



Small mammals of Kampinos National Park and its protection zone, as revealed by analyses of the diet of tawny owls *Strix aluco* Linnaeus, 1758^(*)

Grzegorz LESIŃSKI¹, Jerzy ROMANOWSKI², Jakub GRYZ³, Adam OLSZEWSKI⁴, Marek KOWALSKI⁵, Dagny KRAUZE-GRYZ⁶, Bogumiła OLECH⁷, Danuta PEPEŁOWSKA-MARCUZAK⁴, Adam TARŁOWSKI⁵

¹University of Life Sciences – SGGW, Nowoursynowska 159 C, 02-787 Warsaw, Poland; e-mail: glesinski@wp.pl

²Faculty of Biology and Environmental Studies UKSW, Wóycickiego 1/3, 01-938 Warsaw, Poland;
e-mail: romanowski@cbe-pan.pl

³Department of Forest Ecology, Forest Research Institute, Sekocin Stary, Braci Leśnej 3, 05-090 Raszyn, Poland;
e-mail: J.Gryz@ibles.waw.pl

⁴Kampinos National Park, Tetmajera 38, 05-080 Izabelin, Poland; e-mails: ad.ol@wp.pl, d.marczak@kampinoski-pn.gov.pl

⁵Wildlife Society „Stork”, Radomska 22/32, 02-323 Warsaw, Poland; e-mails: marek@bocian.org.pl, adam.tarlowski@gmail.com

⁶Department of Forest Zoology and Wildlife Management, Warsaw University of Life Sciences – SGGW, Nowoursynowska 159 C, 02-787 Warsaw, Poland; e-mail: Dagny.Krauze@wl.sggw.pl

⁷Czarnieckiego 45 m. 1, 01-548 Warsaw, Poland; e-mail: buki1@poczta.onet.pl

Abstract: Analyses of tawny owl pellets were used to determine the species composition and distribution of small mammals in Kampinos National Park and its protection zone (central Poland). The total material collected from 58 localities contained the remains of 11,235 vertebrates (including 8,335 mammals). The study revealed 29 species of small mammals of the following orders: Soricomorpha – 4, Chiroptera – 9, Rodentia – 14, Lagomorpha – 1 and Carnivora – 1. These included two bat species of special interest (*Myotis myotis* and *Barbastella barbastellus*) listed in the 2nd Annex to the Habitats Directive of the European Union. *Muscardinus avellanarius*, a rodent typical of broad-leaved woodland, appeared to be relatively common and abundant in suitable habitats. Species inhabiting wet habitats, *Microtus oeconomus* and *Neomys fodiens*, were found in many localities, whereas *Arvicola amphibius* was rarer and less abundant. Some important refuges of small mammals were found, mostly in strictly protected areas. Although the studies conducted to date in this area likely reveal a complete list of small species of Soricomorpha and Rodentia, it is possible that 3-5 species of Chiroptera and 2 small species of Carnivora may remain to be identified.

Key words: Soricomorpha, Chiroptera, Rodentia, Lagomorpha, Carnivora, pellet analysis, tawny owl, central Poland

INTRODUCTION

Kampinos National Park with its protected zone is situated close to a large scientific centre, Warsaw, and has been an area of intensive zoological study for some decades, with many studies focussing on the small mammals of the area. Studies on bats conducted in the late 1980s and early 1990s revealed the presence of 12 species (Kowalski & Lesiński 1995), and three species were subsequently discovered (Lesiński 2003, Lesiński et al. 2011). Although the communities of small ground-dwelling mammals have largely been identified through ecological studies based on live trapping (Andrzejewski et al. 1978, Adamczyk et al. 1988, Lesiński et al. 1990, Łopucki et al. 2007), a substantial amount of information on the species

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composition of small mammals has been presented by Romanowski (1988), Goszczyński et al. (1993), Żmihorski (2005), Romanowski & Żmihorski (2006, 2008, 2009) and Lesiński & Gryz (2012) as a result of owl pellet analyses. Andrzejewski (2003) and Danyłow et al. (2012) summarised data regarding this group from Kampinos National Park. Thus far, one species of Erinaceomorpha, four species of Soricomorpha and 13 species of Rodentia have been reported.

Regardless, there remains too little information about the distribution of each species and their main refuges in this area and the structure of their communities in various habitats. Indeed, some areas remain under high anthropogenic pressure, which should strongly influence the structure of small mammal communities. The aim of this study was to obtain data on localities of small mammals in the Park and its protection zone. Taking into account that many parts of the area are highly transformed by human activity, we attempted to assess how this pressure affects the occurrence of small mammals.

STUDY AREA, MATERIAL AND METHODS

The study was conducted in the Kampinos Forest near Warsaw in central Poland (Fig. 1). A large part of this area (38,548 ha) is protected as a national park that was established in 1959 to preserve a landscape in which two broad latitudinal belts of dunes covered by forest are separated by open wetlands. The forest cover of Kampinos National Park is approx. 73%. The Park lies in the Vistula River basin, and its waterway network is substantially transformed anthropogenically; no vast, natural water bodies are present. In some places, permanent water bodies derived from underground water are present, and there are also hollows with stagnant water in the complex of belts of dunes and system of inter-dune cavities. The large open and forested areas are periodically flooded in March/April; long-term droughts occur in summer when the water flow is at its lowest (Andrzejewska et al. 2012). The dunes are covered mostly by pure and mixed coniferous forest; broad-leaved forests and alder forests occur in the lower parts and in swamps. The most numerous tree species covering the dunes are Scots pine *Pinus sylvestris* Linnaeus, 1753 and oaks *Quercus spp.*, birches *Betula spp.* and black alder *Alnus glutinosa* (Linnaeus, 1753) also play an important role in tree stands. The open areas are mostly meadows, including wet and marshy meadows and sedge-dominated wetlands but also xerothermic grasslands and other dune plant communities. A total of 151 plant communities have been recorded in the Park, with a prevalence of forest and shrubland (Andrzejewska et al. 2010).

In the protection zone are mostly cultivated fields and human settlements. The northern and eastern borders of the study area are delineated by the Vistula River, with its valley covered mostly by meadows or riparian forests. The western border lies on the Bzura River. In the south, the study area is bordered by the road between Warsaw and Sochaczew (Fig. 1).

The pellets of tawny owls *Strix aluco* Linnaeus, 1758 were collected in 58 localities (Fig. 1) between 1980-2012 from under trees that were used as breeding or roosting sites (40), boxes for tawny owls (12) and abandoned residential buildings or barns (6). The total number of vertebrate prey items was 11,235 (mammalian prey accounted for 8,335 individuals).

A standard method of pellet analysis was used. The material was rinsed with water, and the identified bone elements were collected, mostly consisting of skulls and mandibles but also humerus bones for moles *Talpa europaea* Linnaeus, 1758. We used the keys of Pucek (1984) and Ruprecht (1987) to determine the species. A reference collection of skulls helped to confirm the preliminary determination, which was particularly useful in the case of bats.

The localities were usually named with regard to the neighbouring villages; a range or forest district with compartment number were used for sites located in the forest interior. In the latter case, the names of forest divisions were abbreviated (KA – Kampinos, KR – Kromków, LA – Laski).

