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# Mammals in the diet of tawny owl *Strix aluco* in western part of Skierniewice Forest District (central Poland)

**Jakub Gryz[1], Dagny Krauze-Gryz[2]**

[1]Forest Research Institute, Department of Forest Ecology, Sękocin Stary, ul. Braci Leśnej 3, 05–090 Raszyn, Poland;

[2]Warsaw University of Life Sciences – SGGW, Faculty of Forestry, Department of Forest Zoology and Wildlife Management, ul. Nowoursynowska 159, 02–776 Warszawa, Poland

*Tel. +48 22 7150419, e-mail: j.gryz@ibles.waw.pl

**Abstract.** The aim of the study was to describe the species diversity of small mammals in the western part of the Skierniewice Forest District (Central Poland) using tawny owl (*Strix aluco*) pellets. The landscape itself is a field and forest mosaic with small forest complexes. Four forest complexes with an area between 70 and 750 ha and surrounded by arable lands as well as loosely scattered buildings were chosen to carry out our work in. Owl pellets were collected in the years 2014–2016 and examined for small mammal remains employing standard protocols.

Altogether, we identified 963 items belonging to 17 different mammalian prey species. The most numerous was the yellow-necked mouse, *Apodemus flavicollis*, which accounted for 33.5% of all identified items. As the second most important group, voles (*Microtus* spp.) accounted for 12.8% of all identified mammals. Unfortunately, we were unable to find species considered rare in central Poland, i.e. hazel dormouse, *Muscardinus avellanarius*, European water vole, *Arvicola amphibius* and field vole, *Microtus agrestis*.

In overall, the species composition of small mammal assemblages in the studied area was similar to adjacent regions.

**Keywords:** central Poland, pellets, rodents, soricomorphs

## 1. Introduction

The results of analyzing the food of owls largely reflect the assemblages of small vertebrates occurring in the studied area in terms of quantity and quality, and thus, such analyses are used to research the distribution of fauna, including mainly mammals (Gryz, Krauze 2007; Lesiński et al. 2008; Żmihorski et 2011; Andrade et al. 2015; Heisler et al. 2015). For example, the faunal data from analyzing the food of owls were the basis for developing maps of the occurrence of small mammals throughout Poland in the 1970s (Pucek, Raczyński 1983). Also today, analyzing owl pellets provides data for the Atlas of Mammals in Poland (http://www.iop.krakow.pl/ssaki/Katalog.aspx). For this purpose, the tawny owl *Strix aluco* is particularly suitable, as it is a sedentary and territorial species throughout the year (Mikkola, Willis 1983). The size of its territory ranges from a dozen to several dozen hectares (Redpath 1995; Sunde, Bolstad 2004). This ensures that its prey was hunted near the place where the pellets were found.

The theriofauna of the western part of the Skierniewice Forest District has not been characterized yet, but intensive research has been carried out in the neighbouring areas (Gryz et al. 2011; Lesiński et al. 2014; Gryz, Krauze-Gryz 2015, 2016a,b; Lesiński et al. 2016). This research has found a number of rare species in Central Poland: the European water vole *Arvicola amphibius*, Eurasian water shrew *Neomys fodiens*, hazel dormouse *Muscardinus avellanarius* and field vole *Microtus agrestis*, adding knowledge about their distribution throughout the country. Knowledge of the theriofauna of economically used and protected areas is indispensable for their effective management (Gryz et al. 2017); therefore, the aim of this research was to understand the species diversity of small mammals in the western part of the Skierniewice Forest District.

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## 2. Study area and methods

The research was carried out in the western part of the Skierniewice Forest District. The landscape is a mosaic of small forest complexes surrounded by agricultural areas and extensive buildings. Pellets and the remains of prey were collected in four isolated forest complexes. The Pszczonów, Bażantarnia, and Zwierzyniec complexes were about 3 to 8 km apart, and the Byliny complex was located about 25 km to the south.

Pszczonów (51°56'45.14"N, 19°56'10.40"E) – a forest with an area about 750 ha, located in the forest district of the same name. The dominant forest species is Scots pine *Pinus sylvestris* L., growing mainly in forest habitats. The eastern part of the complex is the source spring area of the Borówka River. Field work was carried out in 2014–2016. Pellets were collected in three regions located in the western and southern parts of the forest, about 1 km apart from each other. The area was located in quadrant 12 Jc of the Atlas of the Mammals of Poland (http://www.iop.krakow.pl/ssaki/).

