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DYNAMICS OF *ASIO OTUS* L., 1758 (AVES: STRIGIFORMES) WINTER-SPRING TROPHIC REGIME IN WESTERN PLAIN (ROMANIA)

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Abstract. The trophic regime of *Asio otus* is dominated by *Microtus arvalis*. In both areas the proportion of this species in the long-eared owl's food presents an important seasonal variation. In winter it moves usually through tunnels under the snow, thus being less frequently hunted. When the main prey is scarce, alternative food resources are exploited, in these areas mice, which become dominant as a group. A significant variation is recorded also by the mean biomass of preys of *Asio otus* from Satu Mare. The average body mass increases with one third from January to March, when the efficiency of hunt is maximum.

Résumé. La diète d'*Asio otus* est dominée par *Microtus arvalis*. La proportion de cette espèce dans la nourriture de l'hibou moyen duc présente une variation significative. Durant l'hiver le campagnol de champs se déplace sous la neige et il est ainsi moins chassé. Quand la proie principale est rare sont exploitées les ressources alternatives, les murides, qui deviennent dominants. La biomasse moyenne de la proie d'hibou présente aussi une variation saisonnière significative à Satu Mare. Elle augmente d'un tiers de Janvier à Mars, quand l'efficacité de la chasse est maximale.

Key words: long-eared owl, diet, *Microtus arvalis*, mice, rodents, Satu Mare, Cefa.

INTRODUCTION

Although being a feeding specialist preying on Microtidae, *Asio otus* presents in some cases a high variability of its trophic regime, several groups of animals being used as main or alternative food resources. Insects and other invertebrates represent an accidental prey, having a low frequency. Amphibians and reptiles are also preyed upon accidentally (Romanowski & Zmihorski, 2008; Petrescu, 1997). Birds are an alternative food resource, which can be important preys for the long-eared owls in some environments or in some periods (Wijnandts, 1984), reaching over 90% of the preys in some urban environments (Kiat et al., 2008). In Romania the highest ratio (59.3%) of birds was recorded also in a locality, namely Tulcea, at the border of the Danube Delta (Sándor & Kiss, 2008). Among the small mammals, bats are very rarely identified in *Asio otus* pellets (Cecere & Vicini, 2000), although they may represent an important food resource for other owls, like *Strix aluco* (Benedek, 2004). Insectivores appear commonly in the *Asio otus* pellets, usually in low numbers, representing less than 1% (Cecere & Vicini, 2000; Romanowski & Zmihorski, 2008; Benedek, 2004; Murariu et al., 1991). Muridae (mainly *Apodemus* spp. in natural environments, *Mus musculus* and *Rattus norvegicus* in urban areas) represent the main alternative food resource (Cecere & Vicini, 2000; Sike, 2003-2004; Rubolini et al., 2003), several studies revealing their dominance both in numbers and in biomass (Murariu et al., 1991; Petrescu, 1997; Bertolino et al., 2001; Rubolini et al., 2003).

A significant geographical pattern of *Asio otus* diet can be identified, with a stronger feeding specialization in the northern part of the range. In southern Europe

the diet comprises 3 groups of main food resources (muridae, microtidae, and birds) (Galeoti & Canova, 1994; Bertolino et al., 2001) instead of just one (microtidae) in the rest of the continent. The voles are represented in the diet by different species depending on the geographic area. *Microtus arvalis* is the main prey in the central part of Europe. In Romania, it is constantly found in the pellets, being usually the dominant species in the diet. Its share is however very variable, between 8.8% (Murariu et al., 1991) and 88.8% (Benedek, 2004). Among the other voles, in some mountainous areas (probably only in years of peak densities) *M. agrestis* may become an important food resource, reaching 12.96% (Banaru, 1998). In Great Britain, because *M. arvalis* is not present, *M. agrestis* represents the main prey of the long-eared owl (Mikkola, 1983). In northern Europe besides the two species mentioned before, *M. oeconomus* represents an important food resource (Nilsson, 1981; Canova, 1989). In southern Europe these species are replaced by *M. savii* (Cecere & Vicini, 2000). The other vole species appear only sporadically in *Asio otus* pellets, as they either do not commonly occur in habitats where the bird hunts, being typical forest dwelling rodents (*Clethrionomys glareolus, Pitymys subterraneus*), or are very rare (*P. tatricus, P. bavaricus*, etc).