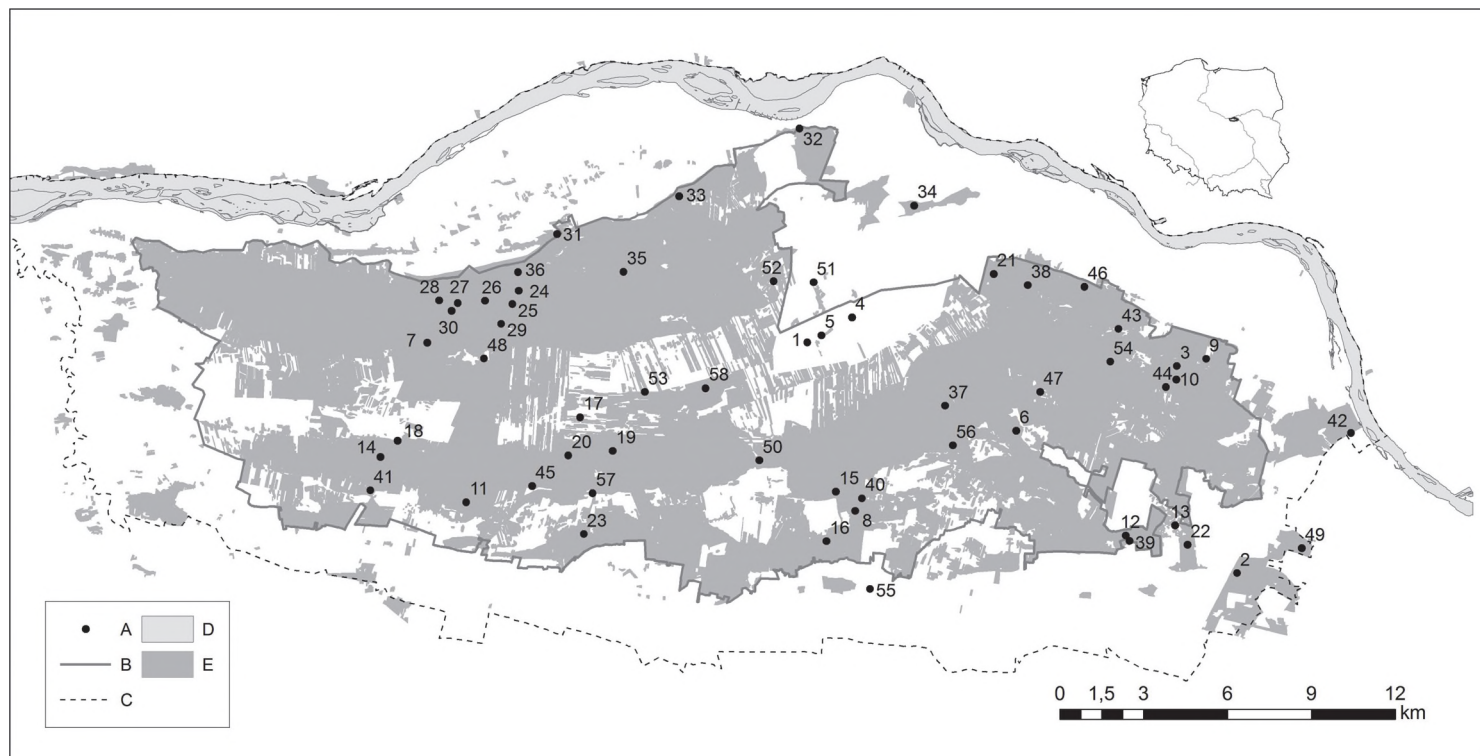


Fig. 1. Study area indicating sites of pellet collection. A – study sites: 1 – Aleksandrów, 2 – Bemowo, 3 – Biały Grąd, 4 – Brzozówka E, 5 – Brzozówka N, 6 – Cyganka, 7 – Dąb Kobendzy, 8 – Debly, 9 – Dziekanów Leśny, 10 – Grabowy Grąd, 11 – Granica, 12 – Hornówek, 13 – Izabelin, 14 – KA 101, 15 – KA 240, 16 – 251, 17 – KA 294, 18 – KA 66, 19 – KA 79, 20 – KA 83, 21 – Kaliszki, 22 – Klaudyn, 23 – Korfowe, 24 – KR 103, 25 – KR 104, 26 – KR 106, 27 – KR 110, 29 – KR 156, 30 – KR 160, 31 – KR 20, 32 – KR 217, 33 – KR 4, 34 – KR 400, 35 – KR 48, 36 – KR 56, 37 – LA 154, 38 – LA 24, 39 – Lipków, 40 – Lawy, 41 – Łazy Leśne, 42 – Młociny Park, 43 – Młynisko, 44 – Na Miny, 45 – Nart, 46 – Palmiry Lomna, 47 – Pocięcha, 48 – Posada Demboskie, 49 – Radiowo, 50 – Roztoka, 51 – Sowa Wola, 52 – Sowa Wola Folwarczna, 53 – Stara Dąbrowa, 54 – Wywrotnia Góra, 55 – Zaborów, 56 – Zaborów Leśny, 57 – Zameczysko, 58 – Żurawiove, B – borders of Kampinos National Park, C – borders of the study area, D – Vistula river, E – forests.

RESULTS

In this study, we confirmed the presence of 29 species belonging to five orders: Soricomorpha (4 species), Chiroptera (9), Rodentia (14), Lagomorpha (1) and Carnivora (1). The first date of pellet collection, with the respective number of individuals (in brackets), is presented in the list of localities.

Soricomorpha

Mole – *Talpa europaea* Linnaeus, 1758

21 localities: Cyganka: 12 III 2012 (1), Grabowy Grąd: 20 I 1982 (1), Izabelin: 2 V 2012 (1), KA 66: 10 II 2000 (1), KA 83: IV 2003 (1), Kaliszki: 18 VII 1984 (1), Korfowe: 12 VII 1999 (1), KR 103: 17 IX 2009 (1), KR 106: 23 IV 2009 (1), KR 108: 4 V 2011 (2), KR 156: 26 IV 2012 (1), Lipków: 26 IV 1982 (1), Ławy: 5 IV 2012 (1), Młociny Park: 25 V 1983 (7), Młynisko: 25 V 1983 (1), Na Miny: 3 X 2011 (7), Posada Demboskie: 31 III 2000 (2), Roztoka: 10 I 2012 (1), Sowie Wola Folwarczna: 27 VI 1996 (1), Wywrotnia Góra: III 2003 (1), Zaborów Leśny: 27 V 1995 (10).

Common shrew – *Sorex araneus* Linnaeus, 1758

37 localities: Aleksandrów: VI 2008 (8), Biały Grąd: 12 V 1983 (3), Brzozówka E: X 2006 (1), Brzozówka N: 10 III 2012 (1), Cyganka: 12 III 2012 (44), Dąb Kobendzy: 19 IV 1983 (14), Dziekanów Leśny: 23 III 1982 (4), Grabowy Grąd: 22 VI 1982 (46), Granica: VII 2004 (1), Izabelin: 2 V 2012 (23), KA 66: 10 II 2000 (4), KA 83: IV 2003 (4), Kaliszki: 18 VII 1984 (16), Korfowe: 12 VII 1999 (16), KR 20: 6 X 2011 (15), KR 56: 6 X 2011 (30), KR 103: 26 IV 2008 (2), KR 104: 23 IV 2009 (1), KR 106: 19 III 2008 (1), KR 108: 4 V 2011 (5), KR 110: 26 IV 2012 (7), KR 156: 23 IV 2009 (5), KR 160: 17 IX 2009 (1), KR 217: 19 V 2010 (1), KR 400: 7 V 2010 (1), LA 154: 25 IV 1993 (8), Łazy Leśne: 11 IV 2012 (8), Młociny Park: 25 V 1983 (7), Młynisko: 25 V 1983 (16), Na Miny: 3 X 2011 (146), Nart: 2 III 1984 (1), Palmiry-Łomna: 18 VII 1984 (2), Posada Demboskie: 4 VIII 1989 (4), Roztoka: 10 I 2012 (37), Sowie Wola Folwarczna: 27 VI 1996 (66), Wywrotnia Góra: 18 X 1994 (5), Zaborów Leśny: 13 VIII 1980 (1).

