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Which Bat Species are Captured by the Long-eared Owl *Asio otus* (Linnaeus, 1758) (Aves: Strigiformes) in Poland?

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Abstract: Twenty-two bat individuals were identified to the species level in published and unpublished data based on diet samples of *Asio otus* from Poland collected between 1989 and 2022. Of the seven species that made up the owl prey, *Myotis nattereri* (9 cases) and *Plecotus auritus* (6 cases) were by far the most numerous. The proportion of bats in the vertebrate prey was very low. In the central and north-eastern parts of the country, it was 0.05% between 1980 and 2002 and 0.04% between 2010 and 2024, although the differences were not statistically significant. The hypothesis that bat species associated with foraging in open areas are more abundant in the diet of this owl species, which hunts mainly in agricultural landscapes, could not be confirmed. The vast majority of prey were species that hunt near trees, in forests or over bodies of water. This indicates that the bats are mostly caught in situations other than typical foraging, e.g. near their roosts or resting places of owls. The fact that typical forest bats (*Myotis bechsteinii*, *Barbastella barbastellus*) were found in the winter diet of *A. otus* suggests that they were caught near underground hibernacula, which may be located in open areas away from forests.

Key words: Strigidae, Chiroptera, diet composition, predation, accidental prey, Central Europe

Introduction

For the long-eared owl *Asio otus* (Linnaeus, 1758), bats are incidental prey and their share in its diet is usually negligible, e.g. only 0.006% of the vertebrate prey in Central Europe (Birrer 2009) and 0.05 on the British Isles (Speakman 1991). This was also confirmed in Poland, where in the central and north-eastern parts, the proportion of bats in the diet of *A. otus* was 0.05% (Kowalski & Lesiński 2002). In Europe, bats were proportionally most abundant in the diet of this owl in the warmer regions in the south of the continent, while they made up only 0.43% of the prey on average (García et al. 2005). The exception is Asia, where bats make up about 1% of the owl's prey on average (Birrer 2009). Locally, in South-Eastern Russia, the proportion of bats can reach around 1.5% of the prey (Rosina & Shokhrin 2011). An exceptionally high proportion of bats (29.3%) was detected in pellets of owls living in urban and suburban areas near Beijing, China (Tian et al. 2015) and also in one breeding pair in Dresden,

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Germany where they represented over 40% of the vertebrate prey (Fabian et al. 2012). This owl species chooses open fields and meadows as primary foraging sites (Mikkola 1983), while bats forage less frequently in such environments and only some species with stronger sonar may regularly occur in open spaces (Dietz & Kiefer 2016).

The Central European populations of *A. otus* forage mainly in agricultural landscapes. Therefore, we hypothesised that the bat species caught by this owl species would be also associated with this type of environment. In Central Europe, the main prey of *A. otus* are rodents of the genus *Microtus*, especially *M. arvalis*. We assumed that bat species foraging in open spaces should dominate among the owl's bat prey. In contrast, the number of species that use echolocation over short distances and forage in or near forests (mainly 'gleaners') is probably small. The aim of this work was to collect existing data from Poland from the last decades and to test the above hypothesis.

Materials and Methods

Previously published data and the authors' unpublished data on the diet of *A. otus* in Poland were analysed. This allowed us to compile a list of individuals representing bat species caught by this owl. In this article, we summarise the data on bats that occurred in the samples collected between 1989 and 2022. Pellets from sites where long-eared owl gather for wintering in large numbers, usually collected between November and March, were labelled as "winter" diet. In contrast, the "spring-summer" diet came from the breeding season, summer and early fall. It was often difficult to determine the exact type of diet.

The bats were divided into four groups, depending on where they hunted. The first group included the open-space aerial foragers *Eptesicus serotinus* and *Nyctalus noctula*. The second group comprised the edge-space trawling forager *Myotis daubentonii*, the third group – the confined-space passive gleaning foragers *Plecotus auritus*, *Myotis nattereri*, *Myotis bechsteinii* and the fourth group – the edge-space aerial forager *Barbastella barbastellus* (Dietz & Kiefer 2016).

At sites in Central and North-Eastern Poland, the proportion of bats in the total prey in the period 2010-2024 was determined and compared with a similar proportion from the same part of Poland in the period 1980-2002. The proportions between the number of bats and the number of other owl prey in the different study periods were compared using the Chi^2 test (df=1), assuming a significance level of p=0.05.