The importance of voles as main prey for the long-eared owl is revealed by some studies that show a significant, strong and positive correlation between the vole population density and the number of owl breeding pairs, clutch size and number of young produced (Korpimäki, 1984). The preference of *Asio otus* (and also other raptor birds) for *M. arvalis* is explained by its body mass, which is close to the weight of "ideal prey", its habitat represented mainly by open fields where the owl hunts, with short vegetation, being more exposed to predators. It is less agile than mice, is gregarious and it is mostly nocturnal and crepuscular, overlapping its activity period with the long-eared owl.

Besides the geographic variation of *Asio otus* trophic regime, several studies pointed out a significant temporal dynamics, a seasonal change (Romanowski & Zmihorski, 2008; Bertolino et al., 2001).

The present study, concerning the composition of *Asio otus'* diet, aims to reveal a possible pattern of its dynamics, comparing it with the results recorded in other areas of Europe.

MATERIAL AND METHODS

The present study was based on the analysis of two sets of *Asio otus* pellets. The first set consisted of four samples totalizing 200 pellets collected from Satu Mare town on the 14th of January, 13th of February, 5th and 20th of March 2000. They come from a colony of 45-50 specimens which overwintered in 5 *Thuja orientalis* from a garden in the vicinity of town centre. The second set comprised 100 pellets from Cefa Nature Park Reserve, collected in January and February 2007. The prey species were identified using the characters of dentition, the maxillary and mandibulary bones, in accordance with Pucek (1981), Murariu (2000), Popescu & Murariu (2001). Some of the skeletal remains from the pellets were not complete, making impossible their identification to the species level. Thus the specimens belonging to *Sylvaemus* subgenus (*Apodemus flavicollis, A. sylvaticus* – prevailing in both sets of pellets, and *A. uralensis*) are considered together. Due to the difficulties of distinguishing them based on morphological and anatomical criteria, the two *Mus* species (*Mus musculus* – probably more frequent in Satu Mare, and *M.*

spicilegus – likely more abundant in Cefa Nature Park), are also considered together.

For the gravimetric structure of *Asio otus'* diet we used the mean values for each species calculated on the biomasses of the specimens captured in Cefa Nature Reserve between 2005-2009 (Benedek & Sîrbu, unpublished data), and where not available, we used the values from the literature (Murariu, 2000; Popescu & Murariu, 2001). For the unidentified *Apodemus* specimens it was used a weighted mean of the species' biomass.

The significance of differences along the study period between the ratios of Microtidae and Muridae in the diet was tested using Z test for two proportions, and between the biomass of preys using t test. The width of ecological niche's trophic dimension was characterized by means of Levins B standardized index, calculated on relative abundance.

RESULTS

In the pellets from Satu Mare 546 prey specimens were identified, all rodents (Tab. 1). The prevailing species is *Microtus arvalis,* other important food resources for *Asio otus* in this area being the species of *Sylvaemus* subgenus and *Micromys minutus*.

Table 1

Number of specimens and biomass of prey species identified in *Asio otus* pellets from Satu Mare in winter-spring 2000.

Sample \ Species		*M. arvalis*	*A. agrarius*	*Sylvaemus* spp	*M. minutus*	*Mus* spp.	Total	Mean prey biomass (g)
14.01.2000	No.	31	13	45	31	6	126	19.65
	Gr.	930	266.5	967.5	217	96	2477	
13.02.2000	No.	88	10	22	17	1	138	25.02
	Gr.	2640	205	473	119	16	3453	
05.03.2000	No.	129	4	10	3	0	146	28.68
	Gr.	3870	82	215	21	0	4188	
21.03.2000	No.	102	11	17	6	0	136	27.15
	Gr.	3060	225.5	365.5	42	0	3693	
Total	No.	350	38	94	57	7	546	25.29
	Gr.	10500	779	2021	399	112	13811	

The mean number of preys per pellet varied between 2.52 (in January) and 2.95 (at the beginning of March), and the mean biomass between 49.54 g and 83.76 g, values recorded in the same periods.

