Acta Zoologica Academiae Scientiarum Hungaricae 57(3), pp. 277–289, 2011

NORTHERN BIRCH MOUSE (*SICISTA BETULINA*) IN LITHUANIA, FINDINGS IN THE DIET OF TAWNY OWL (*STRIX ALUCO*)

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In the period 1996–2009, 31 individual remains of *Sicista betulina* were found during analysis of Tawny Owl diet in north, west, central and south-west Lithuania, based on pellets and food remains in nest-boxes after the breeding period. In general, the proportion of *S. betulina* in the diet was 0.6%, with district annual averages of up to 6.25–7.14% of mammal items. Remains of *S. betulina* were found near spruce, but not in deciduous forests, mainly in forested landscape and in the less anthropogenous habitats. The presence of this species in the diet was related to which other small mammal occurred as the dominant prey species – *S. betulina* was present when a significantly smaller proportion of *Microtus* voles and higher proportion of alternative prey (*S. araneus*) in the diet occurred.

Key words: Northern Birch Mouse, *Sicista betulina*, Tawny owl, *Strix aluco*, owl diet, Lithuania

INTRODUCTION

In western parts of the range, including Lithuania and Belarus, Northern Birch Mouse (*Sicista betulina* PALLAS, 1779) is generally regarded as a rare species. It is included in the IUCN Red List (evaluated as Least Concern) (MEINIG *et al*. 2008) and in the national Red Lists of many states within its range, including Lithuania and Latvia (PILATS 2000, RAŠOMAVIČIUS 2007). Though this species is rarely trapped by snap traps (BALČIAUSKAS & JUŠKAITIS 1997, BALČIAUSKAS *et al*. 1999, BALČIAUSKAS 2005), 43% of earlier findings in Lithuania were nonetheless recorded while trapping (JUŠKAITIS 2004). Of known occurrences of *S. betulina* in Lithuania, the percentage of records originating from the diet of owls has recently increased twofold – from 15% of occurrences prior to 2000 to 30% in 2000–2004 (JUŠKAITIS 2000, 2004). Recent attention to the feeding ecology of owls (BALČIAUSKIENE *et al*. 2000, 2005*a, b*, 2006, BALČIAUSKIENE 2006) has resulted in the detection of more specimens of *S. betulina* and the method of analysing owl pellets is a relatively fast way to collect large amounts of occurrence data for rare small mammal species. It gives faunistic information on mammals which are rarely captured by classic trapping methods (DENYS et *al*. 1999). As an example, one of the rarest small mammals in Central Europe, the Southern Birch Mouse (*Sicista subtilis*) was mainly detected by analysis of Barn Owl (*Tyto alba*) pellets in the

Borsodi Mezőség Landscape Protected Area in Hungary, with a mean frequency 2.4% of prey (CSERKÉSZ 2007). Later, however, choosing the right habitat for trapping, *S. subtilis* was live trapped in numbers in box and pitfall traps (CSERKÉSZ & GUBÁNYI 2008).

The aim of this publication is to show the latest data on the findings of *S. betulina* in Lithuania via analysis of prey remains and pellets of the Tawny Owl (*Strix aluco*). The working hypothesis is that the composition of the main mammalian foods determines the appearance of *S. betulina* in Tawny Owl diet – rare small mammal species occur when staple food species are insufficient in numbers.

MATERIAL AND METHODS

Data on Tawny Owl diet were collected in 1996–2009 in north, west, central and south-west Lithuania (Fig. 1). For the analysis, we used pellets collected throughout the year and food remains in nest-boxes after the breeding period (Table 1). Non-mammalian prey was excluded from further analysis. The total number of investigated samples of food remains (i.e. contents from each nestbox)

