

Diet and nest site characteristics of Eagle Owl (*Bubo bubo*) breeding in two different habitats in north-eastern Greece

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Abstract — One hundred and eighty-five pellets and prey remains of Eagle Owl (*Bubo bubo*) collected during 1990-92 in north-eastern Greece, were examined to determine the owl's food habits. The Eagle Owl took a wide range of prey, its diet consisting of about 59 species. The main food group was vertebrates (95.2% by numbers) supplemented with invertebrates (4.8%). The most important food groups were small mammals (48.9%) and birds (44.1%). Game species played an insignificant role as prey in the Eagle Owl's diet. The diet varied between habitat. In forest habitats Eagle Owls fed mainly on birds and insects, whereas in cultivated habitat they fed predominantly on small mammals. Eagle Owls nested on cliffs facing S-SW. The mean distance between neighbouring nests was 2.8 km (ranging from 2.1 to 5.5 Km).

Introduction

Much information has been published on the ecology and food habits of the Eagle Owl (*Bubo bubo*) in different parts of Europe (Willgoos 1974, Hiraldo *et al.* 1975, 1976, Olsson 1979, Myrsterud and Dunker 1982, Orsini 1985, Donazar and Ceballos 1989). However, data on its feeding habits in Greece are missing.

The Eagle Owl in Greece is considered an extremely efficient raptorial bird and harmful to forest game species. It is a popular belief that Eagle Owl predation has, to a certain extent, contributed to the decline of the hare (*Lepus europaeus*) population. Consequently, all over the country persecution of the Eagle Owl has taken place in an effort to increase the abundance of hares and other game species. The present study was carried out from 1990 to 1992 to determine the feeding habits of the Eagle Owl and assess its predation on game species.

Methods

The area studied comprises localities in the Dadia forest and its surroundings located between 40°59'-41°15' N and 2°19'-2°36' E in north-eastern Greece (Figure 1).

Dadia forest has been declared a wildlife reserve since 1980 due to its unique raptor fauna. A total of 20 raptor species breed in the reserve e.g. Black

Vulture (*Aegypius monachus*), Griffon Vulture (*Gyps fulvus*), Imperial Eagle (*Aquila heliaca*), Golden Eagle (*A. chrysaetos*), Short-toed Eagle (*Circetus gallicus*), White-tailed Eagle (*Haliaeetus albicilla*) making the area not only of national but also of international importance.

The reserve covers an area of about 7.000 ha and is part of a large forest complex of about 40.000 ha. It raises from 50 m above sea level and reaches up to 800 m.

The area supports a Pinus-Quercus association. The main plant species are: *Pinus brutia*, *P. nigra*, *Quercus conferta*, *Q. pubescens* and *Q. cerris*. Other species occurring with lower frequency are: *Erica arborea*, *Phillyrea media*, *Arbutus andrachne*, *Juniperus oxycedrus*.

Apart from the raptors the fauna includes a large number of species of birds (100), mammals (20) and reptiles (21) (Vlachos and Papageorgiou 1992).

The habitat preference of Eagle Owls in the study area was determined from a vegetation map (1:5000) where a circle with a radius 1.5 km around each nest was drawn and the proportions of different types of biotopes were calculated.

The diet of the Eagle Owl was determined by analysis of pellets and prey remains found in nests, at roosts and at loafing sites. Most materials were collected after the hatching of the chicks to avoid disturbance at the nests. Active nests were located at the beginning of the breeding season and were visited at intervals of 14-21 days to collect

after the hatching of the chicks to avoid disturbance at the nests. Active nests were located at the beginning of the breeding season and were visited at intervals of 14-21 days to collect regurgitated pellets and prey remains. Roost and loafing sites outside the breeding season were visited at irregular intervals to obtain pellets.

The identification of mammals was made using a hair key (Papageorgiou and Sfougaris 1989), while for birds, feathers, skulls and feet were used. Reptiles were identified from a scale key (Papageorgiou *et al.* 1993). Insect remains useful for identification were heads, legs and wing covers. Skulls, beaks, sternums and legs were used to determine the number of individual mammals and birds. Unbroken wing covers were used for counting insects.

