

Contribution to the study of the diet of four owl species (Aves, Strigiformes) from mainland and island areas of Greece

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ABSTRACT. The diets of the Barn Owl (*Tyto alba*), Little Owl (*Athene noctua*), Long-eared Owl (*Asio otus*) and Eagle Owl (*Bubo bubo*) were studied through analysis of pellets collected at 13 different continental areas and islands of Greece. The most important prey of the Barn Owl was mammals (mainly *Microtus*, *Mus*, *Apodemus*, *Rattus* and *Crocidura*), although birds and amphibians were of some importance on Antikythera island and Potidea (Central Macedonia), respectively. Average prey biomass ranged from 12.5 g to 42.8 g. The median prey biomass differed significantly between areas ($p < 0.001$). The diet of the Little Owl was more diverse, consisting mainly of mammals (mostly *Microtus*, *Mus*, *Apodemus*, *Micromys* and *Crocidura*) in the Evros and Axios Deltas, mainly of insects (mostly Orthoptera and Coleoptera) in the Kitros Lagoon, Psara and Tilos islands, while birds and reptiles were common supplementary prey. Average prey biomass ranged from 0.7 g to 11.9 g. The median prey biomass differed significantly between the areas studied ($p < 0.001$). The diet of the Long-eared Owl in both Nestos Delta and Porto Lagos consisted mainly of mammals (mostly *Microtus*, *Mus* and *Apodemus*), with some reptiles in the former area and birds in the latter. Average prey biomass was 18.5 g and 19.5 g respectively. The median prey biomass did not differ significantly between the two areas. The diet of the Eagle Owl in the Amvrakikos wetland consisted mostly of birds (62 % by biomass) and mammals (36 %, mainly *Rattus norvegicus*). Insects were the most important prey by numbers - 47 % (1 % by biomass). The prey diversity of the Eagle Owl was the highest while that of the Barn Owl was the lowest. Prey use by owls tended to clump by geographic area. We conclude that the owl species studied make use of prey according to the local availability and in accordance to the hunting abilities of each species.

KEY WORDS : Barn Owl *Tyto alba*, Little Owl *Athene noctua*, Long-eared Owl *Asio otus*, Eagle Owl *Bubo bubo*, diet, feeding ecology, Greece.

INTRODUCTION

Studies carried out on the diet of owls (Strigiformes) in Europe have revealed considerable geographical variation in the diet of each species (BUNN et al., 1982; MIKKOLA, 1983; CRAMP, 1985; TAYLOR, 1994). Generally, prey composition and diversity in the Mediterranean area are different to those in central and northern Europe (HERRERA & HIRALDO, 1976).

In Greece, nine owl species are known to occur and some of them are common in both continent and island habitats (HANDRINOS & AKRIOTIS, 1997) but dietary studies are scarce. The aims of this study were : a) to describe and compare the diet and feeding ecology of the Barn Owl (*Tyto alba* (Scopoli, 1769)), Little Owl (*Athene noctua* (Scopoli, 1769)), Long-eared Owl (*Asio otus* (Linnaeus, 1758)) and Eagle Owl (*Bubo bubo* (Linnaeus, 1758)) studied in various parts of Greece and, b) to compare our results with those of studies carried out in Greece and other European countries.

MATERIAL AND METHODS

The study areas (Fig. 1) encompass different habitats. The Evros, Nestos and Axios Deltas, as well as Porto Lagos, Kitros Lagoon and Amvrakikos area are major wetlands, with a high diversity of habitats, such as salt-marshes, lagoons, reedbeds, tamarisk and riparian forest, marshes and cultivations (MEHPW, 1985; 1986a; 1986b). Potidea and Parthenio areas, both in central Macedonia, include mainly agricultural land. The study sites in Mt. Hymettus and Avlona (both near Athens) include open scrublands (phrygana) habitat and farmland. The islands of Psara (NE Aegean), Tilos (SE Aegean) and Antikythera (between Peloponese and Crete) include mainly phrygana and (to a lesser extent) farmland.

Pellets were collected opportunistically from roosts between December 1997 and August 2001 (Table 1). The material was collected out of the breeding season, mostly in winter, excepting that of the Eagle Owl collected at nests. Pellets were analyzed using reference books (Mammals : LAWRENCE & BROWN, 1973; CHALINE, 1974. Birds : BROWN et al. (1987). Reptiles : ARNOLD & BURTON (1980). Insects : CHINERY (1981)). The average

weight of each prey taxon was taken from the literature (Mammals : MACDONALD & BARRET (1993). Birds : PER-RINS (1987). Reptiles : HELMER & SCHOLTE (1985). Insects : ZERUNIAN et al. (1982)). Because of the difficulty of distinguishing mice *Mus* spp. and *Apodemus* spp. from skulls (VOHRALIK & SOFIANIDOU, 1992), these were often not separated by species. Average prey weight for each sample was estimated by multiplying the numbers of each prey by its average weight, adding the weights produced and dividing the sum by the total numbers of prey in each sample. The trophic diversity (NB) was estimated by using the antilog of the Shannon-Weiner index, while in order to standardize the trophic diversity for comparison within and between the areas we calculated evenness index. Both were calculated on a class prey level. The Mann-Whitney U-test or Kruskal-Wallis test (where appropriate) compared the median prey weights of the same species. Cluster analysis was also performed (using Euclidean distances as distance measure and single linkage as a linkage rule) on biomass proportions of prey in order to determine geographical relationships in the owls' diet. The author names of prey identified in pellets of the owls studied are indicated in Appendix 5.