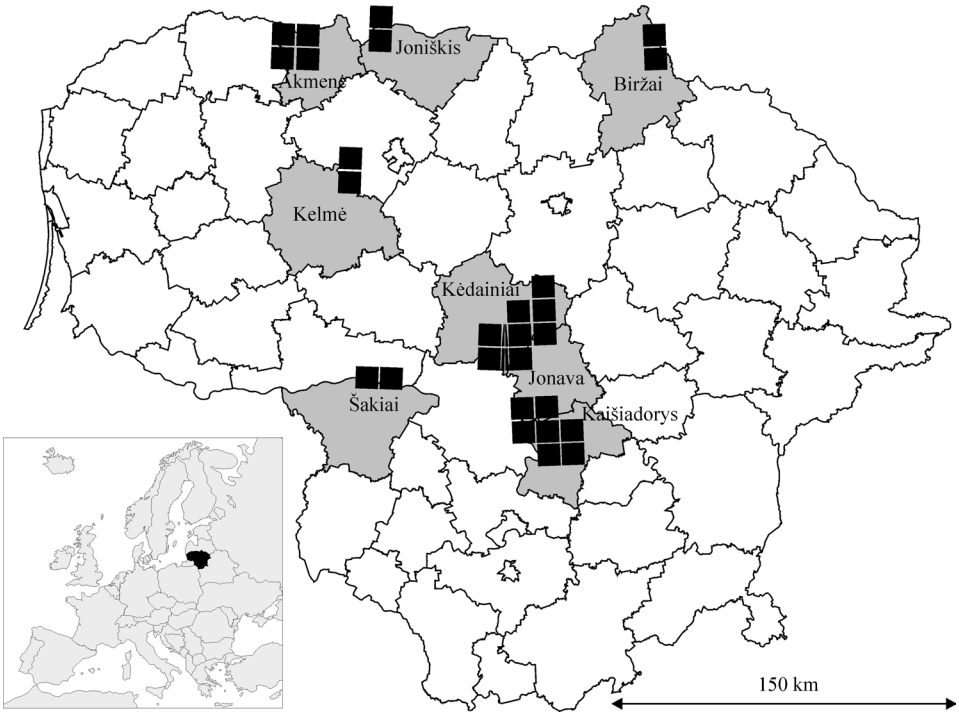

Fig. 1. Sites and UTM squares, where *S. aluco* nestboxes were situated and pellets collected in 1996–2009. Source: BALČIAUSKIENE *et al*. 2000, 2005*a,b*, 2006

Table 1. Material for the analysis of Tawny Owl diet, collected in Lithuania, 1996–2009 (location shown in Fig. 1).

District	Part of the country	UTM codes	Period	Material	Sample size
Akmene	northern	FH2a1, FH2b1, EH4a5, EH4b5	1999–2003	Food remains	10
Joniškis	northern	FH1e4, FH2a4	2008–2009	Pellets	13
Biržai	northern	LC4a3, LC4b3	2003–2005	Pellets	5
Kaišiadorys	central	LA1a2, LA1a3, La1b2, LA1b3, LA1b4, LA1c3, LA1c4	2000–2005	Food remains	16
			1999–2000	Pellets	14
Jonava	central	LB2c3	2005	Pellets	2
Kedainiai	central	LB2a3, LB2b2, LB2b3, LB2c1, LB2c2, LB2d1, LB2d2, FG4c4, FG4c5, FG4d4	1997–2005	Food remains	53
			1999–2005	Pellets	9
Šakiai	south-western	FG2e4, FG2e5	1987, 1997, 2000–2004	Food remains	8
Kelme	western	FG1a3, FG1b3	1996, 1999–2002	Food remains	6

was 93, while the number of pellet samples (each sample defined by place and/or date, containing a number of individual pellets) was 43. In total, the number of analysed intact pellets was 408, plus an unknown number of fragmented pellets. Individuals, recovered from destroyed pellets, were also used for the further calculations.

In the wet spruce and birch stands around the raised bog of Kamanos Strict Nature Reserve (Akmene district, north Lithuania), one to three nestboxes per year were checked (BALČIAUSKIENE *et al.* 2005*b*, BALČIAUSKIENE 2006). Samples from Kelme district, western Lithuania, were collected in the ecotones of coniferous forests, close to farmsteads and a mature deciduous park next to ponds (BALČIAUSKIENE *et al.* 2000–2001). In central Lithuania, samples were collected in deciduous or mixed deciduous stands, with oak or oak-domination, adjacent to meadows or agricultural areas in Kedainiai district (BALČIAUSKIENE & NARUŠEVIČIUS 2006), and in the ecotones of mixed, spruce and deciduous stands, also near water bodies, in Kaišiadorys district (BALČIAUSKIENE & DEMENTAVIČIUS 2006). In Šakiai district, south-west Lithuania, samples of nestbox contents were collected in forests and ecotones of spruce-deciduous forests with meadows (BALČIAUSKIENE *et al.* 2005*b*).

All pellets were collected in forested areas – forests and forest ecotones. In central Lithuania, the number of intact pellets collected in five forests in Kedainiai district was 114, while in three forests in Kaišiadorys district it was 67 and in one forest in Jonava district 52. In northern Lithuania, 30 intact pellets were collected in Biržu Giria forest (Biržai district) and 45 intact pellets in Žagares miškas (Joniškis district). Destroyed pellets were also analysed.

In some cases, due to broken skulls lacking parts required for identification, the species of g. *Microtus* voles and g. *Apodemus* mice in the food remains was not identified. Such individuals were numbered among species *Microtus arvalis/agrestis/oeconomus* or *Apodemus agrarius/flavicollis/uralensis* in the same proportion that such species occurred in the identified part of the particular sample they were found (LUNDBERG 1980).

