# Diet of solitary males Boreal Owls *Aegolius funereus* in the lowlands of the Bydgoszcz Forest (northern Poland)

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## Abstract

The Boreal Owl is one of the owl species that has been observed to increase its range, mainly in Central Europe. This paper presents information on the diet diversity of solitary males in newly colonised areas in northern Poland. The authors believe that colonised commercial forests represent suboptimal habitats in terms of nutritional conditions. The research was carried out in a commercial forest with old-growth pine stands being left intact for Black Woodpecker tree holes. Pellets were collected under a Norway spruce tree near a tree hole occupied by a solitary male; no females or young were observed during this period. The analysis of pellets revealed that the diet of owls consists mainly of small mammals. However, they consume significantly fewer voles (*Microtus* and *Myodes*) compared to Boreal Owls from the north of the species' range, and representatives of insectivores (*Sorex araneus* and *S. minutus*) predominate in their diet in terms of relative abundance. Among rodents, *Apodemus sylvaticus* is the most abundant in the owls' diet and, together with other murids, dominates in terms of biomass consumed. Boreal Owls also supplement their diet with birds and small bats, which indicates food plasticity. This also suggests a possible strategy of males inhabiting the few tree hollows in this area and successful breeding in years with more abundant rodent populations, which has been confirmed by other studies carried out in this area.

## Keywords

Boreal owl, diet of solitary males, range extension, N Poland

## Introduction

Due to their high trophic position, owls, as predators, are considered indicator and umbrella species in nature conservation programmes. Most species of owls living in tree hollows depend on the presence of old-growth forest, and the degradation of forest stands due to intensive forest management observed worldwide affects the availability of key nesting and foraging resources for this specialised group of birds (Sergio et al., 2008; Mc Cure et al., 2018).

One of the owl species that is expanding its range, including in commercially used forests, is the Boreal Owl, also known as Tengmalm's Owl (*Aegolius funereus*). This species is widely distributed across the boreal forests of the Northern Hemisphere (Cramp, 1985; Mikkola, 1983). In northern Europe, Tengmalm's Owl is distributed in a continuous range, but towards the south its distribution becomes fragmented and patchy, with isolated populations occurring mostly in the mountains (Korpimäki, 1997; Hagemeijer & Blair, 1997).

In Poland, the Boreal Owl is a rare breeding species in the Carpathians and the Sudetes and occasionally occurs in extensive coniferous forests in the lowlands (Tomiałojć & Stawarczyk, 2003).

The main lowland populations of the Boreal Owl occur in the forests of north-eastern Poland and Pomerania, with the largest ones in the Kashubian Lakeland (Domaszewicz et al., 2007), Drawsko Lakeland (Chylarecki & Sikora, 2007), Tuchola Forest and Darżlubie Forest (Mikusek & Sikora, 2013).

The changes in the distribution of the Boreal Owl in Poland reported in recent years are due to both the intensification of fieldwork (Domaszewicz et al., 2007), and a real increase in the population size of this species in Central Europe (Kopij, 2011). According to Mikusek & Sikora (2013), population estimates are difficult due to fluctuations in breeding population size and a high proportion of unmated (unpaired) males. Studies in the boreal part of this owl's range show that the size of local populations of this species fluctuates greatly in response to high variability in food resources. Feeding mainly on small rodents, it is strongly affected by the cyclicality of these mammal populations and environmental conditions – mainly snow cover. This also results in migratory and nomadic strategies (Korpimäki, 1986; Korpimäki & Hakkarainen, 2012). As evidenced by long-term research on the Boreal Owl in Finland, the production of fledglings per breeding attempt showed a long-term declining trend, and the timing of egg laying in the population of this species was delayed during the period between the 1970s and the 2010s

(Kouba et al. 2020). The authors suggested that the main reason for this is the loss of mature and old-growth forests, with the consequent reduction in the density of important prey species of Tengmalm's Owls (bank voles, shrews and small birds). Cutting down old-growth forest leads to a reduction in the number and area of habitats where small predators can take refuge from larger ones (e.g. Tawny Owls), and also makes movement between patches of forest quite risky due to predation (Hinam & Clair, 2008).