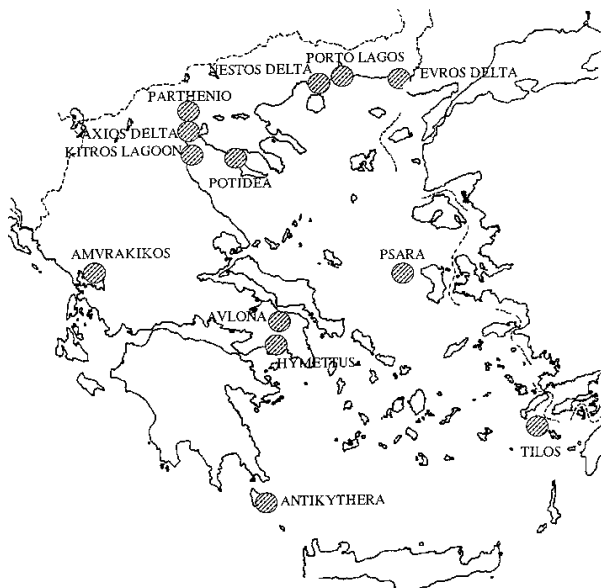


Fig. 1. – Map showing the areas where pellets of owls were collected for this study.

RESULTS

Barn Owl

In the Evros Delta, small mammals (including at least 10 species) composed 90% of the Diet of the Barn Owl (Appendix 1). The most important prey species by biomass was *Microtus rossiaemeridionalis* (37%) followed by *Mus* spp. (20%), *Crocidura suaveolens* (12%) and *Arvicola terrestris* (7%). Birds were moderately important by biomass (9%). Amphibians and arthropods formed only a minor part of this species' diet.

In Porto Lagos small mammals were also the most important prey (of at least five species, 97% by biomass).

M. rossiaemeridionalis was by far the most important prey species (84%). The relative contributions of other mammal species were below 5%. Birds formed only a minor part of the diet in this area (2%).

TABLE 1

Number of samples collected in each study area

Area	<i>Tyto alba</i>	<i>Athene noctua</i>	<i>Asio otus</i>	<i>Bubo bubo</i>
Evros Delta	4	6	-	-
Porto Lagos	1	-	1	-
Potidea	1	-	-	-
Parthenio	1	-	-	-
Hymettus	2	-	-	-
Avlona	1	-	-	-
Antikythera	1	-	-	-
Axios Delta	-	3	-	-
Kitros Lagoon	-	1	-	-
Tilos	-	1	-	-
Psara	-	1	-	-
Nestos Delta	-	-	1	-
Amvrakikos	-	-	-	2

In Potidea, mammalian prey dominated (at least seven species, 92% by biomass). The main prey species was *M. macedonicus* (74 %). Of moderate importance were *Apodemus* spp. (7%), *C. suaveolens* (6%), birds (7%) and frogs (*Rana* spp.) (6%).

In Parthenio, various species of mammals composed the greater part of the diet, although birds, amphibians and insects were also present. The most important species by biomass were *M. rossiaemeridionalis* (35%), *M. macedonicus* (21%), *Rattus* spp. (15%), and *Apodemus sylvaticus* (12%), while birds formed 7% of the diet. Invertebrates were unimportant in the diet.

In Mt. Hymettus, at least eight mammalian species made up 92% of the diet by biomass. The most important prey species by biomass were *A. sylvaticus* (35%), *A. mystacinus* (33%) and *Microtus thomasi* (8%). Other species' participation did not exceed 5%. Birds formed 8% of the diet.

In Avlona, mammals again were the most important prey of the Barn Owl (eight species, 96% by biomass) and birds were also represented (4%). The most important species by biomass was *M. thomasi* (49%), followed by *Mus domesticus* (25%), *M. macedonicus* (8%) and *A. sylvaticus* (6%).

In Antikythera Island, the main prey consisted of three species of mammals (83% by biomass). By far the most important prey was *Rattus rattus* (73%) followed by birds (16%) and *M. domesticus* (6%). Reptiles were represented by geckoes (Gekkonidae) and formed 10% of the diet by number but only 1% by biomass.

The median prey biomass was significantly different between the seven areas (Kruskal-Wallis test, $\chi^2 = 304.04$, $df = 6$, $p < 0.001$). Average prey biomass ranged from 12.5 g in Potidea to 42.8 g in Antikythera. The prey diversity ranged from 1.12 in Porto Lagos to 2.14 in Antikythera, while the evenness ranged from 0.11 in Evros Delta to 0.69 in Antikythera (Table 2).

TABLE 2

Prey size and prey diversity indices of the four owl species in Greece

	N	Average	Median	Min	Max	Diversity	Evenness
<i>Tyto alba</i>							
Evros	487	14.5	12.0	1.0	100	1.17	0.11
P. Lagos	116	17.2	20.0	2.0	20	1.12	0.17
Parthenio	463	18.8	20.0	1.0	150	1.31	0.20
Potidea	296	12.5	12.0	2.0	60	1.20	0.17
Avlona	94	14.8	12.0	2.0	20	1.15	0.20
Hymettus	152	22.2	20.0	6.0	80	1.20	0.27
Antikythera	106	42.8	60.0	5.0	200	2.14	0.69
<i>Athene noctua</i>							
Evros	996	10.7	12.0	0.1	70	2.45	0.46
Axios	273	11.9	12.0	0.2	60	2.24	0.58
Kitros	99	1.1	0.5	0.2	25	1.45	0.26
Lagoon							
Tilos	154	0.7	0.5	0.1	12	1.15	0.12
Psara	74	1.1	1.0	0.1	12	1.45	0.26
<i>Asio otus</i>							
Nestos	52	18.5	20.0	6.0	60	1.29	0.23
P. Lagos	83	19.5	20.0	0.5	100	1.58	0.41
<i>Bubo bubo</i>							
Amvrakikos	66	108.1	3.0	1.0	800	2.88	0.77

Little Owl

The most numerous prey types of the Little Owl in Evros Delta were mammals and insects (54% and 41% by numbers respectively), although other arthropods, reptiles, birds and molluscs were also represented (Appendix 2). The most important prey were mammals (at least six species, 90% by biomass), mainly *M. rossiaemeridionalis* (54%), *Mus* spp. (13%), *Apodemus* spp. (10%) and *Crocidura* spp. (6%). Birds contributed 6% by biomass, insects only 2%.