Statistica ver. 6.0 (StatSoft 2001) was used for statistical analysis. Prey composition (number of individuals eaten) was compared using χ^2 test, re-calculating one set of data as expected to match the total of the other set. The first dataset was species composition of prey containing *S. betulina*, while the second was species composition where *S. betulina* was absent. When the species was absent in the prey, or the frequency was < 5 individuals, frequency data was merged with the nearest cell. The diversity of the diet (expressed as Shannon–Wiener diversity index, H', on the base of $\log_2$) and the Simpson's dominance index, c, according KREBS (1999) are presented. Rényi diversity numbers were used to test if diet composition was different between sites of investigation. We used DivOrd program ver. 1.90 (TÓTHMÉRÉSZ 1993), run in the freeware DOSBox ver. 0.74. Diet diversity was tested among districts as well as pooling samples into containing *S. betulina* and lacking it.

RESULTS

In the eight investigated districts, 22 species of mammalian prey were found in the diet of Tawny Owl (Table 2). The percentage of non-mammalian items in the prey remains by number was 5.8% in Akmene, 7.6% in Kelme, 9.0% in Kedainiai, 17.9% in Kaišiadorys and 16.4% in Šakiai districts. Non-mammalian prey from pellets by number constituted 8.5% in Kedainiai, 0.8% in Kaišiadorys and 25.8% in Biržai districts, while in the pellet samples from Jonava and Joniškis districts only mammals were identified.

In general, about 85% of mammalian prey consisted of five mammal species: *M. glareolus* 28.8% (27.5% in prey remains and 32.9% in pellets); *A. flavicollis* 17.9% (18.5% and 16.1%, respectively); *M. arvalis* 14.0% (10.9% and 23.6%); *M. agrestis* 13.3% (15.3% and 7.1%); and *S. araneus* 10.7% (12.0% and 6.4%, respectively).

In the investigated districts, the proportion of *S. betulina* in Tawny Owl diet was not large – in general, just 0.62% (Table 2). These proportions did not differ between the food remains after breeding (0.63%) and in the pellets (0.58%). There were no districts where the average proportion of *S. betulina* in Tawny Owl diet was over four percent. Higher proportions of *S. betulina* were characteristic of forested sites. No significant correlations were found between the proportions of *S. betulina* in the diet and other prey characteristics – number of species (Pearson's r, n = 10, r = 0.30, NS), number of individuals eaten (r = –0.24, NS), prey diversity (r = 0.47, NS) and prey dominance (r = –0.40, NS).

The number of total mammal items preyed upon on average was 337.2±149.3 in the diet samples including *S. betulina* versus 667.4±348.8 in the diet samples lacking *S. betulina*. The number of mammal species in the diet was 15.0±1.1 versus 12.2±1.9, Shannon's H 2.92±0.13 versus 2.49±0.23, and Simpson's c was 0.19±0.02 versus 0.24±0.04 accordingly (df = 8, NS in all comparisons).

Table 2. Number of individuals of mammalian prey identified in the diet of Tawny Owl in eight districts of Lithuania, 1996–2009

	Prey remains					Pellets				
	Akm	Kel	Ked	Kšd	Šak	Jnš	Ked	Kšd	Brž	Jon
Common Mole (*Talpa europaea*)	1	3	28	3	14	11	2	–	5	–
Common Shrew (*Sorex araneus*)	26	55	228	118	31	8	68	–	2	–
Pygmy Shrew (*Sorex minutus*)	9	5	61	6	6	1	43	1	2	–
Water Shrew (*Neomys fodiens*)	3	4	21	7	6	–	1	–	–	–
Noctule (*Nyctalus noctula*)	–	–	3	–	–	–	–	–	–	–
Nathusius' Pipistrelle (*Pipistrellus nathusii*)	–	–	2	–	–	–	–	–	–	–
Brown Long-eared Bat (*Plecotus auritus*)	–	–	–	3	–	–	–	–	–	–
Serotine Bat (*Eptesicus serotinus*)	–	–	–	2	–	–	–	–	–	–
Northern Birch Mouse (*Sicista betulina*)	1	7	–	16	–	6	–	–	1	–
Common Dormouse (*Muscardinus avellanarius*)	3	6	57	16	11	4	–	–	3	–
Bank Vole (*Myodes glareolus*)	42	38	632	246	89	65	184	80	36	33
Water Vole (*Arvicola terrestris*)	4	9	4	7	–	16	–	–	–	–
Root Vole (*Microtus oeconomus*)	4	23	21	44	14	8	1	8	–	–
Short-tailed Vole (*Microtus agrestis*)	51	37	383	79	33	16	49	7	9	5
Common Vole (*Microtus arvalis*)	46	25	198	51	95	5	43	196	3	39
Harvest Mouse (*Micromys minutus*)	2	2	9	4	1	2	5	10	6	1
Striped Field Mouse (*Apodemus agrarius*)	6	1	78	–	4	–	11	6	–	2
Yellow-necked Mouse (*Apodemus flavicollis*)	33	20	298	313	42	44	60	51	22	18
Pygmy Field Mouse (*Apodemus uralensis*)	1	–	–	–	–	–	–	–	–	1
House Mouse (*Mus musculus*)	5	4	14	6	10	3	–	2	–	–
Brown Rat (*Rattus norvegicus*)	1	4	1	3	9	2	–	3	–	–
Weasel (*Mustela nivalis*)	–	–	3	–	1	–	–	–	1	–
Total	238	243	2041	924	366	191	467	364	90	99
No species	17	16	18	17	15	14	11	10	11	7
Shannon's H	3.10	3.30	2.90	2.70	3.07	2.91	2.56	1.95	2.57	1.97
Simpson's c	0.15	0.13	0.18	0.22	0.16	0,19	0.22	0.36	0.24	0.30
SB%	0.42	2.88	0	1.73	0	3.14	0	0	1.11	0

