls, due to interannual fluctuations (Schipper 1973, Kafkaletou-Diez et al. 2008, Brzeziński et al. 2010, Mikkola & Tornberg 2014). A less exposure to predation may be due to snow cover that hides small mammals and

conversely, several surveys point out the influence of snow cover on the availability of harvest mice for raptors. In Finland, it was shown that Arvicolinae move rather under the snow cover, which makes them more difficult to hunt in case of the cover's larger thickness, whereas Murinae are being found rather above the snow, which usually makes them easier to hunt (Halonen et al. 2007). This was found also in Romania, where Benedek & Sîrbu (2010) showed that the share of common vole (*M. arvalis*), which is the main prey of the long-eared owl, decreases in January whereas harvest mouse becomes the dominant prey: although voles are also active during the cold season, they more frequently move under the snow, while mice prefer moving on the snow surface. In Italy, Canova (1989) also demonstrated that the proportion of harvest mice in the diet of long-eared owls increases with snow cover, from 4.5 % with no cover, to 9.4 % with less than 15 cm of snow and 22.1 % with more than 15 cm of snow. Moreover, in the riparian biotopes, large areas of ground remain free from snow and hygrophilous mammals like harvest mouse may become more available (Canova 1989). However, Stasiak et al. (2014) did not observe such an influence of snow cover in the Lublin region (Poland). Exposure to predators may be linked to the density of vegetation cover. During winter, harvest mice are more prone to owl predation, when vegetation cover is not so dense and the species needs to forage also during the night (Kopij et al. 2012). In some articles, seasonality is mentioned as an important aspect, without precise explanation of impacts on harvest mouse behaviour and vulnerability to raptors. Thus in Great Britain, the percentage of harvest mice in the barn owls' prey rises in the autumn and goes down in the spring: during the months of September to March this species forms more than 4 % of the prey, and after March falls steadily to a low of 1.2 % in late July/early August, rising again to over 4 % in September (Buckley 1977). The influence of winter can also be observed with the great grey shrike in Poland, for which the percentage of *Micromys* in its diet varies from 1.6 % in autumn to 4 % in winter and 0.6 % in spring (Brzeziński et al. 2010). Such increase of hunting on harvest mouse in winter is also recorded for the little owl in central Poland (Romanovski et al. 2013). In a farmland landscape in Italy, Rubolini et al. (2003) have assessed weather variables (mean monthly rainfall and temperatures) on the variation of individual prey categories of long-eared owls. These weather variables have no or limited effects on mammal prey. The only prey whose prevalence

in diet was consistently affected by temperature was the harvest mouse: it may reflect a higher availability of this prey with lower temperatures, when a fraction of the population may be forced to leave cultivated fields by habitat deterioration toward less suitable habitats but preferred by owls for hunting. More precisely, Romanowski & Żmihorski (2009) showed that the share of harvest mouse in the tawny owl diet increases in cold season vs. warm season in higher proportion in farmland than in forest (13.1 % vs. 0.6 % in farmland and 2.3 % vs. 1.2 % in forest). However, as for carnivores and specially the red fox, no increase of proportion of murids (*M. minutus* and *Rattus norvegicus*) in their winter diet has been shown in Finland (Dell'Arte et al. 2007).

Moreover, few reviews are interested in the influence of perturbations on small mammal predation. Among them, floodings are important natural perturbations for the harvest mouse that lives in wetlands. It has been shown that some individuals of *Micromys* find refuge on trees, willows and upper parts of reeds when flood arises (Darinet & Favier 2014) and indubitably this behaviour should enhance their exposure to avian raptors. Other perturbations are anthropogenic such as meadow-mowing and crop harvesting, which may lead to an increase of hunting of harvest mice by birds of prey as well as mammal predators, because of the destruction of vegetation cover.

Information about harvest mouse habitats

The harvest mouse is known to live in a wide variety of habitats (Harris 1979) from disturbed habitats with early vegetal succession, cultivated areas, urban environments, to marshes and wetlands. However, widespread changes in agricultural practice during recent decades have removed large areas of suitable habitat in which harvest mice appeared to be abundant (Harris et al. 1995). Nowadays, in several regions of Great Britain such as Suffolk and Norfolk, it is assumed that only wetland habitats harbour stable core populations of harvest mouse in lowland arable landscapes (Perrow & Jowitt 1995, Meek 2011). These wetland populations may have prevented the loss of the species from many intensive agricultural areas. The proportion of *Micromys* prey in the diet of avian raptors tends to confirm the preference of this species for wetlands. In northern Europe, in these habitats, the lowest quoted proportion (Table 2) is 9.7 % in the Weserinsel Strohauser Plate (Germany) while Uttendörfer (1952) had already found 12 % of *Micromys* remnants in long-eared owl pellets in the Sylt island (northern Germany). In the Netherlands, De

Bruijn (1994) also found that the harvest mouse had a preference for river habitats in a farmland landscape, whereas Deuzeman et al. (2015) showed that *Micromys* represents 60 % of the mammals preyed by the great grey shrike in the Engbertsdijksvennen nature reserve peat bog (over 2314 pellets). For owls, the proportion can reach 42 % in the Danube Delta Biosphere Reserve (Romania), 24.8 % in rice fields and water meadows in the Sesia Natural Park (Italy), 22.1 % in wetlands of the Monticchie Nature Reserve, near the River Po (Italy), 17.9 % in the marshes of the Axios Delta (Greece). However, these figures could also result from the progression towards the south-east of the European range of the harvest mouse, where it is known to disappear from the less humid farmlands and is only found in moist primary biotopes (Böhme 1978). As regards the diet of barn owl, significant correlations have been established between the percentage cover of the wetlands in the hunting territory and the share of harvest mouse in the diet, as for other wet-loving species such as Miller's water shrew (*Neomys anomalus*) and water vole (*Arvicola terrestris*) (Milchev et al. 2006). Thus, the proportion of harvest mouse in the diet of barn owl is more important in valleys of large rivers with wetlands and along some water canals, with extensive grasslands (Stasiak et al. 2014). Similar results are found in other wetlands such as the Novosibirsk oblast and Lake Malye Chany (south-west Siberia), where the harvest mouse is an important prey for long-eared owl since it represents 7.6 % of the total number of vertebrate prey (Dupal & Chernyshow 2013).

