



COMPARATIVE ANALYSIS OF LONG-EARED OWL (*ASIO OTUS*) WINTER DIET FROM TWO EUROPEAN CITIES – CHISINAU (REPUBLIC OF MOLDOVA) AND BACAU (ROMANIA)

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Key words: *Asio otus*, urban environment, trophic spectrum, rodents, *Microtus voles*.

Introduction. Many rodent species are important pests for agriculture and for urban areas. The long-eared owl is a predator that exerts constant pressure on rodent density.

Material and methods. The studies were performed in winters of 2011-2013 in the cities of Chisinau and Bacau, where 599 and 82 pellets of *Asio otus* were collected, respectively. The prey items were identified from cranial bones extracted from pellets.

Results. Long-eared owl's diet in both sites consists of mammals and birds, with rodents being the dominant trophic component. The *Microtus* species were the main prey with the abundance $\geq 70\%$ in both sites. In Chisinau a high proportion of *Mus* species was registered in the diet. The total biomass of prey constituted 43 953 g in Chisinau and 7 038 in Bacau. The highest biomass belongs to *Microtus* species, with 31 710 g and 5 220 g, respectively. The trophic niche width in Chisinau constituted 0.089 and varied monthly from 0.058 to 0.28. In Bacau the WTNs was of 0.134 and varied slightly among the study months.

Conclusions. The rodents were the main trophic source and constituted $\geq 96\%$ in both sites. The prey diversity was higher in Chisinau, that was due to a larger city territory and to a higher number of wintering long-eared owls. The close values of trophic niche width in Chisinau and Bacau confirmed the high hunting specialization of the long-eared owl.

Cuvinte cheie: *Asio otus*, mediu urban, spectru trofic, rozătoare, speciile genului *Microtus*.

ANALIZA COMPARATIVĂ A DIETEI DE IARNĂ A CIUFULUI DE PĂDURE (*ASIO OTUS*) ÎN DOUĂ ORAȘE EUROPENE – CHIȘINĂU (REPUBLICA MOLDOVA) ȘI BACĂU (ROMÂNIA)

Introducere. Multe specii de rozătoare sunt dăunătoare ai agriculturii, inclusiv și zonele urbane. Ciuful de pădure este o specie de păsări de pradă care exercită o presiune relativ constantă asupra densității rozătoarelor.

Material și metode. Cercetările au fost efectuate în orașele Chișinău și Bacău, în perioada de iarnă a anilor 2011-2013, unde au fost colectate 599 și, respectiv, 82 de ingluvii. Au fost identificate speciile pradă după oasele craniene extrase din ingluvii.

Rezultate. Spectrul trofic al ciufului de pădure din ambele situri este format din mamifere și păsări, rozătoarele fiind componentul trofic principal. În ambele situri speciile genului *Microtus* au fost prada principală cu peste 70%. Biomasa totală a prăzii a constituit 43 953 g în Chișinău, iar în Bacău – 7 038 g. Cea mai mare biomasă aparține speciilor gen. *Microtus* – 31 710 g la Chișinău, 5 220 g – la Bacău. Lățimea nișei trofice în Chișinău a fost de 0,089 și a variat lunar de la 0,058 la 0,28. La Bacău, WTNs a constituit 0,134 și a variat lunar în limite mici.

Concluzii. Rozătoarele au reprezentat sursa trofică principală – peste 96% în ambele situri. În localitatea cu suprafața mai mare, spectrul trofic s-a dovedit a fi mai variat. Diversitatea speciilor pradă este mai mare în Chișinău și se datorează suprafeței mai mari a orașului și numărului mai mare de ciuși în colonie. Valorile apropiate ale lățimii nișei trofice în Chișinău și Bacău confirmă specializarea înaltă a ciufului de pădure.

