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Seasonal variation of small mammals in the diet of the barn owl (*Tyto alba*) in the Drinos River valley, southern Albania

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Abstract: The small mammal composition in the diet of barn owls from the Drinos River valley, southern Albania, was studied over the period of 1 year (September 2010–September 2011). A total of 662 pellets was collected and analyzed, and 1951 prey items were identified. Fourteen different small mammal species were identified (5 insectivores and 9 rodents), among which *Microtus thomasi* (frequency, F = 32.9%; biomass, B = 45.5%), *Crocidura suaveolens* (F = 23.5%; B = 9.4%), and *Mus macedonicus* (F = 17.8%; B = 16.3%) were the most abundant. In winter, *Rattus rattus* increased significantly in the consumed prey biomass (18.1%), while in spring *Apodemus sylvaticus* (9.4%) ranked third most common among the prey species. *Neomys anomalus* was more frequent in the diet in autumn and winter than in spring and summer. *Suncus etruscus* had low percentages in the barn owl diet, but was preyed upon during all seasons, confirming the presence of the species in the Drinos valley. Significant seasonal variations in small mammals in the diet of the barn owl were detected. Environmental index (i/r) values indicate that the Drinos valley is mainly an agrocenosis of nonintensive land-use practices.

Key words: Barn owl, *Tyto alba*, Insectivora, Rodentia, seasonal variation, Drinos valley, Gjirokastra, Albania

1. Introduction

The diet of the barn owl *Tyto alba* (Scopoli, 1769) has been studied widely throughout the range of distribution of the species (Glue, 1967, 1974; Cheylan, 1976; Morton et al., 1977; Jaksic and Yanez, 1979; Burton, 1984; Niethammer, 1989; Everett et al., 1992; Bon et al., 1997; Alivizatos and Goutner, 1999; Goutner and Alivizatos, 2003; Tores et al., 2005; Bontzorlos et al., 2005, 2009) due to the fact that pellets are easy to find and small mammal bone parts are well preserved and easy to identify. Analysis of small mammal prey offers an important source of information on the composition and dynamics of small mammal communities within the barn owl's foraging area (Mikuska et al., 1977; Niethammer, 1989; Everett et al., 1992; Mazzotti and Caramori, 1998; Alivizatos and Goutner, 1999; Bego, 2003; Goutner and Alivizatos, 2003; Bego and Kadiasi, 2008). The diet shows both seasonal and spatial variation due to the opportunistic feeding strategy of the owl and its adaptation to different geographical regions, climatic conditions, and diversity of habitats across its distribution (Webster, 1973; Herrera, 1974a, 1974b; Cheylan, 1976; Contoli 1975, 1981; Contoli et al., 1978; Brown, 1981; Burton, 1984; Campbell et al., 1987; Marti, 1988; Tsounis and Dimitropoulos, 1992; Bon et al., 1997; Yom-Tov and Wool, 1997; Bego, 2003; Tores et al., 2005; Bontzorlos et al., 2005; Bego and Kadiasi, 2008). Changes in the diet reflect changes in the small mammal fauna available to the owl (Marti, 1987, 1988; Marti et al., 1993), and analysis of the barn owl diet can be used as a valuable indirect research tool for the management and conservation of small mammal species. In Albania, analysis of barn owl pellets collected along the coastal zone has been used to investigate the small mammal community composition and species distribution in the area (Bego, 2003; Bego et al., 2008; Bego and Kadiasi, 2008; Paspali and Bego, 2008). Finally, small mammals may represent a biological indicator of change in a complex terrestrial ecosystem (biocoenosis) as they occupy various trophic levels and their presence or absence may give information on the degree of biotope alteration (Contoli 1975, 1980).

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The aims of the present study were to: i) provide new information on small mammals in the diet of the barn owl; ii) assess seasonal changes in the small mammal composition of the species' diet; and iii) contribute to the knowledge on the presence and distribution of small mammal species in a mosaic landscape of southern Albania.

2. Materials and methods

2.1. Study area

The Drinos River valley is located in southern Albania between the Lunxhëri–Bureto mountain range to the east and the Gjerë–Kurvelesh mountain range to the west. The valley is some 60 km in length, varies in width from 1 to 5 km, and is situated between 200 and 250 m above sea level. The annual mean temperature is 14 °C, and the mean temperature of the warmest month (July) is 23 °C, while the mean temperature of the coldest month (January) is 5.2 °C. The valley is distinguished for its high precipitation and rich hydrography. The main hydrographical artery is the Drinos River, 1 of the 2 main tributaries of the Vjosa River. The total length of the Drinos River watershed is estimated to be 84.6 km, and it has a surface area of 1324 km^2. Forest coverage is poor, with the main vegetation being shrubs and degraded oak woodland. Relatively well-developed and dense vegetation coverage is found downstream in the valley, comprising typical riparian species dominated by Oriental plane (*Platanus orientalis*) and willows (*Salix* spp.). The largest part of the Drinos valley is occupied by a mosaic of agriculture land, which, following the collapse of the communist regime in 1990, has been abandoned (even now, 2 decades later, about 70% of the former arable land is uncultivated and used for grazing). The land that is cultivated supports crops of alfalfa (60%); wheat (20%); oats, barley, and corn (10%); vines (5%); and vegetables, potatoes, and beans (5%) (INSTAT, 2003).

2.2. Sample collection methodology

Barn owl pellets were collected monthly between September 2010 and September 2011 in abandoned ruined buildings and churches in the Drinos valley. Samples were collected from 8 sites (Figure 1), of which 6 were located on the west side of the valley (Bodrishtë, Bularat, Sofratikë, Lazarat, Gjirokastra, Ura e Kardhiqit) and 2 on the east side (agricultural fields below Libohovë, and Arshi Lengo village).