In the Axios Delta, the most important prey were small mammals (at least eight species, 93% by biomass). The most important species were *M. rossiaemeridionalis* (39%), *Mus* spp. (12%), *Micromys minutus* (11%), *Apodemus* spp. (6%) and *Rattus* spp. (6%). Reptiles contributed 5% to the diet and insects only 1%.

In the Kitros Lagoon insects (mainly Coleoptera) were the most important prey by both number (92%) and biomass (43%), other prey consisting of mammals, Diplopoda and birds. Mammals formed 35% of the diet by biomass, represented by *Mus* spp. (23%) and *Crocidura suaveolens* (12%), while birds formed 19%.

On Tilos Island insects were again the most important prey (97% by numbers, 69% by biomass). Orthoptera (51%) and Coleoptera (14%) were the most important insect groups. Other prey consisted of mammals and reptiles. Mammals formed 27% of the diet by biomass represented by *M. domesticus* (21%) and *C. suaveolens* (5%), while reptiles contributed to 5%.

On Psara Island, insects (mainly Orthoptera and Coleoptera) were also the most important prey (92% by number, 71% by biomass). Prey also included other arthropods and mammals. Mammals formed 24% of the

diet by biomass, represented by only two species, namely *M. domesticus* (15%) and *C. suaveolens* (7%).

The median prey biomass was significantly different between the five areas (Kruskall-Wallis test, $\chi^2 = 367.88$, $df = 4$, $p < 0.001$). Average prey biomass ranged from 0.7 g on Tilos Island to 11.9 g in the Axios Delta. Prey diversity ranged from 1.15 on Tilos Island to 2.45 in Evros Delta, while the evenness ranged from 0.12 on Tilos to 0.58 in the Axios Delta (Table 2).

Long-eared Owl

In the Nestos Delta, the Long-eared Owl preyed mainly on mammals (at least five species, 87% by biomass) and secondarily on reptiles and birds (Appendix 3). The most important mammalian prey was *M. rossiaemeridionalis* (44% by biomass), followed by *M. macedonicus* (11%), *Talpa europaea* (7%), *C. suaveolens* (7%) and *Apodemus* spp. (6%). Reptiles (indeterminate snakes) formed 10% of the prey by biomass. However, because of the small sample, these results should be treated with caution.

In Porto Lagos the diet of this species consisted mainly of mammals (at least four species, 79% by biomass), but also included birds and insects. The most important mammals were *M. rossiaemeridionalis* (52%), *M. macedonicus* (17%) and *Apodemus* spp. (10%). Birds contributed 21% by biomass including small passerines and medium-sized species.

The median prey biomass did not differ significantly between the two areas (Mann-Whitney U test, $Z = -1.20$, n. s.). Average prey biomass was 18.5 g. and 19.5 g. in the Nestos Delta and Porto Lagos respectively. Both prey diversity and evenness were higher in the Nestos Delta (1.29 and 0.23 respectively vs. 1.58 and 0.41) (Table 2).

Eagle Owl

The Eagle Owl in Amvrakikos wetland preyed on mammals, birds, amphibians and insects (Appendix 4). While insects (mainly Orthoptera) formed 47% of the diet by number, they contributed only to 1% by biomass. Birds (of at least eight large-sized species) and mammals (at least seven species) formed 62% and 36% of the biomass of prey respectively. The most important prey species were *Rattus norvegicus* (40%), *Gallinula chloropus* (25%), *Buteo buteo* (11%), *Fulica atra* (10%) and *Erinaceus concolor* (7%). Because of the small size of the sample (though it included prey from two different, distant roosts), these results should not be considered representative of the diet of the species in our region. The prey diversity and evenness were 2.88 and 0.77 respectively. Average prey biomass was 108.1 g. (Table 2).

Dietary comparison between owls

The cluster analysis closely grouped the diets of Barn Owl, Little Owl and Long-eared Owl in the wetlands of northeastern Greece (group on the upper part of the cluster) (Fig. 2). The three Little Owl samples where insects predominated (Kitros Lagoon, Psara and Tilos islands) were also grouped together in the middle area of the cluster. The lower part of the cluster grouped the diets of the

Barn Owl and Eagle Owl mainly from the western part of the study area (Athens region and Amvrakikos).

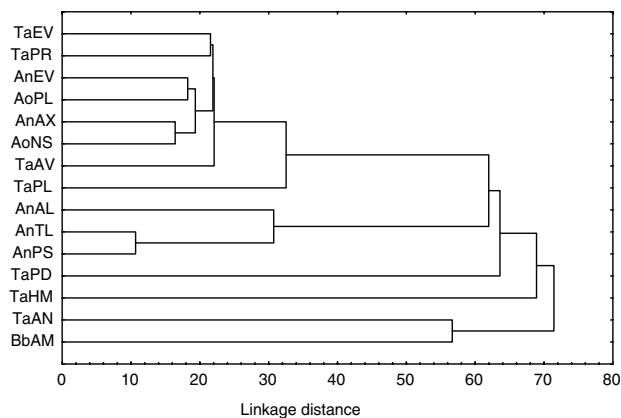


Fig. 2. – Cluster analysis of the prey of the four owl species. Ta : *Tyto alba*; An : *Athene noctua*; Ao : *Asio otus*; Bb : *Bubo bubo*. EV : Evros Delta; PR : Parthenio; PL : Porto Lagos; AX : Axios Delta; NS : Nestos Delta; AV : Avlona; AL : Kitros Lagoon; TL : Tilos; PS : Psara; PD : Potidea; HM : Hymettus; AN : Antikythera; AM : Amvrakikos.