INTRODUCTION

Many of the rodent species are important pests of agricultural crops and cereal deposits, including urban areas. The nocturnal prey birds are regulatory species that contribute to maintaining rodent density at more or less constant level. The long-eared owl (*Asio otus* L.) is a sedentary bird and one of the most widespread in Europe (1-5). During the winter period the density of species increases on the account of the migrant individuals from the northern regions and they form colonies of several tens of individuals. In most cases, the owls prefer to winter each year in the same place. The hunting sectors of the long-eared owl are open type biotopes, where they mainly hunt rodents and occasionally birds, shrews and bats. Following the digestion process, the prey birds regurgitate the indigestible remnants of eaten animals (bones, hair, feathers, fur) in the form of pellets. The pellets analysis can provide important data regarding the feeding regime of the bird, the fauna of small mammals in a certain area, their density and their seasonal and annual dynamics, etc. The long-eared owl is well adapted to anthropic environment and its wintering colonies are frequently registered in urban localities (4).

Taking into consideration the huge importance of long-eared owl trophic activity in biological control of rodent pest species, especially in winter period, its diet was rather well studied in many regions of Europe (1-10). In the Republic of Moldova and Romania the diet of long-eared owl was also rather well studied in different areas of the countries (11-18). There are several studies concerning the long-eared owl's diet in urban areas (19-26).

The long-eared owl is a feeding specialist predator and not all species are equally hunted prey. The attractiveness of a prey species depends on specific qualities, the most important of which is the size (1). The long-eared owl shows strong preference for *Microtus voles* across Europe, but in urban areas it hunts in open type biotopes outside the city and/or use alternative prey (27). In winter, *A. otus* is capable to localize the prey under a snow cover of 40-50 cm (14). As adaptations of winter diet to urban environment can be considered the use of higher ratio of synanthropic rodent species (*Mus musculus*, *Rattus norvegicus*), of bird species as well as more diverse trophic spectrum (4, 24, 28-33).

The aim of the paper is to perform a comparative analysis of long-eared owl winter diet in two European cities, Chisinau and Bacau, with similar environmental – climatic conditions and rather different anthropic impact, in order to emphasize the similarities and the differences.

MATERIAL AND METHODS

The studies were performed in winter periods of 2011-2012 and 2012-2013 in Chisinau and Bacau cities. Chisinau is a large city with the surface of 123 km², situated in the central part of the Republic of Moldova at the altitude of 82 m, coordinates 47001' N 28052' E. Bacau city is the major city of Bacau county, with the surface of 43.19 km², situated in eastern part of Romania at the altitude of 165 m, coordinates 46035' N 26055' E. The climate of both cities is humid continental with warm summers and cool, windy winters. The winter period lasts 78-80 days. The average temperature in winter is -2.3°C in Chisinau and -4 C in Bacau city, while the minimum temperature in January and February can drop below -20°C.

In Chisinau city a colony of long-eared owl (*Asio otus* L.) of 38 individuals was located in a courtyard of a school from Ciocana district with several dozens of tall coniferous and deciduous trees (*Picea abies*, *Populus alba*, *P. tremula*, *Salix alba*) suitable for long-eared owl individuals. In Bacau city a small colony of 7 individuals was located in the yard of the Astronomical Observatory, with several trees of *Thuja orientalis*, *Picea abies*, *Carpinus betulus*. Both locations are situated within the cities limits in heavily urbanized areas.

In Chisinau 599 pellets have been collected and in Bacau 82 pellets. Each pellet was measured, weighed and afterwards unfolded. The bone fragments were cleaned and sorted into categories. Small mammal species were determined according to cranial bones and dentition (34, 35). The sibling species *Microtus arvalis* and *M. rossiaemerdionalis*, *Mus musculus* and *M. spicilegus* that can't be differentiated morphologically were considered as genus *Microtus* and *Mus*, respectively.

The ecological analysis of the prey species was performed using the indexes of abundance ($A = no * 100 / N$, where no – number of individuals of a species, N – total number of individuals); frequency ($F = nop * 100 / N$, where nop – number of pellets with certain species, N – number of pellets); total biomass of consumed prey ($B = no * G$,

where no – number of individuals of a species, G – mean weight of one individual). The mean weight of prey individual was calculated from our own data gathered during long term studies of small mammals and bats. The trophic niche width was estimated using the *B Levins' index*: $B=1/\sum p^2$, (36), in its standardized version B_s (37): $B_s=(B-1)/(n-1)$, where p is the fraction of items in the diet, and n is the number of possible food categories (38). B_s ranges from 0 (100% utilization of a single food category) to 1 (equal use of all categories).