The share of *M. arvalis* (the only Microtidae species identified in the pellets) in the diet of *Asio otus* in the whole period of study is 64.1%, but among the four lots there is a high variation (Fig. 1). In January it represents only 24.6% of the prey specimens, dominant being the Muridae, especially *Micromys minutus* and the species of *Sylvaemus* subgenus. In February the share of *M. arvalis* increases, having a value close to the mean per the entire period, and continues to raise until the beginning of March, when it reaches the maximum of 88.3%, while the mice become accidental preys (*Mus* are not present anymore in the pellets). At the end of March the ratios of the prey species get again close to the mean values from the whole study period.

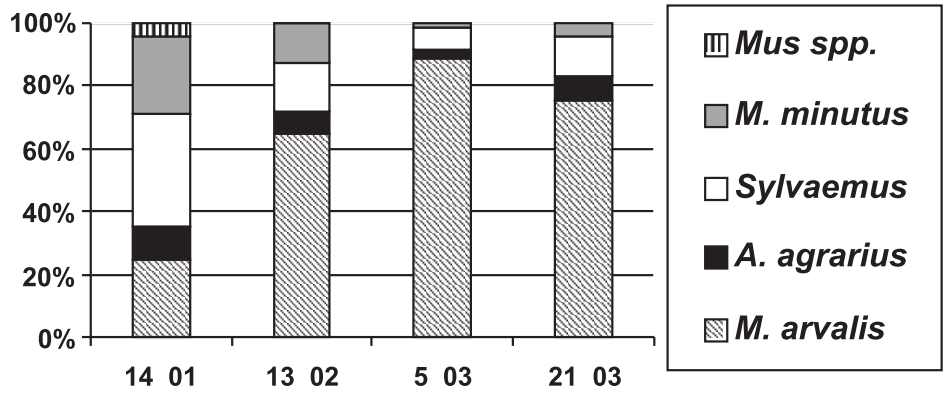

Fig. 1 - Dynamics of *Asio otus*' diet numerical composition in Satu Mare between January and March 2000.

Considering the ratio between voles and mice, the Z test for two proportions confirms a significant variation of diet structure from January to February and from February to the beginning of March ($Z_{January\text{-}February}=3.98$, $Z_{February\text{-}March}=2.88$, $p<0.01$), but the following (during the month of March) change is not significant.

A more detailed image of the diet composition's fluctuations in the period of research can be obtained by spline cubic interpolation (Fig. 2).

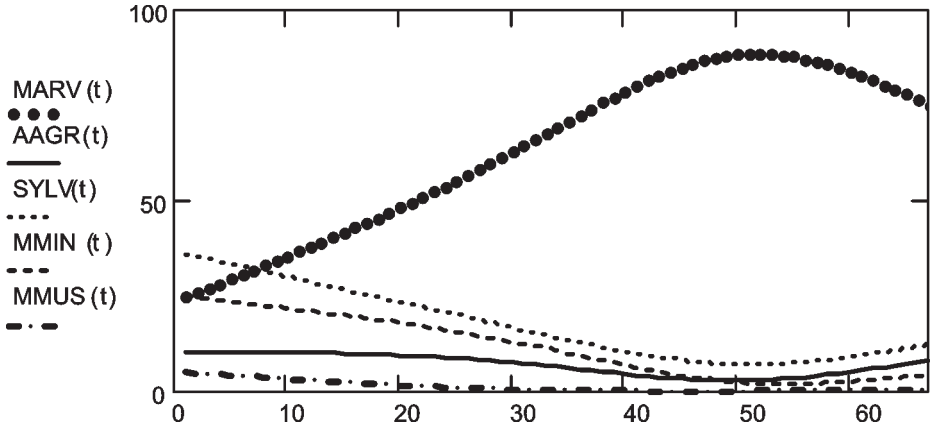

Fig. 2 - Time dynamics of the trophic resources spline cubic function interpolation (relative abundance of each prey related to time range in terms of days) (the codes are MARV- *Microtus arvalis*, AAGR – *Apodemus agrarius*, SYLV – species of *Sylvaemus* subgenus, MMIN – *Micromys minutus*, MMUS – *Mus musculus*).