Each pellet was treated as an individual sample and analyzed separately. Skeletal residues, mainly cranial remains including skull and jaw of prey found in the pellets, were placed in separate plastic envelopes. Prey was identified to the genus and species level using the works of Niethammer and Krapp (1977, 1982, 1983), Yalden (1977), and Erfurt (2003), apart from determination of sibling species of the genus *Mus*, where the works of Macholán (1996) and Kryštufek and Macholán (1998) were followed.

Diet was analyzed by season and expressed in terms of frequency (F) and biomass (B) of the prey items identified. Species biomass was calculated as the number of individuals of each species multiplied by average body mass. The body mass of small mammal species was taken from MacDonald and Barrett (1993).

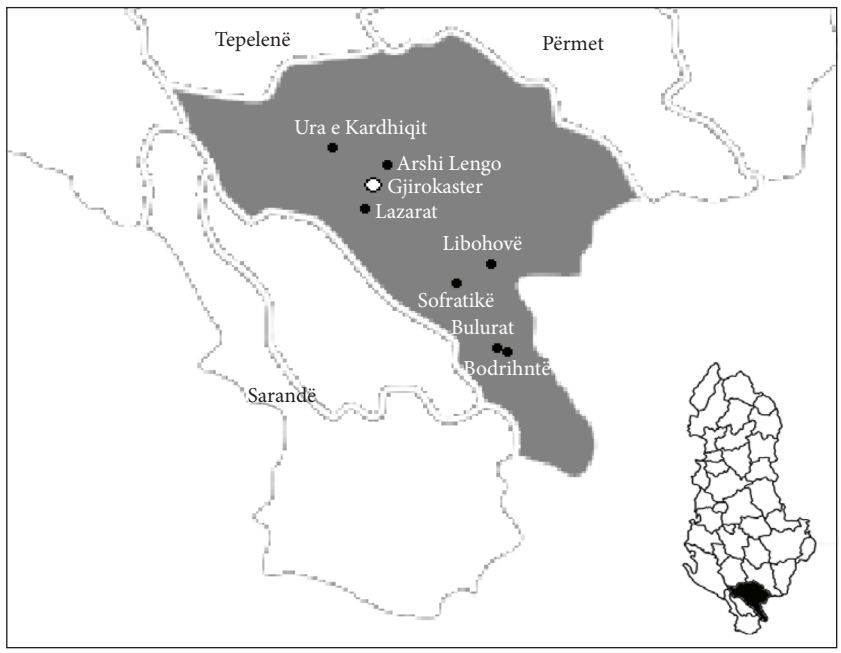

Figure 1. Sample sites in the Drinos valley, where barn owl pellets were collected. The right insert shows position of study area in the map of Albania.

Diet diversity was calculated using the standardized Levins index (FNB_{STA}) (Levins, 1968; Colwell and Futuyma, 1971), where FNB_{STA} = (FNB – 1) / (n – 1), FNB is the Levins index (on a scale from 0 to 1, where 0 = lowest niche breadth and 1 = highest niche breadth), and n is the total number of prey species.

Seasons were defined as follows: spring, March–May; summer, June–August; autumn, September–November; winter, December–February. The significance of seasonal variation in small mammal composition of the diet was tested with one-way ANOVA, using PASW® Statistics 18.

An environmental index was estimated from the ratio of insectivores to rodents (i/r) found in the diet (Mazzotti and Caramori, 1998; Magurran, 2003) and used as an indication of possible biotope alteration within the range of the foraging area of barn owls in the study area.

3. Results

Over the study period, 662 pellets were collected, containing the skeletal remains of 1951 small mammals (average = 2.95 individuals per pellet). Fourteen different species of small mammals (5 insectivores and 9 rodents) were identified. Table 1 summarizes the frequency and biomass across the different seasons, while Table 2 reports the mean values and standard deviations. Of the 14 species, 8 species formed part of the barn owl diet throughout the year. The main prey comprised *Microtus thomasi* (mean frequency, F = 32.9%; biomass, B = 45.5%), *Crocidura suaveolens* (F = 23.5%; B = 9.4%), and *Mus macedonicus* (F = 17.8%; B = 16.3%). In winter *Rattus rattus* increased significantly in the biomass of consumed prey (18.1%), becoming the second ranked main prey species, while in spring *Apodemus sylvaticus* biomass was

Table 1. Seasonal composition of barn owl diet in the Drinos valley, by % frequency (F) and % biomass (B).