The parallel increase in the population size of the Central European Boreal Owl observed since the 1990s may be related to the consolidation of migratory/nomadic trends towards the south and the search for new habitats. It is therefore interesting to study the diet of the Boreal Owl, especially in areas diverging in terms of forest structure from its primary, i.e. boreal–montane habitat optimum. In Europe, most feeding ecology studies were carried out on northern and mountain populations of the Boreal Owl (e.g. Sulkava & Sulkava, 1971; Jäderholm, 1987; Korpimäki, 1988b; Kloubec & Vacík, 1990; Sorbi, 1995; Zárybnická et al., 2011). In Poland, however, despite the intensification of research on the occurrence of the Boreal Owl, little is known about the composition of the diet of this species. Diet composition has only been reported from the eastern part of Poland, the Białowieża Primeval Forest (Jedrzejewska & Jedrzejewski, 2001) and the Knyszynska Forest (Tumiel & Mirski, 2018).

The main objective of this study was to describe and analyse the diet composition and prey diversity of Tengmalm's Owl from the lowland areas of the Bydgoszcz Forest (north–central Poland), where unpaired males were confirmed for the first time in 2016 (Kurowski, 2021).

**Study area**

The study was conducted in the north–central part of Poland (53°1'29"N; 18°10'1"E). The Bydgoszcz Forest is a dense forest with an area of over 550 km² located in the Kujawsko-Pomorskie Province, stretching between the cities of Bydgoszcz and Toruń. It is bounded to the north by the Vistula River and to the south by the edge of the Inowrocław Plain. This forest

complex occupies a large part of the Toruń Basin, which is the eastern fragment of the Toruń–Eberswalde ice-marginal valley (*urstromtal*). The most characteristic landscape features in the Bydgoszcz Forest are inland dunes formed by aeolian processes (Mrózek, 1958). Due to the relatively low annual precipitation (500–520 mm) and permeable sandy substrate, much of the Bydgoszcz Forest is very arid, with podzols and arenosols as the main soil types (Bednarek & Prusinkiewicz, 2001).

More than 99% of the forest area of the Bydgoszcz Forest is used for commercial purposes. According to the draft forest management plan for the Solec Kujawski Forest District, the dominant species in the forest stands is Scots pine *Pinus sylvestris*, which occupies 93.4 % of the forested area. The relative abundance of spruce, as a keystone species for the Boreal Owl, does not exceed 0.1%, while the average age of forest stands in this forest district is 61 years.

A study conducted by Kurowski (2021) in the Bydgoszcz Forest revealed 17 males of the Boreal Owl. The average density in the surveyed plots was 1.7 males/10 km². All tree hollows occupied by male Boreal Owls (N = 9) were pecked by the black woodpecker *Dryocopus martius* in Scots pine trees. Pellets were collected under a Norway spruce tree near a tree hole occupied by a solitary male; no females or young were observed during this period, but the first broods were spotted in 2021 outside the pellet collection site (Kurowski, 2021).

**Methods**

Pellet analysis is a widely accepted method to study the diet of owls, including Tengmalm's Owl (e.g. Mikkola, 1983). The material for this diet study was collected three times in 2020–2022. Given the rate of decomposition of pellets lying under the trees, it was assumed that the collected pellets defined as 'fresh' represent a period corresponding to the owls' activity 2–3 months prior to collection. The first collection (14 December 2020) coincided with the non-breeding season, the second (7 July 2021) and third collection (15 May 2022) coincided with the breeding season.

Pellets were air-dried at room temperature and then carefully examined for all diagnostic remains, such as skulls, mandibles, beaks, and feathers, which were separated for further prey identification. The obtained materials were measured and analysed using digital callipers and a binocular microscope. Mammals were identified by teeth and bones according to Pucek (1984), birds by skulls and other bones according to Moreno (1985, 1986, 1987), Cuisin (1989), Kessler (2015) and Ujhelyi (2016), and a reference collection was also used. Whenever possible, prey items were identified to species, otherwise to the highest possible taxon (genus, order). Bone fragments and teeth found in different pellets were treated as separate prey items. Biomass was calculated according to data from Korpimäki (1988b) and Jędrzejewski & Jedrzejewska (2001). The Shannon–Wiener diversity (H') index was calculated for trophic diversity at the species level using the following formula (Krebs, 1994):

$H = -\Sigma [P_i \log (P_i)]$.

The food niche breadth (FNB) of owls was estimated using the formula of Levins (1968):

$B = 1/\Sigma\, pi2$,

where pi is the proportion of prey category *i* in the total biomass of the owl's diet.