The fact that current harvest mouse populations are lower in farmland than in wetlands is supported by our review: in agricultural landscape, the species is much less abundant in the diet of avian raptors than in wetlands, with percentage ranging from 0.1 % to 8.8 %. Although the decline of harvest mouse in agricultural areas is widely accepted, published data on former population densities in either farmland and wetland biotopes are lacking, as previously noted by Jüdes (1981). My review does not uncover new information on the trend of the harvest mouse, in spite of the huge amount of data on raptor diet, also collected by earlier authors, like Uttendörfer (1929, 1952). Nevertheless, the increasing rarity of the harvest mouse is now accepted and is known to have mixed causes linked to changes in agricultural practices. In crop habitat, mechanical harvesters that appeared in the middle of the twentieth century, cut down the nests woven in the stalks and kill the harvest mice in the field, whereas in earlier times grain crops were manually scythed and

the mice could escape to the margins of the field: in 1874, Gordon who was the vicar of the Harting parish, related that in west Sussex (Great Britain) “the harvest mouse...is not at all uncommon in our cornfields in the summer months, and our corn ricks in winter” (Gordon 1877). Nowadays, it has been shown that even arable field margins and rough grassland support very small numbers of harvest mice because of grass cutting practices and crop chemical use (Meek 2011). However, management of the margins to improve connectivity within a farm can increase the size of harvest mouse populations, especially when fields are surrounded by wet habitats (Jüdes 1981).

Unsurprisingly, this European survey reveals that the harvest mouse seems to be rarely attracted to woodlands, since this type of habitat is linked with the lowest proportions of *Micromys* in the diet of the four main raptor owls (Table 2). However, it is known that woodland borders and young plantations can provide to some extent suitable habitats for the species (Harris 1979). Results may be less predictable for urban environments since several surveys put forward a rather high percentage of harvest mouse in the diet of tawny owl and long-eared owls. For example, in the city of Milan (Italy), it represents 5.3 % for long-eared owls which hunt in the suburbs and the adjoining farmland (Pirovano et al. 2000). Several surveys quote harvest mouse in parks and cemeteries of big cities with shares in the diet of avian raptors often higher than in agricultural landscape. Thus, in Poland, *Micromys* represents 2 % and 4.9 % of the long-eared owl diet respectively in the Lublin and Rzeszów cemeteries (Wiącek et al. 2008, Dziemian et al. 2012) and 6.1 % of the tawny owl diet in the Toruń cemetery (Zalewski 1994). This proportion reaches 9.4 % for long-eared owls which roost in a

cemetery of Wrocław, bordered with large water canal with mowed grassland, shrubs and trees along its bank (Kopij et al. 2012). In Romania, the proportion of harvest mouse reaches 10.4 % of long-eared owls diet which overwintered in a garden in the Satu Mare city (Benedek & Sîrbu 2010). In fact, percentages of harvest mouse depend on the urbanization level: a less urbanized locality means more *Micromys* items in the diet composition (Grzędzicka et al. 2013).

Conclusion and recommendations

A wide distribution range, a high diversity of habitats, a small size and a both nocturnal and diurnal activity rhythm make the harvest mouse available to a great variety of vertebrate predators; consequently, this review cannot claim to be exhaustive. Nevertheless, this study highlights a lack of data concerning the diet of some raptors as common buzzard, kites, hen and marsh harriers, as well as carnivores in general. Long multiannual mammal surveys appear to be rare too, in spite of their high interest for population ecology. In that respect, new studies should assess the impact of predation upon harvest mouse populations in wetlands where it may constitute the main prey for raptors, and also to quantify mechanisms of prey shift to *Micromys* when the main prey becomes scarce. At least, this survey confirms that nowadays wetlands are a very important habitat for the harvest mouse conservation, and in return this tiny and friendly rodent could be a useful flag-ship species for their protection in Europe.

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Literature

- Agnelli P. & Lazzeretti A. 2009: On the distribution of *Micromys minutus* in Italy. *Boll. Zool.* 62: 395–399.
- Alivizatos H., Goutner V. & Zogaris S. 2005: Contribution to the study of the diet of four owl species (Aves, Strigiformes) from mainland and island areas of Greece. *Belg. J. Zool.* 135: 109–118.
- Aplin K., Lunde D., Batsaikhan N. et al. 2008: *Micromys minutus*. IUCN Red List of Threatened Species. Accessed 12 December 2015. <http://www.iucnredlist.org>
- Aulagnier S., Broyer J., Brunet-Lecomte P. et al. 1980: Comparaison de la faune micromammalienne de la Dombes et de la plaine du Forez. *Bièvre* 2: 131–142.
- Baghli A. & Engel E. 2001: Régime alimentaire semi-annuel de la fouine *Martes foina* au Luxembourg. *Bull. Soc. Nat. Luxemb.* 101: 67–74.
- Baghli A. & Engel E. 2002: Feeding habits and trophic niche overlap of two sympatric Mustelidae, the polecat *Mustela putorius* and the beech marten *Martes foina*. *Z. Jagdwiss.* 48: 217–225.
- Baghli A., Walzberg C. & Verhagen R. 2005: Habitat use by the European polecat *Mustela putorius* at low density in a fragmented landscape. *Wildlife Biol.* 11: 331–339.
- Bakaloudis D.E., Vlachos C.G. & Papakosta M.A. 2012: Diet composition and feeding strategies of the stone marten (*Martes foina*) in a typical mediterranean ecosystem. *Scientific World J.* doi: 10.1100/2012/163920.
- Baker P.J., Ansell R.J., Dodds P.A.A. et al. 2003: Factors affecting the distribution of small mammals in an urban area. *Mammal Rev.* 33: 95–100.

