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Trophic niche overlap of two sympatric owl species (*Asio otus* Linnaeus, 1758 and *Tyto alba* Scopoli, 1769) in the North-Western part of Romania

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Abstract. The analysis of the pellets belonging to two sympatric owls (long-eared owl *Asio otus* and barn owl *Tyto alba*) from the Cefa Nature Park in the northwestern part of Romania) showed a clear predominance of small mammals, in diet of both species. A certain degree of specialization can be noted in the case of *A. otus* preying preferentially on *Microtus arvalis*. On the other hand, *T. alba*, consumes large quantities of common voles and constitutes only 31% of its total food source. Both species consume the occasional bird and represents less than 1% of its total prey. The standard Levins Index of the niche for *T. alba* (0.37) shows that the trophic niche-width is considerably larger in the case of *A. otus* (0.17). The barn owl subsists off of a much more diverse diet compared to the long-eared owl (16 vs 9 prey species). The two owl species live sympatricaly, using the same habitats, despite the existence of a considerable dietary overlap, but they avoid competing with each other by using different niches.

Key words: owls, pellets, diversity, overlap, niche, *Asio otus, Tyto alba.*

Introduction

Food habits and feeding ecology research is a fundamental tool to understand the role of each animal taxa within their ecosystems since they indicate relationships based on feeding resources and indirectly indicate community energy flux which allows inferring competition and predation effects on community structure (Roşca & Mânzu 2011, Răescu et al. 2011, Burton 1984).

The long-eared owl (*Asio otus* Linnaeus, 1758) and the barn owl (*Tyto alba* Scopoli, 1769) are two species that have a worldwide distribution, and who also live sympatrically (Burton 1984). Their food consists mainly of small mammals, birds, reptiles, amphibians, and arthropods in different proportions, according to regional studies (Alivizatos & Goutner 1999, Alivizatos et al. 2005, Bencová et al. 2006).

While the diets of the barn owl and the long-eared owl have been studied in Romania (see for *Asio otus*: Murariu et al. 1991, Sándor et al. 1997, Laiu & Murariu 1998, Laiu et al. 2002, Benedek & Sîrbu 2005, 2009, Sándor & Kiss 2008; for *Tyto alba*: Sándor & Sike 2003-2004, Benedek et al. 2007, Sándor 2008, 2009), studies have not been conducted yet regarding the overlap of the trophic niches of these two species in sympatric areas. The two owl species, even if using the same types of habitats, have different ways of capturing prey (Burton 1984). Although they both hunt out in the open, long-eared owls also hunt under tree canopies (Cramp 1985). Barn owls have longer legs than long-eared owls, thus, they are able to prey on Soricidae even in dense vegetative environments (Taylor 1994, Glutz von Blotzheim & Bauer 1991). This may provide enough evidence for the existence of two different trophic niches for these two coexisting species; a matter which has been studied here. There are only a handful of previous studies on this topic, mostly in different ecological conditions. Marks & Marti (1984) made a comparative study on two populations of these species in the state of Idaho in the United States, Alivizatos & Goutner (1999) and Alivizatos et al. (2005) presents data for an additional two species in Greece, and Capizzi & Luiselli (1995) for Italy, and Delibes et al. (1984) for Spain that represent a more Mediterranean climatic zone.

The aim of this study is to make a comparative assessment of the diet of the two species of owls (*Asio otus* and *Tyto alba*) that live sympatrically. Our analysis emphasizes the following aspects: diet composition, the diversity of the trophic niches, the width and overlap of the trophic niches to evaluate the competition and coexistence levels of these two species in continental Europe.

Materials and Methods

The study was carried out in Cefa Nature Park, in the NW part of Romania (46.93608N, 21.65021E; 92m altitude; annual average temperature was 10.5^0C; with a 635 mm annual average rainfall), in an area where there is a high diversity of natural and semi-natural habitat that include: forests, meadows, wetlands, grasslands, rural areas and arable crops. Pellets of *Asio otus* were collected from roosting and nesting sites, located in Cefa, a rural settlement, with a population of 1,300 inhabitants, surrounded by agricultural fields that have maize and wheat crops (arable lands), salt pannonian grasslands with *Peucedanum officinale*, *Statice gmelinii*, *Festuca pseudovina*, *Alopecurus pratensis*, *Poa pratensis*, *Artemisia santonica ssp. monogyna*, and a floodplain forest predominantly composed of *Quercus robur*, *Ulmus minor* and *Fraxinus excelsior* and fish ponds with large areas covered by *Phragmites australis* and channels (See composition of land uses in Table 1).