Nest-site characteristics were determined by measuring the height of the cliff, the height of the nest from the ground and the orientation of the nest. The distance between nests was measured from a topographic map (1:5000).

Results

Feeding habits

The distribution of the 6 nests found in the study area suggests that the Eagle Owls preferred the forest habitat (pine 85%, oaks 10%, agricultural land 2.7%, shrubland 1.7%, rocks and small streams) to the cultivated habitat (agricultural land 46.5%, pine forest mixed with oaks 37.2%, shrubland 15%, rocks and small streams). Four nests were found in the forest habitat and two in the cultivated habitat. A total of 185 pellets were collected over the 3-year period, yielding 630 prey individuals. The size of the pellets varied considerably depending on their structure, content and age of the Eagle Owl producing them. Their mean length was 69 ± 13.9 mm (range from 32 to 121 mm), while their mean width was 30 ± 3.7 mm (range from 25 to 36 mm). The three years of prey data were combined for each nest and are presented for each habitat separately and together (Table 1).

The data show that overall the Eagle Owl's staple diet was of vertebrate origin (accounting for 95.2% of the total number of prey items), supplemented with invertebrates (4.8%). Mammals were the major food source (48.6%), followed by birds (44.1%), insects (4.8%), cold-blooded vertebrates (1.7%) and fish (0.5%). Below we comment on the predominant species in each prey group.

Mammals. Of the 59 identified species found in the Eagle Owl's diet, 13 were small mammals. Among them, Eastern Hedgehog (*Erinaceus concolor*) constituted the owl's staple diet (accounting for 26.6% of all mammalian food items by number).

Other species found to play a significant role in the Eagle Owl's diet were Water Vole (*Arvicola terrestris*), Ship Rat (*Rattus rattus*), Fat Dormouse (*Glis glis*), Wood Mouse (*Apodemus sylvaticus*), Common Vole (*Microtus arvalis*) and Red Squirrel (*Sciurus vulgaris*) (Table 1).

Birds. Eagle Owls fed on a variety of birds. Throughout the year 278 birds belonging to 35 species were found in their diet. The most common prey species was the Jay (*Garrulus glandarius*) comprising 25.5% of the avian species by number, followed by Moorhen (*Gallinula chloropus*), Feral Pigeon (*Columba livia domestica*), *Gallus* sp, Hooded Crow (*Corvus corone cornix*), Turtle Dove (*Streptopelia turtur*) and Woodpigeon (*Columba palumbus*).

Invertebrates. The Stag Beetle (*Lucanus cervus*) constituted 33.3% by number of the invertebrates eaten by the Eagle Owl, followed by *Cerambyx cerdo* and *Oryctes nasicornis*.

Cold-blooded vertebrates and fish. In the present study cold-blooded vertebrates and fish played an insignificant role in the diet of the Eagle Owl because their occurrence by number in the total diet was only 1.7% and 0.5% respectively.

In Table 2 our data are compared with those reported from other parts of Europe.

Variation of the diet between habitats

Using the goodness of fit test on the Eagle Owl's diet in the two habitats it was found that there are significant differences among the main food groups. Birds, insects and reptiles were more important in the forest habitat than in cultivated area (47.3% vs 39.4%, 7.1% vs 1.2%, 1.9% vs 0.0% respectively). Conversely, small mammals were more abundant in the Eagle Owl's diet in the cultivated habitat than in forest habitat (57.8% vs 43.0%).

In the forest habitat Common Vole and Fat Dormouse were the most important mammalian species in the Eagle Owl's diet (68.1% and 67.4% respectively versus 13.9% and 32.6% in the cultivated habitat). Ship Rat, Moorhen and Jay were more abundant in the diet in the cultivated than in the forest habitat (66.7% vs 33.4%, 92.3% vs 7.7% and 76% vs 24% respectively) (Figure 3).

Reptiles were present only among the food remains in the forest habitat.