According to Korpimäki (1988b, after Greene and Jaksić, 1983), a specific level of prey identification was used in the calculations to the extent possible, because supraspecific levels of prey identification consistently underestimate the diet width.

**Results**

A total of 111 pellets and several fragmented pellets were collected during three sampling events. The remains of 310 individuals from eight small mammal species (insectivores and rodents), two species of bats and six different taxa of birds (identified at least to genus) were found in the food of *A. funereus* (Table 1). The estimated biomass was equivalent to over 3.6 kg of live prey weight. Small mammals dominated in the diet, both in terms of prey number

(86.5%) and biomass (82.51%). *Sorex minutus* dominated among the identified prey species, accounting for 39.0% and, together with *S. araneus*, up to 55.2% of all prey (Table 1). Among rodents, the group usually favoured by the Boreal Owl, *A. sylvaticus* was the most abundant in the owl's food, reaching 10.6% of relative abundance (total number of prey items) and 22.5% of total prey biomass.

The diet of the Boreal Owl was supplemented by birds the size of a tit or smaller, as well as equally small bat species. These included Natterer's bat and the brown long-eared bat, whose relative abundance and biomass (birds and bats combined) were 13.5% and 17.3%, respectively.

In terms of season, rodents were most frequently caught in late autumn and early winter (December pellet collection), while they were least abundant in the owl's diet in spring (May and June collection). Possible seasonal or annual fluctuations in the abundance of rodents were compensated for by male owls with insectivores. These relationships are supported by data from June 2021, where, with a minimum rodent abundance of 21.6%, insectivores peaked at 66.9% of relative abundance (Table 1).

The diversity of vertebrates in the diet of *A. funereus* was calculated using Shannon's diversity index and was H = 2.62.

Based on all collected samples, the niche breadth of *A. funereus* containing 15 prey categories was estimated at B = 1.25.

**Discussion**

The diet of male Tengmalm's Owls in our study area consisted mainly of small mammals (94%; Table 1). This percentage is similar to that determined in other areas of Central Europe, as well as at higher latitudes in Northern Europe (reviewed by Korpimäki & Hakkarainen, 2012).

This owl species is a generalist predator and in northern latitudes feeds mainly on *Microtus* and *Myodes* voles (Sulkava & Sulkava, 1971; Korpimäki, 1981, 1988b).

When the abundance of main prey is low, the percentage of alternative prey (usually *Sorex* shrews and birds) in the diet of both northern and central European owl populations increases (Korpimäki & Hakkarainen, 2012; Zárybnická et al., 2015).

Analysis of the diet of unpaired male Boreal Owls in the Bydgoszcz Forest confirmed this assumption. When the relative abundance of Arvicolinae was only 13.2%, the owls preyed mainly on small insectivores, *Sorex araneus* and *S. mintus*, which accounted for more than 50% of the relative abundance. Data on a comparable (although significantly lower) proportion of insectivorous species in the diet of this owl species were reported by Zarybnicka et al. (2015) from the Šumava Mountains in the Czech Republic and Korpimäki (1988b) from western Finland.

The true importance of food can be assessed by looking at the size of the prey consumed. With this assumption, species belonging to the genus *Apodemus* sp. are the most important food group, accounting for 32.5% of the diet (Table 1). The high proportion of species from this group of rodents clearly indicates the similarity of the diet of the Boreal Owl from the Bydgoszcz Forest to that described from other locations in Central Europe (Kloubec & Vacík, 1990; Pokorný et al., 2003; Zárybnická et al., 2012), the Alps (Joveniaux & Durand, 1987), the Jura Mountains (Ravussin et al., 2015), and even the Balkans (Rajkovic, 2018).

Given the fluctuations in the abundance of the main prey of the Boreal Owl, it appears that the predator's natural adaptation is so-called prey switching, in which the predator preferentially consumes the most available type of prey (sensu Begon & Mortimer, 1989). In northern Europe, populations of field voles fluctuate in close temporal synchrony with those of other herbivorous voles of the genera *Microtus* and *Myodes*, and even with insectivorous shrews *Sorex* spp. (Henttonen et al., 1987, 1989; Hanski & Henttonen, 1996), whereas interspecific synchrony with the aforementioned species or other small mammals has not been documented in temperate Europe (Korpimäki & Hakkarainen, 2012). The data presented support the latter

conclusion, as a clear replacement of the preferred Microtidae by Muridae can be observed here, as well as by the smaller but probably also more easily accessible Soricidae. A study by Koivunen et al. (1996) indicates that when representatives of voles and small Insectivora were equally available, Boreal Owls preferred voles, so this high proportion of Sorcidae in the diet can be considered as a substitute food resulting from the unavailability of the preferred prey. Lack of food to hunt is not the only reason for low breeding success, although it is probably the most important factor for this owl species (Jaderholm, 1987).