- Balčiauskas L., Balčiauskiene L. & Alejunas P. 2011: Northern birch mouse (*Sicista betulina*) in Lithuania, findings in the diet of tawny owl (*Strix aluco*). *Acta Zool. Acad. Sci. Hung.* 57: 277–289.
- Balčiauskiene L., Jovaišas A., Naruševičius V. et al. 2006: Diet of tawny owl (*Strix aluco*) and long-eared owl (*Asio otus*) in Lithuania as found from pellets. *Acta Zool. Lituan.* 16: 37–45.
- Bartoszewicz M. & Zalewski A. 2003: American mink, *Mustela vison* diet and predation on waterfowl in the Słońsk Reserve, western Poland. *Folia Zool.* 52: 225–238.
- Baudvin H. & Jouaire S. 2006: Le régime alimentaire d'une population forestière de Chouettes hulottes (*Strix aluco*) en Bourgogne. *Rev. Sci. Bourgogne-Nature* 4: 85–89.
- Bavoux C., Burneleau G., Juillard M. & Nicolau-Guillaumet P. 2003: Le Hibou petit-duc, *Otus scops*, sur l'île d'Oléron (France). Régime alimentaire des poussins. *Nos Oiseaux* 42: 159–170.
- Bencová V., Kašpar T. & Bryja J. 2006: Seasonal and interannual changes in diet composition of the long-eared owl (*Asio otus*) in Southern Moravia. *Tichodroma* 18: 65–71. (in Czech with English summary)
- Benedek A.M. & Sirbu I. 2010: Dynamics of *Asio otus* L., 1758 (Aves: Strigiformes) winter-spring trophic regime in western plain (Romania). *Trav. Mus. Natl. Hist. Nat. "Grigore Antipa"* 53: 479–487.
- Blandford P.R.S. 1987: Biology of the polecat *Mustela putorius*: a literature review. *Mammal Rev.* 17: 155–198.
- Blant M., Marchesi P., Descombes M. & Capt S. 2012: Nouvelles données sur la répartition de la souris des moissons (*Micromys minutus* Pallas, 1771) en Suisse occidentale et implications pour la gestion de son habitat. *Rev. Suisse Zool.* 119: 485–500.
- Böhme W. 1978: *Micromys minutus* (Pallas, 1778) – Zwergmaus. Handbuch der Säugetiere Europas. *Akad. Verlagsges.*: 290–304.
- Bon M., Ratti E. & Sartor A. 2001: Seasonal variations in the diet of the little owl *Athene noctua* (Scopoli, 1769) in a tilled site on the edge of Venice Lagoon. *Boll. Mus. Civ. Stor. Nat. Venezia* 52: 193–212.
- Bon M., Roccarforte P. & Sirna G. 1992: First data on small mammals of the Venetian Lagoon by analyzing pellets of *Tyto alba* (Scopoli, 1769). *Boll. Mus. Civ. Stor. Nat. Venezia* 41: 265–273. (in Italian)
- Bon M., Roccarforte P. & Sirna G. 1997: Trophic ecology of barn owl, *Tyto alba*, in the central-eastern Veneto Plain. *Boll. Mus. Civ. Stor. Nat. Venezia* 47: 265–283.
- Boratynski Z. & Kasprzyk K. 2005: Does urban structure explain shifts in the food niche of the Eurasian kestrel (*Falco tinnunculus*)? *Buteo* 14: 11–17.
- Borkenhagen P. 1978: Von Hauskatzen (*Felis sylvestris* f. *catus* L., 1758) eingetragene Beute. *Z. Jagdwiss.* 24: 27–33.
- Bosè M. & Guidali F. 2001: Seasonal and geographic differences in the diet of the barn owl in an agro-ecosystem in northern Italy. *J. Raptor Res.* 35: 240–246.
- Brzeziński M., Zalewski A., Szałański P. & Kowalczyk R. 2010: Feeding habits of great grey shrike *Lanius excubitor* wintering in north-eastern Poland: does prey abundance affect selection of prey size? *Ornis Fenn.* 87: 1–14.