DISCUSSION

Interspecific variation in owl diet

There were considerable differences in prey use between the four owl species. The Barn Owl preyed mainly on small mammals, while birds and amphibians were only of local importance, and, accordingly, diet showed low diversity. Although the Long-eared Owl preyed mainly on small mammals, also took other prey (particularly birds and reptiles), having a more diverse diet. The diet of the Little Owl was more variable : in two of the study areas the main prey were mammals but other prey involved resulted in relatively high diversity. In the other three areas the species took mainly insects, thus showing a more restricted diet based on small-sized prey. The Eagle Owl had the most diverse diet of all, taking many species of birds, mammals and insects, and, on average, its prey was much larger than that of the other species.

The differences in prey type and size between owl species are due to a variety of factors such as interspecific differences in morphology and hunting techniques, as well as different prey availability in different parts of the species' range (BUNN et al., 1982). The geographical distribution and consequently availability of prey species, seemed to be important in our study as revealed by the cluster analysis where diets were clumped by geographical area rather than by owl species. Despite these, there is evidence that some prey types may be selected by the species studied. Thus, the Barn Owl frequently selects shrews (Soricidae) as prey (BUNN et al., 1982; CRAMP, 1985; TAYLOR, 1994). The Long-eared Owl, preying mainly upon small mammals, takes shrews relatively infrequently, while, on the other hand, it often takes birds, particularly in Europe (MARTI, 1976; MIKKOLA, 1983; CRAMP, 1985; ALIVIZATOS & GOUTNER, 1999). In most relative studies, the Little Owl has been found to prey mainly on arthropods, particularly insects, (ZERUNIAN et

al., 1982; MIKKOLA, 1983; CAPIZZI & LUISELLI, 1995) but in some Mediterranean areas small mammals are dominant in the diet (LO VERDE & MASSA, 1988; GOODMAN, 1988; this study) The much larger Eagle Owl can take much larger prey, mainly mammals and birds (frequently including raptors and other owls) (MIKKOLA, 1983 : CRAMP, 1985; PAPAGEORGIOU et al., 1993, MARCHESI et al., 2002, SERGIO et al., 2003).

Geographical variation in owl diet

In mid-European countries, voles (Microtinae) and shrews are the main prey of the Barn Owl, while in the Mediterranean countries mice (Muridae) are more important (BOHR, 1962; CHEYLAN, 1976; TAYLOR, 1994). Even on a smaller geographical scale, as in this study, there were considerable differences in the diet of the Barn Owl between the areas studied. Although mammals always made up the bulk of the diet, different species predominated in different areas. *Microtus*, *Mus* and to a lesser extent, *Crocidura* species were important prey in most areas, but other taxa were important locally (notably *Apodemus* spp. in Mt. Hymettus and *R. rattus* on Antikythera Island). These differences may be partly seasonal (CAMBELL et al., 1987; TAYLOR, 1994) due to different dates the pellets were collected, but they must also be due to zoogeographical reasons related to the distribution of prey species and also to the type, availability and extent of foraging habitats of the Barn Owl in each area (DOR, 1947; YOM-TOV & WOOL, 1997; MARTI, 1988). Inevitably, habitat differences accounted for dietary differences in this study, as two of the areas sampled (Evros Delta and Porto Lagos) constitute wetlands, three (Parthenio, Potidea and Avlona) included mainly agricultural areas, while the rest (Mt. Hymettus and Antikythera Island) included mainly phryganic habitats. Of Barn Owl prey, *Microtus* spp., as well as *Mus macedonicus*, normally occur in grassland habitats, including agricultural land (VOHRALIK & SOFIANIDOU, 1992), which explains their predominance as prey in areas with this habitat type. The habitat effect in prey selection is also indicated in a previous study in Mt. Hymettus where the diet of the Barn Owl comprised *M. domesticus* (39%), birds (24%) (primarily *Passer domesticus* (15%) and *Turdus merula* (5%)), *A. mystacinus* (19%) and *A. sylvaticus* (17%) (TSOUNIS & DIMITROPOULOS, 1992). It is likely that this study encompassed a different area, probably closer to urban environment, as suggested by the high numbers of *M. domesticus* and *P. domesticus*.

The preponderance of *M. rossiaemeredionalis* in Porto Lagos and of *M. macedonicus* in Potidea may be due to temporarily high population peaks of these species, as reported in many studies, particularly regarding *Microtus* spp. (BUNN et al., 1982; MIKKOLA, 1983; TAYLOR, 1994). It is probable that this phenomenon resulted in the considerable differences in the composition of mammalian prey of the Barn Owl in Porto Lagos found in a previous study (*Mus* spp., 32% by biomass, *M. rossiaemeredionalis* 28%, *Apodemus* spp. 10% and *C. suaveolens* 8%, ALIVIZATOS & GOUTNER, 1999).

The low diversity of mammals in the diet of the Barn Owl on Antikythera Island reflected the poor mammalian fauna on the island. On the other hand, the high diversity

of birds is explained mainly by the fact that the island is an important migration crossroad (MESSINEO et al., 2001).

Generally, the average prey biomass is within the range known for the Mediterranean countries. In our study areas the differences in average biomass of the Barn Owl prey were due to the different proportions of prey types involved in the areas studied. Low values were found where shrews and small mice were the main prey, and high where rats and birds were commonest. The highest value at Antikythera is more similar to that found in Israel and Egypt where large-sized prey such as gerbils and rats are consumed (GOODMAN, 1986; YOM-TOV & WOOL, 1997). Thus, Barn Owls, being mainly predators of small mammals, seem to exploit the most abundant or locally available prey, according to the local conditions.

The diet of the Little Owl also differed considerably in the areas studied. In the deltas the most important prey were mammals (mainly *Microtus*, followed by *Mus* and *Apodemus* spp.). In the three other areas, insects formed most of the diet. These differences could only in part be attributable to seasonal prey variability (CRAMP, 1985; ZERUNIAN et al., 1982) as the pellets from all areas were collected in winter, except on Rsara Island where they were collected in the summer. The diet of *Athene* owls varies greatly according to habitat, location and season, as found in Italy, Spain, North and South America, and differences in diet most likely reflect availability rather than prey selection (ZERUNIAN et al., 1982; JAKSIC & MARTI, 1988). The predominance of *Microtus* spp. among mammalian prey was probably due to the ease of capture (lack of cover after crop harvest).