During the study none of animals was injured or sacrificed.

RESULTS

In Chisinau the length of analyzed pellets varied from 1.16 to 6.95 cm with the average of 3.32 cm. The pellet weight varied between 1.2 and 6.07 g with the average of 2.52 g. After cleaning the bones, 1489 individuals were identified. The number of individuals per pellet varied from 1 to 6, the average constituted 2.46 individuals. In Bacau the pellet length varied between 1.2 and 5.6 cm. The minimal number of individuals/pellets was 1, the maximal number was 5 and the average was 2.56. After cleaning the bones 223 individuals were identified.

The trophic spectrum of long-eared owl in Chisinau consisted of mammals from 3 orders (*Sorico-*

morpha, Rodentia, Chiroptera) and passe-rine birds (fig. 1). In Bacau rodents and passerine birds have been identified (fig. 2). In both sites *Microtus* species dominated with 70.99% in Chi-sinau and 76.31% in Bacau. The house mouse is the second species in Chisinau pellets (10.88%), while in Bacau it constituted less than 1%. The genus *Apodemus* were represented by 4 species in Chisinau and by 3 species in Bacau. In both sites the most numerous was *A. sylvaticus* with 10.34% and 10.97%, respectively (fig. 1, fig. 2). Other *Apodemus* species constituted about 10% in Bacau pellets, while in Chisinau their ratio was less than 4%. In Chisinau the diet of long-eared owl was more diverse, probably due to much larger number of individuals that hunted in a larger variety of ecosystems. Here were identified shrews and bats in lower ratio, while the birds constituted 2.55% and in Bacau – 2.19%. Among rodents two more species have been registered – the arboreal rodent *Muscardinus avellanarius* and the synanthropic species *Rattus norvegicus* with very low ratio of 0.13%.

The diversity indexes (Shannon and Simpson) are higher in Chisinau site 0.45 and 1.89, respectively, than in Bacau 0.71 and 1.68. Although the species number is much higher in Chisinau, the difference between diversity indexes is not very high, due to more even distribution of the species in Bacau site.

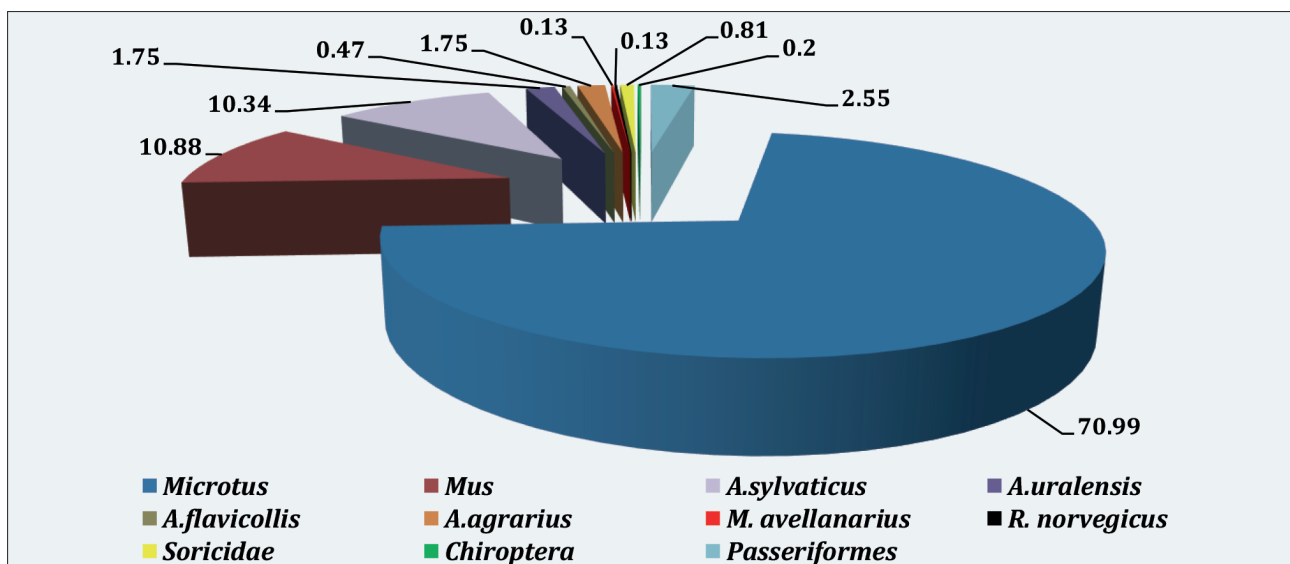


Figure 1. Trophic spectrum of long-eared owl in Chisinau city in 2011-2012.