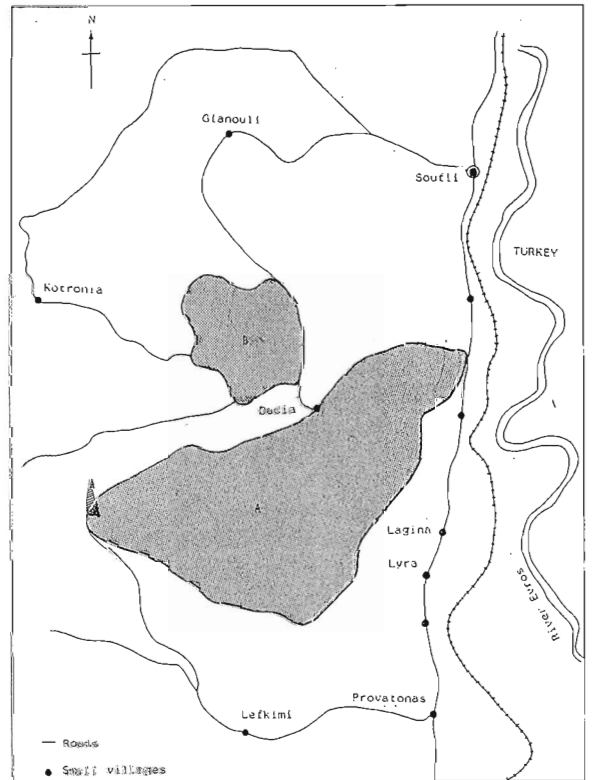
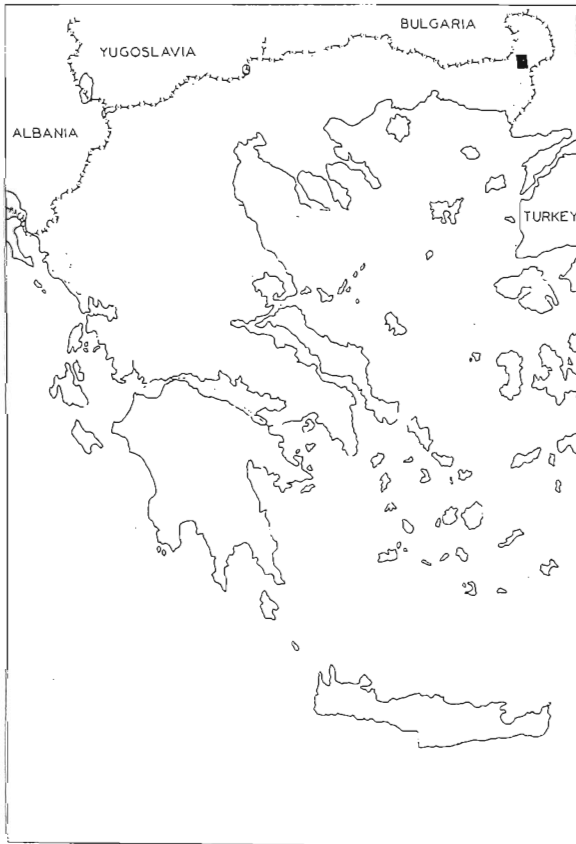
Nest - site characteristics

All nest found in the study area were located on cliff ledges. The data presented in Table 3 show that the Eagle Owls had selected nesting cliffs with an average height of about 38 m and that nests were located about 19 m above the ground. The chosen nesting cliffs were found to face S-SW. The mean distance between neighbouring nests was 2.8 km (ranging from 2.1 to 5.5 km).

Table 1 - Percent by number of prey found in the 185 pellets and remains in the diet of Eagle Owl.