Lesser shrew – *Sorex minutus* Linnaeus, 1766

32 localities: Brzozówka N: 10 III 2012 (1), Cyganka: 12 III 2012 (12), Dąb Kobendzy: 19 IV 1983 (8), Dziekanów Leśny: 20 II 1984 (2), Grabowy Grąd: 22 VI 1982 (26), Granica: VII 2004 (1), Izabelin: 2 V 2012 (1), KA 83: XI 2004 (1), KA240: 10 III 1999 (1), Kaliszki: 18 VII 1984 (2), Korfowe: 12 VII 1999 (6), KR 20: 6 X 2011 (1), KR 56: 6 X 2011 (10), KR 103: 26 IV 2008 (3), KR 104: 26 IV 2008 (1), KR 106: 19 III 2008 (2), KR 108: 4 V 2011 (2), KR 110: 26 IV 2012 (7), KR 156: 23 IV 2009 (4), KR 160: 4 V 2011 (1), LA 154: 25 IV 1993 (2), Lipków: 26 IV 1982 (2), Łazy Leśne: 11 IV 2012 (1), Młociny Park: 12 IV 2008 (1), Młynisko: 25 V 1983 (14), Na Miny: 3 X 2011 (24), Nart: 2 III 1984 (3), Posada Demboskie: 4 VIII 1989 (1), Roztoka: 10 I 2012 (4), Sowie Wola Folwarczna: 27 VI 1996 (25), Wywrotnia Góra: 18 X 1994 (1), Zaborów Leśny: 27 V 1995 (2).

European water shrew – *Neomys fodiens* (Pennant, 1771)

20 localities: Brzozówka N: 10 III 2012 (2), Cyganka: 12 III 2012 (2), Dąb Kobendzy: 16 III 2012 (30), Dziekanów Leśny: 23 III 1982 (3), Grabowy Grąd: 22 VI 1982 (68), KA 66: 10 II 2000 (3), Kaliszki: 8 XI 2011 (1), Korfowe: 12 VII 1999 (1), KR 103: 26 IV 2008 (1), KR 106: 4 V 2011 (2), KR 156: 4 V 2011 (1), Łazy Leśne: 11 IV 2012 (4), Młociny Park: 22 II 1984 (1), Młynisko: 25 V 1983 (36), Na Miny: 3 X 2011 (4), Pocięcha: 7 III 2012 (1), Posada Demboskie: 31 III 2000 (1), Roztoka: 10 I 2012 (3), Zaborów Leśny: 27 V 1995 (3), Zamczysko: 16 IV 2012 (4).

In the food of owls *Sorex araneus* was the most common and abundant within the order Soricomorpha. The remaining three species from this group were not frequently captured by owls, though *Sorex minutus* was relatively common. *Neomys fodiens* occurred in various parts of Kampinos Forest (Fig. 2) but showed a high contribution to small mammal communities only in a few localities. *N. fodiens* was particularly abundant in the wet habitats of “Sieraków”, a strictly protected area: Młynisko – 31.1% of mammalian prey (N=135), Grabowy Grąd – 25.7% (N=448) and Na Miny – 12.5% (N=1,349).

Chiroptera

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

1 locality: KR 156: 17 IX 2009 (1).

Natterer’s bat – *Myotis nattereri* (Kuhl, 1817)

2 localities: Dziekanów Leśny: 22 VI 2011 (1), Roztoka: 3 IV 2012 (1).

Brandt’s bat – *Myotis brandtii* (Eversmann, 1845)

1 locality: Sowie Wola Folwarczna: 27 VI 1996 (1).

Parti-coloured bat – *Vespertilio murinus* Linnaeus, 1758

2 localities: Roztoka: 10 I 2012 (1), Sowie Wola Folwarczna: 15 IV 1997 (1).

Serotine bat – *Eptesicus serotinus* (Schreber, 1774)

3 localities: KR 104: 4 V 2011 (1), Posada Demboskie: 4 VIII 1989 (1), Sowie Wola Folwarczna: 30 V 2005 (7).

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

8 localities: Izabelin: 7 VIII 2012 (1), Kaliszki: 8 XI 2011 (1), KR 103: 17 IX 2009 (1), KR 156: 26 IV 2012 (1), KR 400: 7 V 2010 (1), Młociny Park: 28 III 2008 (1), Młynisko: 8 IX 1984 (1), Sowie Wola Folwarczna: 23 VI 2000 (1).

Nathusius’ pipistrelle – *Pipistrellus nathusii* (Keyserling & Blasius, 1839)

2 localities: Młociny Park: 23 VII 2009 (1), Na Miny: 10 X 2012 (1).

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

5 localities: Dziekanów Leśny: 20 VI 2000 (1), Młociny Park: 9 IV 2010 (1), Posada Demboskie: 12 X 1995 (1), Roztoka: 10 I 2012 (1), Sowie Wola Folwarczna: 27 VI 1996 (1).

Barbastelle bat – *Barbastella barbastellus* (Schreber, 1774)

3 localities: Kaliszki: 8 XI 2011 (1), KR 156: 4 V 2011 (1), Sowie Wola Folwarczna: 15 IV 1997 (1).

Bats were represented by 62 individuals belonging to 9 species. The commonly captured *Nyctalus noctula* and *Plecotus auritus* were found in different parts of the study area. *Eptesicus serotinus* and *Barbastella barbastellus* occurred in three localities. *Vespertilio murinus* was discovered in the western part, while *Pipistrellus nathusii* in the eastern part of Kampinos Forest. The remaining species were found in only a few localities.