Districts: Akm = Akmene, Kel = Kelme, Ked = Kedainiai, Kšd = Kaišiadorys, Šak = Šakiai, Brž = Biržai, Jnš = Joniškis, Jon = Jonava.
SB% = percentage of *S. betulina* individuals in the total mammalian prey.

Table 3. Dynamic of *S. betulina* numbers and proportion (%) in Tawny Owl diet (n/d – no data)

District	1996	1999	2000	2001	2002	2003	2004	2005	2008	2009	Total
Akmene[1]	0	0	1 (7.14)	0	0	0	n/d	n/d	n/d	n/d	1
Kelme[1]	1 (1.79)	3 (6.98)	2 (4.88)	0	1 (1.35)	n/d	n/d	n/d	n/d	n/d	7
Kaišiadorys[1]	n/d	n/d	2 (0.83)	n/d	0	1 (6.25)	12 (3.80)	1 (0.41)	n/d	n/d	16
Biržai[2]	n/d	n/d	n/d	n/d	n/d	0	1 (3.13)	0	n/d	n/d	1
Joniškis[3]	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	2 (2.25	4 (3.88)	6

[1]Food remains (BALČIAUSKIENE *et al*. 2005*b*); [2]Pellets (BALČIAUSKIENE *et al*. 2005*a*); [3]Pellets (new data)

Diversity ordering (Rényi diversity scaling) showed that diet diversity comparison at the district level is not possible – most curves in Rényi plot intersect, and this means no differences between diets. Even comparing pooled samples (*S. betulina* present versus *S. betulina* absent), we do not confirm a higher diversity of the diet including *S. betulina*, as starting from scale parameter 1.0 and higher, the differences were not significant. According TÓTHMÉRÉSZ (1998), owl diet including *S. betulina* is more diverse for the rarely preyed small mammal species.

Thirty-one individuals of *S. betulina* were found in the diet of *S. aluco* in 1996–2009. Out of these, 24 individuals were recovered from the food remains, collected from nest-boxes after the breeding period. The highest proportion of *S. betulina* in the diet was found in Akmene district (7.14%), but this species was preyed upon only in 2000 – one out of the six years of investigation. High but stable proportions of *S. betulina* were registered in two districts – Kelme and Kaišiadorys, where the species accounted for up to 6.98% and 6.25% of all mammal items in the diet (Table 3). In all districts where *S. betulina* was registered as a food item of Tawny Owl, ecotones of spruce forest were involved in the study sites. In Kedainiai and Šakiai districts, where the investigation sites were characterized by highest presence of deciduous forests, the species was not present in the diet during the breeding period. In the both districts, samples were collected in human-affected environments.

We compared the proportions of the main prey (*M. glareolus*, *A. flavicollis*, *Sorex araneus* and *Microtus* voles) and that of rare or infrequently-eaten small mammal species in the years when *S. betulina* was present with years when it was absent in the Tawny Owl diet (Fig. 2). In all cases, proportions differed significantly: Akmene district $\chi^2 = 61.3$, df = 3, Kelme district $\chi^2 = 34.1$, df = 4, Kaišia-

dorys district $\chi^2 = 524.8$, df = 3, Biržai district $\chi^2 = 13.8$, df = 2 (all $p < 0.001$). The absence of the *S. betulina* in the diet was associated with significantly higher proportions of *Microtus* voles in Akmene and Biržai districts and *M. glareolus* in Kaišiadorys district, while with smaller proportions of *Sorex araneus* in Akmene and Kaišiadorys districts and *A. flavicollis* in Kelme district. In general, throughout Lithuania, the presence of *S. betulina* in the diet was related to significantly smaller proportions of *Microtus* voles and higher proportions of *Sorex araneus*.

We also analysed the proportions of the main prey groups in the districts where *S. betulina* was constantly present or absent in the diet. The pattern was the same – this rare species was preyed upon in the districts where the proportion of *Microtus* voles was smaller (20.1% vs 32.9%) and the proportion of *Sorex araneus* higher (14.2% vs 8.9%).