	Autumn 2010		Winter 2010–11		Spring 2011		Summer 2011	
Prey species	F (%)	B (%)	F (%)	B (%)	F (%)	B (%)	F (%)	B (%)
Crocidura suaveolens	22.0	9.0	19.4	6.3	21.3	8.3	31.4	14.3
Crocidura leucodon	8.3	3.4	4.6	1.5	8.7	3.4	7.6	3.4
Crocidura sp.	1.1	0.5	1.1	0.4	1.4	0.5	1.6	0.7
Suncus etruscus	3.8	0.5	2.3	0.2	2.8	0.3	2.2	0.3
Neomys anomalus	6.1	4.6	6.3	3.7	3.4	2.4	0.5	0.5
Talpa stankovici	-	-	0.6	2.8	0.3	1.6	-	-
Microtus thomasi	24.3	35.2	36.6	41.7	37.0	50.8	33.8	54.4
Microtus sp.	3.8	5.3	2.3	2.5	1.1	1.5	0.5	0.8
Mus macedonicus	21.3	20.1	16.6	12.3	14.6	13.1	18.9	19.9
Mus domesticus	0.9	0.8	-	-	0.3	0.3	0.5	0.6
Mus sp.	0.9	0.8	1.1	0.8	0.8	0.8	0.5	0.6
Apodemus sylvaticus	3.3	5.9	5.1	7.1	5.6	9.4	1.4	2.6
Apodemus flavicollis	1.0	1.7	-	-	2.0	3.3	-	-
Apodemus epimelas	0.1	0.2	-	-	-	-	-	-
Apodemus sp.	0.7	1.2	-	-	0.3	0.5	0.5	1.1
Rattus rattus	0.6	7.7	1.7	18.1	0.3	3.6	-	-
Muscardinus avellanarius	1.7	2.5	2.3	2.6	0.3	0.4	0.5	0.9
Glis glis	0.1	0.81	-	-	-	-	-	-
Pipistrellus sp.	0.1	0.04	-	-	-	-	-	-
Total no. of prey	1049		175		357		370	
FNB_{STA}	0.27		0.21		0.20		0.16	
i/r	0.70		0.52		0.60		0.76	

One-way ANOVA: $F_{(3,18)} = 70.411$, $P < 0.0001$ for frequency; and $F_{(3,18)} = 45.184$, $P < 0.0001$ for biomass.

Table 2. Small mammal species composition of diet of barn owls in the Drinos valley, by % frequency (F) and % biomass (B).

Species	Mean F (%)	Mean B (%)	Std. dev. (F)	Std. dev. (B)
Crocidura suaveolens	23.52	9.45	5.33	3.41
Crocidura leucodon	7.28	2.92	1.86	0.96
Crocidura sp.	1.33	0.53	0.23	0.16
Suncus etruscus	2.76	0.34	0.75	0.11
Neomys anomalus	4.07	2.80	2.71	1.81
Talpa stankovici	0.21	1.10	0.27	1.36
Microtus thomasi	32.91	45.51	5.91	8.73
Microtus sp.	1.94	2.52	1.44	1.96
Mus macedonicus	17.83	16.32	2.90	4.21
Mus domesticus	0.42	0.41	0.37	0.35
Mus sp.	0.84	0.74	0.25	0.12
Apodemus sylvaticus	3.86	6.26	1.94	2.81
Apodemus flavicollis	0.73	1.24	0.94	1.57
Apodemus epimelas	0.02	0.05	0.05	0.11
Apodemus sp.	0.37	0.67	0.29	0.55
Rattus rattus	0.64	7.33	0.75	7.83
Muscardinus avellanarius	1.20	1.58	0.95	1.12
Glis glis	0.02	0.20	0.05	0.40
Pipistrellus sp.	0.02	0.01	0.05	0.02

9.4%, ranking third. *Crocidura leucodon* was present in the diet but at a lesser amount (F = 7.3%; B = 2.9%) than *C. suaveolens*. Pygmy white-toothed shrew *Suncus etruscus* was also present throughout the year, though always at a low level, being more common in autumn (F = 3.8%; B = 0.5%). *Neomys anomalus* also was more abundant in autumn and winter (F = 6%) than during the rest of the year. *Muscardinus avellanarius* was present in the diet throughout the year, but with a low contribution, being more common in autumn and winter (B = 2.5% and 2.6%, respectively). Neither *Apodemus flavicollis* nor *A. epimelas* were regularly present in barn owl prey and were always at a low level (F = 0.7% and 0.024%, respectively). *Talpa stankovici*, *Glis glis*, and bats (*Pipistrellus* sp.) were very occasional prey species, with *T. stankovici* occasionally preyed during winter and spring, and *Glis glis* and *Pipistrellus* only in autumn (Tables 1 and 2).

Rodents in comparison to insectivores dominated the diet of barn owls in terms of both frequency and biomass, and also across all seasons (Figure 2). Insectivores were less abundant in the diet during winter, increased during spring, reached the highest percentage in summer, and fell again in autumn. Species diversity in the diet was highest in autumn (FNB_{STA} = 0.27), falling slightly over the rest of the year (Table 1). Prey species' seasonal variation was significant, in terms of both frequency and biomass (see Table 1 and Figures 2, 3, and 4).

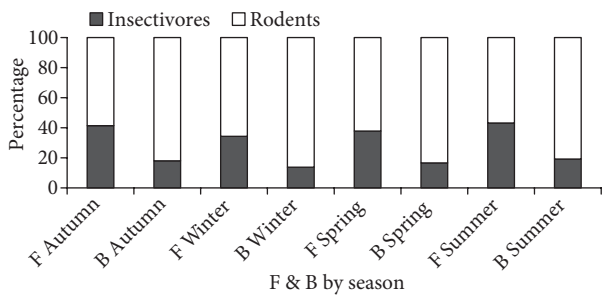

Figure 2. Seasonal variation in frequency (F) and biomass (B) of insectivores and rodents in the diet of barn owls in the Drinos valley.