Table 2

Pearson correlation matrix for the prey species in *Asio otus* diet (the codes are the same as for fig. 2).

	MARV	AAGR	SYLV	MIN	MMUS
MARV	1.000				
AAGR	-0.946	1.000			
SYL	-0.997	0.935	1.000		
MMIN	-0.991	0.926	0.981	1.000	
MMUS	0.941	0.816	0.962	0.910	1.000

Considering the Pearson correlation matrix (Tab. 2), based on all interpolated time series, for 67 days (lags), the relative abundance of *Microtus arvalis* in the diet is strongly and negatively correlated with all the other resources, while the rest of prey species are strongly and positively correlated. All coefficients are significant at $\alpha = 0.01$.

All cross-correlation functions between *Microtus arvalis* and any other food resource show a high degree of instantaneous negative correlation, highly significant ($p<0.01$), which decreases with both negative and positive time lags. Between the mice species the cross-correlation function shows a similar pattern, namely a strong, highly significant and positive instantaneous correlation, which decreases both with positive and negative lags.

Levins B index shows an important variation of the niche's width along the period of study (Fig. 3). In winter *Asio otus* appears to be a generalist feeder, preying in similar proportions on several species (mainly *Microtus arvalis* and *Micromys minutus*). Later, due to the increased availability of *M. arvalis,* it turns to a specialized diet, the calculated niche width value being the lowest at the beginning of March. This pattern appears to be widely spread in central and northern Europe, but is the opposite to that from southern Europe, where the food-niche breadth was low in autumn and winter but increased markedly from May to August (Bertolino et al., 2001).

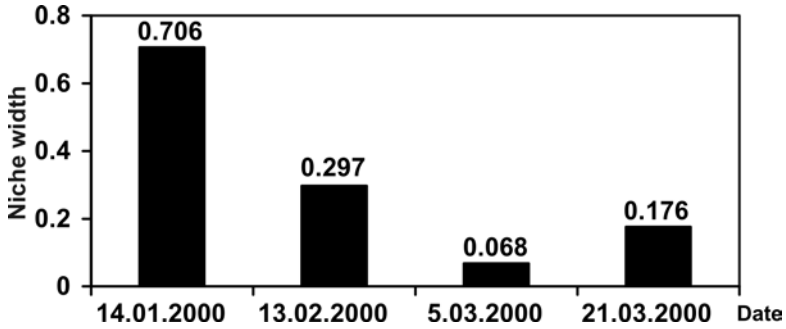

Fig. 3 - Temporal dynamics of the trophic dimension of ecological niches' width in the *Asio otus* population from Satu Mare, given by the Levins-B standardized measure.

The dynamics of *Asio otus* diet's gravimetric composition presents a pattern similar to the numerical structure, but the values are different (Fig. 4) due to the higher biomass of *M. arvalis* compared to the mice (especially *M. minutus*, abundant during winter but with a mean body mass of only 7 g).

The mean weight of prey specimens in the analyzed pellets records an increase from winter to spring, from 19.6 g in January to a mean of 28 g in March (Tab. 1). The t test showed a highly significant difference between the mean values from one sampling date to the other ($t_{January\text{-}February} = 5.44$, $t_{February\text{-}March} = 6.14$, $t_{March\text{-}March} = 3.92$, $p<0.01$).

The diet of *Asio otus* population from Cefa Nature Park presents a more diverse and balanced structure. Besides the rodents found also in Satu Mare, two species of shrews were present, although in low number. *M. arvalis*, which is the dominant prey species also in this area, represents only one third (36.3%) of the identified specimens.