DISCUSSION

In the north of the distribution range, *S. betulina* inhabits mixed or deciduous stands, open spaces and sparse forest with lush grassy vegetation (IVANTER & KUKHAREVA 2008). Deciduous stands and river valleys are important habitat ele-

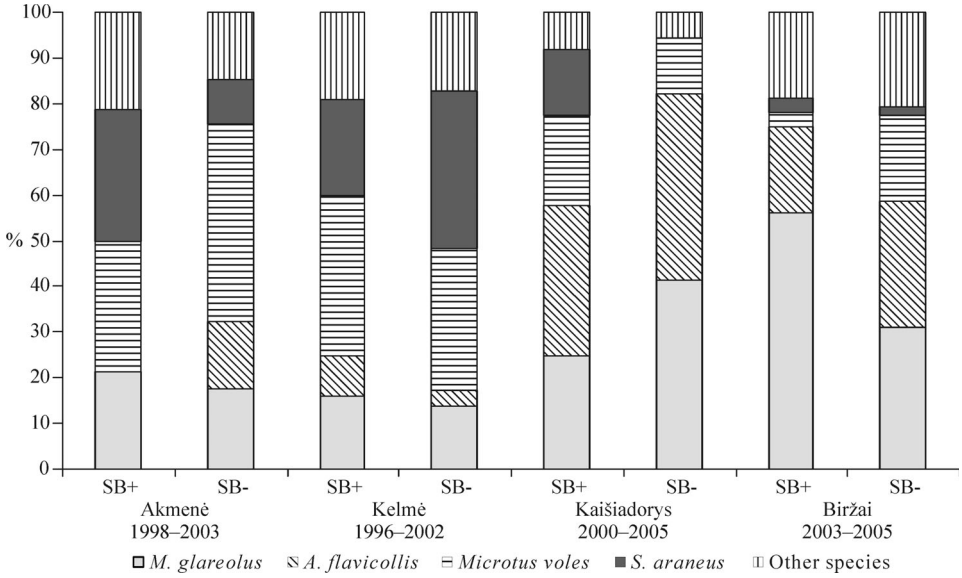

Fig. 2. Proportions of the prey groups in Tawny Owl diet (SB+ – *S. betulina* present, SB – *S. betulina* absent, in all districts $p < 0.001$)

ments for the species in tundra (PILATS & PILATE 2009). River valleys have also proved to be important habitat in the central part of its distribution range, e.g., in Białowieża Primeval Forest (JĘDRZEJEWSKA *et al*. 2001). In Lithuania, *S. betulina* generally lives in woodlands with open places or in open areas near forests, but they have been caught in various types of forest, open grass bogs (usually with sparse small trees and shrubs), glades, meadows near forest, coppices etc. They even live in human-influenced habitats such as clear cuttings, the edges of ditches and peat-bogs (BALČIAUSKAS *et al*. 1999). In Poland *S. betulina* avoids human affected habitats (GRYZ *et al*. 2008).

The maximum proportion of *S. betulina* recorded in owl prey was found in 1980 – 7.5% in the prey of Tengmalm's Owl (*Aegolius funereus*) in east Lithuania (PRUSAITE 1988). From our data on the Tawny Owl diet, the maximum proportions were 6.25–7.14%. Our investigation yielded records of an additional 28 individuals of the species in owl pellets, taking the known total to 31 individuals. We also list here a few other known cases of predation of *S. betulina*, but can not re-calculate proportions, as diet composition was not known. In Kedainiai district, a single individual of *S. betulina* was found in a Tawny Owl nest in Labűnava forest in 1998 (BALČIAUSKIENE *et al*. 2000). Two more *S. betulina* individuals were recovered from pellets in Kelme district: one from a Tawny Owl pellet in 1996 and one from a Tengmalm's Owl pellet in 2003 (leg. A. PNIAUSKAS). In Plunge district, one more *S. betulina* individual was recovered from unidentified owl pellet in 2003 (leg. S. SKUJA). Thus, owl diet investigations have yielded registration of 35 *S. betulina* individuals in Lithuania in the last 14 years.

In Lithuania (including sites not covered by this investigation), the diet of Tawny Owls has been shown to comprise of 23 mammal species (BALČIAUSKIENE 2006). In terms of numbers – 84.2% (74.3–90.3%) – and in terms of biomass consumed – 83.8% (65.2–87.4%), mammalian prey constitutes the greatest proportion of prey matter in Tawny Owl diet. As found from prey remains, the main prey items of Tawny Owl by biomass consumed in the breeding period were: *A. flavicollis* (on average 30.1%), *M. glareolus* (23.5%) and *M. agrestis* (14.2%); the totals of the said species by numbers were: 21.6%, 30.0% and 12.6%, respectively. All *Microtus* voles averaged 26.6% of the prey biomass and 24.3% of the numbers consumed. As found from the pellets collected round the year, 14 small mammal species formed 93.1% of the diet by numbers. *M. glareolus*, *M. arvalis* and *A. flavicollis* were the primary food resources for Tawny Owl – 31.4, 27.9 and 14.3% by numbers, 27.6, 25.0 and 22.4% by biomass consumed (BALČIAUSKIENE *et al.* 2006, BALČIAUSKIENE 2006).