Uroczysko Bażantarnia (51°56'41.00"N, 20°0'19.79"E) – a highly isolated forest complex with an area of nearly 70 ha. In 1982, most of the complex (45 ha) was protected as a reserve to conserve the forest communities. From the 18th century until the outbreak of the First World War, this area was used for hunting and had the character of a park. The current tree stands, established as the result of natural regeneration and planting, are very diverse in terms of species and structure. The oldest pedunculate oaks, *Quercus robur* L., are up to 250—300 years of age. The reserve has significant areas of wetland habitats overgrown with black alder *Alnus glutinosa* Gaertn. (Rąkowski et al. 2006). Pellets were collected in two closely located sites on the southern edge of the complex. Field work was carried out in 2016. The area was located in quadrant 13Ja of the Atlas of the Mammals of Poland (http://www.iop.krakow.pl/ssaki/).

Zwierzyniec (51°57'1.86"N, 20°6'10.12"E) – a complex with an area of over 600 ha along the western border of the city of Skierniewice. From the 17th century to the First World War, this area was used for hunting. The tree stands grow in fertile, moist habitats and are very diverse. There are numerous plots with deciduous trees reaching 200—300 years of age. There are also meadows, a forest nursery and the buildings of the Skierniewice Forest District within the complex. Numerous watercourses flow through the area, where artificial water reservoirs have been built, and until recently, there was a military training range in its southern part. Currently, the entire area is protected as part of the Royal Zwierzyniec Nature and Landscape Complex. Pellets were collected in 2014–2016 in five locations distributed evenly throughout the complex. The area was located in quadrant 13Ja of the Atlas of the Mammals of Poland (http://www.iop.krakow.pl/ssaki/). Byliny (51°43'41.53"N, 20°8'51.99"E) – a highly fragmented forest complex with an area of over 70 ha, including a 170 m high hill. The forest is surrounded by fish ponds on three sides. The tree stands are formed by Scots pine *P. sylvestris* with an admixture of deciduous species. Pellets were collected in 2016 at a site located in the Chociw Forestry District in the atlas quadrant 13 Ji (http://www.iop.krakow.pl/ssaki/).

Pellets were collected at least twice a year (in the spring-summer and autumn-winter seasons) at each of the sites, so the material can be considered representative for all seasons. Laboratory analyses were based on standard procedures (Raczyński, Ruprecht 1974; Yalden, Morris 1990; Gryz, Krauze 2007). Pellets or parts of them were soaked in water for 12 hours, then individual fractions were separated: bones, fur, feathers, invertebrate debris, plant material. The number of mammals was determined based on the number of right and left jawbones. The number of birds was determined on the basis of skulls, eventually breastbones; in the case of frogs, hip bones were used (*osilium*). Mammalian bone remains were identified on the basis of the Pucek key (1984) and more detailed studies (Ruprecht 1979; Wolff et al. 1980; Ruprecht 1987; Balčiauskienė et al. 2002; Ruprecht, Kościów 2007). The remains of reptiles and fish were identified on the basis of a comparative collection of scales and bones. The results are presented as the percentage share of a given taxon in the total number of identified mammals. In order to comprehensively depict the composition of the food, the number of the remaining prey of owls is presented.

## 3. Results

The most material came from the Zwierzyniec complex, and the least from Byliny. Mammals predominated in the pellets found in the four areas (Table 1). In total, 963 mammals belonging to 17 species were found (Table 2). The share of *Microtus* spp. voles was similar in all areas and ranged from 11 to 16%. The common vole *Microtus arvalis* was most frequently captured by the tawny owl. The exception was the Byliny complex, where the tundra vole *Microtus oeconomus* predominated. The European pine vole *Microtus subterraneus* was found only in the Bażantarnia complex. The share of typical forest species (bank vole *Myodes glareolus* and yellow-necked mouse *Apodemus flavicollis*) was the largest in the Pszczonów complex, where both species accounted for over 70% of the total number of prey. The smallest share of forest rodents was found in the Byliny complex. The striped field mouse *Apodemus agrarius* was scarcely represented (4.4−7.7% share). Most house mice *Mus musculus* taken from the pellets were from the Zwierzyniec complex. The largest share of brown rat *Rattus norvegicus* was found in Byliny (9.7%). The pellets from this area also had a very large share of Eurasian harvest mouse *Micromys minutus*, accounting for 19.4% of all the identified mammals. In the complete analysed material, representatives of the four species of the Soricomorpha order were confirmed, having a total share of 10.1% (Table 2), including three specimens of the Eurasian