Pellets of *Tyto alba* were collected from two locations that represent roosting and nesting sites (Fig. 1).

Pellets were collected randomly between May of 2007 and April of 2008. Collecting was irregular and the number of pellets obtained was quite variable so no attempt was made to study their seasonal or temporal diet. All pellets were processed in the laboratory using standard techniques (Yalden 2003). The prey from pellets were identified mainly through cranial remains using references from (Pucek 1984, März & Banz 1987, Jaeger 2001, Yalden 2003, Bang & Dahlstrom 2007, Cserkesz et al. 2008). All prey was identified by species.. *Apodemus flavicollis* (Melchior, 1834) and *Apodemus sylvaticus* (Linnaeus, 1758), are treated together in this paper following Uttendörfer (1952) and Sándor et al. (1997). According to morphometrics criteria, being able to distinguish the two species exclusively through the examination of their pellets may prove problematic (Zoller et al. 2004). Although Barciova & Macholan (2009) offer an efficient key in being able to discriminate between the two species, the morphometric dimensions that were used for most of the skulls collected from pellets cannot be rebuilt.

Table 1. The proportions of different land use categories within a radius of 3 km from where pellets were collected.

Land use	%
Grassland	10.75
Arable land	64.36
Wetlands	12.77
Forest	2.52
Settlement, road	9.60

<u>Ecological parameters of their diet</u>

The index of the relative importance (George & Hadley

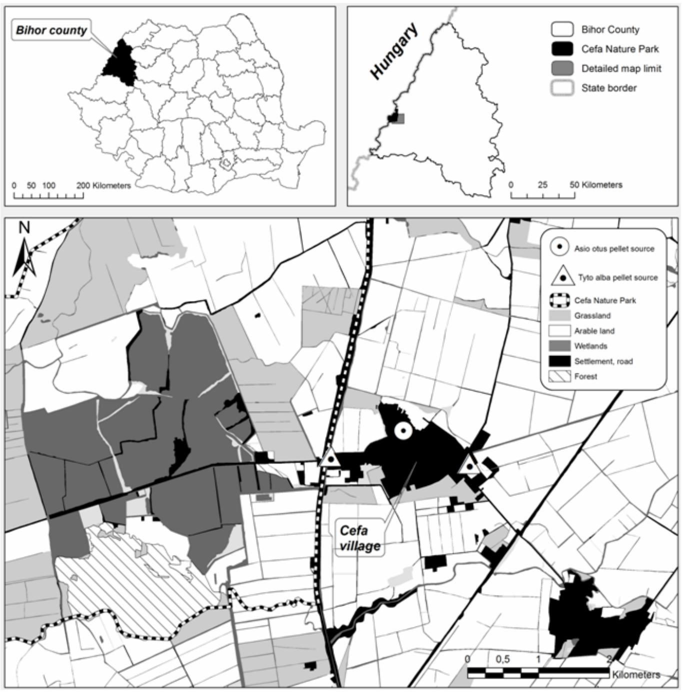

Figure 1. Map showing the study area.

1979) formula is: $R_i = 100A_i/\Sigma A_i$, is based on an 'absolute importance index' (A_i) where: $A_i = F_i+A_i+G_i$. F_i represents a percentage of occurrence for species *i* in the pellets; A_i is the percentage abundance of species *i* by total prey number; G_i is the percentage biomass and was calculated multiplying the number of individuals in the pellets by the estimated body mass of each prey species divided by the total sum of the biomass. Biomass was calculated using mammals trapped in the area (Benedek, AM pers. comm.), that contain additional data from the literature for species not caught by trapping (Murariu & Munteanu 2005, Popescu & Murariu 2001). The trophic dimensions of the ecological niches (niche breadth) were studied by the Levins's Index, $D=1/\Sigma p_i^2$, where *pi* represents the relative abundance of species *i* of the total prey (Levins 1968). Dietary overlap was calculated using a Pianka's symmetrical Index (Pianka 1974), with formula:

$$O = \sum p_{ij} p_{ik} / \sqrt{(\sum p_{ij}^2 \sum p_{ik}^2)}$$

where p_{ij} and p_{ik} represents the proportion of the resource of *i* (relative abundance) used by *j* population and respectively, *k* population. This index was multiplied by 100 to express it as a percentage and ranges from 0% (signifying no overlap) to 100% (signifying a complete overlap) as a measure of them having a similar diet (Herrera & Hiraldo 1976).

