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Research Article

DIET COMPOSITION OF THE WINTERING *Asio otus* L. (STRIGIFORMES: STRIGIDAE) IN TWO DIFFERENT HABITAT TYPES IN TURKEY

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Abstract: In this study, we analysed a total of 691 pellets of the Long-eared Owl (*Asio otus* L.) collected from Edirne (Suburban), İstanbul (Suburban) and Kars (High altitude steppe) provinces in January-February 2019. Dietary contents of the Long-eared Owl were considering the different habitat (steppe and suburban) types. Small mammals constituted the majority of the diet content in all areas, but a small amount of bird remains were also found in pellets. 1474 prey items belonging to 7 different mammal taxa (*Apodemus* sp., *Cricetulus* sp., *Crocidura* sp., *Micromys* sp., *Microtus* sp., *Mus* sp., *Rattus* sp.) were identified. High amount of *Mus* sp. was found in pellets collected from Edirne (50.34%) and İstanbul (41.42%). On the other hand, *Microtus* sp. was the main prey species in Kars. Overall, our study supported that the Long-eared Owl acts as an opportunistic predator and change its dietary contents according to different environmental conditions. Incompatible results were obtained between the trapping study and pellet examination. The reasons could be that some mammal species can be caught by chance, trapping area cannot represent the entire hunting area and some mammal species could avoid trapping.

Özet: Bu çalışmada, Ocak-Şubat 2019'da Edirne (Suburban), İstanbul (Suburban) ve Kars (Dağ bozkırı) illerinden toplanan toplam 691 adet kulaklı orman baykuşu peleti analiz edilmiştir. Diyet içeriği farklı habitat türlerine (bozkır ve suburban) göre karşılaştırılmıştır. Küçük memeliler tüm alanlarda diyet içeriğinin çoğunu oluşturmaktadır, ayrıca peletlerde az miktarda kuş kalıntısı tespit edilmiştir. 7 farklı memeli taksonuna (*Apodemus* sp., *Cricetulus* sp., *Crocidura* sp., *Micromys* sp., *Microtus* sp., *Mus* sp., *Rattus* sp.) ait 1474 av belirlenmiştir. Edirne (%50,34) ve İstanbul'dan (%41,42) toplanan peletlerde yüksek miktarda *Mus* sp. tespit edilmiştir. Kars'tan toplanan peletlerde ise *Microtus* sp. ana av türüdür. Genel olarak, çalışmamız kulaklı orman baykuşunun fırsatçı bir avcı olarak beslendiğini ve diyet içeriğini farklı çevresel koşullara göre değiştirdiğini desteklemiştir. Kapanlama çalışması ile pelet analizi arasında uyumsuz sonuçlar elde edilmiştir. Bunun nedenleri, bazı memeli türlerinin tesadüfen yakalanabilmeleri, kapanlama alanının, baykuşun tüm avlanma alanını temsil edememesi ve bazı memeli türlerinin tuzaktan kaçınmaları olabilir.

Introduction

Pellet analysis is a common, easy and inexpensive way to study owl's diet and behaviour. Owls usually ingest their prey as a whole and then digest them. After the digestion, they eject the indigestible parts of the prey as a compressed pellet. Pellets are elliptical shaped and contain some remains such as bones, furs, feathers, chitinous body parts, claws, mollusc shells and fish scales (Lynch 2007, König & Weick 2008, Yalden 2009). Even the smallest bone parts are preserved well in owl pellets, unlike pellets of birds of prey (König & Weick 2008). Owl pellets may provide a useful method for sampling small mammal communities by being more cost-effective (Heisler *et al*. 2016) because owls are specialized to prey rare and hard-to-detect micro mammal species making traditional standard traps relatively impractical (Teta *et al*. 2010).

The Long-eared Owl (*Asio otus* L.) is a widespread member of Strigidae throughout the Holarctic (Cramp & Simmons 1985). Its range extends to Continental Europe and the British Isles, Northwest Africa (Morocco and Tunisia), the Middle East including Asia Minor, Asia, and North America, south to New Mexico (Weick 2007, König & Weick 2008). It is mostly a resident and a

wintering species, very common in most parts of Turkey except its relatively local distribution in Eastern Anatolia (Kirwan *et al.* 2008). The species can be found in Turkey in all types of habitats with trees (Kirwan *et al.* 2008) and also frequently found in areas close to human settlements (Dziemian *et al.* 2012).