The lack of females and young in the study area therefore indicates that the habitats inhabited by the Boreal Owl are suboptimal in terms of food resources. The study area is a rather poor monoculture coniferous forest habitat, enriched with isolated fragments of approximately150–180 year old pine forests. The recently confirmed occurrence of males in this area may indicate an attempt to colonise new areas that meet the minimum habitat and food requirements with a chance of breeding in years abundant with small rodents.

Based on the obtained results, it can be speculated that populations waiting for years with high availability of rodents or living in suboptimal habitats feed on substitute food (smaller *Sorex*), but also on less accessible food such as birds and even bats. Owls prey on bats only occasionally and opportunistically, although bat aggregations may be a locally important food source for some species and individual owls at certain times. In addition, a decline in the abundance of the main prey (rodents) may cause owls to expand their diet to include bats (Speakman, 1991).

Capturing aerial bats is very rare, probably because of the scarcity of bats in the north or at high altitudes where Boreal Owls usually live (Korpimäki & Hakkarainen, 2012).

Preying on bats can also be considered a manifestation of food opportunism. Small hollow-dwelling bats appear to be incidental but catchable prey for this mainly ambush-hunting owl (Norberg, 1970). The convergence of habitats expressed in the occupation of tree hollows facilitates the specialisation of some owl individuals in catching bats. However, the low

proportion of bats in the diet of this owl species probably indicates that bats quickly leave their hollows once detected or that it is quite difficult for the owls in terms of hunting technique. In the case of birds, which account for a significantly higher proportion of this owl's diet, it can be assumed that they are more easily accessible, but also the method of hunting them is easier and allows, for example, removing sleeping individuals from branches.

Based on the collected data on the availability of individual bat species, it can be concluded that by far the most prevalent species available to this owl is the common noctule *Nyctalus noctula*, which occurs here in great numbers. A study of bat box occupancy in the Bydgoszcz Forest in 2019–2022 showed that common noctules accounted for more than 47% of the total count of bats, i.e. all bat individuals found in the boxes (Kasprzyk & Wojciechowski, unpublished observations). This species is probably too large for the Boreal Owl and therefore difficult to capture. This assumption is supported by aggregated data showing the proportion of bats in the owl diet in Europe (Sieradzki & Mikkola, 2016), where among a total of 22 bats captured by the Boreal Owl, there are no common noctules, but there are small bats, such as the whiskered bat *Myotis mystacinus*, Daubenton's bat *M. daubentonii*, Natterer's bat *M. nattereri* and the brown long-eared bat *Plecotus auritus*, with the northern bat *Eptesicus nilssonii* being the largest bat on the list of captured bats.

According to Schoener (1971), the diversity of predators' diet should increase when the abundance of preferred prey decreases. The optimal foraging theory predicts that FNB should expand when the density of the main prey species decreases and shrink when the main prey increases (Pyke, 1984). Optimal foraging models suggest that food choice reflects the profitability or absolute abundance of prey (Royama, 1970; Pulliam, 1975; Charnov, 1976). However, our study shows that food species diversity of solitary males is low and the food niche is narrow, clearly narrower than that reported by long-term studies conducted in the centre of a

population (e.g. Korpimäki, 1988b). It is worth noting that in the latter studies the narrowest food niche occurred, as in our study, in years with the highest relative abundance of Soricidae. Our study also indicates that fragments of old pine stands may only seemingly provide an appealing sites to attract males to search for breeding sites, as with intensive use of forests (large clear cut areas), such sites will not provide food resources for successful breeding. Males prefer to hunt in spruce and pine forests and avoid hunting in clearings and agricultural areas. The loss of mature and old-growth forests contributes to lower densities of important prey species of Tengmalm's Owls (bank voles, shrews and small birds) (Kouba et al. 2020).