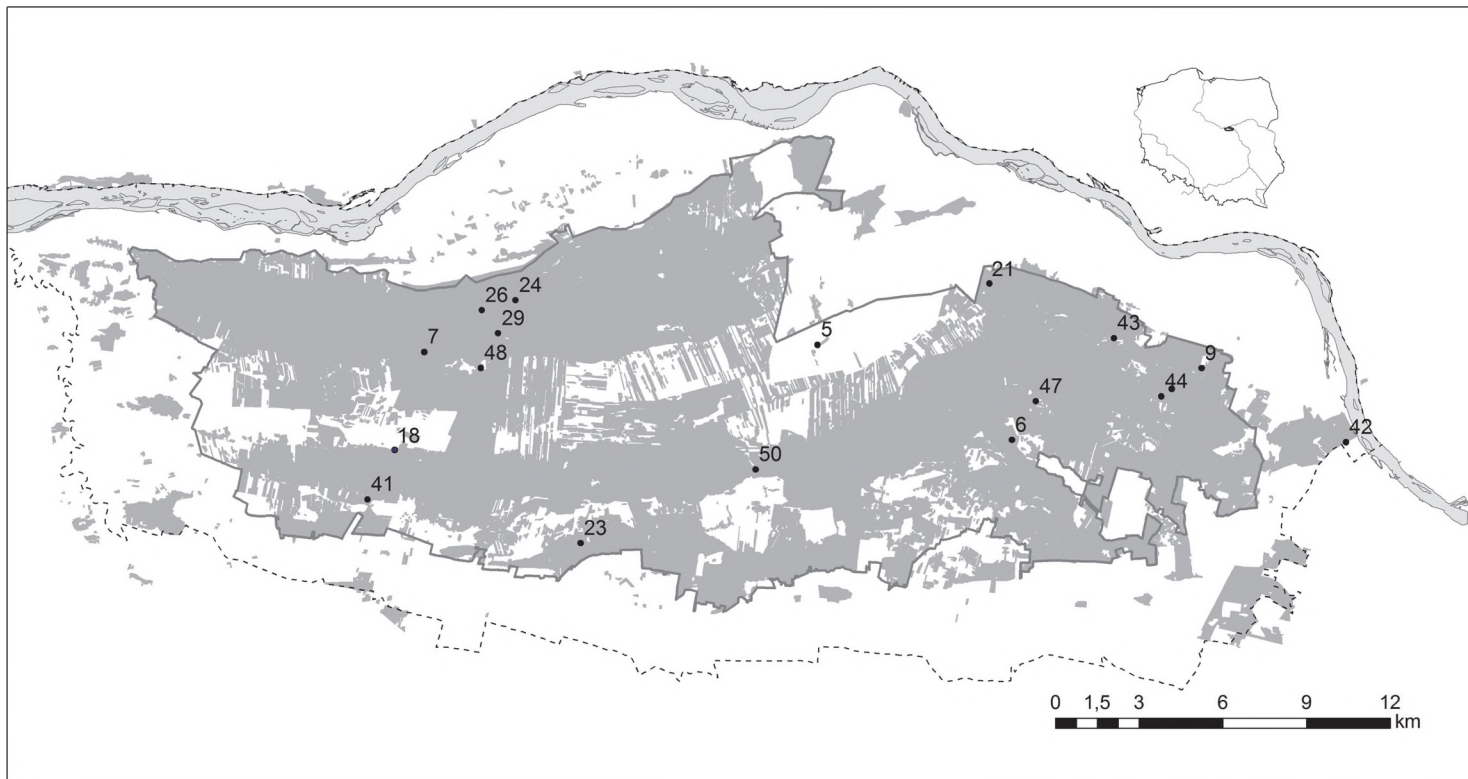


Fig. 2. Localities of *Neomys fodiens* in the study area. For explanations see Fig. 1.

Rodentia

Bank vole – *Myodes glareolus* (Schreber, 1780)

48 localities: Bemowo: 9 X 1998 (3), Biały Grąd: 12 V 1983 (2), Brzozówka E: X 2006 (1), Brzozówka N: 1 V 2012 (1), Cyganka: 12 III 2012 (16), Dąb Kobendzy: 19 IV 1983 (3), Debły: 1 VII 2011 (1), Dziekanów Leśny: 23 III 1982 (4), Grabowy Grąd: 22 VI 1982 (5), Izabelin: 2 V 2012 (3), KA 66: 10 II 2000 (25), KA 83: IV 2003 (15), KA 101: 16 III 1995 (2), KA 240: 10 III 1999 (8), KA 251: 10 III 1983 (4), Kaliszki: 18 VII 1984 (4), Klaudyn: 12 X 2011 (1), Korfowe: 12 VII 1999 (98), KR 20: 6 X 2011 (3), KR 48: 22 III 1991 (7), KR 56: 19 III 2008 (3), KR 103: 26 IV 2008 (5), KR 104: 19 III 2008 (12), KR 106: 19 III 2008 (9), KR 108: 7 V 2010 (2), KR 110: 26 IV 2012 (16), KR 156: 26 IV 2008 (1), KR 160: 17 IX 2009 (1), KR 217: 19 V 2010 (2), KR 400: 7 V 2010 (1), LA24: 16 III 2002 (3), LA154: 25 IV 1993 (2), Lipków: 26 IV 1982 (17), Łazy Leśne: 11 IV 2012 (3), Młociny Park: 25 V 1983 (3), Młynisko: 25 V 1983 (7), Na Miny: 3 X 2011 (84), Nart: 2 III 1984 (41), Palmiry-Łomna: 18 VII 1984 (4), Pocięcha: 7 III 2012 (3), Posada Demboskie: 4 VIII 1989 (8), Radiowo: 30 VIII 1992 (2), Roztoka: 10 I 2012 (7), Sowa Wola Folwarczna: 27 VI 1996 (49), Wywrotnia Góra: 18 X 1994 (17), Zaborów Leśny: 25 IV 1982 (3), Zamczysko: 2 III 1984 (5), Żurawiewo: 6 IV 2005 (1).

Water vole – *Arvicola amphibius* (Linnaeus, 1758)

16 localities: Brzozówka N: 3 IV 2012 (1), Cyganka: 12 III 2012 (1), Dąb Kobendzy: 16 III 2012 (1), Grabowy Grąd: 22 VI 1982 (5), Izabelin: 2 V 2012 (1), KA 83: IV 2003 (1), Kaliszki: 8 XI 2011 (1), Korfowe: 12 VII 1999 (2), Ławy: 3 VI 2012 (2), Łazy Leśne: 11 IV 2012 (2), Młynisko: 25 V 1983 (1), Na Miny: 3 X 2011 (2), Palmiry-Łomna: 18 VII 1984 (1), Posada Demboskie: 31 III 2000 (2), Roztoka: 12 IX 2012 (1), Stara Dąbrowa: 3 V 2012 (1).

European pine vole – *Microtus subterraneus* (de Selys-Longchamps, 1836)

10 localities: Bemowo: 9 X 1998 (1), Dąb Kobendzy: 19 IV 1983 (3), KA 251: 30 III 2007 (6), KR 160: 26 IV 2012 (1), Krzywa Góra: X 2005 (2), Młociny Park: 25 V 1983 (1), Posada Demboskie: 31 III 2000 (4), Roztoka: VI 2010 (1), Wywrotnia Góra: III 2003 (1), Zaborów Leśny: 27 V 1995 (1).

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

28 localities: Aleksandrów: VI 2008 (2), Brzozówka N: 1 V 2012 (1), Dziekanów Leśny: 23 III 1982 (3), Grabowy Grąd: 22 VI 1982 (2), Izabelin: 2 V 2012 (9), KA 83: IV 2003 (2), KA 251: 30 III 2007 (1), Kaliszki: 18 VII 1984 (2), Korfowe: 12 VII 1999 (11), KR 20: 6 X 2011 (2), KR 56: 19 III 2008 (1), KR 103: 17 IX 2009 (1), KR 104: 19 III 2008 (1), KR 106: 4 V 2011 (4), KR 160: 7 V 2010 (1), KR 217: 6 X 2011 (1), KR 400: 7 V 2010 (1), Lipków: 26 IV 1982 (8), Młociny Park: 25 V 1983 (2), Młynisko: 22 VI 1983 (3), Nart: 2 III 1984 (2), Palmiry-Łomna: 18 VII 1984 (6), Posada Demboskie: 4 VIII 1989 (3), Radiowo 30 VIII 1992 (1), Roztoka: 12 IX 2012 (3), Sowa Wola Folwarczna: 7 IV 1994 (9), Wywrotnia Góra: 18 X 1994 (5), Zaborów Leśny: 25 IV 1982 (15).

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

24 localities: Cyganka: 12 III 2012 (2), Dąb Kobendzy: 6 X 2007 (2), Dziekanów Leśny: 23 III 1982 (2), Grabowy Grąd: 22 VI 1982 (4), KA 83: IV 2003 (1), KA 251: 10 III 1983 (3), Kaliszki: 18 VII 1984 (3), Korfowe: 12 VII 1999 (8), KR 56: 6 X 2011 (1), KR 104: 4 V 2011 (2), KR 106: 4 V 2011 (1), KR 110: 26 IV 2012 (6), KR 156: 17 IX 2009 (1), LA 154: 25 IV 1993 (1), Łazy Leśne: 11 IV 2012 (3), Młynisko: 25 V 1983 (1), Na Miny: 3 X 2011 (56), Nart: 2

III 1984 (11), Pociecha: 7 III 2012 (1), Posada Demboskie: 12 X 1995 (1), Sowia Wola Folwarczna: 27 VI 1996 (4), Wywrotnia Góra: 26 II 1995 (3), Zaborów Leśny: 25 IV 1982 (1), Zamczysko: 2 III 1984 (1).