The hunting techniques and feeding niche of *A. otus* in the Palearctic have been well documented. Its diet is usually composed predominantly of small mammals (Birrer 2009). If a certain vole species is abundant in the hunting area, the owl specializes on this particular species (Romanowski & Zmihorski 2008, Basova 2009, Volkov *et al.* 2009, Ekimov 2010, Golova 2011). However, if the vole density is low in the diet, the proportion of prey other than small mammals may increase (Alivizatos & Goutner 1999, Pirovano *et al*. 2000, Rubolini *et al.* 2003, Shao & Liu 2006, Kiat *et al.* 2008, Song *et al.* 2010, Tian *et al.* 2015, Göçer 2016). The diet content can also vary according to seasonal conditions (Kafkaletou-Diez *et al.* 2008, Tome 2009), habitat differences (desert, urban, suburban, woodland, etc.) (Tian *et al.* 2015) and prey density in the hunting area.

The diet content of *A. otus* in Anatolia has been the subject of various studies (Turan 2005, Seçkin & Çoşkun 2006, Bulut *et al*. 2012, Hizal 2013, Göçer 2016, Kaya & Çoşkun 2017, Selçuk *et al.* 2017, 2019, Yorulmaz & Arslan 2019). Nonetheless, no data about the dietary content of the species is available for the population distributed in Thrace region of Turkey. In this study, we present data on the wintering diet of *A. otus* in two different suburban areas in Thrace region (Edirne and Istanbul, northwest of Turkey) and an open dry habitat in Kars (Northeast of Turkey).

Materials and Methods

Study areas

The pellets of *A. otus* were collected between 20th of January and 28th of February 2019 in three areas in Edirne, İstanbul and Kars provinces (Fig. 1). Short descriptions of the collecting areas are provided below and further details of these areas are presented in Table 1. The areas where previous studies were performed are presented in Fig. 1. Each pellet was labelled and bagged individually and only the well-preserved pellets were included in the analyses. All collecting areas were communal winter roosting sites and the roosting groups were determined to be consisted of 2 to 35 birds which perched on coniferous and deciduous trees.

The collecting area in the Thrace region of Turkey is located in Edirne Province (N41.619521, E26.652396). The area is a common garden of a small settlement surrounded by a cultivated area and a breeding site of *A. otus*. Pellets were collected under the Mediterranean cypress (*Cupressus sempervirens* L.), Arizona cypress (*Cupressus arizonica* Greene), Oriental arborvitae (*Platycladus orientalis* L.) and Black locust (*Robinia pseudoacacia* L.) trees on which both first-winter and adult owls were observed. The number of owls varied from 3 to 35 in this area.

Fig. 1. Map showing the available locations where diet studies of *A. otus* in Turkey were performed so far. The black stars denote the localities of the present study and the numbers denote previous studies ([1]Turan, 2005, [2]Seçkin & Çoşkun, 2006, [3]Bulut *et al.*, 2012, [4]Hizal, 2013, [5]Göçer, 2016, [6,7]Selçuk *et al*., 2017, 2019, [8]Kaya & Çoşkun, 2017, [9]Yorulmaz & Arslan, 2019).

Table 1. Some climatological data about the collection areas (MGM, 2019).

Collection Areas	Altitude (m)	Temperature (Monthly Average) (ºC)		Temperature (Annual Average) (ºC)	Precipitation (Monthly Average) (mm)		Precipitation (Annual Average (mm)
		January	February		January	February	
Edirne	90	2.7	4.6	13.8	66.5	53.2	608.1
İstanbul	35	6.0	6.1	14.4	105.5	77.8	823.0
Kars	1,750	-10.3	-8.6	4.9	21.3	22.1	502.7

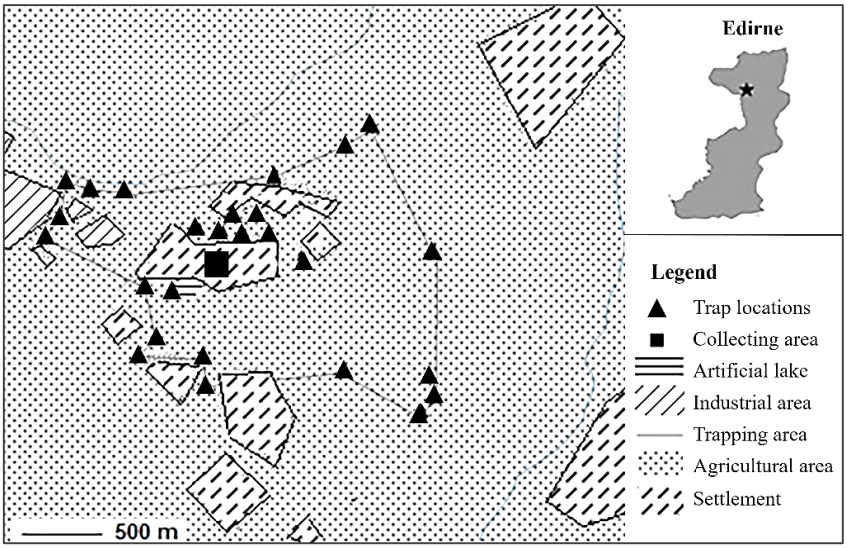

Fig. 2. The collecting area and the trapping localities in Edirne Province.