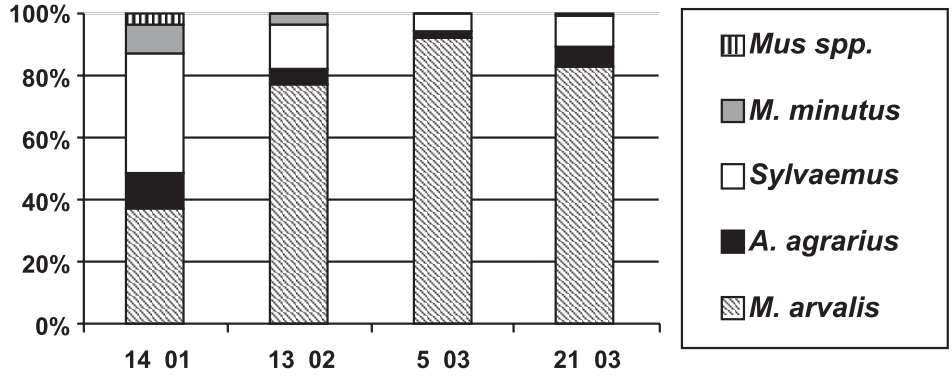

Fig. 4 - Dynamics of *Asio otus* diet's biomass composition in Satu Mare between January and March 2000.

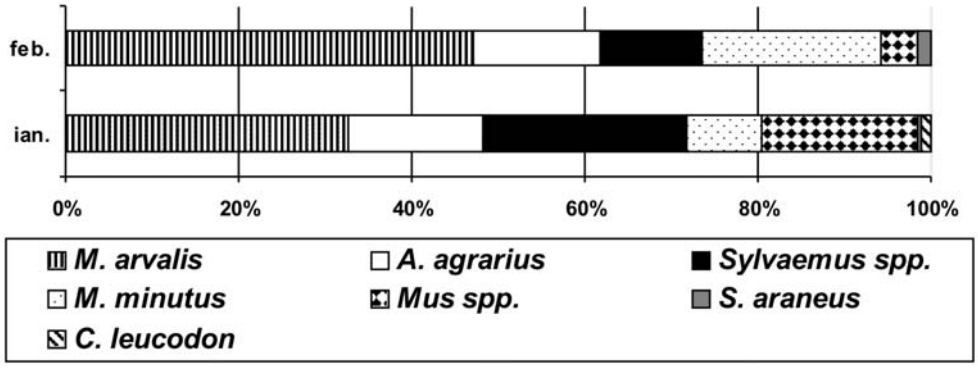

Fig. 5 - Dynamics of *Asio otus* diet's biomass composition in Cefa Nature Park.

Considering separately the two lots of pellets (Fig. 5), there is a significant difference in the numerical composition of the diet concerning the ratio between voles and mice ($Z = 2.21$, $p<0.05$). Like in Satu Mare, the share of *M. arvalis* in the pellets increases from one third (32%) in January to almost one half (47%) in February. Contrary to Satu Mare, where all mice recorded a more or less significant decrease of their ratio, in the pellets from Cefa *M. minutus* presents a significantly higher share in February than in January ($Z = 2.73$, $p<0.01$) and *A. agrarius* has a constant share in *Asio otus* diet during the two months ($Z = 0.25$, $p>0.2$), probably due to its high availability in the area, characterized by a high humidity that favours this hygrophilous mouse, but also because it is less agile than its related species.

In Cefa Nature Park the decrease of Muridae ratio among the prey specimens is given by the species of the genus *Mus* and subgenus *Sylvaemus*.