On the other hand, as suggested by Nikolov et. al (2022), the Boreal Owl appears to be more tolerant to habitats where logging has been carried out in the past. Boreal Owls often occupy old-growth forests or forests with fragments of old-growth stands, but can also benefit from forest edges with stands of younger successional stages or open spaces. The occurrence of breeding Boreal Owls in the Bydgoszcz Forest (Kurowski, 2021) indicates that food plasticity involving adaptation to existing resources can be an effective strategy for colonising suboptimal habitats. The ability to adapt to local food resources may explain the observed increase in the range of this species to lowland areas.

This research also provides guidance for management programmes in commercial forests, which by definition are also designed to enable biodiversity conservation functions. These recommendations can also be implemented in commercial forests where Scots pine is the dominant species. However, in order to improve nesting rates and population sustainability, it is necessary not only to increase the presence of single senile trees or patches of old-growth forest, but also to increase the area of such patches and the presence of the key species – spruce (Korpiamaki 1988a), which mainly serves as shelter for juveniles (Mikusek & Sikora, 2013).

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## References


Begon, M., Mortimer, M., 1989, Ekologia populacji. Studium porównawcze zwierząt i roślin [Population ecology. A comparative study of animals and plants], PWRiL, Warszawa.

Bednarek, R., Prusinkiewicz, Z., 2001, Differentiation and distribution of soils, [in:] Nature of the Kuyavian-Pomeranian Voivodeship, A. Przystalski (ed.), Kuj.−Pom. Urząd Wojewódzki, Wojewódzki Konserwator Przyrody, Bydgoszcz: 33−40.

Błaszczyk, K., 1999, Rozmieszczenie, liczebność oraz wybiórczość środowiskowa włochatki *Aegolius funereus* w Puszczy Darżlubskiej i Lasach Lęborskich, Praca magisterska [Distribution, abundance, and habitat selectivity of the Boreal Owl *Aegolius funereus* in the Darżlubska Forest and Lębork Forest, Master's thesis], Katedra Zool. Leśnej i łowiectwa SGGW, Warszawa.

Chylarecki, P., Sikora, A., 2007, Assessment of the number of breeding species in Poland, [in:] The Atlas of breeding birds in Poland 1985–2004, Sikora A., Rohde Z., Gromadzki M., Neubauer G., Chylarecki P., [eds.], Bogucki Wyd. Nauk., Poznań: 34–416.

Mc Clure, C. J.W., Westrip, J. R. S. & Johnson, J.A., 2018, State of the world's raptors: distributions, threats, and conservation recommendations, Biol Conserv., 227: 390–402.

Cramp, S. (ed.), 1985, The Birds of the Western Palearctic, vol. 4, Oxford University Press, Oxford.

Cuisin, J., 1989, L'identification des cranes de Passereaux (Passeriformes: Aves). Universite de Bourgogne, pp. 340.

Domaszewicz, A., Mikusek, R. & Sikora A., 2007, Tengmalm's Owl *Aegolius funereus*. In: Sikora A., Rohde Z., Gromadzki M., Neubauer G., Chylarecki P., [eds.], The Atlas of breeding birds in Poland 1985–2004, Bogucki Wyd. Nauk., Poznań: 280–281.

Greene, H. W., Jaksić, F. M., 1983, Food-Niche Relationships among Sympatric Predators: Effects of Level of Prey Identification, Oikos, 40: 151–154.

Grzywaczewski, G., Łapińska, K., Łapiński, P. & Gustaw W., 2009, Sowy *Strigiformes* Lasów Sobiborskich, [in:], Ptaki–Środowisko–Zagrożenia–Ochrona,Wybrane aspekty ekologii ptaków, [*Strigiformes* owls in the Sobibór Forest, in: Birds – Environment – Threats – Protection, Selected aspects of bird ecology], Wiącek J., Polak M., Kucharczyk M., Grzywaczewski G., Jerzak L. [eds], Lubelskie Towarzystwo Ornitologiczne, Lublin: 125–139.

Hagemeijer, W., Blair, M., 1997, The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance, T. & A. D. Poyser, London.

Hansson, L., 1971, Small rodent food, feeding and population dynamics – comparison between granivorous and herbivorous species in Scandinavia, Oikos, 22: 183–198.

Hinam, H. L., Clair, C. C. S., 2008, High levels of habitat loss and fragmentation limit reproductive success by reducing home range size and provisioning rates of northern saw-whet owls, Biol. Conserv., 141: 524–535.

