



Small vertebrates in the diet of the tawny owl *Strix aluco* (Linnaeus 1758) in the Garwolin Forest District

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Abstract: The diet of tawny owl *Strix aluco* was analysed in 10 sites within boundaries of Garwolin Forest District (1,428.9 km²) in Mazowieckie Voivodship (central and eastern Poland) in the years 2015-2022. We collected 1,731 vertebrates, among them 1,519 mammals (87.8%), 60 birds (3.5%), 1 reptile (0.06%) and 151 amphibians (8.7%). Mammals were represented by 20 species: 5 soricomorphs, 1 hedgehog, 3 bats, 11 rodents. Dominating prey-species were bank vole *Clethrionomys glareolus* (18.4% of vertebrates), the yellow-necked mouse *Apodemus flavicollis* (13.2%) and the common vole *Microtus arvalis* (6.1%), which occurred at all sites. Most interesting species were water shrew *Neomys fodiens*, bicoloured white-toothed shrew *Crocodyria leucodon*, greater mouse-eared bat *Myotis myotis* and common dormouse *Muscardinus avellanarius*.

Key words: tawny owl, small mammals, comparative osteology, central Poland

INTRODUCTION

The tawny owl *Strix aluco* Linnaeus 1758 is one of the most common owl species in Poland, and its presence in forests is an important indicator of the health of the ecosystem. In the Garwolin Forest District, located in central Poland, there are various forest habitats that support the development of the tawny owl population. The current data on small mammals in this area are very scarce. The aim of this study was to analyze the diet composition of the tawny owl in this territory in various tree stands and to identify the main food and rare species. Analysis of the tawny owl pellets is non-invasive method that allows the detection of a wide range of species (Gryz & Krauze 2007).

The food of the tawny owl and the occurrence of small mammals in the described area have not been systematically studied so far, unlike the Masovian Landscape Park located to the north (Celestynów Forest District - Lesiński et al. 2016b) and Kozienice Landscape Park located west of the Vistula river (Lesiński & Wojtowicz 2021). The only published data from the Garwolin area concern the eastern end of the forest district (Lesiński & Jobda 2018).

STUDY AREA

The Garwolin Forest District (1,428.9 km²) is located in the Masovian Lowlands, in the south-eastern part of the Masovian Voivodship, and its borders largely coincide with the borders of Garwolin County (1,284 km²). The state forests of the forest district (40%) are located mainly in the southwestern part of the area (Garwolińskie Forests, remnants of the southern part of old historical forest "Puszcza Osiecka"), and in the eastern part private supervised forests (60%) predominate. The forest district covers three geographical mesoregions: the Middle Vistula Valley (partially protected as the Nadwiślański Landscape Protection Area and Natura 2000 site),

the Garwolin Plain and the Żelechów Upland. In the Vistula Valley, pine forests prevail on sandy soils, on the edge of the valley and on the plateau there are tree stands in the habitat of oak-hornbeam forests on moraine formations. Locally, there are riparian forests on the rivers tributaries of the Vistula (Okrzejka, Promnik, Przerytka, Wilga), and alder forests in depressions.