The collecting area in İstanbul (N41.03887, E28.54947**)** is located in the European side (Thrace region). Pellets were collected under Mediterranean cypress (*Cupressus sempervirens*) trees in a cemetery. The cemetery is surrounded by suburban settlements and cultivated areas and is about 1 km away from the southwestern coast of Büyükçekmece Lake. The number of owls varied from 2 to 8 in this area.

The collecting area in Kars Province (N40.576547, E43.042095**)** is located in Eastern Anatolia. Pellets were collected under Scots pine (*Pinus sylvestris* L.) trees in the campus of the Kafkas University. The collecting area is surrounded by high altitude steppe and is located about 1 km from the east side of Kars River. The number of owls varied from 6 to 7 in this area.

Identification of prey and analysis of the pellets

The identification of small mammals was performed according to Kryštufek & Vohralik (2001, 2005, 2009) and Barciova & Macholan (2009). Skull and lower jaw remains were used for identifications.

Since many species may show geographic, sexual and individual-related differences in body weight (biomass), uncertain biomass calculations may occur in pellet studies (Birrer 2009). Therefore, the data from Kryštufek & Vohralik (2001, 2005, 2009) was evaluated for biomass calculations since it reflected former samplings in Turkey. The identification of avian taxa was performed according to Svensson (1992) and Brown *et al.* (2003).

The minimum number of individuals, frequency, average prey and biomass ratios of small mammals and birds contained in each pellet were calculated.

Trapping small mammals

The trapping study was carried out between February 18th and 28th 2019 in order to identify small mammals in the collecting area in Edirne. Around this area, 200 Sherman-type live-capture traps were placed inside an area of approximately 2.82 km^2 (Fig. 2). The size of the trapping area was calculated as a minimum convex polygon in ArcMAP 10.7. The traps were placed in different types of habitat, such as shrub communities on the edge of agricultural areas, riparian areas, and dense shrub communities in urban areas and under a pine plantation site and checked every morning and evening during 10 days (2000 trapping night). All trapped specimens are preserved in the cytogenetic laboratory of Biology Department, Faculty of Science, Ondokuz Mayıs University.

The Chi-square analysis was applied to check if the observed availability of micro-mammals fits their expected frequency in the owl's diet.

Results

Pellet analysis

A total of 691 pellets were collected, 521 from Edirne, 144 from İstanbul and 26 from Kars. 1170 preys belonging to 7 different taxa (6 small mammals and 1 bird) were determined in the pellets collected in Edirne province. The prey rate per pellet is 2.28. A significant portion of the diet content (F=97.86%; B=98.36%) consists of small mammals. Rodentia has the highest rate of diet content (97.18%). *Mus* sp. (F=50.34%; B=31.15%) were the main prey in the diet followed by *Microtus* sp. (F=27.26%; B=46.64%) (Table 2). 239 preys belonging to 7 different taxa (6 small mammals and 1 bird) were determined in the pellets collected in İstanbul province. The prey rate per pellet is 1.65. A significant portion of the diet content (F=92.89%; B=95.37%) consists of small mammals. *Mus* sp. (F=41.42%; B=21.71%) were the main prey in the collecting area followed by *Microtus* sp. (F=38.08%; B=55.17%) (Table 2). 65 preys belonging to 5 different taxa (4 small mammals and 1 bird) were determined in the pellets collected in Kars province. The prey rate per pellet is 2.50. A significant portion of the diet content (F=96.92%; B=98.34) consists of small mammals. *Microtus* sp. (F=64.62%; B=77.63%) were the main prey in the collecting area followed by *Mus* sp. (F=15.38%; B=6.69%) (Table 2).

Table 2. Diet composition of *Asio otus* as revealed by pellet analysis collected from Edirne, İstanbul and Kars provinces in Turkey in winter season. MNI: the minimum number of individuals, F%: frequency (F%), B%: biomass.