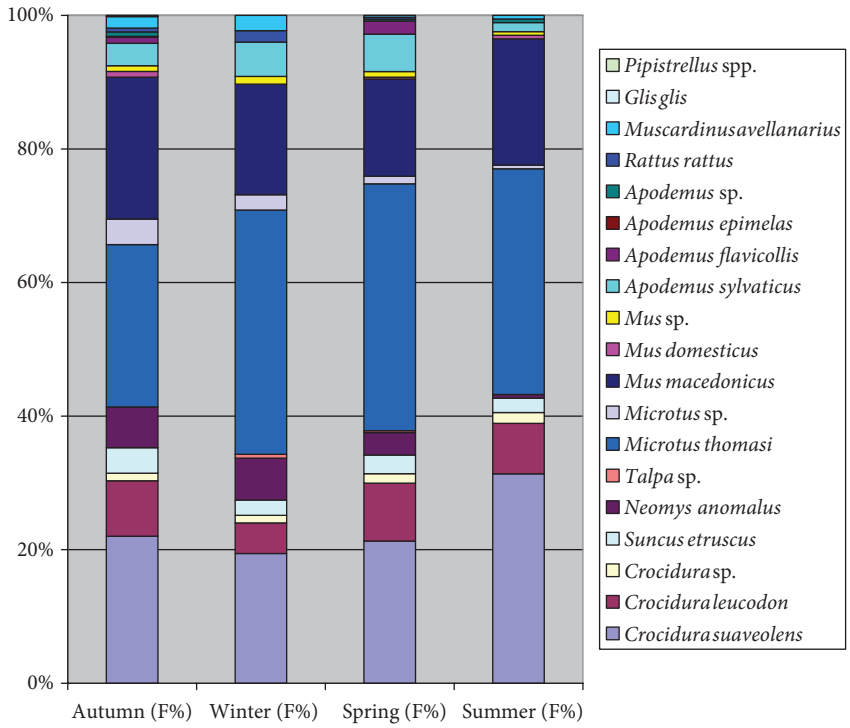

Figure 3. Seasonal variation in frequency (%) of small mammal species in the diet of barn owls in the Drinos valley.

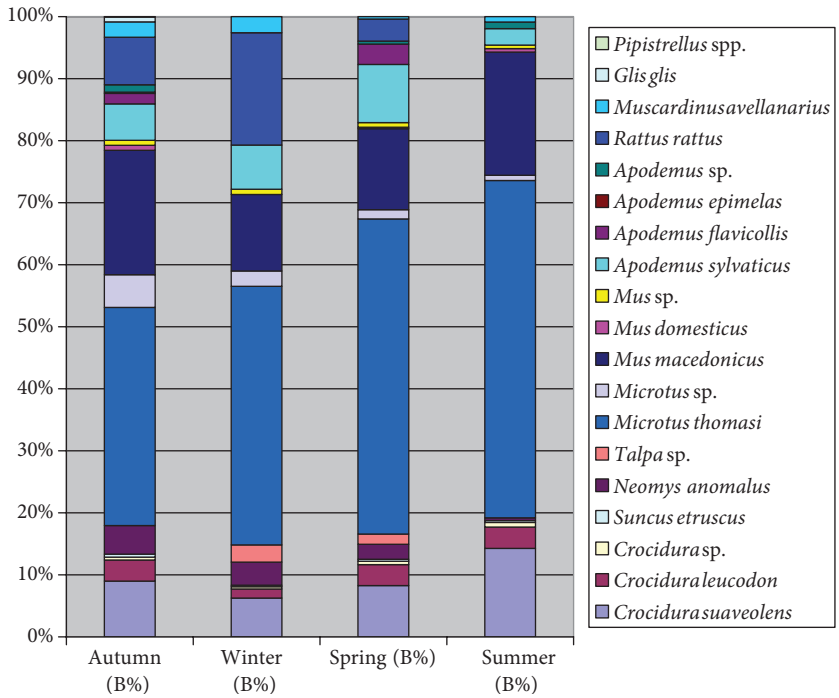

Figure 4. Seasonal variation in biomass (%) of small mammal species in the diet of barn owls in the Drinos valley.

4. Discussion

The results obtained from the present study show that the Drinos River valley provides suitable habitats for the barn owl, with an abundance of small mammal prey species (rodents and insectivores). The vegetation coverage, the rich hydrography of the Drinos River and its tributaries, the natural and seminatural grasslands, cultivated fields, and proximity to urban areas create an assemblage and mosaic of habitats suitable to many species of rodents and insectivores.

The composition of the small mammal community in the diet of barn owls along the Drinos valley and i/r values (Table 1) suggest a low degree of habitat heterogeneity across the different seasons (Nott and Pimm, 1997; Mazzotti and Caramori, 1998; Magurran, 2003). Seasonal values of the environmental index (i/r) in the Drinos valley oscillate between 0.52 and 0.76. They are higher than i/r values from more intensive agricultural fields of Albania, such as Vurgu and Myzeqe (0.24 and 0.03), and very similar to i/r values from the Divjaka-Karavasta area (0.4 and 0.8), where a more mosaic landscape and less intensive agriculture have developed (Bego, 2003; Bego and Kadiasi, 2008). Mazotti and Caramori (1998), in their study on small mammal communities in the southeastern Po River valley, reported much higher i/r values in sites of high habitat heterogeneity.

Analysis of the diet composition shows that significant seasonal variations do exist in the frequency and biomass of prey species. There are similar examples reported in the literature (e.g., Marti, 1974; Petretti, 1977; Marks and Marti, 1984; Taylor, 1994; Roulin, 1996; Ruboliniet al., 2003; Bontzorlos et al., 2005, 2009; Tores et al., 2005), where variation in the composition of mammalian species in the diet of nocturnal birds has been attributed to various climatic factors, seasonal population cycles, seasonal variation in abundance and activity of small mammals, and changes in vegetation cover during the year, particularly in agricultural areas, where annual agricultural cycles cause major changes in the soil surface. In the case of the Drinos valley, a small valley with a typical Mediterranean climate where most of the study area contains noncultivated arable land used mainly as grassland for grazing, these seasonal variations can be attributed to seasonal population cycles, seasonal variation in abundance and activity of small mammals, and changes in vegetation cover.