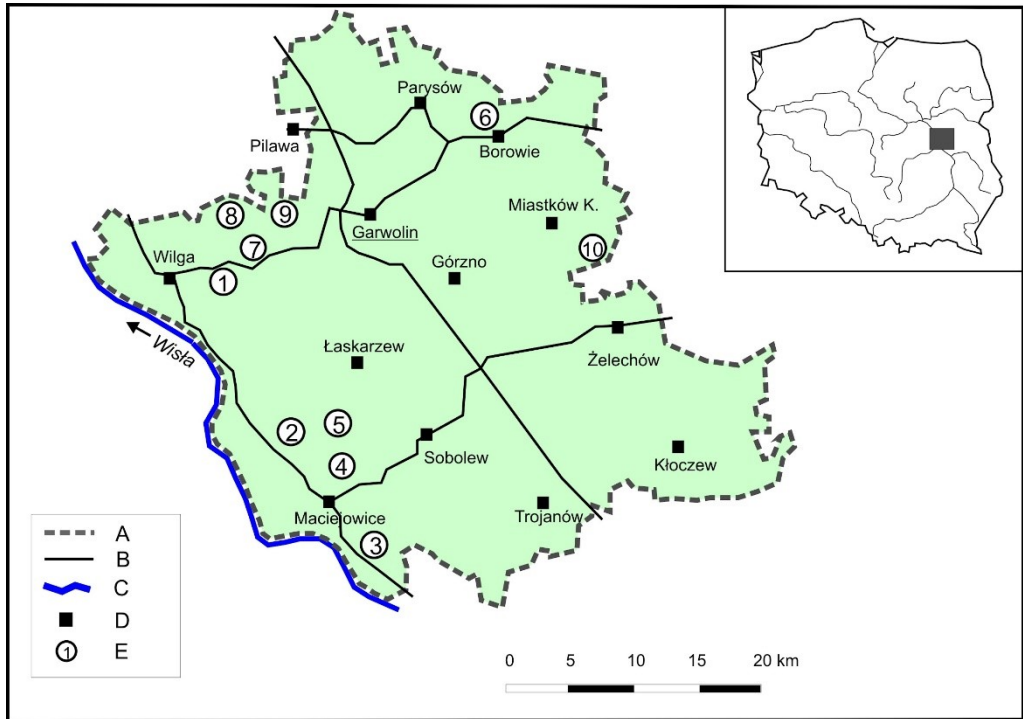


Fig. Study area with distribution of sites where pellets of tawny owl were collected: A – boundaries of Garwolin Forest District, B – main roads, C – main rivers, D – towns and villages, E - study sites.

Table 1. The list of study sites in the Garwolin Forest District and study periods

| No. | Site/UTM plot | Habitat type | Site of pellet collection | Years |
|-----|-----------------------|---|---------------------------|-----------|
| 1. | Cyganówka EC34 | Pine forest near Wilga river | nesting box | 2016–2022 |
| 2. | Domaszew EC33 | Pine forest near road 801 | nesting box | 2016–2022 |
| 3. | Kobylnica EC42 | Pine forest near Przerytka river | nesting box | 2016–2022 |
| 4. | Polik EC43 | Pine forest and pond | nesting box | 2016–2022 |
| 5. | Szkółki Krępskie EC33 | Pine forest | nesting box | 2016–2022 |
| 6. | Borowie EC55 | Oak-hornbeam forest | under trees | 2016 |
| 7. | Budy Uśniackie EC34 | Pine forest | nesting box | 2016–2022 |
| 8. | Uśniaki EC34 | Mixed forest | nesting box | 2016–2022 |
| 9. | Zimna Woda EC35 | Pine forest and pond | nesting box | 2016–2022 |
| 10. | Zwola Poduchowna EC54 | Oak-hornbeam forest and abandoned barn near Wilga river | under trees and in barn | 2015–2016 |

METHODS

Pellets were collected in 10 localities (Fig. & Table 1), mainly from nesting boxes installed in 2016. Additional pellets were found in resting places of tawny owl under trees and in old hay barn on the edge of forest. Pellets were prepared with wet method. Prey species were

Table 2. Small vertebrates in diet of the tawny owl in each site under study in the geographic mesoregions of the Garwolin Forest District.