All statistical analyses were carried out using Statistica version 9.0 for Windows (StatSoft, Inc.) and the significance level for t-Student test was set to 0.05 (Zar 1999).

Results

This study was carried out using 493 intact pellets (175 pellets of the long-eared owl and 318 pellets of the barn owl) out of which 1722 prey-individuals were identified. The mean number of prey types per pellet differed significantly between owl species: 2.4 [95% CI: 2.26 -2.54] prey types per pellet for *Asio otus*, and 4.1 [95% CI: 3.9 – 4.3] prey types per pellet for *Tyto alba* (t-Student test, p<0.0001). The maximum amount of prey types found in a single pellet was 6 for *A. otus* and 11 for *T. alba*.

A total of 17 prey-species were identified altogether (Aves and Mammalia, Table 2). Rodents were found to be the primary diet of both owl species, however *A. otus* eats almost exclusively rodents (99.8% by number), while *T. alba* in this category reaches 64.6%, (35% of the prey belonging to the Soricomorpha order). Based on the total consumed biomass (Table 1), the composition is almost the same for *A. otus,* (99.7%), while for *T. alba* the value goes up to 81.1% for rodents. For both owl species, birds formed less than 1% of the overall diet, as a number and as a biomass.

Table 2. Frequency (*Fi*), abundance (*Ai*), biomass (*Gi*) percentages and the relative importance index (*Ri*) of prey items found in *Asio otus* and *Tyto alba* pellets.

Prey	*Asio otus* (175 pellets)				*Tyto alba* (318 pellets)			
	F_i (%)	A_i (%)	G_i (%)	R_i (%)	F_i (%)	A_i (%)	G_i (%)	R_i (%)
Cls. Aves								
Passer domesticus	0	0	0	0	1.2	0.3	0.6	<0.01
Passer montanus	0.6	<0.01	0.2	<0.01	0	0	0	0
Fringilla coelebs	0	0	0	0	0.3	0.1	0.1	<0.01
Cls. Mammalia								
Ord. Soricomorpha								
Sorex araneus	0	0	0	0	21	8.4	4.3	0.77
Sorex minutus	0	0	0	0	18	6.9	2.6	0.33
Crocidura suaveolens	0.6	0.2	0.1	<0.01	26	8.6	3.9	0.88
Crocidura leucodon	0	0	0	0	26	11	7.3	2.12
Neomys fodiens	0	0	0	0	0.3	0.1	0.1	<0.01
Ord. Rodentia								
Microtus arvalis	84	62.1	58	95.74	70	31	40	87.97
Microtus subterraneus	9.7	4.9	4.5	0.07	4.7	1.3	1.5	<0.01
Apodemus agrarius	14	6.3	6.2	0.17	16	4.3	5.8	0.4
A.flavicollis/sylvaticus	33	15.1	23	3.63	28	9.5	17	4.58
Micromys minutus	2.3	1	0.3	<0.01	11	3.9	1.6	0.07
Mus musculus	2.3	1	0.7	<0.01	12	4.7	4.2	0.24
Mus spicilegus	19	9.4	7	0.4	27	9.7	9.9	2.63
Rattus norvegicus	0	0	0	0	0.3	0.1	1	<0.01
Muscardinus avellanarius	0	0	0	0	0.3	0.1	0.1	<0.01
Mean of number prey/pellet	2.4 [95%CI: 2.26 -2.54]				4.1 [95%CI: 3.9 – 4.3]			
Mean of prey biomass /pellet (g)	45.8 [95%CI: 43.13 – 48.47]				60.17 [95%CI: 56.15 – 64.2]			

The average biomass of the prey per pellet is 60.17 g [95% CI: 56.15 – 64.2] for *Tyto alba* (Table 2), which is significantly larger than *Asio otus* (t-Student test, $p<0.00001$).