Food items	A Forest habitat		B Cultivated habitat		A + B Both habitats	
	N	% in total prey	N	% in total prey	N	% in total prey
INSECTS						
<i>Lucanus cervus</i>	10	2.5	—	—	10	1.6
<i>Cerambyx cerdo</i>	1	0.3	1	0.4	2	0.3
<i>Oryctes nasicornis</i>	1	0.3	1	0.4	2	0.3
<i>Copris lunaris</i>	1	0.3	—	—	1	0.2
<i>Calosima violaceus</i>	1	0.3	—	—	1	0.2
<i>Carabus sp.</i>	1	0.3	—	—	1	0.2
Unknown coleoptera	12	3.1	1	0.4	13	2.0
Total	27	7.1	3	1.2	30	4.8
CRUSTACEANS						
Crabs	1	0.2	—	—	1	0.2
Total	1	0.2	—	—	1	0.2
FISHES						
Unknown	—	—	3	1.2	3	0.5
Total	—	—	3	1.2	3	0.5
AMPHIBIANS						
Frogs	2	0.5	1	0.4	3	0.5
Total	2	0.5	1	0.4	3	0.5
REPTILES						
<i>Lacerta viridis</i>	3	0.8	—	—	3	0.5
<i>Nalpolon monspensulanus</i>	1	0.3	—	—	1	0.2
<i>Testudo sp.</i>	2	0.5	—	—	2	0.3
Unknown snakes	2	0.5	—	—	2	0.3
Total	7	1.9	—	—	7	1.2
AVES						
<i>Garrulus glandarius</i>	54	14.2	17	6.8	71	11.2
<i>Pica pica</i>	3	0.8	2	0.8	5	0.8
<i>Corvus monedula</i>	6	1.6	2	0.8	8	1.2
<i>Corvus corone cornix</i>	10	2.5	7	2.8	17	2.7
<i>Columba livia domestica</i>	8	2.0	13	5.2	21	3.3
<i>Sireptopelia turtur</i>	10	2.5	2	0.8	12	1.9
<i>Columba palumbus</i>	8	2.0	3	1.2	11	1.7
<i>Gallinula chloropus</i>	36	9.5	3	1.2	39	6.1
<i>Fulica atra</i>	—	—	1	0.4	1	0.1
<i>Haematopus ostralegus</i>	—	—	8	3.2	8	1.2
<i>Recurvirostra avosetta</i>	—	—	2	0.8	2	0.3
<i>Athene noctua</i>	6	1.6	5	2.0	11	1.7
<i>Tyto alba</i>	4	1.2	3	1.2	7	1.1
<i>Strix aluco</i>	1	0.3	—	—	1	0.1
<i>Accipiter gentilis</i>	1	0.3	—	—	1	0.1
<i>Accipiter nisus</i>	4	1.2	1	0.4	5	0.8
<i>Buteo buteo</i>	1	0.3	1	0.4	2	0.3
Unknown Falconidae	1	0.3	—	—	1	0.1
<i>Alectoris chukar</i>	1	0.3	4	1.6	5	0.8
<i>Gallus sp.</i>	3	0.8	2	0.8	5	0.8
<i>Picus viridis</i>	1	0.3	6	2.4	7	1.1
<i>Dentrocopus syriacus</i>	—	—	2	0.8	2	0.3
<i>Sturnus vulgaris</i>	3	0.8	1	0.4	4	0.6
<i>Bombycilla garrulus</i>	—	—	1	0.4	1	0.1
<i>Turdus merula</i>	5	1.3	1	0.4	6	0.9
<i>Anas platyrhynchos</i>	—	—	3	1.2	3	0.5
<i>Egretta garzetta</i>	—	—	1	0.4	1	0.1
<i>Numenius arquata</i>	2	0.5	1	0.4	3	0.5
<i>Oriolus oriolus</i>	3	0.8	—	—	3	0.5
<i>Cuculus canorus</i>	—	—	1	0.4	1	0.1

<i>Coracias garrulus</i>	3	0.8	1	0.4	4	0.6
<i>Fringilla coelebs</i>	1	0.3	—	—	1	0.1
Unknown Frigillidae	2	0.5	3	1.2	5	0.8
<i>Galerida cristata</i>	1	0.3	—	—	1	0.1
<i>Carduelis chloris</i>	1	0.3	—	—	1	0.1
<i>Lanius senator</i>	1	0.3	—	—	1	0.1
<i>Erithacus rubecula</i>	—	—	1	0.4	1	0.1
Total	180	47.3	98	39.4	278	44.1
MAMMALS						
<i>Erinaceus concolor</i>	43	11.3	39	15.7	82	13.0
<i>Talpa europaea</i>	1	0.3	—	—	1	0.2
<i>Cracidura suaveolans</i>	2	0.5	—	—	2	0.3
<i>Rhinolophus ferrumequinum</i>	1	0.3	—	—	1	0.2
<i>Sorex araneus</i>	1	0.3	—	—	1	0.2
<i>Lepus europaeus</i>	4	1	20.0	5	1.6	
<i>Sciurus vulgaris</i>	5	1.3	4	1.6	9	1.4
<i>Arvicola terrestris</i>	32	8.4	15	47	15.3	
Unknown Microtinae	1	0.3	2	0.8	3	0.5
<i>Microtus arvalis</i>	9	2.4	22	8.9	31	4.9
<i>Apodemus sylvaticus</i>	16	4.2	17	33	10.7	
<i>Rattus rattus</i>	15	3.9	30	12.0	45	7.1
<i>Glis glis</i>	29	7.6	14	5.6	43	6.8
Unknown Gliridae	5	1.3	—	—	5	0.8
Total	164	43.0	144	57.8	308	48.6
Grand Total	381	100.0	249	100.0	630	100.0