The highest frequency in pellets from both urban areas belongs to *Microtus* species that was found in most of the pellets followed by *Mus* species and *A. sylvaticus* in Chisinau and by *A. sylvaticus* and *A.*

flavicollis in Bacau (tab. 1). The birds, represented by *Passeriformes* had a frequency of 6.43% in Chisinau and 6.1% in Bacau.

The total biomass of prey items constituted 43 953 g in 6 study months in Chisinau and 7 038 in 4 months in Bacau. The highest biomass belongs to *Microtus* species, with 31 710 g in Chisinau and

5 220 in Bacau (tab. 2). In both sites a decrease of prey number and biomass was registered from November to December and from November to February in Chisinau.

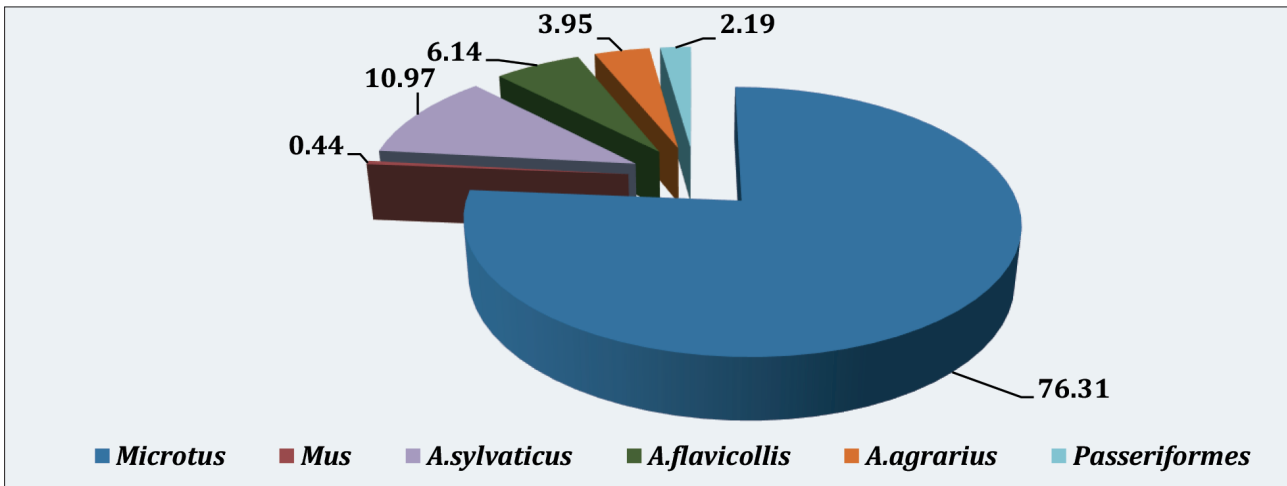


Figure 2. Trophic spectrum of long-eared owl in Bacau city in 2011-2012.

Table 1. Frequency of animal species in *Asio otus* pellets.

Nr.	Genus/species	Chisinau		Bacau	
		No pellets	Frequency, %	No pellets	Frequency, %
1.	<i>Microtus</i>	368	61.44	62	75.61
2.	<i>Mus</i>	136	22.71	1	1.22
3.	<i>A. sylvaticus</i>	125	20.87	21	25.61
4.	<i>A. uralensis</i>	25	4.17	-	-
5.	<i>A. flavicollis</i>	6	1.0	12	14.63
6.	<i>A. agrarius</i>	24	4.01	9	10.98
7.	<i>M. avellanarius</i>	2	0.33	-	-
8.	<i>R. norvegicus</i>	2	0.33	-	-
9.	<i>Soricomorpha</i>	10	1.67	-	-
10.	<i>Chiroptera</i>	2	0.33	-	-
11.	<i>Passeriformes</i>	38	6.34	5	6.1

The trophic niche index in Chisinau site was 1.89 and varied monthly between 1.58 to 3.77. The standardized index was of 0.089 and varied monthly from 0.058 to 0.28 and indicate that in December 2012 the prey used belonged to many categories with more even distribution. In Bacau the trophic niche index was 1.67 with low variation degree between months. The standardized index was of 0.134 and varied slightly among the studied months (tab. 2). In Bacau WTNs index was slightly higher because only prey categories hunted there were considered.