Prey	Weight (g)	Edirne (Thrace Region)			İstanbul (Thrace Region)			Kars (Northeast of Turkey)		
		MNI	F%	B%	MNI	F%	B%	MNI	F%	B%
***Apodemus* sp.**	28.7	199	17.01	18.76	27	11.30	10.56	6	9.23	7.15
***Cricetulus* sp.**	33.1	8	0.68	0.87	-	-	-	5	7.69	6.87
***Crocidura* sp.**	8.4	8	0.68	0.22	1	0.42	0.11	-	-	-
***Micromys* sp.**	9.9	22	1.88	0.72	1	0.42	0.13	-	-	-
***Microtus* sp.**	44.5	319	27.26	46.64	91	38.08	55.17	42	64.62	77.63
***Mus* sp.**	16.1	589	50.34	31.15	99	41.42	21.71	10	15.38	6.69
***Rattus* sp.**	188	-	-	-	3	1.26	7.68	-	-	-
Total mammals		**1145**	**97.86**	**98.36**	**222**	**92.89**	**95.37**	**63**	**96.92**	**98.34**
Birds	20.0	25	2.14	1.64	17	7.11	4.63	2	3.08	1.66
Total prey		**1170**	**100**	**100**	**239**	**100**	**100**	**65**	**100**	**100**
Number of preys per pellet		2.28+-1.06 Min-max: 1-6			1.65+-0.79 Min-max:1-4			2.5+-1.06 Min-max:1-6		
Number of pellets		521			144			26		

A total of 96 small mammals belonging to 6 taxa were caught in the collecting area of Edirne Province (Table 3). The most common small mammals were *Apodemus* spp. (n=30 for *A. flavicollis* (Melchior) and n=32 for *A. sylvaticus* (L.)) (F%=64.58) followed by *Crocidura suaveolens* Pallas (n=12), *Mus macedonicus* Petrov & Ruzic (n=7) and *M. domesticus* Schwarz and Schwarz (n=14), respectively (Table 3). *Microtus levis* Miller was captured only once (F%=1.04). There is a significant difference between the frequency of small mammals in pellets and trapping results (x^2: 213.355; df: 5; $p < 0.0001$).

Table 3. Number and frequency of mammalian preys.

Species	Number of Individuals (F)	Frequency (F%)
***Apodemus* sp.**	62	64.58
***Crocidura* sp.**	12	12.5
***Microtus* sp.**	1	1.04
***Mus* sp.**	21	21.88
Total	**96**	**100**

Discussion

The diet of *A. otus* has been revealed in detail particularly in Central Europe but the data in some other areas, such as Africa and Asia, are under-represented (Birrer 2009). Many studies were conducted to determine the diet of *A. otus* in Turkey except Thrace region. Birrer (2009) reviewed more than 475 studies and reported that main preys of *A. otus* are members of the order Rodentia. The present study corroborated the previous findings that rodents are dominant prey. On the other hand, it is a fact that the diet content of *A. otus* depends on the sampling season (Kafkaletou-Diez *et al.* 2008, Romanowski & Zmihorski 2008, Tome 2009, Song *et al.* 2010, Gryz & Krauze-Gryz 2015) and habitat type where the individuals are sampled (Capizzi & Luiselli 1998, Romanowski & Zmihorski 2008, Tian *et al.* 2015, Lesinski *et al*. 2016).

Asio otus is an opportunistic predator (Bertolino *et al.* 2001, Shao & Liu 2006, Tulis *et al.* 2015,). Therefore, if the density of rodent species in its diet is low or if rodents are completely absent, its tendency to prey on other species may increase (e.g. bird preys: Kiat *et al.* 2008, Sándor & Kiss 2008, Göçer 2016; bat preys: Tian *et al.* 2015). The main reason for this change in dietary content is the availability of different prey in different types of habitats and the adaptability of the owl regarding its choice of prey. Moreover, *A. otus* may change its prey preference according to the prey density in the hunting area (Song *et al.* 2010). Except for the results of study on the urban habitat (Göçer 2016), *Microtus* sp. are the dominant prey in Turkey. However, according to the results of this study, primary prey differs in Thrace region (Edirne and İstanbul) and Kars (steppe habitat) province. According to the optimal foraging theory, owls feed on the most beneficial prey. Therefore, it is expected to expand its feeding niche when the density of the main prey decreases in the hunting area. On the contrary, when the density of the main prey species increases and they become more available, the predators are more selective in capturing more profitable species (Schoener 1971, Pyke 1984).