Scale 1:100,000

Figure 1 - Study area.

Table 2 - Percent by number of prey groups in the diet of Eagle Owl in different European countries compared with those of the present study.

Food group	West Balkans ¹		Bulgaria ¹		Spain ³		Norway ⁴		Sweden ⁵		Finland ⁶		Norway ⁷		Present study	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Mammals	410	60.4	388	43.2	2271	64.9	670	83.0	3314	51.4	3305	78.2	1581	41.4	308	48.6
Aves	234	34.4	459	51.1	887	23.3	94	11.6	2913	45.2	748	17.7	2282	50.9	278	44.1
Reptiles	—	—	—	—	28	0.8	—	—	2	0.1	—	—	—	—	7	1.2
Amphibians	35	5.2	15	1.7	12	0.4	34	4.2	110	1.7	122	2.9	286	6.4	3	0.5
Fishes	—	—	—	—	92	2.7	9	1.2	100	1.5	21	0.5	37	0.8	3	0.5
Insects	—	—	36	4.0	209	5.9	—	—	7	0.1	30	0.7	20	0.5	30	4.8
Crustaceans	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	0.2
TOTAL	679	100	898	100	3499	100	807	100	6446	100	4226	100	4476	100	630	100

Sources: 1, 2 Baumgart (1975)

3 Hiraldo, Andrada, Parareno (1975)

4 Mysteruo, Dunker (1983)

5 Olsson (1979)

6 Suomalainen (1915) (From Mikkola, 1983)

7 Willgoths (1974)

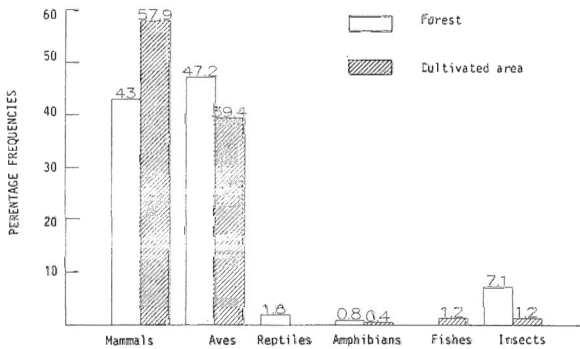


Figure 2 - Percent by number of the most important food groups in the Eagle Owl diet in the two habitats.

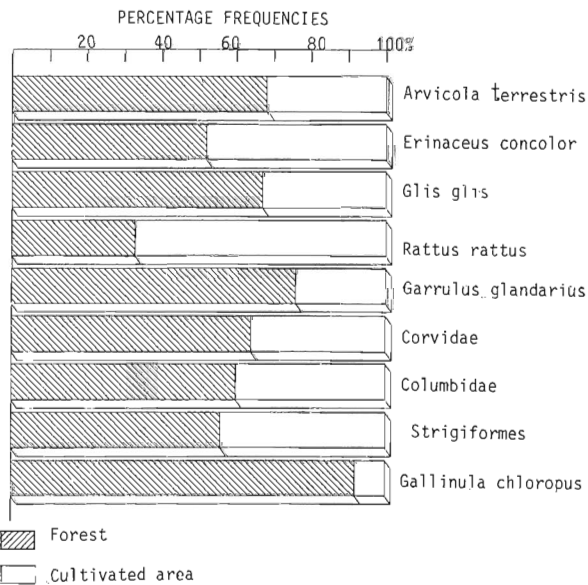


Figure 3 - Percent by number of the most important prey species found in the Eagle Owl diet in the two habitats.