Jäderholm, K., 1987, Diets of the Tengmalm's owl *Aegolius funereus* and the Ural owl *Strix uralensis* in central Finland, Ornis Fenn., 64: 149–153.

Jedrzejewska, B., Jedrzejewski, W., 2001, Ekologia zwierząt drapieżnych Puszczy Białowieskiej [Ecology of predatory animals of the Białowieża Forest], PWN, Warszawa.

Joveniaux, A., Durand, G., 1987, Gestion forestière et écologie des populations de chouette de Tengmalm (*Aegolius funereus*) dans l'Est de la France, *Rev. Eco. (Terre Vie)*, Suppl. 4: 83–96.

Kajtoch, Ł., 2006, Sowy *Strigiformes* Pogórza Wielicko-Wiśnickiego i Beskidu Wyspowego. [*Strigiformes* owls of the Wieliczka-Wiśnicz Foothills and the Beskid Wyspowy Mountains] Not. Orn., 47: 252–259.

Kessler, J. E., 2015, Osteological guide of songbirds from Central Europe, Ornis Hungarica, 23: 62–155.

Kloubec, B, Vacík R., 1990, Outline of food ecology of Tengmalm's Owl (*Aegolius funereus* L.) in Czechoslovakia, Tichodroma, 3: 103–125.

Kopij, G., 2011, Population and range expansion of forest boreal owls (*Glaucidium passerinum*, *Aegolius funereus*, *Strix uralensis*, *Strix nebulosa*) in East-Central Europe. Vogelwelt, 132: 93–100.

Korpimäki, E., 1986, Gradients in population fluctuations of Tengmalm's Owl Aegolius funereus in Europe, Oecologia, 69: 195–201.

Korpimäki, E., 1988a, Effects of territory quality on occupancy, breeding performance and breeding dispersal in Tengmalm's Owl, Anim. Ecol., 57: 97–108.

Korpimäki, E., 1988b, Diet of breeding Tengmalm's Owls Aegolius funereust long-term changes and year-to-year variation under cyclic food conditions. Ornis Fennica, 65: 21–30.

Korpimäki, E., 1997, Tengmalm's owl *Aegolius funereus*. [in], The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance, Hagemeijer, E. J. M. and Blair, M. J. [eds.], T. & A. D. Poyser, London.

Korpimäki E, Hakkarainen H., 2012, The Boreal Owl: Ecology, Behaviour and Conservation of a Forest-Dwelling Predator, Cambridge University Press., Cambridge, UK: 420–421.

Kouba, Marek & Bartos, Ludek & Bartošová, Jitka & Hongisto, Kari & Korpimäki, Erkki. (2020). Interactive influences of fluctuations of main food resources and climate change on long-term population decline of Tengmalm's owls in the boreal forest. Scientific Reports. 10. 10.1038/s41598-020-77531-y.

Kurowski, R., 2021, Abundance and distribution of the Boreal Owl *Aegolius funereus* in the Bydgoszcz Forest in 2020, Ornis Polonica, 62: 74–82.

Mikkola, H., 1983, Owls of Europe, Poyser, Calton.

Mikusek, R., Sikora, A., 2004, Włochatka – *Aegolius funereus* (L., 1758). [in:], Poradniki ochrony siedlisk i gatunków Natura 2000 – podręcznik metodyczny. Ptaki, [Boreal Owl – *Aegolius funereus* (L., 1758). In: Natura 2000 habitat and species protection guides – methodological manual. Birds] Gromadzki M. [ed.], Warszawa.

Mikusek, R., Sikora, A., 2013, Stan populacji włochatki *Aegolius funereus* w Parku Narodowym „Bory Tucholskie" i Puszczy Darżlubskiej w roku 2012, Ptaki Pomorza, [Population status of the Boreal Owl *Aegolius funereus* in the "Bory Tucholskie" National Park and the Darżulbska Forest in 2012, Birds of Pomerania] 4: 97–110.

Moreno, E., 1985, Clave osteologica para la identification de los Passeriformes ibericos. I. Aegithalidae, Remizidae, Paridae, Emberizidae, Passeridae, Fringillidae, Alaudidae, Ardeola, 32(2): 295–377.

Moreno, E., 1986, Clave osteologica para la identificacion de los Passeriformes ibericos.11. Hirundinidae, Prunellidae, Sittidae, Certhiidae, Troglodytidae, Cinclidae, Laniidae, Oriolidae, Corvidae, Stumidae, Motacillidae, Ardeola, 33(1–2):69–129.