| No. Prey | Vistula River Valley | | | | | Garwolin Plain | | | | Żelechów Upland | Total N (%) |
|-------------------------------------|----------------------|----------|-----------|-------|------------------|----------------|----------------|---------|------------|------------------|-------------|
| | Cyganówka | Domaszew | Kobylnica | Polik | Szkółki Krępskie | Borowie | Budy Uśniackie | Uśniaki | Zimna Woda | Zwola Poduchowna | |
| 1. <i>Talpa europaea</i> | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 2 | 1 | 4 | 11 (0.6) |
| 2. <i>Sorex araneus</i> | 7 | 18 | 2 | 3 | 6 | 0 | 2 | 5 | 17 | 3 | 63 (3.6) |
| 3. <i>S. minutus</i> | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 7 (0.4) |
| 4. <i>Neomys fodiens</i> | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 (0.1) |
| 5. <i>Crocidura leucodon</i> | 0 | 0 | 1 | 2 | 0 | 1 | 3 | 0 | 0 | 1 | 8 (0.5) |
| 6. <i>Erinaceus sp.</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 (<0.1) |
| 7. <i>Myotis myotis</i> | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 (<0.1) |
| 8. <i>Nyctalus noctula</i> | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (<0.1) |
| 9. <i>Plecotus auritus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 (<0.1) |
| 10. <i>Clethrionomys glareolus</i> | 15 | 26 | 20 | 34 | 40 | 1 | 65 | 25 | 60 | 33 | 319 (18.4) |
| 11. <i>Microtus arvalis</i> | 13 | 16 | 1 | 7 | 5 | 2 | 17 | 10 | 19 | 16 | 106 (6.1) |
| 12. <i>M. oeconomus</i> | 6 | 0 | 1 | 0 | 0 | 0 | 3 | 2 | 3 | 0 | 15 (0.9) |
| 13. <i>M. agrestis</i> | 3 | 0 | 0 | 2 | 1 | 0 | 0 | 3 | 5 | 0 | 14 (0.8) |
| 14. <i>Microtus spp.</i> | 8 | 1 | 0 | 4 | 0 | 0 | 3 | 2 | 3 | 0 | 21 (1.2) |
| 15. <i>Mus musculus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 1 | 0 | 1 | 9 (0.5) |
| 16. <i>Rattus norvegicus</i> | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 5 (0.2) |
| 17. <i>Apodemus agrarius</i> | 6 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 5 | 14 (0.8) |
| 18. <i>A. sylvaticus</i> | 1 | 2 | 3 | 5 | 4 | 0 | 3 | 2 | 2 | 0 | 22 (1.3) |
| 19. <i>A. flavicollis</i> | 24 | 6 | 20 | 17 | 32 | 2 | 48 | 26 | 44 | 10 | 229 (13.2) |
| 20. <i>Apodemus spp.</i> | 106 | 11 | 23 | 30 | 86 | 0 | 89 | 128 | 130 | 35 | 638 (36.9) |
| 21. <i>Micromys minutus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 4 (0.1) |
| 22. <i>Muscardinus avellanarius</i> | 6 | 5 | 0 | 4 | 3 | 0 | 6 | 0 | 3 | 0 | 27 (1.6) |
| 23. Aves | 6 | 4 | 3 | 3 | 4 | 0 | 6 | 7 | 1 | 26 | 60 (3.5) |
| 24. Reptilia | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (<0.1) |
| 25. Anura | 39 | 0 | 16 | 0 | 0 | 0 | 13 | 49 | 3 | 31 | 151 (8.7) |
| Total | 243 | 91 | 92 | 113 | 184 | 7 | 270 | 265 | 293 | 173 | 1731 (100) |

determined based mainly of the features of their skulls/mandibles and only in a few cases based on other characteristic bones. Determining the species of mammals, we used the key edited by Pucek (1984). We calculated Sørensen similarity index $QS=2C/(A+B)$, when C is number of common species and A & B numbers of species in sites A and B. We also estimated Margalef richness index $D=(S-1)/\log N$ where S is the number of species, and N is the total number of individuals.

RESULTS

Remains of 1,731 vertebrates were detected in the processed material: 1,519 mammals (87.8%), 60 birds (3.5%), 1 reptile (0.06%) and 151 amphibians (8.7%). Mammals were represented by 20 species: 5 soricomorphs, 1 hedgehog, 3 bats, 11 rodents (Table 2).

The mammals most frequently caught by the tawny owl were the bank vole (18.4% of vertebrates), the yellow-necked mouse (13.2%) and the common vole (6.1%), which occurred at all sites. The common dormouse was detected at 6 sites, and the bicoloured white-toothed shrew, the field vole and the root vole at 5 sites. Shrews accounted for 5.3% of the prey, rodents 82.3%, the least widespread and least frequently caught mammals were hedgehog 0.06% and bats 0.17%. Among the detected species of mammals, four are under strict legal protection and eight are under partial protection (Regulation 2016). Among frogs dominated common spadefoot *Pelobates fuscus* (Laurenti, 1768) 63.6%.