- Brzeziński M. & Żurowski W. 1992: Spring diet of the American mink *Mustela vison* in the Mazurian and Brodnica Lakelands, northern Poland. *Acta Theriol.* 37: 193–198.
- Buckley J. 1973: The prey of short-eared owls wintering on the Berkshire Downs. *Br. Birds* 66: 143–146.
- Buckley J. 1977: Barn owl predation on the harvest mouse. *Mammal Rev.* 7: 117–121.
- Buckley J. & Goldsmith J.G. 1975: The prey of the barn owl (*Tyto alba alba*) in East Norfolk. *Mammal Rev.* 5: 13–16.
- Canova L. 1989: Influence of snow cover on prey selection by long-eared owls *Asio otus*. *Ethol. Ecol. Evol.* 1: 367–372.
- Capizzi D. 2000: Diet shifts of the tawny owl *Strix aluco* in central and northern Italy. *Ital. J. Zool.* 67: 73–79.
- Casagrande S., Nieder L., Di Minin E. et al. 2008: Habitat utilization and prey selection of the kestrel *Falco tinnunculus* in relation to small mammal abundance. *Ital. J. Zool.* 75: 401–409.
- Chanin P.R. & Linn I. 1980: The diet of mink (*Mustela vison*) in southwestern Britain. *J. Zool. Lond.* 192: 205–223.
- Cserkés T. 2007: High relative frequency of *Sicista subtilis* (Dipodidae, Rodentia) in owl-pellets collected in Borsodi Mezőség (NE Hungary). *Folia Historico Naturalia Musei Matraensis* 31: 173–177.
- Darinot F. & Favier C. 2014: Inondation hivernale et mouvements migratoires au sein d'une population de rat des moissons, *Micromys minutus* (Pallas, 1771). *Bull. Mens. Soc. Linn. Lyon* 83 (9–10): 235–244.
- De Bruijn O. 1994: Population ecology and conservation of the barn owl *Tyto alba* in farmland habitats in Liemers and Achterhoek (The Netherlands). *Ardea* 82: 1–109.
- Dell'Arte G.L., Laaksonen T., Norrdahl K. & Korpimäki E. 2007: Variation in the diet composition of a generalist predator, the red fox, in relation to season and density of main prey. *Acta Oecol.* 31: 276–281.
- Demerdzhiev D., Dobrev D., Isfendiyaroglu S. et al. 2014: Distribution, numbers, breeding parameters, threats and prey preferences of the eastern imperial eagle (*Aquila heliaca*) in European Turkey. *Slovak Rapt. J.* 8: 17–25.
- Deuzeman S., van den Berg A., van den Akker P. & van Turnhout C. 2015: Diet, fitness and site fidelity of wintering grey shrikes. *Limosa* 88: 2–10. (in Dutch)
- Dolenc Z. & Kiš N. 2010: Winter prey of the long-eared owl (*Asio otus*) in northern Croatia. *Nat. Croat.* 19: 249–252.
- Dombrovski V. 2010: The diet of the greater spotted eagle (*Aquila clanga*) in Belarusian Polesie. *Slovak Rapt. J.* 4: 23–36.
- Dupal T.A. & Chernyshow V.M. 2013: Small mammals in the diets of the long eared owl (*Asio otus*) and short eared owl (*A. flammeus*) in the South of Western Siberia. *Russ. J. Ecol.* 44 (5): 397–401.
- Dziemian S., Piłacińska B. & Pitucha G. 2012: Winter diet composition of urban long-eared owls (*Asio otus*) in Rzeszów (SE Poland). *Biol. Lett.* 49: 107–114.
- Fasola M., Gaelotti P., Bogliani G. & Nardi P. 1981: Food of night heron (*Nycticorax nycticorax*) and little egret (*Egretta garzetta*) feeding in rice fields. *Riv. Ital. Orn.* 51: 97–112.