DISCUSSIONS

In both cities the *Microtus* voles are the most important prey item in the winter diet of Long-eared owl, as previously registered in open land ecosystems thorough Europe (1, 2, 3, 5, 7, 9, 10, 39, 40, 41, 42), as well as in urban areas (17, 21, 22, 24, 25, 29, 43, 44). *Apodemus* species constitute an important trophic source for long-eared owl in urban area. Their share can vary between 3% and 66% (17, 23, 28, 39, 40, 44) depending on location, climatic conditions, hunting sectors and prey availability. In some urban areas the *Apodemus* species even were the most abundant prey during winter period (28, 29, 43).

The difference between the ratio of *Mus* species in both cities is very high. This fact can be explained by city size and structure. In Chisinau there are many tall buildings and a massive production of waste, while in Bacau small houses are most numerous and the city is much cleaner. The higher ratio of *Mus* species (up to 10%) in winter diet of the long-eared owl was noted for large cities (9, 21, 29, 40, 45) and much lower ratio, up to 3% in small cities (17, 24, 43).

Among other rodent species in Chisinau pellets there were found *R. norvegicus* and *M. avellanarius*.

The last one is arboreal species and usually hibernates during winter, therefore its share is very low in different regions of Europe, up to 1% (21, 28), but in most of studies it wasn't re-registered. The brown rat had a very low ratio in Chisinau pellets and wasn't registered in Bacau, although in previous studies it was found in *A. otus* diet with 0.14% (23). In many other studies in European cities the species also had a low share, up to 5% (9, 20, 21, 29, 31, 39), but in some large cities the species is one of the main preys, reaching about 20% and 60-70% biomass (28).

Table 2. Individual number and biomass of prey species in studied months.

Species	City	Chisinau						Bacau					
		Par.	XI.11	XII.11	I.12	II.12	XI.12	XII.12	Total	XI.11	XII.11	XI.12	XII.12
<i>Microtus</i>	No	346	242	175	174	67	53	1057	53	27	63	31	174
	BM	10 380	7 260	5 250	5 220	2 010	1 590	31 710	1 590	810	1 890	930	5 220
<i>Mus</i>	No	64	29	16	19	21	13	162	-	-	1	-	1
	BM	1 152	522	288	342	378	234	2 916	-	-	18	-	18
<i>A. sylvaticus</i>	No	37	23	19	31	30	14	154	9	4	9	3	25
	BM	1 036	644	532	868	840	392	4 312	252	112	252	84	700
<i>A. uralensis</i>	No	5	7	4	7	3	-	26	-	-	-	-	0
	BM	115	161	92	161	69	-	598	-	-	-	-	0
<i>A. flavicollis</i>	No	2	-	1	2	-	2	7	5	-	6	3	14
	BM	70	-	35	70	-	70	245	175	-	210	105	490
<i>A. agrarius</i>	No	8	7	2	4	3	2	26	2	1	5	1	9
	BM	200	175	50	100	75	50	650	50	25	125	25	225
<i>R. norvegicus</i>	No	-	-	-	-	2	-	2	-	-	-	-	0
	BM	-	-	-	-	300	-	300	-	-	-	-	0
<i>M. avellanarius</i>	No	-	2	-	-	-	-	2	-	-	-	-	0
	BM	-	40	-	-	-	-	40	-	-	-	-	0
Soricidae	No	-	-	4	1	5	2	12	-	-	-	-	0
	BM	-	-	32	8	40	16	96	-	-	-	-	0
Chiroptera	No	-	-	-	-	3	-	3	-	-	-	-	0
	BM	-	-	-	-	36	-	36	-	-	-	-	0
Passeriformes	No	1	2	2	5	20	8	38	-	3	-	2	5
	BM	75	150	150	375	1 500	600	2 850	-	225	-	150	375
Total ind.	No	463	312	223	243	154	94	1 489	69	35	84	40	228
Total biomass	BM	13 028	8 852	6 429	7 144	5 248	2 952	43 653	2 067	1 172	2 495	1 294	7 028
WTN		1.71	1.62	1.58	1.95	3.77	2.7	1.89	1.64	1.61	1.72	1.63	1.67
WTNs		0.071	0.062	0.058	0.095	0.28	0.17	0.089	0.128	0.122	0.144	0.126	0.134