The Eagle Owl is known to take a great variety of prey, much larger on average than those of other owls. Mammals and birds are the main prey but the participation of mammals found in our study (36.2% by biomass) is the lowest reported in Europe ranging from 62% to 94% (MARTINEZ et al., 1992). In addition, the main prey of the Eagle Owl in other Mediterranean areas is *Oryctolagus cuniculus* (MARTINEZ et al., 1992), lacking from the diet in Greece. Insects, which usually constitute a prey taken in small numbers (MIKKOLA, 1983; CRAMP, 1985; PAPA-GEORGIOU et al., 1993), in this study are exceptionally high in their numerical representation. The differences may be due to a higher availability of other prey types in Greece and suggest a rather opportunistic foraging behaviour in this part of the region. The mammalian prey of the Long-eared Owl was rather similar in the two study areas, made up mainly by *Microtus*, *Mus* and *Apodemus* species. No conclusion can be drawn on the relative importance of birds in Porto Lagos and reptiles in the Nestos Delta in this study due to small sample sizes. In a previous study in Porto Lagos the Long-eared Owl was found to prey mainly on *Mus* spp. (35%), *Apodemus* spp. (28%), birds (16%), and only 15% on *M. rossiaemeridionalis* (ALIVIZATOS & GOUTNER, 1999). The predominance of the latter species in the present study can, as in the case of the Barn Owl, be attributed either to a temporary high population increase or recent habitat changes. In Greece, mice have been recorded as the most important prey (ALIVIZATOS & GOUTNER, 1999; AKRIOTIS unpubl. data) but in mid-Europe voles are more important (MIKKOLA, 1983).

Birds are often important prey in Europe but not in North America (MARTI, 1976).

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APPENDIX 1

Prey of the Barn Owl in the areas studied. N: numbers; B: biomass

Prey	EVROS DELTA			P. LAGOS			POTIDEA			PARTHENIO			HYMETTUS			AVLONA			ANTI-KYTHERA		
	N	%	N % B	N	%	N % B	N	%	N % B	N	%	N % B	N	%	N % B	N	%	N % B	N	%	N % B
CHILOPODA	2	0.4	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Scolopendra</i> spp.	2	0.5	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
INSECTA	3	0.7	<0.1	-	-	-	-	-	-	3	0.6	0.1	-	-	-	-	-	-	-	-	-
Tettigoniidae	2	0.6	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carabidae	1	0.2	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Gryllotalpa gryllotalpa</i>	-	-	-	-	-	-	-	-	-	2	0.4	<0.1	-	-	-	-	-	-	-	-	-
Scarabaeidae	-	-	-	-	-	-	-	-	-	1	0.2	<0.1	-	-	-	-	-	-	-	-	-
AMPHIBIA	1	0.2	0.4	-	-	-	7	2.4	5.7	6	1.3	2.1	-	-	-	-	-	-	-	-	-
<i>Rana</i> spp.	-	-	-	-	-	-	7	2.4	5.7	6	1.3	2.1	-	-	-	-	-	-	-	-	-
Anura indet.	1	0.2	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
REPTILIA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	10.4	1.2
Gekkonidae indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	10.4	1.2
AVES	12	2.5	9.3	3	2.6	3.2	4	1.3	2.1	19	4.1	7.4	7	4.6	8.4	3	3.2	3.5	17	16.0	15.6
<i>Gallinago gallinago</i>	1	0.2	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Erithacus rubecula</i>	1	0.2	0.3	1	0.9	1.1	-	-	-	-	-	-	-	-	1	1.1	1.0	-	-	-	-
<i>Sturnus vulgaris</i>	4	0.8	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Fringilla coelebs</i>	-	-	-	2	1.7	2.1	-	-	-	3	0.7	0.7	4	2.6	4.6	2	2.1	2.7	-	-	-
<i>Streptopelia</i> sp.	-	-	-	-	-	-	-	-	-	1	0.2	1.7	-	-	-	-	-	-	-	-	-