On average in Lithuania, the share of *Sorex araneus* by number was 11.7%, but the biomass consumed averaged just 3.7% (BALČIAUSKIENE 2006). Optimal

foraging theory predicts that as main prey abundance declines, the predator should take less profitable prey (KREBS & DAVIES 1993). Thus, we expected when main food sources declined (*M. glareolus*, *A. flavicollis* and *Microtus* voles), Tawny Owl should take less profitable prey – first *Sorex araneus* and then, according to presence and possibility, *S. betulina*. This hypothesis was confirmed by our material with few exceptions.

For those countries immediately north of Lithuania (Latvia and Estonia), there are no published data on owl diet, so we researched the presence of *S. betulina* in the owl diet in countries to the south of Lithuania, where species abundance is higher (MEINIG *et al*. 2008).

In Belarus, *S. betulina* comprised 0.2% of the prey by number in Great Grey Owl (*Strix nebulosa*), 0.6% in Ural Owl (*S. uralensis*) and 0.7% in Tawny Owl (TISHECHKIN 1997).

The proportion of *S. betulina* in the prey of Tawny Owls increased significantly towards the northeast in a transect from Germany through Poland to the Latvian border (ŻMIHORSKI *et al*. 2008). There are several other publications in Poland on the findings of *S. betulina* in owl pellet analysis, which are important in the context of our data. In most cases, *S. betulina* as prey was not very numerous in owl diet and it may be discussed whether this species is not preferred or may be absent/not abundant in the owl feeding places. The edge of the continuous range of this species goes through Poland (LESIŃSKI & GRYZ 2008). ZAVADZKA and ZAVADZKI (2007) in NE Poland (Wigry National Park) have not found this species in Tawny Owl diet despite its presence in the rodent community and they reached the conclusion that *S. betulina* were avoided as prey. In another area of NE Poland, Romincka forest, *S. betulina* comprised 2.0% of Tawny Owl prey by number or 1.03% by biomass consumed. It was also considered as a very rare small mammal species (OSOJCA & ŻMIHORSKI 2004, ŻMIHORSKI & OSOJCA 2006).

In three more localities where Tawny Owl diet included *S. betulina* in C and NE Poland, individuals were found in 69 collections of pellets. In total, four, three and 29 individuals were recovered, comprising 26.7%, 7.35% and 9.7% of the vertebrate food respectively (LESIŃSKI & GRYZ 2008). From comparison of Tawny Owl diets in forest and rural habitats in NE Poland, *S. betulina* is strictly a forest species (LESIŃSKI *et al*. 2009). We recalculated the data of these authors and found that in forested areas, the average proportion of *S. betulina* in all mammalian prey was 3.8%, but in two territories this proportion was very high – 66.7% and 15.1% by number respectively. No significant correlations were found between proportions of *S. betulina* in the diet and other prey characteristics – total number of mammals eaten (Pearson's r, $n = 8$, $r = –0.26$, NS), number of species ($r = –0.40$, NS),

Table 4. Proportions of the prey groups in Tawny Owl diet (SB+ – *S. betulina* present, SB – *S. betulina* absent; data recalculated from LESIŃSKI *et al*. (2009))

	Number of individuals (N)		Proportion (%)	
	SB+	SB-	SB+	SB-
M. glareolus	20	213	8.7	27.3
A. flavicollis	1	181	0.4	23.2
Microtus voles	40	126	17.3	16.2
Sorex araneus	70	62	30.3	8.0
Other species	100	197	43.3	25.3
Total	231	779	100.0	100.0

prey diversity (r = –0.56, NS) or dominance (r = –0.69, NS). The absence of significant correlations was confirmed by our data too.

When comparing the proportions of the main prey groups (*M. glareolus*, *A. flavicollis*, *Sorex araneus* and *Microtus* voles) in the locations in NE Poland where *S. betulina* was present or absent in Tawny Owl diet, we fully confirmed our hypothesis (Table 4). Proportions differed significantly ($\chi^2 = 1656.5$, df = 3, $p < 0.001$). *S. betulina* was preyed upon under conditions of low proportions of *M. glareolus* and *A. flavicollis* and high proportion of *S. araneus* in the diet. In Lithuania, from our data, the main driving factor was *Microtus* voles.

We described possible differences of Tawny Owl diet in a NE direction in Poland and Lithuania, relating them to the ratio of Muridae and Arvicolidae. It can be expected that closer to the northern limit of its range, the average densities of *A. flavicollis*, as well as its competitive ability, should be smaller than compared to *M. glareolus*. A gradual replacement of Muridae with Arvicolidae in small mammal communities towards the NE seems to be a reliable explanation for the observed changes in the Tawny Owl diet composition (ŻMIHORSKI *et al*. 2008, analysis based on MITCHELL-JONES *et al*. 1999). This explains why the trigger for Tawny Owl diet change towards rare small mammal species was insufficient abundance of *Microtus* voles in Lithuania, while it was that of *M. glareolus* and *A. flavicollis* in Poland.