Microtus thomasi was the main prey species of the barn owl in the Drinos valley, with a frequency in the diet ranging between 24.3% and 37%, and a biomass that varies between 35.2% in autumn and 54.4% in summer. Bunn et al. (1982) described the barn owl as a nonselective predator on small mammals, while Taylor (1994) and Leader et al. (2010) suggested that it shows a preference for voles (*Microtus*), due to their small size and ease of catching. The frequency of *Microtus* in the Drinos valley barn owl diet increases in winter and spring, a time when that of mice (*Mus* sp.) considerably decreases. The increase in *Microtus* in the winter diet may be explained by the low vegetation cover and the ease with which this prey is caught (Pirovano et al., 2000). The increased proportion of voles in the barn owl diet in spring could be linked to the reproductive cycle and the seasonal increase in temperature, both of which increase the activity of voles but also their vulnerability to predation by owls.

Crocidura suaveolens is the second most common prey in the barn owl diet (F = 23.5%), while its congeneric species *Crocidura leucodon* is 3 to 4 times less common (F = 7.3%). Although shrews are generally not a preferable food item to most birds of prey, barn owls catch them in abundance, which is perhaps due to their local availability (Bunn et al., 1982; Mikkola, 1983). As mentioned above, many of the fields around the Drinos River are uncultivated and left as grassland, providing thus a good habitat for shrews, especially for *Crocidura suaveolens* (Bego et al., 2008).

Mus macedonicus is another important food item in the diet of barn owls in the Drinos valley. The increased occurrence of *M. macedonicus* in the diet in late summer and autumn (F = 21.3%; B = 20.1%) may be explained by the seasonal abundance of foodstuffs (seeds and cereals) for mice, as well as by the traditional burning of cultivated cropland at this time of the year to manage invasive plant species. *Mus macedonicus* is a species that invades habitats soon after they are burned and during the first stages of habitat regeneration (Haim et al., 1999), and therefore owls can prey easily on this small mouse at such times. According to Vohralik and Sofianidou (1992), both *Microtus* spp. and *Mus macedonicus* normally occur in grassland habitats, including agricultural land. The fields around the Drinos are typical of such grasslands, and this could explain why voles and mice are the dominant prey of barn owls in the area.

Neomys anomalus accounted for 4.1% of the barn owl diet. This species is recorded so far in Albania only in the Drinos valley (Bego et al., 2008) and is linked with the presence here of streams and other smaller tributaries whose banks, covered with thick, dense vegetation, provide a typical habitat for the species (Spitzenberger, 1990; Kryštufek and Quadracci, 2008). During the summer, a sharp decline in the presence of this species in the barn owl diet was recorded, possibly explained by the long dry summer, during which most of the local streams

dry out almost completely, probably with a negative impact on local populations of this insectivore.

Suncus etruscus, although making a very small contribution to the barn owl diet (F = 2.8%), was always present on the list of prey species in all seasons, though more commonly in autumn (F = 3.8%). It appears that this species is well established in the Drinos valley. The dominant grasslands support such a prey available to the foraging barn owl, although it is not a highly preferred prey, given its small size and low biomass (Vohralik and Sofianidou, 2000; Bego et al., 2008).

In spring, although the contribution of *Mus macedonicus* in the diet decreased, an increase in the presence of *Apodemus sylvaticus* was recorded (F = 5.6%; B = 9.4%), though its presence fell drastically in the summer (F = 1.4%; B = 2.6%), only to gradually increase in the following autumn and winter. This seasonal variation may be explained by the fact that the *A. sylvaticus* breeding season starts in March (MacDonald and Barrett, 1993). Marti (1974) reported that adult mice are more active during the breeding season, when juveniles and subadults may be found in areas less familiar and suitable for them during dispersal and consequently may be vulnerable to predation. The occasional presence of *A. flavicollis* and *A. epimelas* in the barn owl diet may be due to the fact that habitats suitable for these 2 species are very rare within the hunting area of the barn owls along the Drinos valley. Both species prefer woodlands, which are very scarce in the valley.

The presence of *Rattus rattus* and *Muscardinus avellanarius* in the barn owl diet is explained by the presence in the study area of natural grasslands, orchards, and farmland hedgerows, known as suitable habitats for both species (Becker, 1978; Storch, 1978; Morris, 1979; Montgomery, 1985; Bright and Morris, 1996). During winter, a considerable increase in the *Rattus* contribution to the biomass (18.1%) was noticed, probably as a result of increased need for minimizing foraging costs and energy recompensation by capturing high biomass species, because during winter barn owls forage and capture prey with greater difficulty due to weather conditions (Roulin, 1996; Pirovano et al., 2000; Rubolini et al., 2003; Bontzorlos et al., 2009). The contribution of the rat (F = 0.6%; B = 7.3%) to the barn owl diet is similar to the levels reported for other Mediterranean countries: in the Iberian peninsula and Italy, rats form a small percentage of the barn owl diet (F = 0%–4%: Herrera, 1974; Maurizio, 1999), though it has contributed a larger amount in Greece (F = 0%–11%: Bontzorlos et al., 2005).

Glis glis is for the first time recorded in this part of Albania, although it represents an occasional prey species for the barn owl in the Drinos valley. The fat dormouse is a typical woodland species (MacDonald and Barrett, 1993; Bright and Morris, 1996) and, therefore, as expected, it is a very rare species within the study area. The small percentage of moles (*Talpa stankovici*) in the diet is explained by their very low surface activity (Giger, 1965). Bats (*Pipistrellus*) also are very scarcely seen in the diet and then only in autumn, probably explained by the increased population size and activity of bats in the time prior to hibernation (Kunz and Lumsden, 2003).