Results

The analysis of previously published and unpublished data revealed that *A. otus* preyed on 22 bats in Poland, for which the species was identified. Seven species were found, most of which (about 2/3) were *M. nattereri* (9) and *P. auritus* (6). One species was represented by three individuals (*M. daubentonii*) and the remaining species (*M. bechsteinii, E. serotinus, N. noctula, B. barbastellus*) were found with one individual each (Table 1). In addition, one bat, whose species was not identified, was found in Gulin (Central Poland) on 24 July, 1990 (unpublished data).

The bats captured by *A. otus* are predominantly species that forage near vegetation or over water. In total, there were 20 individuals belonging to five species. The bats foraging in open spaces include the remaining two individuals belonging to two species (Fig. 1).

For relatively few of the analysed diet samples, it was possible to determine the exact period from which the pellets originated. Almost half of samples were collected in the winter. However, the data presented (Table 1) do not indicate a clearly different number of finds in the two different periods.

Using data from Central and North-Eastern Poland, we found that the proportion of bats was 0.05% in the period 1980-2002 and 0.04% in the period 2010-2024 (Table 2). There were no statistically significant differences (Chi^2=0.21, p=0.65).

Discussion

Analysing the results of more than 300 studies on the diet composition of *A. otus* around the world, Birrer (2009) showed that bats are very rarely caught. On average, bats made up 0.04% of the prey, which is very close to the result of studies in Central and North-Eastern Poland: 0.04-0.05%. Our study shows no significant changes in this parameter during the different study periods (Table 2). In the 1980s, bats in Central Europe probably reached a minimum population density (Węgiel et al. 2021). One of the most important factors influencing the decline of bats during this period was the chemical pollution of their environments (Jefferies 1972, Leeuwangh & Voûte 1985, Stebbings 1988, Zukal et al. 2015). Bat populations have recovered in recent decades and the abundance of some species has even increased manifold over time (Horáček 2010, Lesiński et al. 2011, Van Der Meij et al. 2015, Bator-Kocoł & Cichocki 2020). The lack of observed differences in the frequency of bat capture in *A. otus* in the two study periods is probably because

Table 1. List of identified bat species in the diet of *Asio otus* in Poland. Legend: WD – winter diet, SSD – spring-summer diet.

Species	Locality	Region of Poland	Pellet collection date	Diet type	Data source
Plecotus auritus	Stefanów	Eastern	26 Apr 1989	SSD	Unpublished data
Plecotus auritus	Zasiadały	Eastern	15 Aug 1989	SSD	Unpublished data
Myotis nattereri	Jarczew	Eastern	6 Jul 1991	SSD	Unpublished data
Myotis daubentonii	Kębłów Nowy	Eastern	7 Jun 1992	SSD	Unpublished data
Plecotus auritus	Kębłów Nowy	Eastern	7 Jun 1992	SSD	Unpublished data
Plecotus auritus	Kębłów Nowy	Eastern	9 May 1993	SSD	Unpublished data
Plecotus auritus	Wola Żelechowska	Eastern	23 Apr 1995	SSD	Unpublished data
Myotis nattereri	Rogoźnik	Southern	9 Apr 2009	WD	Unpublished data
Nyctalus noctula	Głuchów	Central	13 Apr 2012	WD	Lesiński et al. 2014
Myotis daubentonii	Brzeźce	Central	11 Oct 2015	SSD	Unpublished data
Myotis daubentonii	Brzeźce	Central	Mar 2016	WD	Stolarz et al. 2017c
Myotis nattereri	Wieliszew	Central	20 Mar 2016	WD	Stolarz et al. 2017a
Myotis nattereri	Brzeźce	Central	Sep 2016	SSD	Stolarz et al. 2017c
Plecotus auritus	Brzeźce	Central	Sep 2016	SSD	Stolarz et al. 2017c
Myotis nattereri	Bielsk	Central	23 Nov 2016	WD	Stolarz et al. 2017b
Myotis nattereri	Michałowice	Central	Feb 2017	WD	Stolarz et al. 2018b
Myotis nattereri	Mierczyce	Southwestern	6 Mar 2017	WD	Unpublished data
Myotis bechsteinii	Antolin	Southeastern	11 Mar 2017	WD	Stolarz & Lesiński 2017
Barbastella barbastellus	Antolin	Southeastern	11 Mar 2017	WD	Unpublished data
Myotis nattereri	Żarów	Southwestern	3 Jun 2017	SSD	Unpublished data
Eptesicus serotinus	Ciechanów	Central	17 Mar 2018	WD	Unpublished data
Myotis nattereri	Szreńsk	Central	23 Feb 2022	WD	Unpublished data