Table 3 - Nest-site characteristics of six Eagle Owl's nests in NE Greece.

NESTS	1	2	3	4	5	6
Height (m)	21	15	32	4	11	20
Direction of nest-sites	304°	230°	120°	268°	240°	273°
Direction of cliff	W	S	SE	SW	SW	W
Elevation (m)	140	110	105	212	141	138
Height of cliffs (m)	53	47	34	13	35	47
Distance from road (m)	750	300	385	150	735	775
Distance from water (m)	435	215	130	500	625	500

Discussion

The wide range of prey making up the Eagle Owl's diet suggests that it is an opportunistic predator, even though it feeds mainly on birds and small mammals. Other authors have come also to a similar conclusion (Baumgart 1975, Hiraldo *et al.* 1975, Mysterud and Dunker 1983, Olsson 1979, Suomalainen 1915, Willgoths 1974).

Our results show that the staple food of Eagle Owls in our study area is small rodents, making Eagle Owl a valuable species in biological control of rodent populations. The low occurrence of game species in the diet suggests that Eagle Owl predation on such species is slight since only in a few cases were found remains of hares, chukars and ducks.

The low proportion of cold-blooded vertebrates in the diet can be explained by the fact they are active only during the warmest time of the day making them invulnerable to Eagle Owl predation, as the Eagle Owl hunts during the night and early morning hours.

Small prey species, such as insects, were found in an unexpectedly high proportion in the Eagle Owl's diet. Probably they were taken during their seasonal irruptions, partly they may have been consumed taken together with other prey species, or large prey were not available in the study area in adequate quantities. However, it is questionable if this kind of prey provide a positive energetic yield to a large size predator, such as the Eagle Owl. Our data, supported by those of other workers in Spain (Hiraldo *et al.* 1975) and Bulgaria (Baumgart *et al.* 1973) suggest that insects play a more significant role in the Eagle Owl's diet in South Europe than in northern regions, such as Norway (Willgohs 1974, Mysterud and Dunker 1983), Finland (Suomalainen 1915) and Sweden (Olsson 1979), where their abundance and distribution are limited.

The presence of other raptors remains in the diet reveals that Eagle Owls feed on a number of other predatory birds (*Athene noctua*, *Tyto alba*, *Accipiter nisus*, *Strix aluco*, *Buteo buteo*) and therefore may influence their spatial distribution and abundance.

More Eagle Owls were found to nest in forest (pine mixed with oak) than in cultivated habitat. The data on diet in the two types of habitat showed that Eagle Owls preyed more heavily on small mammals in the cultivated habitat, while in the forest they fed on birds, reptiles and invertebrates (Figure 3).

The Eagle Owl's choice of nesting cliffs facing S-SW indicates that this direction favours its breeding success. The S-SW direction of the nests in the study area provides a more favourable microclimatic environment ensuring more heat from the sun during the incubation and rearing of the young. From this study it can be concluded that the Eagle Owl: a) is an opportunistic predator; b) its predominant food is vertebrates, mainly small mammals and birds; c) its predation on game species is very slight; d) prefers forest than cultivated areas and e) nest mainly in cliffs facing S-SW.

Riassunto - Questo studio riguarda l'analisi di 185 borre e resti di predazione di Gufo reale raccolti tra il 1990 e il 1992 nella Grecia nord-orientale. La dieta si compone di 59 specie.

Il gruppo maggiormente rappresentato è quello dei vertebrati (95.2%) con scarsa presenza di invertebrati (4.8%). Nella dieta del Gufo reale sono presenti piccoli mammiferi (48.9%) ed uccelli (44.1%); le specie di interesse venatorio hanno un ruolo insignificante. La dieta varia notevolmente in funzione dell'habitat: in foresta il Gufo reale mangia soprattutto uccelli ed insetti, mentre in ambienti agricoli, piccoli mammiferi. Le coppie individuate nidificano su pareti verticali esposte S-SW. La distanza media tra nidi è di 2.8 km con un intervallo compreso tra 2.1 e 5.5 km.

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