The results of our study support the findings of other authors (Contoli et al., 1978; Jaksic and Yanez, 1979; Marks and Marti, 1984; Marti, 1988; Marti et al., 1993; Bon et al., 1997; Bego, 2003; Bontzorlos et al., 2005, 2009; Bego and Kadiasi, 2008) that the barn owl is an opportunistic predator of high ability to easily switch between prey species, and that its feeding strategy is based on food availability. Nevertheless, Tores et al. (2005) defined the barn owl as a selective opportunistic predator, i.e. neither a pure opportunist nor a pure selective hunter. Whereas the barn owl prefers a certain type of prey with particular characteristics (e.g., being crepuscular or nocturnal, with a high population density, of an appropriate size, easy to capture), it will easily switch to a different prey species if the population density of the preferred species declines below a certain level. Other authors (Taylor, 1994; Yom-Tov and Wool, 1997; Leader at al., 2010) claim that barn owls demonstrate a preference for certain types of prey over the others, especially when in sympatry and in competition with other owl species. This finding must be considered in future studies in southern Albania, as the presence of other owl species, such as the long-eared owl and the little owl, is already verified in the Drinos valley.

In the coming years, with the expected revitalization of the agricultural sector accompanied by changes in land-use practices and intensive agriculture, the habitat structure in Drinos River valley may change, impacting the small mammal communities and hence the diet composition of the barn owl and other predators. Therefore, monitoring small mammal communities will be a good means of monitoring environmental changes and the adaptation response of small mammals to such changes.

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References

Alivizatos, H. and Goutner, V. 1999. Winter diet of the barn owl (*Tyto alba*) and long-eared owl (*Asio otus*) in northeastern Greece: a comparison. J. Raptor Res. 33(2): 160–163.

Becker, K. 1978. Black rat. In: Handbuch der Säugetiere Europas, Band1/I, Rodentia I [Manual of European Mammals, Volume 1/1, Rodentia I] (Eds. J. Niethammer and F. Krapp). AULA–Verlag, Wiesbaden, pp. 382–400 (in German).

Bego, F. 2003. Te dhena mbi komunitetet e gjitareve te vegjel (Mammalia: Rodentia dhe Insectivora) te fushes se Vurgut (Mesopotam) dhe Myzeqese (Apolloni) [Data on the small mammals (Mammalia: Rodentia and Insectivora) of Vurgu field (Mesopotam) and Myzeqe field (Apolloni)]. Akademia e Shkencave: Studime Biologjike. No. 7, pp. 123–131 (in Albanian with English summary).

Bego, F. and Kadiasi, N. 2008. Perberja dhe dinamika e komuniteteve te gjitareve te vegjel (Mammalia: Insectivora dhe Rodentia) te ekosistemit ligatinor Divjake–Karavasta [Structure and dynamics of the communities of small mammals (Mammalia: Insectivora and Rodentia) in the ecosystem of the Divjaka–Karavasta area.]. In: Proceedings of the International Conference on Biological and Environmental Sciences. UT, FSHN, pp. 280–286 (in Albanian with English summary).

Bego, F., Kryštufek, B., Paspali, G. and Rogozi, E. 2008. Small terrestrial mammals of Albania: annotated list and distribution. Hystrix Ital. J. Mamm. 19(2): 83–101.

Bon, M., Roccaforte, P. and Sirna, G. 1997. Ecologia trofica del barbagianni, *Tyto alba* (Scopoli, 1769), nella pianura veneta centro–orientale (Aves, Strigiformes) [The trophic ecology of the Barn owl, *Tyto alba* (Scopoli, 1769), in an agricultural landscape of central–eastern Italy]. Bolletino del museo civico di storia naturale di Venezia 47: 265–283 (in Italian).

Bontzorlos, V.A., Peris, S.J., Vlachos, C.G. and Bakaloudis, D.E. 2005. The diet of barn owl in the agricultural landscapes of central Greece. Folia Zool. 54(1–2): 99–110.

Bontzorlos, V.A., Peris, S.J., Vlachos, C.G. and Bakaloudis, D.E. 2009. Barn owl prey in Thessaly, and evaluation of Barn owl diets throughout Greece. ARDEA 97(4): 625–630.

Bright, P. and Morris, P. 1996. Why are dormice rare? A case study in conservation biology. Mamm. Rev. 26: 157–187.

Brown, D.J. 1981. Seasonal variations in the prey of some Barn Owls in Gwynnedd. Bird Study 28: 139–146.

Bunn, D.S., Warburton, A.B. and Wilson, R.D.S. 1982. The Barn Owl. T. and A.D. Poyser, Carlton, UK.

Burton, J.A. 1984. Owls of the World. Tanager Books, Dover, New Hampshire, USA.

Campbell, R.W., Manuwal, D.A. and Harestad, A.S. 1987. Food habits of the Common Barn-Owl in British Columbia. Can. J. Zool. 65: 578–586.

Cheylan, G. 1976. La régime alimentaire de la chouette effraie (*Tyto alba*) en Europe Méditerranéene [The feeding habits of the Barn owl (*Tyto alba*) in Mediterranean Europe]. Terre Vie (Rev. Ecol.) 4: 565–579 (in French).

Colwell, R.K. and Futuyma, D.J. 1971. On the measurement of niche breadth and overlap. Ecology 52: 567–576.