- Galeotti P., Tavecchia G. & Bonetti A. 1997: Home-range and habitat use of long-eared owls in open farmland (Po plain, Northern Italy), in relation to prey availability. *J. Wildlife Res.* 2: 137–145.
- Godin J. 1975: Données sur le régime alimentaire de la chouette effraie (*Tyto alba*) en Belgique et dans le nord de la France. *Aves* 12: 105–126.
- Gonzales Oreja J.A., Lorenzo Rodolfo J.C. & Perez de Ana J.M. 1993: Nota sobre la alimentación de la lechuza común en dos zonas de Viscaya. *Est. Mus. Cienc. Nat. de Alava* 8: 227–230.
- Gordon H.D. 1877: The history of harting. *Printed for the author by W. Davy, London.*
- Goszczvnski J. 1976: Composition of the food of martens. *Acta Theriol.* 21: 527–534.
- Gotta A. & Pigozzi G. 1997: Trophic niche of the barn owl and little owl in a rice field habitat in northern Italy. *Ital. J. Zool.* 64: 55–59.
- Graham I.M., Redpath S.M. & Thirgood S.J. 1995: The diet and breeding density of common buzzards *Buteo buteo* in relation to indices of prey abundance. *Bird Study* 42: 165–173.
- Gryz J., Krauze D. & Goszczyński J. 2008: The small mammals of Warsaw as inferred from tawny owl (*Strix aluco*) pellet analyses. *Ann. Zool. Fenn.* 45: 281–285.
- Grzędzicka E., Kus K. & Nabielec J. 2013: The effect of urbanization on the diet composition of the tawny owl (*Strix aluco* L.). *Pol. J. Ecol.* 61: 391–400.
- Halonen M., Mappes T., Meri T. & Suhonen J. 2007: Influence of snow cover on food hoarding in pygmy owls *Glaucidium passerinum*. *Ornis Fenn.* 84: 105–111.
- Hanski I., Hansson L. & Henttonen H. 1991: Specialist predators, generalist predators, and the microtine rodent cycle. *J. Anim. Ecol.* 60: 353–367.
- Hanski I. & Henttonen H. 1996: Predation on competing rodent species: a simple explanation of complex patterns. *J. Anim. Ecol.* 65: 220–232.
- Harris S. 1979: Breeding season, litter size and nestling mortality of the harvest mouse, *Micromys minutus* (Rodentia: Muridae), in Britain. *J. Zool. Lond.* 188: 437–442.
- Harris S., Morris P., Wray S. & Yalden D. 1995: A review of British mammals: population estimates and conservation status of British mammals other than cetaceans. *The Joint Nature Conservation Committee, Peterborough, U.K.*
- Hata S. 2011: Nesting characteristics of harvest mice (*Micromys minutus*) in three types of Japanese grasslands with different inundation frequencies. *Mamm. Study* 36: 49–53.
- Hetmański T., Aleksandrowicz O. & Ziolkowski M. 2008: The food of the barn owl *Tyto alba* and the long-eared owl *Asio otus* from the Pomeranian province, N Poland. *Ślupskie Prace Biologiczne* 5: 53–61.
- Holyoak D. 1968: A comparative study of the food of some British Corvidae. *Bird Study* 15: 147–153.
- Hume R. 2014: Birds of Britain and Europe. *Ed. Dorling Kindersley, London, U.K.*
- Indelicato N. 2000: Aspects biogéographiques de la distribution des micromammifères dans le Limousin (France). *Annales Scientifiques du Limousin* 11: 61–79.
- Jakubas D. & Mioduszewska A. 2005: Diet composition and food consumption of the grey heron (*Ardea cinerea*) from breeding colonies in northern Poland. *Eur. J. Wildlife Res.* 51: 191–198.
- Janžekovič F. & Ficko M. 2000: Diet composition of the barn owl *Tyto alba* at Goričko. *Acrocephalus* 21 (98–99): 27–29.
- Jędrzejewska B., Sidorovich V.E., Pikulik M.M. & Jędrzejewski W. 2001: Feeding habits of the otter and the American mink in Białowieża Primal Forest (Poland) compared to other Eurasian populations. *Ecography* 24: 165–180.
- Jędrzejewski W., Jędrzejewska B. & Brzeziński M. 1993: Winter habitat selection and feeding habits of the polecats (*Mustela putorius*) in the Białowieża National Park, Poland. *Z. Säugetierkd.* 58: 75–83.
- Jędrzejewski W., Jędrzejewska B. & Szymura A. 1989: Food niche overlaps in a winter community of predators in the Białowieża Primeval Forest, Poland. *Acta Theriol.* 43: 487–496.
- Jędrzejewski W., Szymura A. & Jędrzejewska B. 1994: Reproduction and food of the buzzard *Buteo buteo* in relation to the abundance of rodents and birds in Białowieża National Park, Poland. *Ethol. Ecol. Evol.* 6: 179–190.
- Jüdes U. 1981: Some notes on population density of *Micromys minutus* in a secondary biotope. *Z. Säugetierkd.* 46: 226–243.
- Kafkaletou-Diez A., Tsachalidis E.P. & Poirazidis K. 2008: Seasonal variation in the diet of the long-eared owl (*Asio otus*) in a northeastern agricultural area of Greece. *J. Biol. Res.-Thessalon.* 10: 181–189.
- Kalivoda B. 2001: Data of barn owl (*Tyto alba*) studies from South-Tiszántúl (south-eastern Hungary) in 2000. *Crisicum* 5: 195–219.
- Karanović P.J.J. 1991: First data on small mammal fauna from Krnjeuša (Bosanska Krajina), as obtained by a barn owl *Tyto alba* pellet analysis. *Biol. Vesin.* 39 (3): 41–44.
- Karlsson S. 2007: Food consumption and roosting behaviour of great grey shrikes *Lanius excubitor* wintering in south-western Finland. *Ornis Fenn.* 84: 57–65.
- Kean E. 2006: Post release survival and dispersal of harvest mice, *Micromys minutus*, in relation to reintroduction method. *BIAZA Research Newsletter* 7 (2).
- Kečkéšová L. & Noga M. 2008: The diet of the common kestrel in the urban environment of the city of Nitra. *Slovak Rapt. J.* 2: 81–85.
- Kitowski I. 2005: Food composition of marsh harrier *Circus aeruginosus* during autumnal migration in eastern Poland. *Acta Biol. Univ. Daugavp.* 5: 85–89.
- Kitowski I. 2013: Winter diet of the barn owl (*Tyto alba*) and the long-eared owl (*Asio otus*) in Eastern Poland. *North-West. J. Zool.* 9: 16–22.
- Kitowski I. 2014: The response of Eurasian kestrel *Falco tinnunculus* to falconry at Deblin Military Airfield, East Poland. *Turk. J. Zool.* 38: 298–305.
- Kitowski I. & Pitucha G. 2007: Diet of the Eurasian tawny owl in farmland of East Poland. *Berkut* 16 (2): 225–231.