Kontogeorgos (2019) suggested that the prey-size is another important factor in feeding habits and behaviour of predator species. *Asio otus* usually prefer preys smaller than 50 g but they were observed to catch preys larger than 50 g when the prey is weak or young (Vorisek *et al.* 1998, Manegold, 2000, Pirovano *et al.* 2000, Tome 2000, Birrer 2009). Kontogeorgos (2019) showed that rats weighing 250 g in the area selected for the study were consumed less. The reason could be that catching rats is not cost-

effective (Mori & Bertolini 2015). This study showed that the occurrence of rats in the diet (F_{Edirne}=0%, $F_{İstanbul}$=1.26%, F_{Kars}=0%) was significantly lower than other preys, as in previous studies (Escala *et al.* 2009, Cecere *et al.* 2013, Kontegeorgos 2019, Tulis *et al.* 2019).

Many diet studies reported that *Microtus* species were the primary food source of *A. otus* (Balčiauskienė *et al.* 2006, Sergio *et al.* 2008, Birrer 2009, Dziemian *et al.* 2012, Milchev & Ivanov 2016,). Studies conducted in different seasons and habitats in Anatolia (except Göçer 2016) reported that *Microtus* spp. were the main prey in the diet. *Microtus* sp. was the main prey in both winter diet determined in the present study (F=64.62%) and summer diet of the previous study performed in Selim district in Kars (F=81.63%) (Selçuk *et al.* 2019). However, when the population density of *Microtus* species in the hunting area is low or if they are completely absent, *Apodemus* or *Mus* spp. become the main prey in the diet of the species (Galeotti & Canova 1994, Bertolino *et al.* 2001, Escala *et al.* 2009). In Edirne and İstanbul (in this study), and in Porto Lagos (Western Thrace, Greece) (Alivizatos & Goutner 1999), *Mus* spp. was found to be the main prey. Palomo *et al.* (2007) reported that the reason for *Mus* spp. becoming the primary prey was the habitat degradation as a result of human activity. In rare cases, groups such as *Arvicola* spp. (Nilsson 1981), *Meriones* spp. (Shao & Liu 2006), *Cricetulus* spp. (Ma & Xiao 1995), *Rattus* spp. (Pirovano *et al.* 2000) and *Sigmodon* spp. (Noland *et al.* 2013, González- Rojas *et al.* 2017) may also be the primary or secondary prey. Additionally, when the prey availability is quite low in winter, owls can even feed on carrion (Mori *et al.* 2014).

Asio otus usually avoids hunting shrew species as a result of their undesirable taste. Therefore, in numerous studies, the ratio of shrew species in the dietary content is quite low (Birrer 2009). However, other studies reported that it was occasionally the secondary prey in the dietary content (F=22.4%, Dupal & Chernyshov 2013). The ratio of the shrew species in the diet studies conducted in Turkey is lower than 5% (Turan 2005, Seçkin & Çoşkun 2006, Bulut *et al.* 2012, Hizal 2013, Göçer 2016, Selçuk *et al.* 2017, 2019, Yorulmaz & Arslan 2019, in this study).

Birds in the dietary content have been reported to constitute less than 10% in most studies in Europe (Wijnandts 1984, Korpimäki 1992, Tome 1994, Pirovano *et al.* 2000, Navarro *et al.* 2003, Kovinka & Sharikov 2020). However, the proportion of birds in dietary content could be increasing in urban and suburban areas (Wijnandts 1984, Göçer 2016). In addition, urban cemeteries serve as shelters for birds and have a rich bird diversity (Lussenhop 1977, Čanády & Mošanský 2017). We observed that the frequency of birds found in pellets was higher in the collecting area in İstanbul, which is a cemetery in contrast to Kars (steppe area) and Edirne (suburban area) (Table 2).

In this study, and in many others, the composition of small mammalian in the diet from the pellet and from the trapping is different (Perrin, 1982, Yom-Tov & Wool 1997, Petrovici *et al.* 2013). In Edirne Province, although the predominant prey was found to be *Mus* spp. as a result of pellet analysis, *Apodemus* spp. had the highest rate (64.58%) in the trapping study. This may be due to the fact that some mammal species can be caught by chance (e.g. *Micromys* sp., *Cricetulus* sp.), the surface of the trapping area cannot represent the entire hunting area of *A. otus* (Petrovici *et al.* 2013), and the efficiency of capture methods (Vieira *et al.* 2014). Although owl pellets are an important alternative option for more detailed small mammal studies, it is still not recommended to rely on pellets to completely replace traditional trapping methods (Heisler *et al.* 2016).

The diet composition of *A. otus* in this study supports that this species has an opportunistic foraging behaviour. Our results also support the hypothesis that feeding strategy can vary depending on the type of habitat, climatic conditions and distribution, diversity and abundance of potential prey. We emphasize that Turkey has a great potential to investigate the diet of *A. otus*, because of vegetation, altitude, climatic conditions, and prey diversity vary greatly throughout the country.

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