Root vole – *Microtus oeconomus* (Pallas, 1776)

32 localities: Brzozówka N: 1 V 2012 (1), Cyganka: 12 III 2012 (4), Dąb Kobendzy: 7 VIII 1994 (1), Dziekanów Leśny: 12 IV 1984 (6), Grabowy Grąd: 20 I 1982 (3), Izabelin: 2 V 2012 (13), KA 66: 10 II 2000 (12), KA 83: IV 2003 (1), KA 240: 10 III 1999 (2), KA 251: 10 III 1983 (1), Kaliszki: 18 VII 1984 (1), Korfowe: 12 VII 1999 (19), KR 103: 4 V 2011 (1), KR 106: 23 IV 2009 (1), KR 108: 26 IV 2008 (1), KR 156: 17 IX 2009 (1), KR 160: 4 V 2011 (3), KR 217: 6 X 2011 (2), LA 154: 25 IV 1993 (1), Lipków: 26 IV 1982 (3), Łazy Leśne: 11 IV 2012 (6), Młociny Park: 25 V 1983 (1), Młynisko: 25 V 1983 (2), Na Miny: 3 X 2011 (2), Nart: 2 III 1984 (4), Posada Demboskie: 4 VIII 1989 (3), Roztoka: 10 I 2012 (4), Sowia Wola: 13 VII 2012 (1), Sowia Wola Folwarczna: 7 IV 1994 (3), Wywrotnia Góra: 18 X 1994 (4), Zaborów Leśny: 25 IV 1982 (16), Żurawiove: 6 IV 2005 (1).

Western house mouse – *Mus musculus* Linnaeus, 1758

19 localities: Aleksandrów: VI 2008 (1), Brzozówka N: 4 XI 2012 (1), Cyganka: 12 III 2012 (1), Dziekanów Leśny: 12 IV 1984 (4), Izabelin: 2 V 2012 (8), KA 83: 7 IV 2005 (1), Kaliszki: 18 VII 1984 (2), Korfowe: 12 VII 1999 (13), KR 20: 6 X 2011 (6), KR 104: 6 X 2011 (1), KR 106: 23 IV 2009 (1), Lipków: 26 IV 1982 (1), Młynisko: 25 V 1983 (1), Na Miny: 3 X 2011 (1), Posada Demboskie: 19 II 1990 (1), Radiowo: 30 VIII 1992 (1), Roztoka: 10 I 2012 (1), Sowia Wola Folwarczna: 7 IV 1994 (1), Zaborów Leśny: 23 II 1984 (3).

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

13 localities: Dziekanów Leśny: 20 VI 2000 (1), Grabowy Grąd: 22 VI 1982 (1), Izabelin: 2 V 2012 (1), KA 83: IV 2003 (1), KA 251: 30 III 2007 (1), Kaliszki: 18 IX 2012 (1), KR 106: 4 V 2011 (1), KR 160: 4 V 2011 (2), Lipków: 26 IV 1982 (1), Młociny Park: 28 III 2008 (1), Posada Demboskie: 4 VIII 1989 (2), Roztoka: 10 I 2012 (1), Sowia Wola Folwarczna: 27 VI 1996 (9).

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

25 localities: Aleksandrów: VI 2008 (1), Bemowo: 9 X 1998 (1), Brzozówka N: 31 XII 2012 (6), Dąb Kobendzy: 7 VIII 1994 (1), Dziekanów Leśny: 23 III 1982 (1), Grabowy Grąd: V 1983 (1), Izabelin: 2 V 2012 (3), KA 66: 10 II 2000 (1), KA 83: 7 IV 2005 (2), KA 251: 30 III 2007 (7), Kaliszki: 8 XI 2011 (2), Korfowe: 12 VII 1999 (4), KR 20: 4 V 2011 (15), KR 106: 23 IV 2009 (1), KR 108: 4 V 2011 (1), KR 156: 4 V 2011 (2), KR 160: 4 V 2011 (2), Lipków: 11 II 1983 (3), Młociny Park: 9 II 1984 (7), Młynisko: 25 V 1983 (1), Posada Demboskie: 3 VI 1996 (1), Radiowo: 30 VIII 1992 (1), Sowia Wola Folwarczna: 27 VI 1996 (20), Wywrotnia Góra: III 2003 (1), Zaborów Leśny: 23 II 1984 (1).

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

21 localities: Brzozówka E: X 2006 (1), Dąb Kobendzy: 7 VIII 1994 (2), Dziekanów Leśny: 23 III 1982 (1), Grabowy Grąd: 28 IV 1983 (1), Hornówek: 14 IV 1994 (2), KA 79: 16 IV 1994 (1), KA 83: XI 2004 (1), KA 101: 16 III 1995 (1), Kaliszki: 18 VII 1984 (1), Korfowe: 12 VII 1999 (5), KR 48: 22 III 1991 (1), KR 108: 4 V 2011 (1), KR 156: 4 V 2011 (3), KR 160: 4 V 2011 (1), Lipków: 26 IV 1982 (2), Nart: 2 III 1984 (2), Palmiry-Łomna: 18 VII 1984 (3), Posada Demboskie: 4 VIII 1989 (3), Sowia Wola Folwarczna: 7 IV 1994 (1), Wywrotnia Góra: 18 X 1994 (5), Zaborów Leśny: 23 II 1984 (2).

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

35 localities: Biały Grąd: 12 V 1983 (4), Brzozówka N: 4 XI 2012 (1), Cyganka: 12 III 2012 (5), Dąb Kobendzy: 7 VIII 1994 (2), Dziekanów Leśny: 20 II 1984 (4), Grabowy Grąd: 22 VI 1982 (1), Granica: VII 2004 (1), Izabelin: 7 VIII 2012 (3), KA 83: IV 2003 (2), KA 240: 10 III 1999 (3), Kaliszki: 8 XI 2011 (4), Korfowe: 12 VII 1999 (20), KR 20: 6 X 2011 (1), KR 56: 6 X 2011 (2), KR 103: 6 X 2011 (4), KR 104: 7 V 2010 (2), KR 106: 19 III 2008 (1), KR 108: 4 V 2011 (3), KR 110: 26 IV 2012 (3), KR 156: 26 IV 2008 (1), KR 160: 4 V 2011 (1), KR 217: 19 V 2010 (1), Lipków: 11 II 1983 (1), Łazy Leśne: 11 IV 2012 (3), Młociny Park: 25 V 1983 (2), Młynisko: 25 V 1983 (2), Na Miny: 3 X 2011 (22), Nart: 2 III 1984 (8), Palmiry-Łomna: 18 VII 1984 (3), Pocięcha: 7 III 2012 (1), Posada Demboskie: 4 VIII 1989 (5), Roztoka: 10 I 2012 (2), Sowia Wola Folwarczna: 7 IV 1994 (1), Wywrotnia Góra: 18 X 1994 (5), Zaborów Leśny: 13 VIII 1980 (1).

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

29 localities: Brzozówka N: 10 III 2012 (6), Cyganka: 12 III 2012 (1), Dąb Kobendzy: 16 III 2012 (2), Dziekanów Leśny: 23 III 1982 (2), Grabowy Grąd: I 1983 (2), Izabelin: 2 V 2012 (7), KA 66: 10 II 2000 (4), KA 83: 4 V 2011 (8), KA 251: 30 III 2007 (5), Kaliszki: 8 XI 2011 (1), Korfowe: 12 VII 1999 (11), KR 4: 13 IV 2012 (2), KR 103: 26 IV 2012 (1), KR 104: 19 III 2008 (2), KR 106: 23 IV 2009 (2), KR 108: 4 V 2011 (1), KR 110: 26 IV 2012 (3), KR 156: 23 IV 2009 (1), KR 160: 4 V 2011 (1), Lipków: 26 IV 1982 (1), Ławy: 5 IV 2012 (1), Młociny Park: 9 II 1984 (2), Młynisko: 22 VI 1983 (2), Na Miny: 3 X 2011 (7), Posada Demboskie: 19 II 1990 (1), Roztoka: VI 2010 (2), Sowia Wola Folwarczna: 27 VI 1996 (46), Wywrotnia Góra: 18 X 1994 (1), Zaborów Leśny: 27 V 1995 (16).