<i>Alcedo atthis</i>	1	0.2	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Turdus merula</i>	1	0.2	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Emberiza</i> sp.	1	0.2	0.4	-	-	-	-	-	-	1	0.2	0.3	-	-	-	-	-	-	-	-	-
<i>Parus major</i>	-	-	-	-	-	-	1	0.3	0.4	-	-	-	-	-	-	-	-	-	-	-	-
<i>Turdus</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	0.7	2.3	-	-	-	-	-	-
<i>Passer</i> spp.	-	-	-	-	-	-	-	-	-	2	0.4	0.6	2	1.3	1.4	-	-	-	-	-	-
<i>Alectoris chukar</i> (pull.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.9	2.2
<i>Porzana</i> spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1.9	2.2
<i>Otus scops</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.9	1.8
<i>Hirundo rustica</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1.9	0.9
<i>Ficedula</i> spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1.9	0.5
<i>Lanius</i> spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1.9	1.3
<i>Miliaria calandra</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.9	0.9
Passeriformes indet.	3	0.6	1.3	-	-	-	3	1.0	1.6	12	2.6	4.1	-	-	-	-	-	-	2	1.9	1.3
Aves indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3.8	4.4
MAMMALIA	468	96.1	90.2	113	97.4	96.8	285	96.3	92.2	435	94.0	90.4	145	95.4	91.6	91	96.8	96.5	78	73.6	83.2
<i>Neomys anomalus</i>	10	2.1	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Crocidura leucodon</i>	26	5.3	3.0	-	-	-	2	0.7	0.4	2	0.4	0.2	2	1.3	0.5	-	-	-	-	-	-
<i>Crocidura suaveolens</i>	144	29.6	12.3	13	11.2	4.2	39	13.2	6.4	42	9.2	2.9	14	9.2	2.4	9	9.6	3.7	-	-	-
<i>Crocidura</i> spp.	-	-	-	-	-	-	-	-	-	-	-	-	3	2.0	0.6	-	-	-	-	-	-
<i>Suncus etruscus</i>	2	0.4	0.1	1	0.9	0.1	2	0.7	0.1	-	-	-	-	-	-	3	3.2	0.4	-	-	-
<i>Micromys minutus</i>	-	-	-	-	-	-	-	-	-	7	1.5	0.6	-	-	-	-	-	-	-	-	-
<i>Microtus rossiaemeridionalis</i>	136	27.9	38.6	78	67.2	83.7	1	0.3	0.5	150	32.9	34.6	-	-	-	-	-	-	-	-	-
<i>Microtus guentheri</i>	1	0.2	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Apodemus</i> spp.	18	3.7	5.1	4	3.4	4.3	13	4.4	7.1	-	-	-	5	3.3	4.3	-	-	-	-	-	-
<i>Apodemus sylvaticus</i>	-	-	-	-	-	-	-	-	-	54	11.8	12.4	60	39.5	34.6	4	4.2	5.5	-	-	-
<i>Apodemus mystacinus</i>	-	-	-	-	-	-	-	-	-	-	-	-	29	19.1	33.4	-	-	-	-	-	-
<i>Cricetulus migratorius</i>	-	-	-	-	-	-	-	-	-	-	-	-	2	1.3	1.2	1	1.1	1.4	-	-	-
<i>Microtus thomasi</i>	-	-	-	-	-	-	-	-	-	-	-	-	13	8.6	7.5	35	37.2	48.5	-	-	-
<i>Mus domesticus</i>	-	-	-	-	-	-	-	-	-	2	0.4	0.3	-	-	-	30	31.9	24.9	22	20.8	5.8
<i>Mus macedonicus</i>	-	-	-	17	14.7	4.5	224	75.7	73.5	151	33.1	20.9	15	9.9	5.2	9	9.6	7.5	-	-	-
<i>Mus</i> spp.	117	24.0	20.0	-	-	-	-	-	-	-	-	-	1	0.7	0.3	-	-	-	-	-	-
<i>Mustela nivalis</i>	1	0.2	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Rattus rattus</i>	-	-	-	-	-	-	2	0.7	3.3	9	2.0	6.2	1	0.7	1.7	1	1.1	4.2	55	51.9	73.0
<i>Rattus norvegicus</i>	-	-	-	-	-	-	-	-	-	3	0.7	2.1	-	-	-	-	-	-	-	-	-
<i>Rattus</i> spp.	-	-	-	-	-	-	-	-	-	9	2.0	6.2	-	-	-	-	-	-	-	-	-
<i>Arvicola terrestris</i>	8	1.6	6.8	-	-	-	-	-	-	3	0.7	2.1	-	-	-	-	-	-	-	-	-
<i>Talpa europaea</i>	-	-	-	-	-	-	-	-	-	3	0.7	2.1	-	-	-	-	-	-	-	-	-
<i>Oryctolagus cuniculus</i> (juv.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.9	4.4
Muridae indet.	3	0.6	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rodentia indet.	2	0.4	0.6	-	-	-	2	0.7	1.4	-	-	-	-	-	-	-	-	-	-	-	-
Total No of prey	486	-	-	116	-	-	296	-	-	463	-	-	152	-	-	94	-	-	106	-	-