- Kociuba M. 2012: Factors affecting diet composition of the Ural owl *Strix uralensis* at the foothills of the Central Beskid Mountains, SE Poland. *Ornis Polonica* 53: 283–292.
- Koks B.J., Trierweiler C., Visser E.G. et al. 2007: Do voles make agricultural habitat attractive to Montagu's harrier *Circus pygargus*? *Ibis* 149: 575–586.
- Kopij G., Moska M., Nikiel R. & Kozyra K. 2012: A large proportion of *Micromys minutus* in winter diet of the long-eared owl *Asio otus*. *Čas. Slez. Muz. Opava (A)* 61: 91–92.
- Korpimäki E. 1986: Prey caching of breeding Tengmalm's owls *Aegolius funereus* as a buffer against temporary food shortage. *Ibis* 129: 499–510.
- Korpimäki E. 1988: Diet of breeding Tengmalm's owls *Aegolius funereus*: long-term changes and year-to-year variation under cyclic food conditions. *Ornis Fenn.* 65: 21–30.
- Korpimäki E., Norrdahl K. & Rinta-Jaskari T. 1991: Responses of stoats and least weasels to fluctuating food abundances: is the low phase of the vole cycle due to mustelid predation? *Oecologia* 88: 552–561.
- Kuhar B., Kalan G. & Janžekovič F. 2006: Diet of the tawny owl *Strix aluco* in the Kozjansko region (East Slovenia). *Acrocephalus* 27 (130/131): 147–154.
- Lanski J., Giannatos G., Dolev A. et al. 2010: Late autumn trophic flexibility of the golden jackal *Canis aureus*. *Acta Theriol.* 55: 361–370.
- Lanski J. & Széles L.G. 2006: A diet composition of stone martens (*Martes foina*) living in the Drava district, Hungary, in spring. *Somogyi Múzeumok Közleményei* 17: 199–206.
- Latková H. 2008: Seasonal changes in food composition of the barn owl (*Tyto alba*) in the northern part of the "Záhorie" region. *Slovak Rapt. J.* 2: 107–112.
- Lawicki Ł. & Raclawski B. 2006: Food little owl *Athene noctua* in the breeding season of the agricultural landscape Niziny Mazowieckiej. *Notatki Ornitologiczne* 47 (3): 203–206. (in Polish with English summary)
- Lesiński G., Błachowski G. & Siuchno M. 2009: Vertebrates in the diet of the tawny owl *Strix aluco* in northern Podlasie (NE Poland) – comparison of forest and rural habitats. *Fragm. Faun.* 52: 51–59.
- Lesiński G., Romanowski J., Gryz J. et al. 2013: Small mammals of Kampinos National Park and its protection zone, as revealed by analyses of the diet of tawny owls (*Strix aluco* Linnaeus, 1758). *Fragm. Faun.* 56: 65–81.
- Lesiński G. & Stolarz P. 2012: Small mammals in pellets of the tawny owl *Strix aluco* from the village of Paszkówka near Krakow. *Chrońmy Przynr. Ojcz.* 68 (2): 109–113. (in Polish with English summary)
- Lodé T. 1996: Polecat predation of frogs and toads at breeding sites in western France. *Ethol. Ecol. Evol.* 8: 115–124.
- Lodé T. 1997: Trophic status and feeding habits of the European polecat *Mustela putorius* L. 1758. *Mammal Rev.* 177–184.
- Lustrat P. 2002: Le régime alimentaire de la Chouette effraie dans le massif de Fontainebleau. *La voix de la forêt* 1: 16–18.
- Macdonald D.W., Tattersall F. & Barrett P. 2001: Britain's mammals: the challenge for conservation. *People's trust for Endangered Species, London, U.K.*
- Malecha A.W. & Antczak M. 2013: Diet of the European polecat *Mustela putorius* in an agricultural area in Poland. *Folia Zool.* 62: 48–53.
- Marquiss M. 1980: Habitat and diet of male and female hen harriers in Scotland in winter. *Br. Birds* 73: 555–560.
- Meek M. 2011: Suffolk's harvest mice in focus. *Report by Suffolk Wildlife Trust to the People's Trust for Endangered Species, London, U.K.*
- Meisener K., Sunde P., Kuhlmann Clausen K. et al. 2014: Foraging ecology and spatial behaviour of the red fox (*Vulpes vulpes*) in a wet grassland ecosystem. *Acta Theriol.* 59: 377–389.
- Meyburg B.U. 1970: On the biology of the lesser spotted eagle (*Aquila pomarina*). *Deutscher Falkenorden* 1969: 32–66.
- Migula P., Grodziński W., Jasiński A. & Musiałek B. 1970: Vole and mouse plagues in South-Eastern Poland in the years 1945-1967. *Acta Theriol.* 15: 233–252.
- Mikkola H. 1972: Hawk owl and their prey in northern Europe. *Br. Birds* 65: 453–460.
- Mikkola H. & Tornberg R. 2014: Sex-specific diet analysis of the Eurasian eagle owl in Finland. *Ornis Fenn.* 91: 1–6.
- Mikusek R., Kloubec B. & Obuch J. 2001: Diet of the pygmy owl (*Glaucoedon passerinum*) in eastern Central Europe. *Buteo* 12: 47–60.
- Milchev B., Boev Z. & Kodjabashev N. 2006: Breeding distribution and diet composition of the barn owl *Tyto alba* (Scopoli, 1769), (Aves: Strigiformes) in the North-Western Upper Thracian Plain (Bulgaria). *Acta Zool. Bulgar.* 58: 83–92.
- Millán de la Pena N., Butet A., Delettre Y. et al. 2003: Response of the small mammal community to changes in western French agricultural landscapes. *Landsc. Ecol.* 18: 265–278.
- Millon A., Bourrioux J.L., Riols C. & Bretagnolle V. 2002: Comparative breeding biology of hen harrier and Montagu's harrier: an 8-year study in north-eastern France. *Ibis* 144: 94–105.
- Miltschev B., Boev Z. & Georgiev V. 2004: Food of the barn owl (*Tyto alba*) in South-eastern Bulgaria. *Egretta* 47: 66–77. (in German with English summary)
- Nelson S.H., Evans A.D. & Bradbury R.B. 2005: The efficacy of collar-mounted devices in reducing the rate of predation of wildlife by domestic cats. *Appl. Anim. Behav. Sci.* 94: 273–285.
- Nistreanu V. 2007: The importance of the long-eared owl *Asio otus otus* (L.) in rodent control. *Bulletin USAMV-CN* 63: 424–429.
- Noga M. & Dobry M. 2013: Nesting and non-nesting occurrence of the short-eared owl *Asio flammeus* in the Záhorie region (SW Slovakia). *Slovak Rapt. J.* 7: 73–80.
- Obuch J. 2011: Spatial and temporal diversity of the diet of the tawny owl (*Strix aluco*). *Slovak Rapt. J.* 5: 1–120.
- Obuch J., Danko Š., Mihók J. et al. 2013: Diet of the Ural owl (*Strix uralensis*) in Slovakia. *Slovak Rapt. J.* 7: 59–71.