**Table 1.** Prey recorded in tawny owl *Strix aluco* pellets (n prey items) in western part of Skierniewice Forest Disrict

| Class | Site | | | | |
|---|---|---|---|---|---|
| | Pszczonów | Bażantarnia | Zwierzyniec | Byliny | Total |
| Mammalia | 252 | 183 | 435 | 93 | 963 |
| Aves | 22 | 37 | 42 | 8 | 109 |
| Reptilia | 1 | | 1 | | 2 |
| Anura | 1 | 53 | 72 | 32 | 158 |
| Actinopterygii | | | 1 | 3 | 4 |
| Insecta | 29 | 40 | 136 | 19 | 224 |
| Total | 305 | 313 | 687 | 155 | 1460 |

**Table 2.** Mammals recorded in tawny owl *Strix aluco* pellets in western part of Skierniewice Forest District

| Prey | Site | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pszczonów | | Bażantarnia | | Zwierzyniec | | Byliny | | Total | |
| | N | % | N | % | N | % | N | % | N | % |
| *M. arvalis* | 23 | 9.1 | 17 | 9.3 | 29 | 6.7 | 4 | 4.3 | 73 | 7.6 |
| *M. oeconomus* | | | 2 | 1.1 | 9 | 2.1 | 9 | 9.7 | 20 | 2.1 |
| *Microtus* spp. | 7 | 2.8 | 4 | 2.2 | 11 | 2.5 | 2 | 2.2 | 24 | 2.5 |
| *M. subterraneus* | | | 6 | 3.3 | | | | | 6 | 0.6 |
| ∑ *Microtus* | 30 | 11.9 | 29 | 15.8 | 49 | 11.3 | 15 | 16.1 | 123 | 12.8 |
| *M. glareolus* | 41 | 16.3 | 69 | 37.7 | 68 | 15.6 | 16 | 17.2 | 194 | 20.1 |
| *A. agrarius* | 11 | 4.4 | 14 | 7.7 | 33 | 7.6 | 7 | 7.5 | 65 | 6.7 |
| *A. flavicollis* | 136 | 54.0 | 32 | 17.5 | 146 | 33.6 | 9 | 9.7 | 323 | 33.5 |
| *A. sylvaticus* | 1 | 0.4 | 5 | 2.7 | 4 | 0.9 | | | 10 | 1.0 |
| *Apodemus* spp. | 24 | 9.5 | 9 | 4.9 | 39 | 9.0 | 6 | 6.5 | 78 | 8.1 |
| *M. musculus* | | | 1 | 0.5 | 16 | 3.7 | | | 17 | 1.8 |
| *M. minutus* | | | 1 | 0.5 | 14 | 3.2 | 18 | 19.4 | 33 | 3.4 |
| *R. norvegicus* | | | 1 | 0.5 | 9 | 2.1 | 9 | 9.7 | 19 | 2.0 |
| *Sciurus vulgaris* | 1 | 0.4 | | | | | | | 1 | 0.1 |
| *S. araneus* | 5 | 2.0 | 10 | 5.5 | 18 | 4.1 | 11 | 11.8 | 44 | 4.6 |
| *S. minutus* | 1 | 0.4 | 1 | 0.5 | 3 | 0.7 | | | 5 | 0.5 |
| *Neomys fodiens* | | | | | 2 | 0.5 | 1 | 1.1 | 3 | 0.3 |
| *T. europaea* | 2 | 0.8 | 9 | 4.9 | 33 | 7.6 | 1 | 1.1 | 45 | 4.7 |
| Chiroptera indet. | | | | | 1 | 0.2 | | | 1 | 0.1 |
| *Mustela nivalis* | | | 2 | 1.1 | | | | | 2 | 0.2 |
| ∑ Mammalia | 252 | 100.0 | 183 | 100.0 | 435 | 100.0 | 93 | 100.0 | 963 | 100.0 |

N – number of individuals, % – percentage share in total number of mammals

**Table 3.** Comparison of share of selected taxa in tawny owl *Strix aluco* pellets in study sites in central Poland: 1 – this study, 2 – Bolimowska Forest (Lesiński et al. 2016a), 3 – Chojnów Landscape Park (Romanowski et al. 2014), 4 – Masovian Landscape Park (southern part) (Lesiński et al. 2016b), 5 – Kampinos National Park (Lesiński et al. 2013), 6 – Rogów Forest District (Gryz, Krauze-Gryz 2016b), 7 – Warsaw (Gryz et al. 2008), 8 – suburban areas of Warsaw (Romanowski et al. 2016)