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

20 localities: Biały Grąd: 12 V 1983 (1), Cyganka: 12 III 2012 (5), Dziekanów Leśny: 20 VI 2000 (1), Grabowy Grąd: V 1983 (1), KA 83: IV 2003 (5), Kaliszki: 18 IX 2012 (1), Korfowe: 12 VII 1999 (5), KR 103: 4 V 2011 (2), KR 104: 23 IV 2009 (1), KR 106: 23 IV 2009 (1), KR 108: 4 V 2011 (2), KR 156: 23 IV 2009 (1), KR 160: 4 V 2011 (1), Młynisko: 25 V 1983 (1), Na Miny: 3 X 2011 (8), Posada Demboskie: 28 IV 1992 (1), Roztoka: 10 I 2012 (2), Sowia Wola Folwarczna: 7 IV 1994 (2), Wywrotnia Góra: 18 X 1994 (5), Zaborów Leśny: 13 VIII 1980 (1).

Red squirrel – *Sciurus vulgaris* Linnaeus, 1758

2 localities: Dąb Kobendzy: 6 X 2007 (1), Posada Demboskie: IV 2006 (1).

Myodes glareolus was the most common and a relatively abundant species in the rodent communities throughout the study area (48 localities), followed by *Apodemus flavicollis* (35 localities) and *Microtus oeconomus* (32 localities). Among the rodents connected to wet habitats, *Microtus oeconomus* was noted frequently, whereas *Arvicola amphibius* appeared to be rare (Fig. 3) (highest share in the owls' diet: 1.8% of mammals – Grabowy Grąd, N=448). In the group of rodents typical of open areas, *Microtus arvalis* was the most frequent (28 localities) and abundant. The most frequent presence of *Muscardinus avellanarius* (Fig. 4), a species typical of broad-leaved tree stands, including wet forests with alders, was close to the strictly protected areas. *M. avellanarius* was relatively frequently captured in Cyganka – 5.0% (N=119), Wywrotnia Góra – 4.4% (N=113), KA 83 – 4.0% (N=273) and Sowia Wola Folwarczna – 3.5% (N=1,271). Another arboreal rodent (*Sciurus vulgaris*) was an extremely rare prey of the examined owls, and synanthropic rodents (*Mus musculus* and *Rattus norvegicus*) occurred in low numbers in various parts of Kampinos Forest. *Microtus subterraneus* was very rarely captured by owls, except for the eastern edges of the study area where it was relatively abundant at some sites (e.g., Młociny Park).

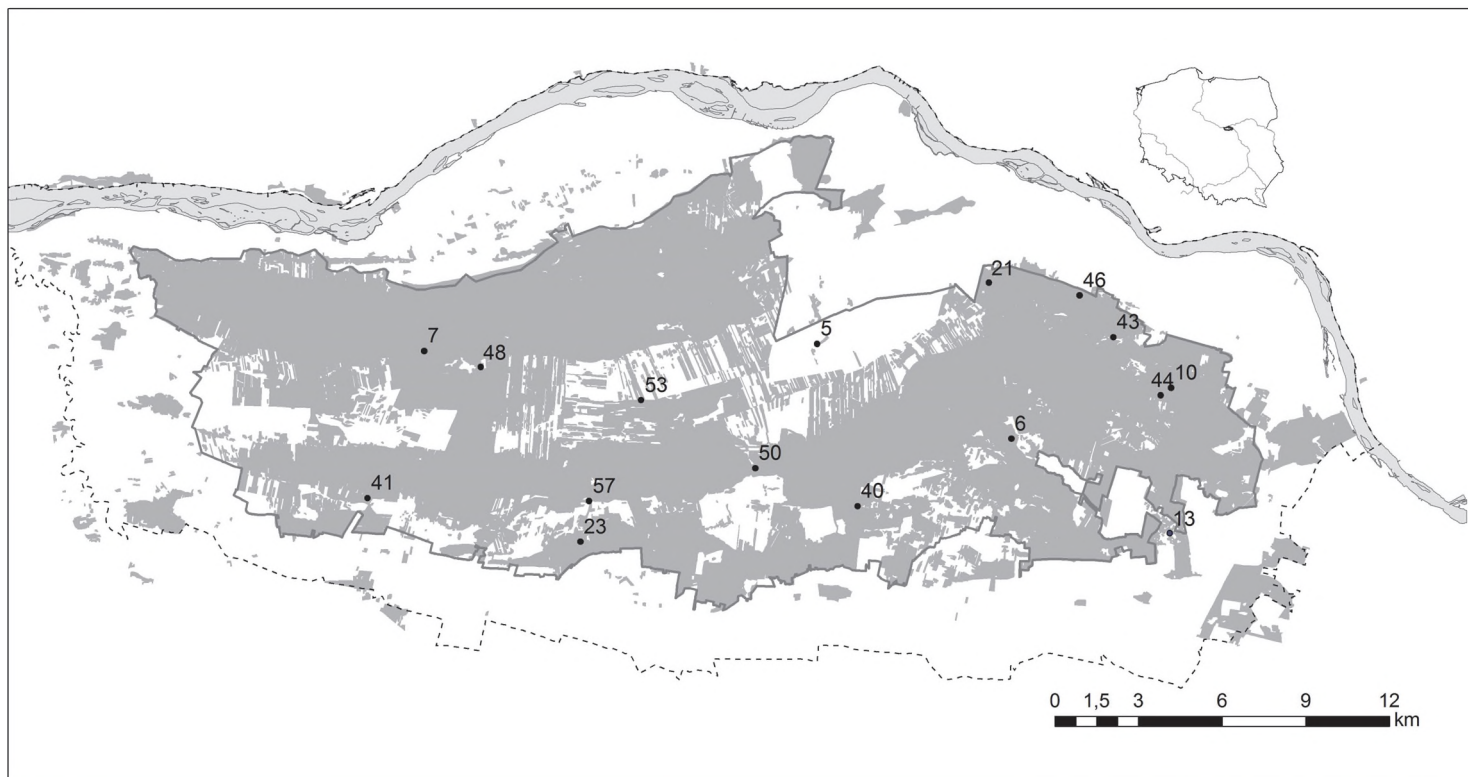


Fig. 3. Localities of *Arvicola amphibius* in the study area. For explanations see Fig. 1.