CONCLUSIONS

During 14 years of Tawny Owl diet studies in Lithuania, the remains of 31 individual of Northern Birch Mouse (*Sicista betulina*) were identified, and this constitutes on average a mere 0.6% from the over 5000 mammalian food items. From these studies of owl diet, *S. betulina* can be considered one of the rarest small mammals in Lithuania.

The presence–absence of *S. betulina* in Tawny Owl diet was primarily dependant on habitat: the species was preyed upon near spruce, but not deciduous forests, mainly in forested landscape and in less anthropogenous habitats. *S. betulina* was not found in the diet in south-west and central Lithuania (Šakiai and Kedainiai districts), where the sample collection places did not match these requirements.

Our data show that the presence or absence of *S. betulina* in Tawny Owl diet was not related to the diet diversity or the number of preyed items. In general, the presence of *S. betulina* in the diet of Tawny Owl in Lithuania was related to the availability of dominant small mammal prey species. Specifically, it was preyed upon in association to significantly smaller proportions of *Microtus* voles and higher proportions of alternative prey (*S. araneus*) in the diet. In NE Poland, the presence of *S. betulina* in the diet of the Tawny Owl was related to a low abundance of other main prey species – *M. glareolus* and *A. flavicollis*.

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Acknowledgements – Authors thank anonymous reviewers and Prof. G. BAKONYI for ideas and help in diet diversity analysis. English language was kindly reviewed by JOS STRATFORD.

REFERENCES

BALČIAUSKAS, L. (2005) Results of the long-term monitoring of small mammal communities in the Ignalina Nuclear Power Plant Region (Drukšiai LTER site). *Acta Zoologica Lituanica* **15**(2): 79–84.

BALČIAUSKAS, L. & JUŠKAITIS, R. (1997) Diversity of small mammal communities in Lithuania (1. A review). *Acta Zoologica Lituanica* **7**: 29–45.

BALČIAUSKAS, L., TRAKIMAS, G., JUŠKAITIS, R., ULEVIČIUS, A. & BALČIAUSKIENE, L. (1999) *Atlas of Lithuanian mammals, amphibians and reptiles*. 2nd ed. Akstis, Vilnius 120 pp.

BALČIAUSKIENE, L., JUŠKAITIS, R. & NARUŠEVIČIUS, V. (2000) Small mammals in the diet of the Tawny owl (Strix aluco) in central Lithuania. *Folia Theriologica Estonica* **5**: 15–26.

BALČIAUSKIENE, L., JUŠKAITIS, R. & LOPETA, V. (2000–2001) Investigations on the tawny owl diet in the Kurtuvenai regional park. *Kurtuva. The Chronicle of Kurtuvenai Regional Park* **6–7**: 30–35.

BALČIAUSKIENE, L., SKUJA, S. & ZUB, K. (2005*a*) Avian predator pellet analysis in biodiversity and distribution investigations. *Acta Biologica Universitatis Daugavpiliensis* **5**(1): 67–73.

BALČIAUSKIENE, L., JUŠKAITIS, R. & ATKOČAITIS, O. (2005*b*) The diet of the Tawny Owl (Strix aluco) in south-western Lithuania during the breeding period. *Acta Zoologica Lituanica* **15**(1): 13–20.

BALČIAUSKIENE, L. (2006) *Feeding ecology of Tawny Owl (Strix aluco) and Long-eared Owl (Asio otus), based on craniometry of prey.* Abstract of doctoral dissertation. Vilnius, Institute of Ecology of Vilnius University, 40 pp.

BALČIAUSKIENE, L. & DEMENTAVIČIUS, D. (2006) Habitat determination of tawny owl (Strix aluco) prey composition during breeding period. *Acta Biologica Universitatis Daugavpiliensis* **6**(1–2): 1–12.

BALČIAUSKIENE, L., JOVAIŠAS, A., NARUŠEVIČIUS, V., PETRAŠKA, A. & SKUJA, S. (2006) Diet of Tawny Owl (Strix aluco) and Long-eared Owl (Asio otus) in Lithuania as found from pellets. *Acta Zoologica Lituanica* **16**(1): 37–45.

BALČIAUSKIENE, L. & NARUŠEVIČIUS, V. (2006) Coincidence of small mammal trapping data with their share in the Tawny Owl diet. *Acta Zoologica Lituanica* **16**(2): 93–101.

CSERKÉSZ, 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.

CSERKÉSZ, T. & GUBÁNYI, A. (2008) New record of Southern Birch Mouse, Sicista subtilis trizona in Hungary. *Folia Zoologica* **57**(3): 308–312.

DENYS, C., CHITAUKALI, W., MFUNE, J. K., COMBREXELLE, M. & CACCIANI, F. (1999) Diversity of small mammals in owl pellet assemblages of Karonga district, northern Malawi. *Acta zoologica cracoviensia* **42**(3): 393–396.