Moreno, E., 1987, Clave osteologica para la identificacion de los Passeriformes ibericos.lII. Muscicapidae, Ardeola, 34(2): 243–273.

Norberg, R. A., 1970, Hunting Technique of Tengmalm's Owl *Aegolius funereus* (L.), Ornis Scand., 1:51–64.

Osojca, G., 2004, Liczebność i wybiórczość siedliskowa sów *Strigiformes* w Puszczy Rominckiej w latach 1998–2002 [Abundance and habitat selectivity of *Strigiformes* owls in the Romincka Forest in 1998–2002], Not. Orn., 45: 13–20.

Plan urządzenia lasu Nadleśnictwa Solec Kujawski (obręby: Leszyce, Solec); sporządzony na okres od 1 stycznia 2022 roku do 31 grudnia 2031 roku, na podstawie stanu lasu w dniu 1 stycznia 2022 roku. [Forest management plan for the Solec Kujawski Forest District (forest ranges: Leszyce, Solec); prepared for the period from 1 January 2022 to 31 December 2031, based on the condition of the forest on 1 January 2022].

Pokorný, J, Kloubec, B. & Obuch, J., 2003, Comparison of Tengmalm's Owl *Aegolius funereus* diet in several Czech mountain areas, Vogelwelt, 124: 313–323.
Pucek, Z. (1984) Keys to Vertebrates of Poland: Mammals, PWN, Warszawa, pp. 357.

Ravussin, P.A., Trolliet, D., Daenzer, C., Longchamp, Romailler, K. & Métraux, V., 2015, Quel avenir pour la Chouette de Tengmalm Aegolius funereus dans le massif du Jura? Bilan de trente années se suivi, Nos Oiseaux, 62: 5–28.

Schoener T. W., 1971, Theory of feeding strategies, Annu Rev Ecol Syst, 2: 369–404.

Sergio, F., Caro, T., Brown, D., Clucas, B., Hunter, J., Ketchum, J., Mchugh, K. & Hiraldo, F., 2008, Top Predators as Conservation Tools: Ecological Rationale, Assumptions, and Efficacy, Annu Rev Ecol Evol S, 39: 1–19.

Sikora, A., Mikusek R., 2009, Włochatka *Aegolius funereus*. [in:], Monitoring ptaków lęgowych. Poradnik metodyczny dotyczący gatunków chronionych dyrektywą ptasią [Boreal

Owl *Aegolius funereus*. In: Monitoring of breeding birds. Methodological guide for species protected by the Birds Directive], Chylarecki P., Sikora A., Cenian, Z., [eds.], Biblioteka Monitoringu Środowiska, Warszawa: 439–447.

Speakman, J. R., 1991, The impact of predation by birds on bat populations in the British isles, Mammal Rev, 21: 123–142.

Sulkava, P., Sulkava, S., 1971, Die nistzeitliche Nahrung des Rauhfusskauzes *Aegolius funereus* in Finnland 1958–67, Ornis Fenn., 48: 117–124.

Tomiałojć, L., Stawarczyk, T., 2003, Avifauna of Poland. Distribution, abundance and changes. PTTP „pro Natura". Wrocław, pp. 868.

Tumiel, T., Mirski, P., 2018, Diet of boreal owl (*Aegolius funereus*) in lowlands of north-eastern Poland, Slovak Raptor Journal, 12(1): 41–45.

Ujhelyi, P., 2016, Cranial morphology of European passerine bird families (Aves, Passeriformes), Ornis Hungarica, 24: 54–77.

Table 1. Diet composition of the Boreal Owl *Aegolius funereus* in Bydgoszcz Forest, N% – percentage of diet by abundance, B% – percentage by biomass. Sampling date: I – 14 December 2020; II – June–July 2021; III – April–May 2022. Weight of prey in brackets after species name.