- Obuch J. & Karaska D. 2010: The Eurasian eagle-owl (*Bubo bubo*) diet in the Orava Region (N Slovakia). *Slovak Rapt. J.* 4: 83–98.
- Pailley M. & Pailley P. 2000: Le régime alimentaire de la Chouette effraie *Tyto alba* en Maine-et-Loire. *Crex* 5: 41–53.
- Pekkarinen P. & Heikkilä J. 1997: Prey selection of the least weasel *Mustela nivalis* in the laboratory. *Acta Theriol.* 42: 179–188.
- Perrow M.R. & Jowitt A.J.D. 1995: What future for the harvest mouse? *British Wildlife* 6: 356–365.
- Petrovici M., Molnar P. & Sandor A.D. 2013: Trophic niche overlap of two sympatric owl species (*Asio otus* Linnaeus, 1758 and *Tyto alba* Scopoli, 1769) in the North-Western part of Romania. *North-west. J. Zool.* 9: 250–256.
- Piechocki R. 1958: Die Zwergmaus *Micromys minutus* Pallas. Neue Brehm Bücherei H 222. A. Ziemsen Verlag, Wittenberg Lutherstadt, Germany.
- Pirovano A., Rubolini D., Brambilla S. & Ferrari N. 2000: Winter diet of urban roosting long-eared owls *Asio otus* in northern Italy: the importance of the brown rat *Rattus norvegicus*. *Bird Study* 47: 242–244.
- Plass J. 2004: Zur Ernährung der Schleiereule (*Tyto alba guttata* C.L. Brehm 1831) im nördlichen Machland, Oberösterreich. *Naturschutz Aktuell.* 12: 21–28.
- Pocora V., Popovici M., Mancu C.O. & Iorgu I.S. 2012: Feeding of the little owl during nesting season in the Danube delta (Romania). *An. Stiint. Univ. Al. I. Cuza* 58: 107–114.
- Poláček M., Baláž M. & Obuch J. 2012: Diet of the tawny owl (*Strix aluco*) in urban and forest environment. *Tichodroma* 24: 29–39. (in Slovak with English summary)
- Prestt I. 1971: An ecological study of the viper *Vipera berus* in Britain. *J. Zool. Lond.* 164: 373–418.
- Prigioni C. & De Marinis A.M. 1995: Diet of the polecat *Mustela putorius* L. in riverine habitats (Northern Italy). *Hystrix* 7: 69–72.
- Prigioni C. & Tacchi F. 1991: Trophic niche of the fox *Vulpes vulpes* in the Ticino Valley (Northern Italy). *Hystrix* 3: 65–75.
- Purger J.J. 1990: Diet of barn owl, *Tyto alba* (Scop, 1769) in Western Bačka (Vojvodina, Yugoslavia) using the pellets analysis. *Larus* 41–42: 135–139.
- Purger J.J. 2014: Survey of the small mammal fauna in north-western Somogy county (Hungary), based on barn owl *Tyto alba* (Scopoli, 1769) pellet analysis. *Nat. Somogy.* 24: 293–304.
- Rolland C. 2011: Programme régional d'atlas des micromammifères de Rhône-Alpes. *Le Bièvre* 25: 44–54.
- Romanowski J., Altenburg D. & Zmihorski M. 2013: Seasonal variation in the diet of the little owl, *Athene noctua* in agricultural landscape of Central Poland. *North-West. J. Zool.* 9: 310–318.
- Romanowski J. & Zmihorski M. 2009: Seasonal and habitat variation in the diet of the tawny owl (*Strix aluco*) in Central Poland during unusually warm years. *Biologia* 64: 365–369.
- Roulin A. 1996: Alimentation hivernale de la chouette effraie (*Tyto alba*), du hibou moyen-duc (*Asio otus*), du busard Saint-Martin (*Circus cyaneus*) et du faucon crécerelle (*Falco tinnunculus*). *Bull. Soc. Vaud. Sci. Nat.* 84: 19–32.
- Roulin A., Ducret B., Bize P. et al. 2008: Régime alimentaire de la Chouette hulotte *Strix aluco* en Suisse romande de 1986 à 2007. *Nos Oiseaux* 55: 149–156.
- Rubolini D., Pirovano A. & Borghi S. 2003: Influence of seasonality, temperature and rainfall on the winter diet of the long-eared owl, *Asio otus*. *Folia Zool.* 52: 67–76.
- Ružić M., Spremo N. & Durakić M. 2009: The diet of barn owl *Tyto alba* in Central Banat. *Ciconia* 18: 99–113.
- Sándor A.D. 2009: The summer diet of barn owl (*Tyto alba*) (Aves: Strigiformes) in the Southern part of Danube delta biosphere reserve. *Acta Zool. Bulgar.* 61: 87–92.
- Schipper W.J.A. 1973: A comparison of prey selection in sympatric harriers, *Circus*, in western Europe. *Le Gerfaut* 63: 17–120.
- Schmitt M. & Hofer J. 2011: Kleinsäuger aus Wiesenlebensräumen bei Rheinberg, Niederrhein. *Elektronische Aufsätze der Biologischen Station Westliches Ruhrgebiet* 21: 1–6.
- Selås V., Tveiten R. & Aanonsen O.M. 2007: Diet of common buzzards (*Buteo buteo*) in southern Norway determined from prey remains and video recordings. *Ornis Fenn.* 84: 97–104.
- Sergio F. & Boto A. 1999: Nest dispersion, diet, and breeding success of black kites (*Milvus migrans*) in the Italian Alps. *J. Raptor Res.* 33: 207–217.
- Shrubbs M. 1980: Farming influences on the food and hunting of kestrels. *Bird Study* 27: 109–115.
- Skierczyński M. 2006: Food niche overlap of three sympatric raptors breeding in agricultural landscape in Western Pomerania region of Poland. *Buteo* 15: 17–22.
- Sleptsov M.M. 1947: The biology of *Micromys minutus ussuricus* B.-Ham. *Fauna and ecology of rodents 2. Materialy k poznaniyu fauny i flory SSSR, n.s.* 8: 69–100. (in Russian)
- Sommer R.S., Niederle M., Labes R. & Zoller H. 2009: Bat predation by the barn owl *Tyto alba* in a hibernation site of bats. *Folia Zool.* 58: 98–103.
- Spitzenberger F. & Steiner H.M. 1975: Die Ökologie der Insectivora und Rodentia (Mammalia) der Stockerauer Donau-Auen (Niederösterreich). *Bonn. Zool. Beitr.* 18 (3–4): 258–296.
- Stasiak K., Piekarska K. & Kusal B. 2014: The comparison of the winter diet of long-eared owl *Asio otus* in two communal roosts in Lublin region (Eastern Poland) according to selected weather conditions. *Ecol. Balk.* 6: 103–108.
- Stiebling U. 1998: Der Rotfuchs, *Vulpes vulpes* (L., 1758), im Biosphärenreservat Schorfheide-Chorin. *Nat. Schutz. Landsch. Pfl. Brandenburg* 1: 89–92.
- Szymański P., Malecha A.W. & Tobółka M. 2010: Food composition of the short-eared owl *Asio flammeus* wintering in Pomorze Zachodnie (northwestern Poland). *Chrońmy Przyr. Ojcz.* 66 (4): 295–298. (in Polish with English summary)
- 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: 495–503.
- Teagle W.G. 1964: The harvest mouse in the London area. *Lond. Nat.* 43: 136–149.