GRYZ, J., KRAUZE, D. & GOSZCZYŃSKI, J. (2008) The small mammals of Warsaw as inferred from tawny owl (Strix aluco) pellet analyses. *Annales Zoologici Fennici* **45**: 281–285.

IVANTER, E. V. &. KUKHAREVA, A. V. (2008) To ecology of the northern birch mouse (Sicista betulina) at the northern margin of its range. *Zoologicheskij Zhurnal* **87**(4): 476–493. [in Russian with English summary]

JĘDRZEJEWSKA, B., SIDOROVICH, V. E., PIKULIK, M. M. & JĘDRZEJEWSKI, W. (2001) Feeding habits of the otter and the American mink in Białovieża Primeval Forest. *Ecography* **24**: 165–180.

JUŠKAITIS, R. (2000) New data on the birch mouse (Sicista betulina) in Lithuania. *Folia Theriologica Estonica* **5**: 51–56.

JUŠKAITIS, R. (2004) Northern birch mouse (Sicista betulina) in Lithuania: the situation in 2004. *Theriologia Lituanica* **4**: 25–32. [in Lithuanian with English summary]

KREBS, CH. J. (1999) *Ecological methodology*. 2nd ed. Addison-Wesley Educational Publishers, Inc., Menlo Park, CA, 624 pp.

KREBS, J. R. & DAVIES, N. B. (1993) *An introduction to behavioural ecology*. Blackwell Scientific Publications, Oxford, 432 pp.

LESIŃSKI, G. & GRYZ, J. (2008) Localities of three rare mammal species in central and northeastern Poland. *Fragmenta Faunistica* **51**(1): 63–69.

LESIŃSKI, G., BLACHOWSKI, 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. *Fragmenta Faunistica* **52**(1): 13–16.

LUNDBERG, A. (1980) Why are the Ural Owl Strix uralensis and the Tawny Owl S. aluco parapatric in Scandinavia? *Ornis Scandinavica* **11**: 116–120.

MITCHELL-JONES, A. J., AMORI, G., BOGDANOWICZ, W., KRYŠTUFEK, B., REIJNDERS, P. J. H., SPITZENBERGER, F., STUBBE, M., THISSEN, J. B. M., VOHRALÍK, V. & ZIMA, J. (eds) (1999) *The Atlas of European Mammals*. Academic Press, London, 484 pp.

MEINIG, H., ZAGORODNYUK, I., HENTTONEN, H., ZIMA, J. & COROIU, I. (2008) Sicista betulina. *In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1.* www.iucnredlist.org. [Downloaded on 04 June 2010]

OSOJCA, G. & ŻMIHORSKI, M. (2004) New locality of common dormouse Muscardinus avellanarius L. in Romincka Forest (NE Poland). *Kulon* **9**(1): 129–130.

PILATS, V. (2000) Northern birch mouse Sicista betulina (Pallas, 1778). – *In:* ANDRUŠAITIS, G. (ed.) *Red Data Book of Latvia*. Vol. 6. Birds and mammals. LU Biologijas Inst., Rîga, pp. 234–235.

PILATS, V. & PILATE, D. (2009) Discovery of Sicista betulina (Pallas, 1779) (Rodentia, Dipodidae) far in the north outside the known species range. *Acta Biologica Universitatis Daugavpiliensis* **9**(1): 35–38.

PRUSAITE, J. (ed.) (1988) *Fauna of Lithuania. Mammals*. Mokslas, Vilnius. pp. 116–118. [in Lithuanian with English and Russian summaries]

RAŠOMAVIČIUS, V. (ed.) (2007) *Red Data Book of Lithuania.* Lutute, Vilnius, 266 pp.

STATSOFT, Inc. (2001) *STATISTICA (data analysis software system), version 6*. www.statsoft.com.

TISHECHKIN, A. K. (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 Int. Symp. USDA Forest Service General Technical Report NC-190. North Central Research Station, St. Paul, MN, pp. 456–460.

TÓTHMÉRÉSZ, B. (1993) DivOrd 1.50: a program for diversity ordering. *Tiscia* **27**: 33–44.

TÓTHMÉRÉSZ, B. (1998) On the characterization of scale-dependent diversity. *Abstracta Botanica* **22**: 149–156.

ZAWADZKA, D. & ZAWADZKI, J. (2007) Feeding ecology of Tawny Owl (Strix aluco) in Wigry National Park (North East Poland). *Acta Zoologica Lituanica* **17**(3): 234–241.

ŻMIHORSKI, M. & OSOJCA, G. (2006) Diet of the tawny owl (Strix aluco) in the Romincka forest (Northeast Poland). *Acta Zoologica Lituanica* **16**(1): 54–60.

ŻMIHORSKI, M., BALČIAUSKIENE, L. & ROMANOWSKI, J. (2008) SW–NE gradient in Central European variability of Micromammalia communities in the Tawny Owl Strix aluco diet. *Polish Journal of Ecology* **56**(4): 693–700.

Revised version received June 23, 2010, accepted February 20, 2011, published August 22, 2011