| Prey | Study site | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| *Sorex araneus* | 4.6 | 12.7 | 16.7 | 12.8 | 23.5 | 2.4 | 4.9 | 4.9 |
| *Neomys fodiens* | 0.3 | 0.1 | 0.7 | | 5.4 | 0.1 | | |
| Chiroptera | 0.1 | 1 | 0.3 | 0.4 | 0.8 | 0.1 | 5.3 | 1.0 |
| *Arvicola amphibius* | | | | | 0.7 | | 0.2 | |
| *Myodes glareolus* | 20.1 | 18.8 | 33.8 | 23.3 | 24.7 | 12.2 | 11.1 | 10.3 |
| *Microtus agrestis* | | | | 4.8 | 4.5 | | | |
| *Mus musculus*+ *Rattus norvegicus* | 3.8 | 7.3 | 1.1 | 3.3 | 3.1 | 4.6 | 16.3 | 10.8 |
| *Muscardinus avellanarius* | | 0.3 | | 2.6 | 1.8 | | | |
| N prey | 963 | 1650 | 1038 | 682 | 7522 | 1239 | 569 | 611 |
| N species | 17 | 24 | 15 | 16 | 29 | 16 | 21 | 15 |

water shrew *Neomys fodiens*, which are rare in Central Poland. In analyzing the collected material, it was impossible to determine the occurrence of the remaining rare species of small mammals: the European water vole (*Arvicola amphibius*), hazel dormouse (*Muscardinus avellanarius*) and field vole.

## 4. Discussion

The obtained results are not very different from the data from the Rogów Forest Inspectorate, adjacent to the research area to the west. In this area, a similar number of species and share of individual taxa were found, with the dominance of the yellow-necked mouse in the food of the tawny owl (Gryz, Krauze-Gryz 2016a, b). The highest species richness of mammals in central Poland, studied by analyzing the tawny owl pellets, was found in Kampinos National Park (KNP) (Table 3). 29 species were identified there, including 9 bats (Lesiński et al. 2013). In the eastern part of the Skierniewice Forest District and adjacent areas, 24 mammalian species were identified, including 8 bat species (Lesiński et al. 2016). The remaining areas where the studies were conducted, that is, the Chojnów Forest District (Romanowski et al. 2014), Warsaw (Gryz et al. 2008, 2017), suburban areas to the southwest of Warsaw (Romanowski et al. 2016), had similar results of rodent and soricomorpha numbers to those obtained in this study. However, the number of bats differed − the number of species found was higher in all areas except for the Rogów Forest District (Gryz, Krauze-Gryz 2016b). Apart from the KNP, no hazel dormice were found in the areas mentioned above. The water vole (one individual) was found only in Wilanów Park in Warsaw. The two remaining rare species, the field vole and Eurasian water shrew, were not found outside the KNP or their share was negligible. The samples collected in the aforementioned studies should be considered representative (Żmihorski et al. 2011). They did not confirm the presence of the hazel dormouse, which was recorded in 2009 in the western part of the Skierniewice Forest District (Lesiński et al. 2016a; Table 3). This site is located near the village of Wólka Łasiecka (Bolimowska Forest), 10 km northeast of the Zwierzyniec complex. The occurrence of this rodent is most likely limited to the dense Bolimowska Forest complex. The hazel dormouse is a species sensitive to habitat fragmentation (Bright et al. 2006; Alessio et al. 2010). The complexes investigated in this study have probably been isolated from the Bolimowska Forest for nearly 400 years, and some tree stands are the result of afforestation of post-agricultural lands, which is not conducive to the occurrence of this rodent. In the case of the water vole, current research has confirmed that it is a rare species in central Poland (Lesiński et al. 2017). This is in accordance with the data from the Atlas of the Mammals of Poland, which is currently being developed (http://www.iop.krakow.pl/ssaki/). The closest large population of this species is found in the Kampinos Forest (Lesiński et al. 2013; Lesiński et al.

2017; Table 3). The remains of two water voles were found in pellets collected in 2002 near the Byliny complex (Gryz et al. 2011), but subsequent intensive studies did not confirm the presence of this rodent. This may indicate the disappearance of the water vole population, probably associated with the expansion of the American mink *Neovison vison* or the degradation of watercourses (Macdonald et al. 2002; Zalewski, Brzeziński 2014).

In summary, the fauna of small mammals in the western part of the Skierniewice Forest District is analogous to the fauna of neighbouring Central Poland with a similar landscape structure.

## Conflict of interest

The authors declare that there are no potential conflicts of interest.

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## Authors' contributions

J.G – concept, field and laboratory work, text preparation; D.K-G – laboratory work, developing the results, text preparation.

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