| Species | I | | II | | III | | Total | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | %N | N | %N | N | %N | N | %N | B | %B |
| *Sorex araneus* (8) | 9 | 11.8 | 26 | 17.6 | 15 | 17.4 | 50 | 16.1 | 400 | 10.9 |
| *S. minutus* (3.5) | 21 | 27.6 | 73 | 49.3 | 27 | 31.4 | 121 | 39.0 | 423.5 | 11.6 |
| **Insectivora** | **30** | **39.5** | **99** | **66.9** | **42** | **48.8** | **171** | **55.2** | **823.5** | **22.5** |
| *Myotis nattereri* (8) | 2 | 2.6 | 1 | 0.7 | 0 | 0.0 | 3 | 1.0 | 24 | 0.7 |
| *Plecotus auritus* (8) | 0 | 0.0 | 1 | 0.7 | 0 | 0.0 | 1 | 0.3 | 8 | 0.2 |
| Chiroptera indet. (8) | 2 | 2.6 | 0 | 0.0 | 0 | 0.0 | 2 | 0.6 | 16 | 0.4 |
| **Bats** | **4** | **5.3** | **2** | **1.4** | **0** | **0.0** | **6** | **1.9** | **48.0** | **1.3** |
| *Myodes glareolus* (16.5) | 7 | 9.2 | 2 | 1.4 | 9 | 10.5 | 18 | 5.8 | 297 | 8.1 |
| *M. arvalis* (19) | 3 | 3.9 | 1 | 0.7 | 0 | 0.0 | 4 | 1.3 | 76 | 2.1 |
| *M. oeconomus* (26) | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| *M. agrestis* (23) | 5 | 6.6 | 4 | 2.7 | 1 | 1.2 | 10 | 3.2 | 230 | 6.3 |
| *Microtus* spp. (22.5) | 3 | 3.9 | 0 | 0.0 | 0 | 0.0 | 3 | 1.0 | 67.5 | 1.8 |
| *Microtidae* spp. (21.25) | 2 | 2.6 | 4 | 2.7 | 0 | 0.0 | 6 | 1.9 | 127.5 | 3.5 |
| *A. sylvaticus* (25) | 10 | 13.2 | 12 | 8.1 | 11 | 12.8 | 33 | 10.6 | 825 | 22.5 |
| *A. flavicollis* (31) | 0 | 0.0 | 1 | 0.7 | 0 | 0.0 | 1 | 0.3 | 31 | 0.8 |
| *Apodemus* spp. (24) | 6 | 7.9 | 2 | 1.4 | 6 | 7.0 | 14 | 4.5 | 336 | 9.2 |
| *Muridae* ssp. (26.6) | 1 | 1.3 | 6 | 4.1 | 0 | 0.0 | 7 | 2.3 | 186.2 | 5.1 |
| *Rodentia* sp. (23.4) | 0 | 0 | 0 | 0 | 1 | 1.2 | 1 | 0.3 | 23.4 | 0.6 |
| **Rodents** | **37** | **48.7** | **32** | **21.6** | **28** | **32.6** | **97.0** | **31.3** | **2199.6** | **60.0** |
| *Fringilla coelebs* (25) | 0 | 0.0 | 2 | 1.4 | 1 | 1.2 | 3 | 1.0 | 75 | 2.0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Emberiza schoeniclus* (18) | 0 | 0 | 0 | 0 | 1 | 1.2 | 1 | 0.3 | 18 | 0.5 |
| *Carduelis spinus* (14) | 1 | 1.3 | 0 | 0.0 | | 0.0 | 1 | 0.3 | 14 | 0.4 |
| *Parus major* (20) | 0 | 0 | 0 | 0 | 1 | 1.2 | 1 | 0.3 | 20 | 0.5 |
| *Paridae* sp. (20) | 0 | 0 | 0 | 0 | 2 | 2.3 | 2 | 0.6 | 40 | 1.1 |
| *Regulus* sp. (5.5) | 0 | 0 | 0 | 0 | 4 | 4.7 | 4 | 1.3 | 22 | 0.6 |
| *Phylloscopus* sp. (9) | 2 | 2.6 | 0 | 0.0 | 1 | 1.2 | 3 | 1.0 | 27 | 0.7 |
| Tit-sized prey (18) | 2 | 2.6 | 13 | 8.8 | 6 | 7.0 | 21 | 6.8 | 378 | 10.3 |
| **Birds** | **5** | **6.6** | **15** | **10.1** | **16** | **18.6** | **36** | **11.6** | **594.0** | **16.2** |
| **Mammals** | **71** | **93.4** | **133** | **89.9** | **70** | **81.4** | **274** | **88.4** | **3071** | **83.8** |
| **Vertebrata subtotal** | **76** | **100** | **148** | **100** | **86** | **100** | **310** | **100** | **3665** | **100** |