- Temme M. 2006: Die Beutetiere aus Gewöllen von Schleiereulen *Tyto alba* von der Weserinsel Strohauser Plate. *Natur und Umweltschutz (Zeitschrift Mellumrat)* 5: 5–10.
- Ternois V. 1999: Détermination des micromammifères entrant dans le régime alimentaire du Hibou moyen-duc *Asio otus* dans la vallée de l'Avalasse. *Avifaune Picarde* 8: 77–80.
- Tishechkin A. 1997: Comparative food niche analysis of *Strix* owls in Belarus. In: Duncan J.R., Johnson D.H. & Nicholls T.H. (eds.), Biology and conservation of owls of the northern hemisphere. *2nd International Owl Symposium, February 5-9, 1997, Winnipeg, Manitoba, Canada*: 456–460.
- Toffoli R. 1994: Winter feeding of hen harrier (*Circus cyaneus*) in Piemonte (Aves, Accipitriformes). *Riv. Piemont. Stor. Nat.* 15: 155–161. (in Italian)
- Tome D. 2000: Winter diet of the long-eared owl *Asio otus* in Slovenia. *Acrocephalus* 21 (98–99): 3–7.
- Tome D. 2009: Changes in the diet of long-eared owl *Asio otus*: seasonal pattern of dependence on vole abundance. *Ardeola* 56: 49–56.
- Trnka A. & Obuch J. 2006: On the diet of short-eared owls (*Asio flammeus*) wintering in south-western Slovakia. *Tichodroma* 18: 71–72.
- Trout R.C. 1978: A review of studies on population of wild harvest mice (*Micromys minutus* Pallas). *Mammal Rev.* 8: 143–158.
- Tulis P. 2011: Variegated diet composition of long-eared owl (*Asio otus*) in eastern part of Nitrianska Pahorkatina Hills. *Young Scientists and Pedagogues Conference Proceedings, Constantine the Philosopher University, Nitra, Slovakia*: 496–503.
- Underhill-Day J.C. 1985: The food of breeding marsh harriers *Circus aeruginosus* in East Anglia. *Bird Study* 32: 199–206.
- Uttendörfer O. 1929: Studien zur Ernährung unserer Tagraubvögel und Eulen. *Naturforschende Gesellschaft zu Görlitz, Görlitz, Germany*.
- Uttendörfer O. 1952: Neue Ergebnisse über die Ernährung der Greifvögel und Eulen. *E. Ulmer, Stuttgart, Germany*.
- Vrezec A. 2001: Winter diet of one female Ural owl (*Strix uralensis*) at Ljubljansko barje (central Slovenia). *Buteo* 12: 71–76.
- Wavrin de H., Walravens M. & Rabosée D. 1991: Nidifications exceptionnelles du Hibou moyen-duc (*Asio otus*) et du Faucon crécerelle (*Falco tinnunculus*) en 1991 en forêt de Soignes (Brabant). *Aves* 28 (4): 169–188.
- Ważna A., Cichocki J., Lupicki D. et al. 2011: Diet of barn owl *Tyto alba* in Lubuskie region. *UP Wroc., Biol. Hod. Zwierz., LXII* 580: 65–87. (in Polish)
- Weber D. 1989: Foraging in polecats (*Mustela putorius* L.) of Switzerland: the case of a specialist anuran predator. *Z. Säugetierkd.* 54: 377–392.
- Wiącek J., Krawczyk R. & Polak M. 2011: The influence of the winter weather conditions on the food of long-eared owl *Asio otus* in Dabrowa Forest near Lublin. *Studia i Materiały CEPL w Rogowie* 13 (Suppl. 27): 114–119. (in Polish with English summary)
- Wiącek J. & Niedźwiedz M. 2005: The food of Montagu's harriers during pre-laying period. *Berkut* 14 (2): 189–192.
- Wiącek J., Polak M. & Niedźwiedz M. 2008: The diet composition of the tawny owl *Strix aluco* in forest and urban zone in Lublin: a comparison. *Ochronić różnorodność biologiczną w miastach*: 501–505. (in Polish with English summary)
- Wiącek J., Polak M. & Niedźwiedz M. 2009: The diet composition of the tawny owl *Strix aluco* in the Kozłówka forest (eastern Poland). *Annales UMCS Sec. C* 64 (2): 75–81.
- Wijnandts H. 1984: Ecological energetics of the long-eared owl (*Asio otus*). *Ardea* 72: 1–92.
- Wilson D.E. & Reeder D.M. 2005: Mammal species of the world: a taxonomic and geographic reference, 3rd edition. *Johns Hopkins University Press, Baltimore, Maryland*.
- Wise M.H., Linn J. & Kennedy C.R. 1981: A comparison of the feeding biology of mink *Mustela vison* and otter *Lutra lutra*. *J. Zool. Lond.* 195: 181–213.
- Witrowski J. 1989: Breeding biology and ecology of the marsh harrier *Circus aeruginosus* in the Barycz valley, Poland. *Acta Ornithol.* 25: 223–320.
- Woods M., Mc Donald R.A. & Harris S. 2003: Predation of wildlife by domestic cats *Felis catus* in Great Britain. *Mammal Rev.* 33: 174–188.
- Wuntke B. & Ludwig I. 1998: Zur Nahrungswahl der Schleiereule (*Tyto alba guttata*) im Landkreis Potsdam-Mittelmark (Brandenburg). *Brandenburgische Umwelt Berichte* 3: 19–24.
- Zabala J. 1973: Contribución al conocimiento de *Micromys minutus* (Mammalia, rodentia) en el Cantábrico. *Munibe* 1: 39–44.
- Zalewski A. 1994: Diet of urban and suburban tawny owls (*Strix aluco*) in the breeding season. *J. Raptor Res.* 8: 246–252.
- Zalewski A. 2007: Does size dimorphism reduce competition between sexes? The diet of male and female pine martens at local and wider geographical scales. *Acta Theriol.* 52: 237–250.
- Zárybnická M., Sedláček O. & Korpimäki E. 2009: Do Tengmalm's owls alter parental feeding effort under varying conditions of main prey availability? *J. Ornithol.* 150: 231–237.
- Żmihorski M. & Osojca G. 2006: Diet of the tawny owl (*Strix aluco*) in the Romanincka forest (north east Poland). *Acta Zool. Lituan.* 16: 54–60.
- Żmihorski M. & Rejt L. 2007: Weather-dependent variation in the cold-season diet of urban kestrels *Falco tinnunculus*. *Acta Ornithol.* 42: 107–113.
- Zschille J., Stier N., Roth M. & Mayer R. 2014: Feeding habits of invasive American mink (*Neovison vison*) in northern Germany – potential implications for fishery and waterfowl. *Acta Theriol.* 59: 25–34.
- Zub K., Pugaczewicz E., Jędrzejewska B. & Jędrzejewski W. 2010: Factors affecting habitat selection by breeding lesser spotted eagles *Aquila pomarina* in northeastern Poland. *Acta Ornithol.* 45: 105–114.