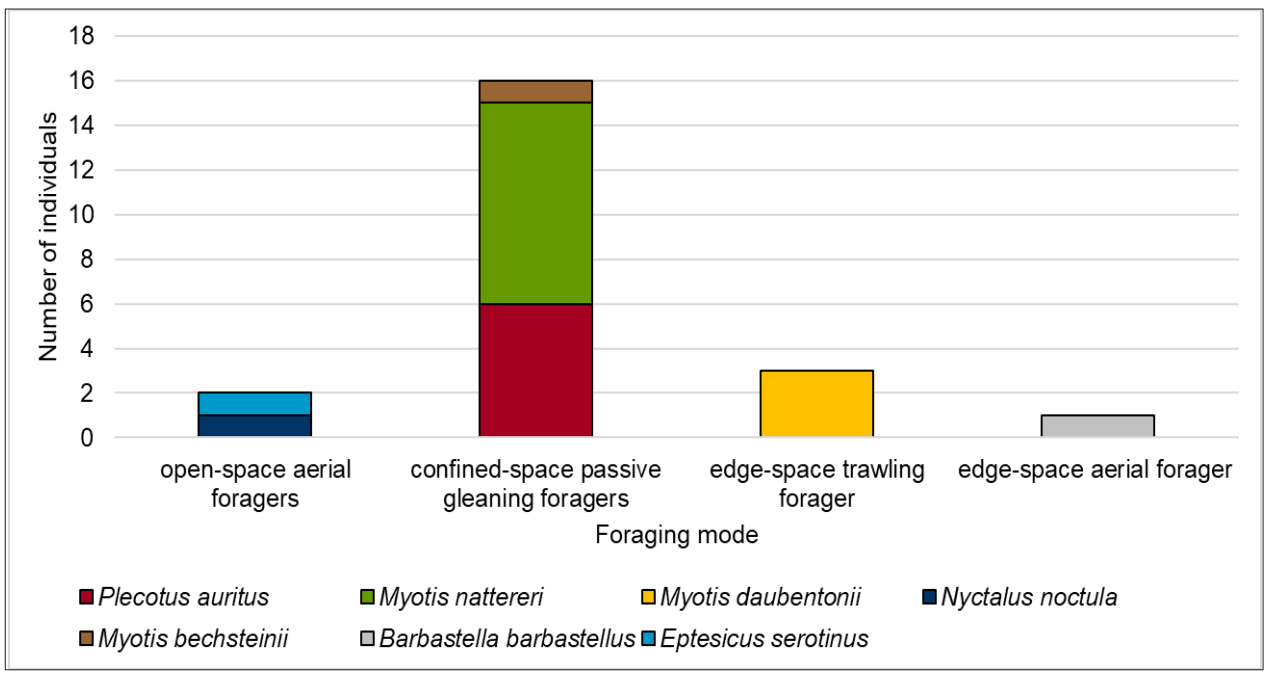

Fig. 1. Proportion of bat species in the diet of *Asio otus* foraging in different habitat types in Poland (N=22).

Table 2. Comparison of the proportion of bats in the diet of *Asio otus* in Central and North-Eastern Poland in 1980–2002 (Kowalski & Lesiński 2002) and 2010–2024 (Gryz & Krauze-Gryz 2015, Stolarz & Lesiński 2015, Lesiński et al. 2016a, 2016b, Stolarz et al. 2017a, 2017b, 2017c, 2018a, 2018b, 2018c, Romanowski & Lesiński 2019, Lesiński & Kasprzak 2023, authors' unpublished data). Individuals not identified to the species level are also included.

Study period	Bat number	Vertebrate prey	%
1980-2002	9	18292	0.05
2010-2024	10	27887	0.04

bats are an extremely rare and highly irregular component of its diet.