Note: No – number of individuals, BM – biomass, WTN – width of trophic niche, WTNs – width of trophic niche standardized

Among other mammal groups in the diet of long-eared owl from Chisinau representatives of shrews and bats have been registered in very low percent. The shrews were represented by 4 species (*Crocidura suaveolens*, *C. leucodon*, *Sorex minutus*, *S. araneus*) and the bats – by 2 species (*Eptesicus serotinus* and *Vespertilio murinus*). The shrews are an alternative prey type for *A. otus* and are mostly hunted when the abundance of *Microtus* species is low. Furthermore, it was established that the sha-

re of shrews in the owl's diet depends on the abundance of *Microtus* species and doesn't depend on shrew abundance in certain area (46). The presence of bats in the diet of *A. otus* is usually accidental and constitutes less than 0.5%, while in the diet of other owl species (*Tyto alba*, *Bubo bubo*) Chiroptera groups can reach more than 10% (47, 48).

The passerine birds constituted about 2-3% in *A. otus* diet from both cities, as well as in other urban studies, where their share constituted 0.5-10%

(26, 29, 39, 40, 43, 49). The higher ratio of birds in some studies is conditioned by the abundant snow cover, when owls can shift their hunting areas into urban habitats, where the availability and density of bird populations, especially house sparrow, are higher (4). In the studied period in urban localities Chisinau and Bacau the snow cover did not exceed 10-20 cm and in November-December periods there was no snow cover, therefore the share of birds was rather low.

The prey diversity is higher in Chisinau site than in Bacau, which is due to larger surface of Chisinau city and to larger number of long-eared owl individuals. The higher diversity in larger cities was mentioned in many other studied (21, 28,

29, 40), while in smaller localities the diversity is lower (22, 26, 39).

The long-eared owl is a specialized predator and hunt individuals that weight between 15 g and 50 g, therefore, the ratio of preferred prey – *Microtus voles* remain high in spite of the availability of other prey types (1, 2). According to optimal foraging theory only the abundance of preferred prey influence upon the optimal choice of prey type, while the abundance of other prey types is not important (50). The close values of trophic niche breadth in Chisinau and Bacau prove the high hunting specialization of the long-eared owl and highlight its importance in rodent regulation in urban areas and surroundings.

CONCLUSIONS

1. The trophic spectrum of long-eared owl in Chisinau and Bacau cities consists of mammals and birds, the rodents being the dominant trophic source (8 species in Chisinau and 5 species in Bacau with over 95%). The *Microtus* species were the main prey and constitute more than 70% in both sites.
2. The higher prey diversity in Chisinau in comparison to Bacau is due to larger surface of Chisinau city and to larger number of long-eared owl wintering individuals. In larger cities the trophic spectrum is more diverse.
3. The total biomass of prey items constituted 43 953 g in 6 study months in Chisinau and 7 038 in 4 months in Bacau. The highest biomass belongs to *Microtus* species, with 31 710 g in Chisinau and 5 220 in Bacau.
4. The trophic niche index in Chisinau site was 1.89 and varied monthly between 1.58 to 3.77. The standardized index was of 0.089 and varied monthly from 0.058 to 0.28 In Bacau the trophic niche index was 1.67 with low variation degree between months. The standardized index was of 0.134 and varied slightly among the studied months. The close values of trophic niche breadth in Chisinau and Bacau prove the high hunting specialization of the long-eared owl and highlight its importance in rodent regulation in urban areas and surroundings.

CONFLICT OF INTERESTS

The authors do not declare any conflict of interest.

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