In total, 15 species of mammals were detected at sites in the Middle Vistula Valley, 16 species on the Garwolin Plain, and 13 on the Żelechów Upland. Sørensen index between Middle Vistula Valley and Garwolin Plain was 0.839, between Vistula Valley and Żelechów Upland 0.643 and between Garwolin Plain and Żelechów Upland 0.759.

SURVEY OF MAMMALS SPECIES

Eulipotyphla - Insectivores

***Talpa europaea* Linnaeus, 1758 – European mole**

Found in seven sites but not often caught by owls. It accounted 0.6 % of mammals in the diet of the tawny owl. Two individuals were regurgitated whole with partially digested anterior part of body.

***Sorex araneus* Linnaeus, 1758 – Common shrew**

One of the most common species of mammals frequently caught by owls. Found in 9 sites.

***Sorex minutus* Linnaeus, 1766 – Pygmy shrew**

Very scarce (0.4%) in comparison with common shrew. Found in five sites

***Neomys fodiens* (Pennant, 1771) – Water shrew**

Extremely scarce (0.1%), found in two places on the territory of Vistula river Valley.

***Crocidura leucodon* (Hermann, 1780) – Bicoloured white-toothed shrew**

Very scarce (0.5%) but found in five sites in three mesoregions.

***Erinaceus sp.*, Linnaeus, 1758 – Hedgehog**

Extremely scarce. Remnants of one individual (needles in pellet and skin flaps to 2 x 5 cm on pile of pellets) were found in site Zwola Poduchowna. Geographical ranges of hedgehogs in Poland suggest it was *Erinaceus roumanicus* (Barret-Hamilton, 1900). Probably hedgehog was not hunted by owl but found death on road.

Chiroptera - Bats

***Myotis myotis* (Borkhausen, 1797) – Greater mouse-eared bat**

One individual was found in Szkółki Krępskie site.

***Nyctalus noctula* (Schreber, 1774) – Noctule bat**

One individual was noted in Kobylnica site.

***Plecotus auritus* (Linnaeus, 1758) – Brown long-eared bat**

One individual was found in Zwola Poduchowna site.

Rodentia – Rodents

***Clethrionomys glareolus* (Schreber, 1870) – Bank vole**

Most common (18.4%) and most frequent species of mammals in the diet of the tawny owl, found in all sites.

***Microtus arvalis* (Pallas, 1779) – Common vole**

The species relatively often caught by tawny owl (6.1%). Present in all sites.

***Microtus agrestis* (Linnaeus, 1761) – Field vole**

Widespread but not very numerous (0.8%). Found in five sites. Occurred predominantly on the Garwolin Plane.

***Microtus oeconomus* [*Alexandromys oeconomus*] (Pallas, 1776) – Root vole**

Widespread but relatively rare (0.9%). Occurred in two sites in the Vistula river Valley and in tree sites on the Garwolin Plane.

***Mus musculus* (Linnaeus, 1758) – House mouse**

Rare, as a species not typical for large forest area. Found in tree sites. Absent in Vistula river Valley.

***Rattus norvegicus* (Berkenhout, 1769) – Brown rat**

Very rare, noted in four sites.

***Apodemus agrarius* (Pallas, 1771) – Striped field mouse**

Relatively rare (0.5%), found in four sites.

***Apodemus sylvaticus* (Linnaeus, 1758) – Wood mouse**

Widespread but relatively rare (1.3%). Detected in eight sites.

***Apodemus flavicollis* (Melchior, 1834) – Yellow-necked mouse**

Most common species from Muridae family (13.2%). Found in all analysed sites.

***Micromys minutus* (Pallas, 1771) – Harvest mouse**

Very rare (0.1%). Found in two places.

***Muscardinus avellanarius* (Linnaeus, 1758) – Common dormouse**

Widespread but relatively rare (1.6%). Was found in six sites situated in two mesoregions.