Contoli, L. 1975. Micro-mammals and environment in Central Italy: data from *Tyto alba* (Scop.) pellets. Boll. Zool. 42: 223–229.

Contoli, L. 1980. Borre di Strigiformi e ricerca teriologica in Italia. Natura e Montagna 3: 73–94 (in Italian).

Contoli, L. 1981. Ruolo dei Micromammiferi nella nicchia trofica del barbagianni (*Tyto alba*) nell'Italia Centro Meridionale. Avocetta 5: 49–64 (in Italian).

Contoli, L., Ragonese, B., and Tizi, L. 1978. Sul sistema trofico "Micromammiferi – *Tyto alba*" nei pantani di vendicari [On the trophic system "Small mammals – Barn owl" in Vendicari Marsh]. Animalia 5(1–3): 79–105 (in Italian).

Erfurt, J. 2003. Bestimmung von Säugetierschädeln in Fraßresten und Gewöllen [Determination of mammalian skulls in nutrition remnants and pellets]. Methoden feldökol. Säugetierforsch 2: 471–535 (in German).

Everett, M., Prestt, I. and Wgagestaffe, R. 1992. Barn and bay owls. In: Owls of the World: Their Evolution, Structure and Ecology (Ed. J.A. Burton). Peter Lowe, London, pp. 35–60.

Giger, R.D. 1965. Surface activity of moles as indicated by remains in barn owl pellets. Murrelet 46: 32–36.

Glue, D.E. 1967. Prey taken by the barn owl in England and Wales. Bird Study 14: 169–183.

Glue, D.E. 1974. Food of the barn owl in Britain and Ireland. Bird Study 21: 200–210.

Goutner, V. and Alivizatos, H. 2003. Diet of the Barn Owl (*Tyto alba*) and Little Owl (*Athene noctua*) in wetlands of northeastern Greece. Belg. J. Zool. 133(1): 15–22.

Haim, A., Shabtay, A. and Arab, Z. 1999. The thermoregulatory and metabolic responses to photoperiod manipulations of the Macedonian mouse (*Mus macedonicus*), a post-fire invader. J. Thermal Biol. 24: 279–286.

Herrera, C.M. 1974a. Regimen alimenticio de *Tyto alba* en España sudoccidental [Feeding habits of *Tyto alba* in south-western Spain]. Ardeola 19: 359–393 (in Spanish).

Herrera, C.M. 1974b. Trophic diversity of the Barn owl (*Tyto alba*) in continental western Europe. Ornis Scand. 5: 181–191.

INSTAT, 2003. Vjetari statistikor 1993 – 2001 [Statistical Annual Year Book 1993–2001]. Albanian Institute of Statistics, Tirana, Albania (in Albanian).

Jaksic, F.M. and Yanez, J.L. 1979. The diet of the Barn Owl in central Chile and its relation to the availability of prey. Auk 96: 619–621.

Kryštufek, B. and Macholán, M. 1998. Morphological differentiation in *Mus spicilegus* and the taxonomic status of mound-building mice from the Adriatic coast of Yugoslavia. J. Zool., Lond. 245: 185–196.

Kryštufek, B. and Quadracci, A. 2008. Effects of latitude and allopatry on body size variation in European water shrews. Acta Theriologica 53(1): 39–46.

Kunz, T.H. and Lumsden, L.F. 2003. Ecology of cavity and foliage roosting bats. In: Bat Ecology (Eds. T.H. Kunz and M.B. Fenton). University of Chicago Press, Chicago and London, pp. 3–89.

Leader, Z., Yom Tov, Y., and Motro, U. 2010. Diet comparison between two sympatric owls – *Tyto alba* and *Asio otus* – in the Negev Desert, Israel. Israel J. Ecol. Evol. 56: 207–216.

Levins, R. 1968. Evolution in Changing Environments: Some Theoretical Explorations. Princeton University Press, Princeton, New Jersey, USA.

MacDonald, D. and Barrett, P. 1993. Mammals of Britain and Europe. Harper Collins, London.

Macholán, M. 1996. Key to European house mice (*Mus*). Fol. Zool. 45(3): 209–217.

Magurran, A.E. 2003. Measuring Biological Diversity. Blackwell Publishing, Oxford.

Marks, J.S. and Marti, C.D. 1984. Feeding ecology of sympatric Barn Owls and Long-eared Owls in Idaho. Ornis Scand. 15: 135–143.

Marti, C.D. 1974. Feeding ecology of four sympatric owls. Condor 76: 45–61.

Marti, C.D. 1987. Raptor food habit studies. In: Raptor Management Techniques Manual (Eds. B.A. Pendleton, B.A. Millsap, K.W. Cleine and D.M. Bird). National Wildlife Federation, Washington DC, pp. 67–79.

Marti, C.D. 1988. A long-term study of food-niche dynamics in the Common Barn-Owl: comparisons within and between populations. Can. J. Zool. 66: 1803–1812.

Marti, C.D., Korpimaki, E. and Jaksić, F.M. 1993. Trophic structure of raptor communities: a three-continent comparison and synthesis. In: Current Ornithology, Vol. 10 (Ed. D.M. Power). Plenum, New York, pp. 47–137.

Maurizio, A.S. 1999. Dati sulla dieta del Barbagianni (*Tyto alba*) in ambiente urbano in Sicilia [Data about the diet of Barn owl (*Tyto alba*) in an urban area in Sicily]. Nat. Sicil. 23(3–4): 587–589 (in Italian).

Mazzotti, S. and Caramori, G. 1998. Analysis of small mammal communities in south-eastern Po Valley. Gortania Atti Museo Friul. di Storia Nat. 20: 253–262.