The most important prey species for *Asio otus*, was the field vole *Microtus arvalis*, both numerically and when examining their overall biomass (62.1% and 58% respectively). The *Apodemus flavicollis/sylvaticus* complex reaches a numerical abundance of 15.1% (23% as a biomass).

Microtus arvalis is also a favourite prey for *Tyto alba*; although its percentage in the diet is smaller (31% numerical and 40% as biomass). Five more species were represented with a numerical percentage of between 7% and 15%, and nine prey-species with less than 5%. *Microtus arvalis* represented the most important prey for both species, with indexes as 87.97% for *T. alba* and as 95.74% for *A. otus* (Tabel 1). All the other prey-species are characterized by values less than 5%.

The value of the Levins index, obtained for *Tyto alba* (6.49) has a breadth of the trophic niche twice as much compared to *Asio otus* (2.36). The differences are significant where: (X^2 = 207.65, df = 289, $p<0.999907$) and the Pianka index, which shows an overlap of the two niches by 87%.

Discussion

The ratio of prey to pellet in the case of *T. alba* is significantly larger than in individual *A.otus*. Similar results were found in a number of other studies (Tiranti 1993, Gotta & Pigozzi 1997, Purger & Reider 1998, Laiu et al. 2002, Bontzorlos et al. 2005, Benedek et al. 2007). This fact may be related to a smaller biomass of shrews and *Mus* mice species that *T. alba* consumes in a larger proportion than *A. otus*.

While the individual representation of different mammal species within the diet of the two owls may differ according to their hunting habitat (Alivizatos & Goutner 1999, Mikkola 1983, Mebs & Scherzinger 2000), it can certainly be asserted that both owls prefer mammals. In most cases, the diet of *Tyto alba*, is made up by small-sized mammals. Thus, Benedek et al. (2007) reported that 61.8% of their prey are shrews; while Sándor & Sike (2003-2004) show preferences for smaller dimension prey-species in the northwestern part of Romania. Based on a long-term study, it was found that barn owls rely heavily on species with a smaller weight in wetlands and grasslands of the Danube Delta region, where less than 20% of the prey has a weight larger than 20g (Sándor 2008, 2009). Bunn et al. (1982) described the barn owl as an unspecialized predator of small mammals (primarily shrews in temperate regions).

By contrast, the long-eared owl hunts shrews somewhat infrequently (Alivizatos et al. 2005, Bunn et al. 1982, Burton 1984). Instead, this predator seems to concentrate on relatively few mammal species that usually have a somewhat larger dimension like Arvicolinae voles. *Microtus arvalis* in our case, represents 58% of the prey biomass and 62.1% of their number. These values fall between the averages found in Romania in Iasi (52.99%) and Bacau (73.95%) by Laiu et al. (2002). However, they are much lower than those found in Timişoara (96.7%) or Cluj (96.9%) (Sándor et al. 1997).

Microtus arvalis is exploited preferentially by *Tyto alba* (31% numerical and 40% as biomass), but in a smaller proportion due to its preference for several smaller types of prey.

The relative question here is if their primary prey of *M. arvalis* is selected by the owls or if they are simply taken according to its availability. The results of using 9 live traps in the region between 2005 and 2008 (Table 3) reveal the clear dominance of *Apodemus agrarius* (63.33%) - a hygrophilous species which find suitable conditions in the habitats that form the Cefa Fish Ponds (Benedek & Sîrbu 2009). Therefore, we can assert that the diet of these owls does not reflect the availability of the mammals within their environment. The most abundant species (*Microtus arvalis*) contained 2.92% of the pellets (see Table 3) (Benedek & Sîrbu 2009).

A number of species on the owls menu are not present among live-trap captures. This fact may be due to the use of a much larger area within their diverse habitat, or due to a reduced efficiency when trapping them. It could also be due to an avoidance of certain mammal species (Pratoni et al. 1997). Birds are not favoured by either of these two predator species (Mikkola 1983, Cramp 1985, Glutz von Blotzheim & Bauer 1991, Taylor 1994, Roulin 2004). However, local prey specialization may occur (Milchev et al. 2006, Sándor & Kiss 2008, Birrer 2009). In this study, birds were numbered less than 1% of the total prey that was consumed. A study from the nearby Crişana region produces almost identical results for *Asio otus,* with a relative abundance of the birds at 0.21% (Benedek et al. 2007). However, wintering popula-

Table 3. Percentage numerical abundance of species of mammals in Cefa Nature Park, in 2005-2008 (live trapping) and owls' diet (present study).