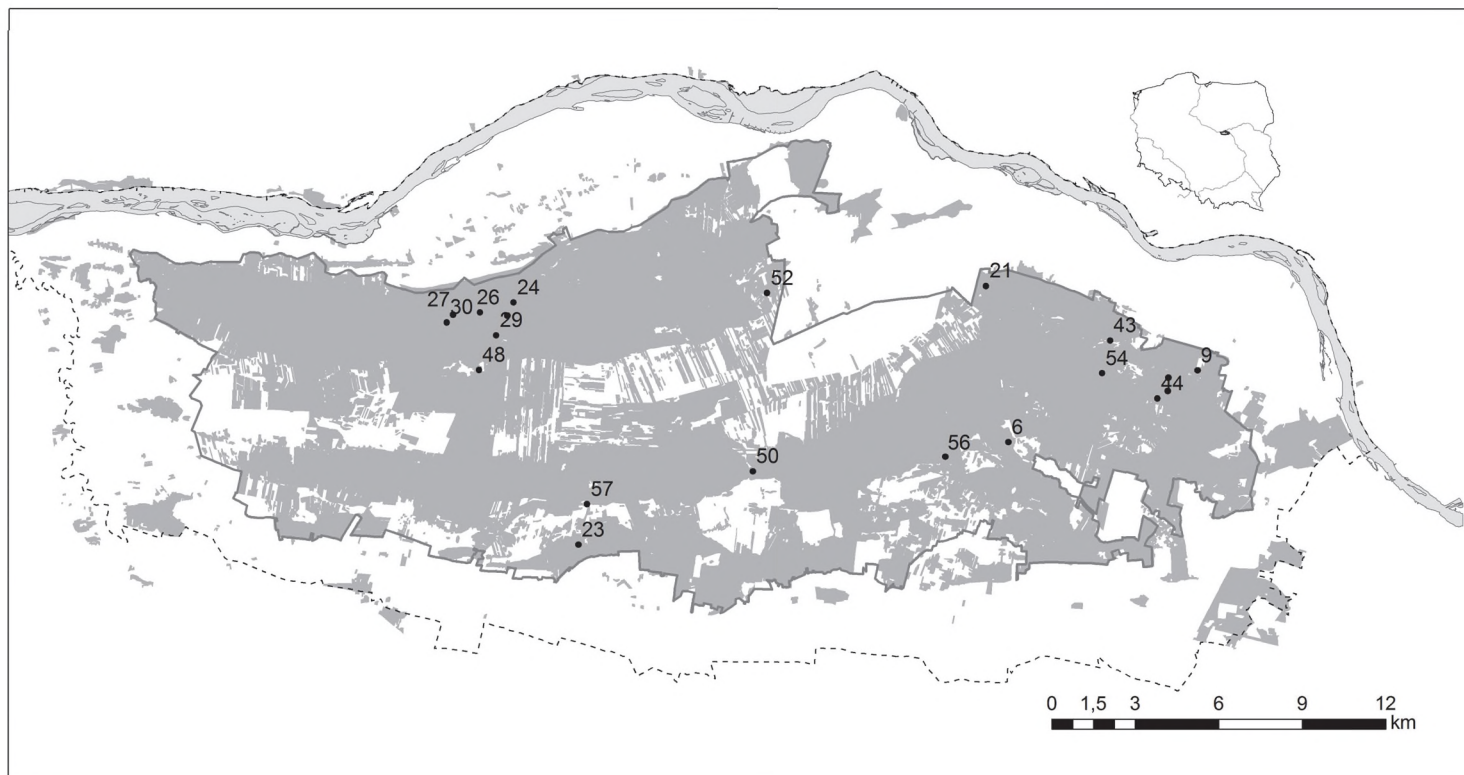


Fig. 4. Localities of *Muscardinus avellanarius* in the study area. For explanations see Fig. 1.

Lagomorpha

Brown hare – *Lepus europaeus* Linnaeus, 1758

2 localities: Korfowe: 12 VII 1999 (1), Sowie Wola Folwarczna: 15 IV 1994 (1).

This order was only sporadically represented in the diet of tawny owls in the study area. Only young individuals were captured individually.

Carnivora

Weasel – *Mustela nivalis* Linnaeus, 1766

4 localities: KR 156: 17 IX 2009 (1), Młociny Park: 14 IV 2012 (1), Na Miny: 3 X 2011 (1), Sowie Wola Folwarczna: 7 IV 1994 (1).

A species from the family Mustelidae was an accidental owl prey. Only four localities from different parts of the study area were represented.

The most common and abundant in the total analysed material of owl pellets were: *Myodes glareolus*, *Sorex araneus*, *Apodemus flavicollis* and *Sorex minutus*. Some species connected to open areas (*Microtus arvalis*, *M. oeconomus*) or waters (*Neomys fodiens*) were also captured relatively frequently (Fig. 5).

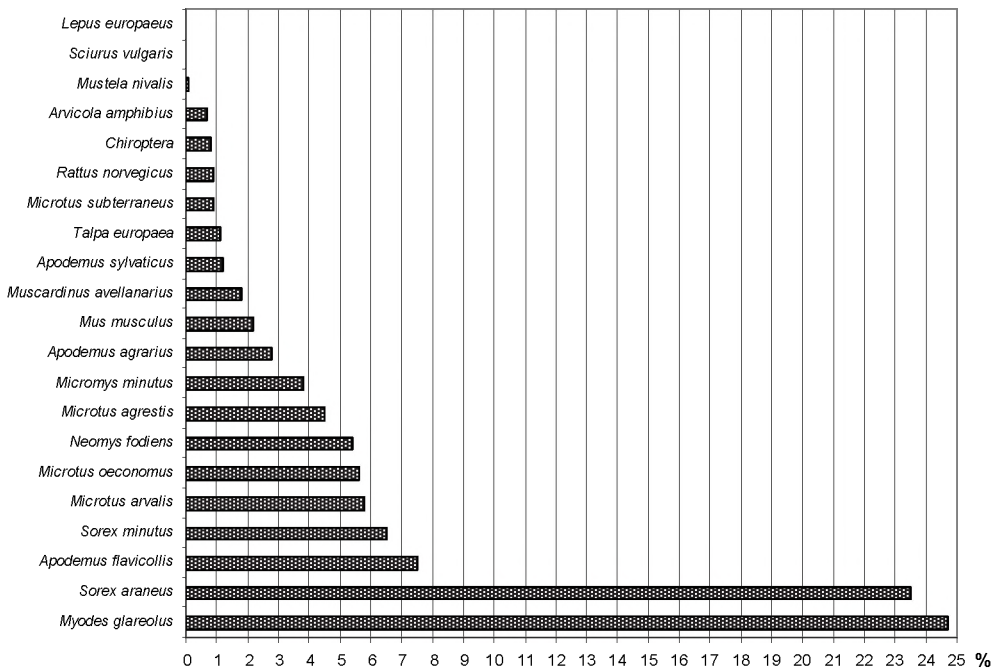


Fig. 5. Percentage of species or groups of species in the food of tawny owls in the study area. Only individuals identified to the species level (7,522) were considered in the analysis.

DISCUSSION

Compared to the results of previous work (Goszczyński et al. 1993, Andrzejewski 2003, Lesiński 2003, Lesiński et al. 2011, Danyłow et al. 2012), there were no new species recorded in the present study. Nevertheless, the data shown provide more precise information on the proportion of species in the community and the distribution of their localities.

Kampinos Forest in central Poland offers suitable habitats for diverse communities of small mammals, though the species richness does not differ distinctly, even compared to more fragmented forests. In the smaller forests within the vicinity of Łódź, only one species of rodents, *Muscardinus avellanarius*, was absent (Gryz et al. 2011).

The distribution of *Muscardinus avellanarius* in Kampinos Forest was related to the presence of wet forest, which occurs frequently, covering large areas in some places. Most likely, these areas represent an important refuge of this species on the border of its continuous range in Poland. *M. avellanarius* was reported in single, isolated localities in areas situated in the north and north-west (Pucek 1983, Neubauer & Zagalska-Neubauer 2003) and was absent in several owl diet studies (Kowalski 1961, Kowalski & Lesiński 1986, 1988, Lesiński & Gryz 2008). This arboreal rodent is the only representative of the family Gliridae in Kampinos Forest. The nearest localities of edible dormouse *Glis glis* (Linnaeus, 1866) were found approx. 100 km southeast (Kozienice Forest – Kurowski 1997). Therefore, the presence of this species in Kampinos Forest is not likely.

The study area offers suitable habitats for small mammals that are associated with water bodies or marshes. *Microtus oeconomus* and, to a lesser degree, *Neomys fodiens* appear to be relatively common and locally abundant. *Arvicola amphibius* was less frequently captured by owls and was not abundant. Compared to some samples of tawny owl diets from southern Poland, sites where it was one of the most important prey (Bocheński jun. 1990, Ruprecht 2002, Lesiński & Stolarz 2012), we could presume that *A. amphibius* in Kampinos Forest is not abundant.

Our study confirmed the absence of the northern birch mouse *Sicista betulina* (Pallas, 1778) in Kampinos Forest, though the closest locality of this rodent is known approx. 30 km east – in Okuniew-Rembertów Forest (Lesiński et al. 1998). Most of the wet forests in the study area might be unsuitable for this species.