Mikkola, H. 1983. Owls of Europe. T. and A.D. Poyser, Carlton, UK.

Mikuska, J., Tvrtkovic, N. and Dzukic, G. 1977. Collecting and analysis of bird pellets as one of more important methods for studying the fauna of mammals in Yugoslavia. Arh. Biol. Nauka, Beograd 29(3–4): 157–160.

Montgomery, W. 1985. Interspecific competition and the comparative ecology of two congeneric species of mice. In: Case Studies in Population Biology (Ed. L.M. Cook). University of Manchester Press, Manchester, UK, pp. 129–187.

Morton, S.R., Happold, M., Lee, A.K. and MacMillen, R.E. 1977. The diet of the Barn Owl, *Tyto alba*, in south-western Queensland. Aust. Wild. Res. 4(1): 91–97.

Morris, P. 1979. Rats in the diet of the Barn owl (*Tyto alba*). J. Zool. 189: 540–545.

Niethammer, J. 1989. Gewöllinhalte der Schleiereule (*Tyto alba*) von Kos und aus Südwestanatolien. Bonn. Zool. Beitr. 40: 1–9.

Niethammer, J. and Krapp, F. 1977. Handbuch der Säugetiere Europas – Band 1, Nagetiere 1 [Manual of the European Mammals, Volume 1, No 1]. AULA–Verlag, Wiesbaden (in German).

Niethammer, J. and Krapp, F. 1982. Handbuch der Säugetiere Europas – Band 2/1, Nagetiere 2 [Manual of the European Mammals, Volume 2/1, No 2]. AULA–Verlag, Wiesbaden (in German).

Niethammer, J. and Krapp, F. 1983. Handbuch der Säugetiere Europas – Band 3/1, Insektenfresser – Herrentiere [Manual of European Mammals, Volume 3/1, Insectivora]. AULA–Verlag, Wiesbaden (in German).

Nott, M.P. and Pimm, S.L. 1997. The evaluation of biodiversity as a target for conservation. In: The Ecological Basis of Conservation: Heterogeneity, Ecosystems, and Biodiversity (Eds. S.T.A. Pickett, R.S. Ostfeld, M. Shachak and G.E. Likens). Chapman and Hall, New York, pp. 125–13.

Paspali, G. and Bego, F. 2008. On the small mammals (Mammalia: Rodentia and Insectivora) of the Drinos valley (Gjirokaster) and Vurgu field (Delvine). In: Proceedings of the International Conference on Biological and Environmental Sciences. UT, FSHN, pp. 265–270 (in Albanian with English summary).

Petretti, F. 1977. Seasonal food habits of Barn owl (*Tyto alba*) in an area of central Italy. Le Gerfaut 67: 225–233.

Pirovano, A., Rubolini, D., Brambilla, S. and Ferrari, N. 2000. Winter diet of urban roosting long-eared owls *Asio otus* in northern Italy: the importance of the brown rat *Rattus norvegicus*. Bird Study 47: 242–244.

Roulin, A. 1996. Wintering diet of the barn owl (*Tyto alba*), long-eared owl (*Asio otus)*, hen harrier (*Circus cyaneus*) and kestrel (*Falco tinnunculus*). Bulletin de la Société Vaudoise des Sciences Naturelles 84: 19–32.

Rubolini, D., Pirovano, A. and Borghi, S. 2003. Influence of seasonality, temperature and rainfall on the winter diet of the long-eared owl, *Asio otus*. Fol. Zool. 52: 67–76.

Spitzenberger, F. 1990. Gattung *Neomys* Kaup, 1829. In: Handbuch der Säugetiere Europas, Band 3/I [Manual of European Mammals, Volume 3/I]. (Eds. J. Niethammer and F. Krapp). AULA–Verlag, Wiesbaden, pp. 313–374 (in German).

Storch, G. 1978. Haselmaus. In: Handbuch der Säugetiere Europas, Band 1/I, Rodentia I [Common dormouse. In: Manual of European Mammals, Volume 1/I, No 1] (Eds. J. Niethammer and F. Krapp F.). AULA–Verlag, Wiesbaden, pp. 259–280 (in German).

Taylor, I. 1994. Barn Owls: Predator–Prey Relationships and Conservation. Cambridge University Press, Cambridge, UK.

Tores, M., Motro, Y., Motro, U. and Yom-Tov, Y. 2005. The Barn Owl – a selective opportunist predator. Israel J. Zool. 51: 349–360.

Tsounis, G. and Dimitropoulos, A. 1992. Seasonal variation of the feeding of Barn owl, *Tyto alba* (Scopoli 1769) in Mount Hymetus, Attica, Greece. Biol. Gallo-hell. 19: 29–36.

Vohralik, V. and Sofianidou, T. 1992. Small mammals (Insectivora, Rodentia) of Thrace, Greece. Acta Univ. Carol. Biol. 36: 341–369.

Vohralik, V. and Sofianidou, T. 2000. New records of *Suncus etruscus* (Mammalia: Insectivora) in Bulgaria and Greece and distribution of the species in the Balkans. Lynx (Prague) 31: 143–148.

Webster, J.A. 1973. Seasonal variation in mammal contents of barn owl castings. Bird Study 20: 185–196.

Yalden, D.W. 1977. The identification of remains in owl pellets. Occas. Publ. Mammal. Soc., London.

Yom-Tov, Y. and Wool, D. 1997. Do the contents of barn owl pellets accurately represent the proportion of prey species in the field? Condor 99: 972–976.