	Numeric abundance (%)		
	Live-traps Capture (Benedek & Sîrbu2009)	*A. otus* pellets (present study)	*T. alba* pellets (present study)
Apodemus flavicollis	16.25	-	-
Apodemus sylvaticus	7.50	-	-
Apodemus flavicollis/sylvaticus	23.75	15.10	9.50
Sorex araneus	2.92	0.00	8.40
Apodemus agrarius	63.33	6.30	4.30
Crocidura suaveolens	0.83	0.20	8.60
Microtus arvalis	2.92	62.10	31.00
Crocidura leucodon	4.58	0.00	11.00
Mus musculus	1.67	1.00	4.70
Other species	-	15.30	22.50

Table 4. The niche breadth (Levins index) values for *Asio otus* and *Tyto alba* in different studies.

Autors	Area	*A. otus*	*T. alba*
Herrera & Hiraldo 1976	Central Europe	2.73	4.6
Alivizatos et al. 2005	Mediterranean islands,(Greece)	1.29-1.58	1.12–2.14.
Sandor & Sike 2003-2004	Dobrogea (Romania)	-	2.71
	Satu Mare (Romania)	-	2.89
Alivizatos & Goutner 1999	Northeastern Greece	-	5.19
Goutner & Alivizatos 2003	Wetlands Greece	-	0 – 1.39
Bencova et al. 2006	Southern Moravia (Czech Republic)	0.88-1.99	-
Navarro et al. 2003	Kazakhstan	2.85	-
Benedek et al. 2007	Crişana Region (Romania)	-	5.172 and 4.737
Bontzorlos et al. 2005	Central Greece	-	4.32 – 5.8
Present study	Cefa (Romania)	2.36	6.49

tions of long-eared owls in Cluj and Timişoara consumed ten times more birds, caused by the lack of availability of small mammals from the cold season, snow cover and the presence of urban habitats (Sándor et al. 1997). Research in Bulgaria in the 1960s and 1970s showed that birds represented between 7.5 and 18.2% by number of prey individuals (Simeonov 1978, Simeonov et al. 1981). But Schöpfer et al. (1984) signals that in northern Germany that for some years, up to 83% of birds were contained within *Asio otus* pellets. However birds may represent almost 90.7% of *A. otus'* prey in places where they are more abundant than mammals (Sándor and Kiss 2008, Yosef et al. 2008).

Similar finds are reported for *Tyto alba* across its range regarding birds in their diet, with 0.1% in Nordwestmecklenburg (Zoller et al. 2004) and 0.77% in Potsdam (Wuntke & Ludwig 1998), and in Dobrogea – Romania, at Histria (0,4%) (Sándor & Sike 2003-2004, Sándor 2008, 2009). In Satu Mare (northern part of Romania), in a habitat with a strong anthropic impact, the abundance of birds in the food was 20.3% (Sándor & Sike 2003-2004), a value much higher than in the previous case.

The importance of the *Mus* mice species (*musculus* and *spicilegus*) is hard to compare with other studies as in most cases these two species are treated together, due to identification problems (Cserkesz et al. 2008). The diversity of the niches of the two predator species is also significantly different and clearly shows a more varied diet for *T. alba*. This fact is also described by the authors when comparing a diet selection of these two owl species (Table 4).

The niche breadth is wider for *T. alba,* compared to *A. otus,* and shows less specialization for certain prey categories compared to *A. otus*. Within the studied area, certain potential prey species types were not utilised by *A. otus*, (like rats, hazel dormice and none of the 4 species of shrews that are normally present). The presence in *T. alba*'s diet of both large dimensional prey (*Rattus*) and small bodied (shrews, *Mus sp.*), shows that this predator is less selective according to its size.

Living in sympatry, using the same habitat, and having approximately the same basic hunting techniques (nocturnal searching by scanning over open rangeland, clearings and fallow fields), the two sympatric species can coexist even if the overlap of the trophic niches is wide (87%). A way of doing so is by adopting different niche breadths (Amat & Soriguer 1981, Veiga 1981, Capizzi & Luiselli 1995).

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