DISCUSSION

Many authors draw attention to the great ability of the tawny owl to adapt to food depending on the environment and seasonal availability of prey (Mikkola 1983, Lesiński et al. 2013, 2016b, Romanowski et al. 2023). We revealed differences on the level of mesoregion, but habitats in study sites were rather similar. The detection of the bicoloured white-toothed shrew in the Middle Vistula river Valley in sites Kobylnica and Polik marks the new south-western limit of the range

of this species in the Masovian Lowland. Diet of tawny owl from Zwola Poduchowna was very similar to this one from Wola Zadybska (UTM EC53) situated 12 km south (Lesiński & Jobda 2018) with QS 0.889. The absence of the water vole *Arvicola amphibius* (Linnaeus, 1758) and the edible dormouse *Glis glis* (Linnaeus, 1766) in our material (sometimes included in popular and official studies on the Garwolińskie Forests) indicates that they do not occur in the studied area, which was previously indicated in studies covering the entire Masovian Lowland (Lesiński et al. 2016b, 2017). European pine vole *Microtus subterraneus* (de Selys-Longchamps, 1836), which is quite abundant in the western and northern parts of the region and is occasionally caught by the tawny owl in the not too distant Masovian Landscape Park (Lesiński et al. 2016a), was also not detected. The species diversity of mammals, determined by the D index, reached the value of 5.56 in the study area.

In the Mazowiecki Landscape Park, Celestynów Forest District (FD) D-index value was 5.38 (Lesiński et al. 2016a), in Chojnów FD 4.64 (Romanowski et al. 2014). In the most intensively researched Drewnica FD 7.55 (Lesiński 2016, Lesiński et al. 2016b, Stolarz & Lesiński 2024). In the South Mazovian Upland in Spała FD 5.88 (Gryz & Krauze-Gryz 2024), in Rogów FD 4.20 (Gryz & Krauze-Gryz 2016), in Radziwiłłów 4.98 (Lesiński et al. 2016a), in Skierniewice FD 5.36 (Gryz & Krauze-Gryz 2017). In other regions in the forest districts with a large share of deciduous tree stands D-index was 5.2 in Oława FD in Odra river Valley (Gramsz 1991), 5.08 in Świdnik FD (Wiącek et al. 2009) and 7.08 in Białowieża FD outside the national park (Gryz et al. 2012).

The low share of root vole and field vole and the relatively small share of amphibians indicates a little content of peat bogs and swamps in the study area, which was caused by a series of years with low rainfall. The relatively high share of common dormouse may indicate the ongoing regeneration of oak-hornbeam forests in areas previously planted with pine. The very low share of the harvest mouse indicates poor undergrowth in forest and the lack of ecotones and extensively used meadows and fallow lands. In the Mazowiecki Landscape Park (Celestynów FD) the share of this species was much higher (Lesiński et al. 2016a).

CONCLUSIONS

Analysis of the tawny owl's food allows for the detection of most small terrestrial mammals occurring in the study area. Detecting the presence of bats requires examining very large collections of pellets.

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STRESZCZENIE

[Kręgowce w pokarmie puszczyka *Strix aluco* na terenie Nadleśnictwa Garwolin]

W latach 2015–2022 zbadano skład pokarmu puszczyka na 10 stanowiskach na terenach leśnych w różnych rejonach Nadleśnictwa Garwolin. Wykryto 1731 ofiar, w tym 1519 ssaków, 60 ptaków, 1 gada i 151 płazów. Ssaki były reprezentowane przez 20 gatunków. Puszczyk najczęściej łowił nornicę rudą *Clethrionomys glareolus*, mysz leśną *Apodemus flavicollis* i nornika zwyczajnego *Microtus arvalis*. Względnie rzadkie, ale rozpowszechnione były zębiełek białawy *Crocidura leucodon* i orzesznica leszczynowa *Muscardinus avellanarius*. Do najrzadszych ofiar należały rzęsorek rzeczek *Neomys fodiens* i nietoperze, w tym nocek duży *Myotis myotis*.

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