It is possible that some small mammals, particularly bats, might still be found in Kampinos Forest. To date, 15 species comprise the bat fauna of this area (Lesiński 2003). The northern bat *Eptesicus nilssonii* (Keyserling & Blasius, 1839) was recorded in Warsaw (Lesiński et al. 2001) and in the vicinity of Narszewo (Lesiński et al. 2008) (8 and 12 km from the study area, respectively). The common pipistrelle *Pipistrellus pipistrellus* (Schreber, 1774) and Bechstein's bat *Myotis bechsteinii* (Kuhl, 1817) are also possible. The former is known in many regions of Poland, though it is rare in the central and eastern part (Sachanowicz et al. 2006). Despite its continuous range being limited to areas situated approx. 50 km south (Ciechanowski & Piksa 2004), a locality of *M. bechsteinii* was found north of the study area – in Strubiny fort near Modlin (Fuszara & Kowalski 2009). Moreover, bat species only occasionally found in central Poland, such as the giant noctule *Nyctalus lasiopterus* (Schreber, 1780) (Ruprecht 1970) or Kuhl's pipistrelle *Pipistrellus kuhlii* (Kuhl, 1817) (Popczyk et al. 2008), can not be excluded.

Bats are considered to be highly endangered by human activity. Two of the species found in the tawny owl pellet samples from Kampinos Forest (*Myotis myotis* and *Barbastella barbastellus*) were included in the 2nd Annex to the Habitats Directive of the European Union. Moreover, one species (*Vespertilio murinus*) was mentioned in the Polish Red Data Book under the category 'least concerned' (LC) (Głowaciński 2001).

With regard to Soricomorpha and Rodentia, all possible small species have most likely been identified. The continuous range of the bicolour white-toothed shrew *Crocidura leucodon* (Hermann, 1780) is rather distant from the study area (Pucek & Michalak 1983). *Sciurus vulgaris* is the largest rodent prey. The northern white-breasted hedgehog *Erinaceus roumanicus* Barrett-Hamilton, 1900 is only rarely captured by tawny owls (Gryz et al. 2008) as are carnivores larger than *Mustela nivalis* (Korpimäki & Norrdahl 1989, Gryz et al. 2008). Within Carnivora, the American mink *Neovison vison* Schreber, 1777 and stoat *Mustela erminea* Linnaeus, 1758 were found in the tawny owl pellets. No rabbits *Oryctolagus cuniculus* (Linnaeus, 1758) were found in our material, however, this species was recorded in Toruń (Zalewski 1994). Species representing the order Lagomorpha are extremely rare prey for tawny owls.

There was a relatively high proportion of synanthropic rodents (*Mus musculus* and *Rattus norvegicus*) and water-connected rodents (*Arvicola amphibius* and *Neomys fodiens*) in the diet of the tawny owls in Kampinos Forest compared to some forests of north-eastern Poland: Białowieża Forest, Romincka Forest, Augustów Forest, Forests of Biebrza National Park and Knyszyn Forest. However, *Apodemus flavicollis* – an important prey item, particularly in Białowieża and Knyszyn Forests – occurred in lower proportions in the study area. In all the mentioned forests, *Myodes glareolus* was abundantly captured by tawny owls. Bats were recorded relatively frequently in Kampinos Forest, and their proportion in owl diets was higher only in Knyszyn Forest (Table 1). This finding most likely results from the fact that our study area is a mosaic of different habitats, both only slightly and highly transformed by human activity.

Table 1. Proportions of selected mammal taxa in the diets of the tawny owl from the study area and several forests of northeastern Poland; (1) – this study, N=7,522; (2) – after Table 1 in Jędrzejewski et al. (1994), N=2,603; (3) – Gryz et al. 2012, N=309 (only forest habitats); (4) – Lesiński et al. 2009, N=147; (5) – Lesiński et al. 2009, Gryz et al. 2011, N=1,669; (6) – Zawadzka & Zawadzki 2007, N=543; (7) – Żmihorski & Osojca 2006, N=245; N – number of mammalian prey items.

Taxon	Kampinos Forest (1)	Białowieża Forest (2)	Białowieża Forest (3)	Knyszyn Forest (4)	Forests of Biebrza National Park (5)	Augustów Forest (6)	Romincka Forest (7)
<i>Sorex araneus</i>	23.5	16.5	21.4	1.4	13.7	7.0	19.6
<i>Neomys fodiens</i>	5.4	0.4	8.1	0	1.9	0.4	0
Chiroptera	0.8	0	0	2.7	0.5	0	0
<i>Arvicola amphibius</i>	0.7	no data*	0.3	0	0.7	0	0
<i>Myodes glareolus</i>	24.7	34.6	20.7	19.0	30.5	16.6	27.8
<i>Microtus oeconomus</i>	5.6	6.5	1.9	0	8.5	4.2	1.2
<i>Microtus agrestis</i>	4.5	1.0	4.9	3.4	3.9	3.1	1.2
<i>Apodemus flavicollis</i>	7.5	28.5	17.8	42.9	7.8	3.9	8.2**
<i>Mus musculus</i> & <i>Rattus norvegicus</i>	3.1	no data	0.3	0.7	2.8	3.7	0
<i>Muscardinus avellanarius</i>	1.8	no data	0	0	0.8	0	2.4

* – 0.2% calculated from Table 4 in Jędrzejewski et al. (1994);

** – *Apodemus flavicollis* and *A. sylvaticus* were not distinguished.

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STRESZCZENIE

[Drobne ssaki Kampinoskiego Parku Narodowego i jego otuliny wykazane w wyniku analizy diety puszczyków *Strix aluco* Linnaeus, 1758]

W pracy analizowano zrzutki puszczyka *Strix aluco* w celu określenia składu gatunkowego, stanowisk i względnego zagęszczenia drobnych ssaków w Kampinoskim Parku Narodowym i jego otulinie (Fig. 1). Materiał zebrany na 58 stanowiskach zawierał szczątki 11235 ofiar kręgowych, wśród których znajdowało się 8335 ssaków. Wykryto 29 gatunków: ryjówkoksształtne Soricomorpha – 4, nietoperze Chiroptera – 9, gryznie Rodentia – 14, zajęczaki Lagomorpha – 1, drapieżne Carnivora – 1. W badanym materiale stwierdzono

obecność trzech cennych gatunków nietoperzy: dwóch wymienionych w II Załączniku Dyrektywy Siedliskowej Unii Europejskiej (nocka dużego *Myotis myotis* i mopka *Barbastella barbastellus*) oraz mroczka posrebrzanego *Vespertilio murinus* znajdującego się Polskiej Czerwonej Księdze Zwierząt (kategoria – „gatunek mniejszej troski” LC). Spośród gryzoni z rodziny popielicowatych Gliridae zanotowano obecność orzesznicy *Muscardinus avellanarius*, gatunku związanego z drzewostanami liściastymi, zwłaszcza olsami. W odpowiednich środowiskach jej udział w diecie puszczyka wynosił ok. 5%. Stosunkowo często i licznie notowano niektóre gatunki związane ze środowiskami podmokłymi (nornika północnego *Microtus oeconomus* i rzesorka rzeczka *Neomys fodiens*), natomiast karczownik *Arvicola amphibius* był notowany rzadziej i mniej licznie (Fig. 5). Ważne ostoje bogatych zgrupowań drobnych ssaków zlokalizowano głównie na terenach objętych ochroną ścisłą. W porównaniu z kompleksami leśnymi zlokalizowanymi w północno-wschodniej Polsce, Puszcza Kampinowska wyróżnia się stosunkowo dużym udziałem w diecie puszczyków takich ssaków, jak: nietoperze, gatunki związane ze środowiskiem podmokłym oraz gatunki synantropijne (Tab. 1). Przedstawione tu wyniki pozwoliły na wykazanie prawdopodobnie pełnej listy drobnych ssaków z rzędów: ryjówkoksztalne i gryzonie, podczas gdy możliwe jest jeszcze odnalezienie 3–5 gatunków nietoperzy i dwóch małych gatunków drapieżnych.

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