APPENDIX 2

Prey of the Little Owl in the areas studied N: numbers; B: biomass

Prey	EVROS DELTA			AXIOS DELTA			KITROS LAGOON			TILOS			PSARA		
	N	% N	% B	N	% N	% B	N	% N	% B	N	% N	% B	N	% N	% B
DIPLOPODA	-	-	-	-	-	-	3	3.0	2.9	-	-	-	-	1.4	0.6
Julidae	-	-	-	-	-	-	3	3.0	2.9	-	-	-	-	1.4	0.6
MOLLUSCA	1	0.1	<0.1	-	-	-	-	-	-	-	-	-	-	-	-
Stylommatophora indet.	1	0.1	<0.1	-	-	-	-	-	-	-	-	-	-	-	-
CHILOPODA	1	0.1	<0.1	-	-	-	-	-	-	-	-	-	-	-	-
<i>Scolopendra sp.</i>	1	0.1	<0.1	-	-	-	-	-	-	-	-	-	-	-	-
ARACHNIDA	2	0.2	<0.1	-	-	-	-	-	-	-	-	-	3	4.1	3.7
Aranae indet.	2	0.2	<0.1	-	-	-	-	-	-	-	-	-	-	-	-
Solifugae indet.	-	-	-	-	-	-	-	-	-	-	-	-	3	4.1	3.7
INSECTA	408	41.1	2.4	50	17.9	1.3	91	91.9	43.2	150	97.4	68.8	68	91.9	71.1
Dermoptera	56	5.6	0.2	4	1.5	0.1	2	2.0	0.4	-	-	-	1	1.4	0.2
Labiduridae	37	1.9	0.1	3	1.1	<0.1	-	-	-	-	-	-	-	-	-
Forficulidae	19	3.7	0.1	1	0.4	<0.1	2	2.0	0.4	-	-	-	1	1.4	0.2
Odonata	55	5.5	0.5	-	-	-	-	-	-	-	-	-	-	-	-
Anisoptera indet.	55	5.5	0.5	-	-	-	-	-	-	-	-	-	-	-	-
Orthoptera	154	15.4	1.2	34	12.5	1.2	-	-	-	114	74.0	50.9	60	81.1	65.8
<i>Gryllotalpa gryllotalpa</i>	24	2.4	0.4	21	7.7	0.7	-	-	-	-	-	-	-	-	-
Tettigoniidae	50	5.0	0.4	6	2.6	0.4	-	-	-	-	-	-	48	64.9	58.5
Acrididae	77	7.7	0.4	7	2.2	0.1	-	-	-	114	74.0	50.9	12	16.2	7.3
Hemiptera	6	0.6	<0.1	-	-	-	-	-	-	-	-	-	-	-	-
Heteroptera indet.	6	0.6	<0.1	-	-	-	-	-	-	-	-	-	-	-	-
Coleoptera	68	6.8	0.3	6	2.6	0.1	89	89.9	42.0	18	11.7	13.8	5	6.8	4.9
Staphylinidae	3	0.3	<0.1	-	-	-	4	4.0	1.9	-	-	-	-	-	-
Scarabaeidae	3	0.3	<0.1	2	0.7	<0.1	-	-	-	1	0.6	0.9	3	4.1	3.7
Curculionidae	1	0.1	<0.1	1	0.4	<0.1	-	-	-	-	-	-	-	-	-
Carabidae	49	4.9	<0.1	1	1.5	<0.1	85	85.9	40.1	3	1.9	1.3	2	2.7	1.2
<i>Dytiscus marginalis</i>	4	0.4	<0.1	-	-	-	-	-	-	-	-	-	-	-	-
<i>Hydrophilus sp.</i>	1	0.1	<0.1	-	-	-	-	-	-	-	-	-	-	-	-
Coleoptera indet.	2	0.2	<0.1	1	0.4	<0.1	-	-	-	-	-	-	-	-	-
Tenebrionidae	-	-	-	-	-	-	-	-	-	2	1.3	0.9	-	-	-
Geotrupidae	-	-	-	-	-	-	-	-	-	12	7.8	10.7	-	-	-
Dytiscidae	5	0.5	<0.1	-	-	-	-	-	-	-	-	-	-	-	-
Coccinellidae	1	0.1	<0.1	1	0.7	<0.1	-	-	-	-	-	-	-	-	-
Hymenoptera	59	5.9	0.1	-	-	-	-	-	-	15	9.7	1.3	2	2.7	0.2
Formicidae	59	5.9	0.1	-	-	-	-	-	-	15	9.7	1.3	2	2.7	0.2
Mantodea	14	1.4	0.1	1	0.4	<0.1	-	-	-	3	1.9	2.7	-	-	-
Mantidae	14	1.4	0.1	1	0.4	<0.1	-	-	-	3	1.9	2.7	-	-	-
REPTILIA	15	1.5	1.5	25	9.2	4.6	-	-	-	1	0.6	4.5	-	-	-
<i>Podarcis taurica</i>	13	1.3	0.5	24	8.8	3.1	-	-	-	-	-	-	-	-	-
<i>Natrix sp.</i>	1	0.1	0.5	-	-	-	-	-	-	-	-	-	-	-	-
Colubridae indet.	1	0.1	0.5	1	0.4	1.6	-	-	-	-	-	-	-	-	-
Lacertilia indet.	-	-	-	-	-	-	-	-	-	1	0.6	4.5	-	-	-
AVES	22	2.8	6.1	2	0.7	1.3	1	1.0	19.2	-	-	-	-	-	-
Passeriformes indet.	16	3.6	3.6	2	0.7	1.3	1	1.0	19.2	-	-	-	-	-	-
<i>Galerida cristata</i>	2	0.2	0.7	-	-	-	-	-	-	-	-	-	-	-	-
<i>Sturnus vulgaris</i>	1	0.1	0.6	-	-	-	-	-	-	-	-	-	-	-	-
<i>Eriothacus rubecula</i>	2	0.2	0.4	-	-	-	-	-	-	-	-	-	-	-	-
Passer spp.	3	0.3	0.7	-	-	-	-	-	-	-	-	-	-	-	-
MAMMALIA	520	54.2	90.2	69	72.2	92.8	4	4.0	34.6	3	1.9	26.8	2	2.7	24.4
<i>Crocidura suaveolens</i>	25	2.5	5.7	8	2.9	1.5	2	2.0	11.5	1	0.6	5.4	1	1.4	7.3
<i>Crocidura leucodon</i>	2	0.2	0.1	-	-	-	-	-	-	-	-	-	-	-	-
<i>Microtus rossiaemeridionalis</i>	296	29.7	54.0	51	18.7	38.5	-	-	-	-	-	-	-	-	-
<i>Apodemus spp.</i>	56	5.6	10.2	10	3.7	6.3	-	-	-	-	-	-	-	-	-
<i>Mus spp.</i>	118	11.8	12.9	31	11.4	11.7	2	2.0	23.1	-	-	-	-	-	-
<i>Mus domesticus</i>	-	-	-	-	-	-	-	-	-	1	1.3	21.4	1	1.4	14.6
<i>Rattus spp.</i>	-	-	-	3	1.1	5.7	-	-	-	-	-	-	-	-	-
<i>Micromys minutus</i>	-	-	-	49	17.9	10.8	-	-	-	-	-	-	-	-	-
<i>Suncus etruscus</i>	-	-	-	1	0.4	0.1	-	-	-	-	-	-	-	-	-
<i>Pipistrellus sp.</i>	-	-	-	1	0.4	0.2	-	-	-	-	-	-	-	-	-
Muridae indet.	14	1.4	1.9	18	6.6	8.5	-	-	-	-	-	-	-	-	-
Rodentia indet.	28	2.8	5.1	25	9.2	15.8	-	-	-	-	-	-	-	-	-
Mammalia indet.	1	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Total No of prey	996	-	-	273	-	-	99	-	-	154	-	-	74	-	-