A significantly higher proportion of bats in the diet of *A. otus* was found in the urban environment of the large metropolitan area of Beijing, China (Tian et al. 2015) and in Dresden in East Germany (Fabian et al. 2012). In Poland, similar results were found in another owl species, the tawny owl *Strix aluco* (Lesiński et al. 2009a). The analysed diet samples of *A. otus* from Poland did not originate from large urban areas and the owls' hunting grounds mainly comprised open areas in agricultural landscapes.

The species composition of the bats caught by *A. otus* in Poland is quite surprising. The species that were most numerous were the confined-space passive gleaning foragers (*M. nattereri, P. auritus*) and the edge-space trawling forager (*M. daubentonii*). The classic representatives of the open-space aerial foragers group were only two species: *E. serotinus* and *N. noctula*, which were each represented by one individual. The assumed hypothesis is therefore not confirmed. Perhaps some bats were foraging near the edge of the forest or the tree line among the fields. It is possible that there are lookouts of *A. otus* in such places. It is also possible that some bats were caught near their roosts, as many owls hunt in such situations (Petrželková et al. 2004, Spitzenberger et al. 2014, Sieradzki & Mikkola 2020, Fabian et al. 2021). This could explain the presence of *M. bechsteinii* and *B. barbastellus*, typically forest species (Dietz & Kiefer 2016), in the long-eared owl winter diet. It can be assumed that these bats were caught during swarming near their underground wintering sites, which were located in an open area. *Asio otus* often forms aggregations in winter and occupies trees in buffer strips or small forests as well as in parks, often in village centres. Such green islands can also provide suitable roosts for bats.

In some studies, bats feeding in open spaces were recorded in the diet of *A. otus*. *Eptesicus serotinus* and *Vespertilio murinus* were found in a sample from Moldova (Nistreanu et al. 2020). Several dozen of individuals of *N. noctula* were found in samples from Slovakia (Tulis et al. 2015, 2019). However, there is no evidence that they were caught in the open areas of fields and meadows. The results of these studies show a very different picture of the species composition of bats captured by *A. otus* than our data from Poland.

Studies in Poland confirm observations from Southern Europe that *A. otus* does not select bat species with large body mass (García et al. 2005). The most numerous bat prey of *A. otus* in Poland was *M. nattereri*, which has been observed in increasing numbers at wintering sites in recent decades (Fuszara et al. 2010, Bator-Kocoł & Cichocki 2020). It is noteworthy that *M. nattereri* was predominantly found in the diet of *A. otus* in the period 2009-2022 (Table 1).

Determining the season from which the owl pellet originates is important, as bats hibernate in winter and are less available as potential prey. However, some species, including the dominant bat prey of long-eared owls (*P. auritus* and *M. nattereri*), are sometimes active in winter (Hope et al. 2014, Blomberg et al. 2021). The results presented do not clearly show a higher number of bats in spring and summer. This is an additional argument in favour of the bats not being hunted mainly in foraging areas in open terrains. However, it cannot be ruled out that collecting more pellet material from these owls from the period of the highest bat hunting activity (summer, early fall) would provide more information on bats as prey. In Southern Europe, these mammals are most frequently part of the diet of *A. otus* in summer and spring (García et al. 2005) and in East Asia in fall (Rosina & Shokhrin 2011).

The results presented here are only a preliminary assessment of the predation pressure of long-eared owls on bat populations in Poland. However, they show that it is low compared to some other owl species (Krzanowski 1973, Kowalski & Lesiński 2002, Sieradzki & Mikkola 2020). In particular, *S. aluco* clearly preys more frequently on bats – in urban environments they can account for up to 2% of vertebrate prey on average (Lesiński et al. 2009a). Some individuals of tawny owl may exhibit opportunistic behaviour near large aggregations of these mammals, feeding on them locally in much greater numbers (Obuch 1998, Lesiński et al. 2009b). So far, only seven of the 27 species recorded in Poland have been documented as prey of the long-eared

owl. However, estimates for the British Isles (similar area and proportion of bats in the diet of *A. otus* as in Poland) indicate that representatives of this owl species can reduce the number of bats by up to 10,000 individuals per year (Speakman 1991).

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