DISCUSSION

The dynamics of *Asio otus* diet composition in the two localities (Satu Mare and Cefa Nature Reserve) in the same period of the year show some similarities, indicating the influence of season and meteorological conditions on the long-eared

owl's feeding. In both areas a significant increase of *M. arvalis* ratio is recorded passing from winter to spring (in Satu Mare), or from mid to the end of winter (in case of Cefa Nature Park). The seasonal change of diet was recorded also in other areas, both in northern (Poland) and southern (Italy) Europe (Romanowski & Zmihorski, 2008; Bertolino et al., 2001; Cecere & Vicini, 2000). The low frequency of the common vole in the pellets sampled in the mid-winter followed by a significant increase during the end of winter and beginning of spring is explained by the reduced availability of this rodent for the long-eared owl. Although voles are also active during the cold season, they more frequently move under the snow, while mice prefer moving on the snow surface (Jdrezejewska & Jdrezewski, 1998). There is a significant, strong and negative correlation between the ratio of *M. arvalis* (and voles in general) in the owl's diet and the depth of snow cover (Canova, 1989; Sándor et al., 1997).

The proportions of common vole and mice are strongly and negatively correlated, as the reduction of voles' availability leads to exploitation of alternative resources (Mikkola, 1983). The melting of snow in spring gives the predator access to the voles and mice are less preyed upon. Thus, in March the shares of *Sylvaemus* spp. and *Mus* spp. drop significantly.

The peculiarities of the owls' diet composition in Cefa Nature Park reflects the structure of small mammals communities in the area. The park, comprising a mosaic of habitats, especially wetlands, shelters a rich fauna of small mammals, dominated by *Apodemus agrarius* (Benedek & Sîrbu, 2009). Thus, in this locality *A. agrarius* has not only a higher proportion in the owl's diet during winter, but it also remains constant in spring. Because dry grassland is less represented in the park, the frequency and density of common vole population is low, this species is less abundant in the pellets from Cefa compared to the results based on samples collected by the authors elsewhere (Benedek, 2004; Benedek & Sîrbu, unpublished data), but also to most of the data published from Romania (Banaru, 1998; Murariu et al., 1991; Sike, 2003-2004). The high diversity of mammal fauna from Cefa Nature Park is illustrated also by the presence of the two insectivore species, *Sorex araneus* and *Crocidura leucodon*.

An important aspect of feeding energetics in raptors is represented by the ratio between the energy spent for hunting and the intake of energy by consuming the kill. In the Satu Mare population the significant increase of the prey mean body weight shows that for the same hunting effort (or even less, as voles are less agile than mice – personal observations - and therefore easier to catch) the amount of food obtained in spring is significantly higher (with one third) than in winter, in the presence of snow cover.

Conclusions

The diet of the studied *Asio otus* populations is dominated by *Microtus arvalis*, its main prey species in Romania. There is a significant difference between the ratio of the common vole in the pellets from the two localities, due to peculiar characteristics of small mammal community from Cefa Nature Park. In both areas the proportion of *M. arvalis* in the long-eared owl's food presents an important seasonal variation. In winter it moves usually through tunnels under the snow, thus it is less frequently hunted. When the main prey is scarce, alternative food resources are exploited. In the two areas they are represented by mice, which become dominant as a group. Among them *A. agrarius* has a higher and constant ratio in

Cefa Nature Reserve, due to the humidity of the region. Birds were not identified in neither of the pellet sets. Shrews were identified only from Cefa, in low numbers. A significant variation is recorded also by the mean biomass of preys of *Asio otus* from Satu Mare. The average body mass increases from January to March, when it gets with one third higher.

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DINAMICA REGIMULUI TROFIC DE IARNĂ-PRIMĂVARĂ AL SPECIEI *ASIO OTUS* L., 1758 (AVES: STRIGIFORMES) ÎN CÂMPIA DE VEST (ROMÂNIA)

REZUMAT

Regimul trofic al populațiilor studiate de *Asio otus* este dominat de *Microtus arvalis*. Ponderea acestuia înregistrează însă o variație sezonieră puternică. În timpul iernii șoarecele de câmp se deplasează de obicei prin tunele săpate în zăpadă, fiind astfel mai puțin vânat. Când prada pincipală este puțin disponibilă sunt exploatate resurse alternative, în acest caz muridele, care devin dominante ca grup în cadrul dietei. O variație semnificativă este înregistrată de asemenea de biomasa medie a prăzii, care crește cu o treime din ianuarie până în martie, când randamentul este maxim.

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