APPENDIX 3

Prey of the Long-eared Owl in the areas studied.
N: numbers; B: biomass

Prey	NESTOS DELTA			P. LAGOS		
	N	% N	% B	N	% N	% B
INSECTA	-	-	-	2	2.4	0.1
Acrididae	-	-	-	1	1.2	0.1
Tenebrionidae	-	-	-	1	1.2	0.1
REPTILIA	2	3.8	10.4	-	-	-
Colubridae indet.	2	3.8	10.4	-	-	-
AVES	1	1.9	2.1	9	10.8	21.1
<i>Alauda arvensis</i>	-	-	-	1	1.2	2.5
<i>Turdus</i> sp.	-	-	-	1	1.2	5.0
<i>Fringilla coelebs</i>	-	-	-	1	1.2	1.3
<i>Carduelis</i> sp.	-	-	-	1	1.2	0.9
Passeriformes indet.	1	1.9	2.1	4	4.8	5.0
Aves indet.	-	-	-	1	1.2	6.3
MAMMALIA	49	94.2	87.5	72	86.7	78.8
<i>Crociodura suaveolens</i>	11	21.1	6.9	1	1.2	0.4
<i>Talpa europaea</i>	2	3.8	14.6	-	-	-
<i>Microtus rossiaemeridionalis</i>	21	40.4	43.8	41	49.4	51.7
<i>Apodemus</i> spp.	3	5.8	6.3	8	9.6	10.1
<i>Mus macedonicus</i>	9	17.3	11.3	22	26.5	16.6
Rodentia indet.	3	5.8	4.7	-	-	-
Total No of prey	52	-	-	83	-	-

APPENDIX 4

Prey of the Eagle Owl in Amvrakikos.
N: numbers; B: biomass

Prey	N	% N	% B
INSECTA	35	53.0	1.4
Orthoptera	31	47.0	1.3
Tettigoniidae	31	47.0	1.3
Coleoptera	4	6.1	0.1
<i>Carabus</i> sp.	1	1.5	<0.1
<i>Oryctes</i> sp.	2	3.0	0.1
<i>Cerambyx cerdo</i>	1	1.5	0.7
AMPHIBIA	1	1.5	0.7
<i>Rana</i> sp.	1	1.5	0.7
AVES	13	20.0	61.7
<i>Buteo buteo</i>	1	1.5	11.2
<i>Gallinula chloropus</i>	6	9.1	25.2
<i>Fulica atra</i>	1	1.5	9.8
Charadriiformes indet.	1	1.5	1.4
<i>Columba livia</i>	1	1.5	3.5
<i>Streptopelia decaocto</i>	1	1.5	2.8
<i>Tyto alba</i>	1	1.5	4.2
<i>Asio otus</i>	1	1.5	3.5
MAMMALIA	17	25.8	36.2
<i>Erinaceus concolor</i>	1	1.5	7.0
<i>Sciurus vulgaris</i>	1	1.5	2.8
<i>Glis glis</i>	1	1.5	1.4
<i>Microtus thomasi</i>	1	1.5	0.3
<i>Rattus rattus</i>	1	1.5	1.4
<i>Rattus norvegicus</i>	11	16.7	39.9
<i>Mus</i> sp.	1	1.5	0.2
Total No of prey	66	-	-

APPENDIX 5

Full names of prey identified in owls' pellets in this study

ARTHROPODA

Scolopendra Linnaeus 1758
Gryllotalpa gryllotalpa Linnaeus 1758
Dytiscus marginalis (Linnaeus 1758)
Hydrophilus Geoffroy 1762
Carabus Linnaeus 1758
Oryctes Illiger 1798
Cerambyx cerdo Linnaeus 1758

AMPHIBIA

Rana Linnaeus 1758

REPTILIA

Podarcis taurica Pallas 1814
Natrix Laurenti 1765

AVES

Buteo buteo (Linnaeus 1758)
Alectoris chukar (J. E. Gray 1830)
Porzana Vieillot 1816
Gallinula chloropus (Linnaeus 1758)
Fulica atra Linnaeus 1758
Gallinago gallinago (Linnaeus 1758)
Columba livia Gmelin 1789
Streptopelia decaocto (Frisvaldsky 1838)
Streptopelia Bonaparte 1855
Tyto alba (Scolopi 1769)
Asio otus (Linnaeus 1758)
Otus scops (Linnaeus 1758)
Alcedo atthis (Linnaeus 1758)
Alauda arvensis Linnaeus 1758
Galerida cristata (Linnaeus 1758)
Hirundo rustica Linnaeus 1758
Lanius Linnaeus 1758
Ficedula Brisson 1760
Erithacus rubecula (Linnaeus 1758)
Turdus merula Linnaeus 1758
Turdus Linnaeus 1758

Parus major Linnaeus 1758
Emberiza calandra Linnaeus 1758
Emberiza Linnaeus 1758
Fringilla coelebs Linnaeus 1758
Carduelis Brisson 1760
Passer Brisson 1760
Sturnus vulgaris Linnaeus 1758

MAMMALIA

Erinaceus concolor Martin 1838
Neomys anomalus Cabrera 1907
Talpa europaea Linnaeus 1758
Suncus etruscus (Savi 1822)
Crocidura suaveolens (Pallas 1811)
Crocidura leucodon (Hermann 1780)
Crocidura Wagler 1832
Pipistrellus Kaup 1829
Oryctolagus cuniculus (Linnaeus 1758)
Sciurus vulgaris (Linnaeus 1758)
Glis glis (Linnaeus 1766)
Cricetulus migratorius (Pallas 1773)
Microtus rossiaemeridionalis Ognev 1924
Microtus guentheri (Danford & Alston 1880)
Microtus thomasi (Berrett-Hamilton 1903)
Arvicola terrestris (Linnaeus 1758)
Rattus norvegicus (Berkenhout 1769)
Rattus rattus (Linnaeus 1758)
Rattus Fischer 1803
Apodemus sylvaticus (Linnaeus 1758)
Apodemus Kaup 1829
Apodemus mystacinus (Danford & Alston 1877)
Micromys minutus (Pallas 1771)
Mus domesticus Swarz & Swarz 1943
Mus Linnaeus 1766
Mus macedonicus Petrov & Ruzic 1983
Mustela nivalis Linnaeus 1766