

## Diet of the Lesser Spotted Eagle (*Clanga pomarina*) in Amvrakikos Wetlands National Park, Greece

HARALAMBOS ALIVIZATOS<sup>1\*</sup>, DIMITRIS PAPANDROPOULOS<sup>2</sup> & STAMATIS ZOGARIS<sup>3</sup>

<sup>1</sup> 4 Zaliki Str., 115 24 Athens, Greece, e-mail: [xaraaliv@otenet.gr](mailto:xaraaliv@otenet.gr)

<sup>2</sup> 21 Zaimi Str., 265 00 Rion, Greece, e-mail: [d\\_papandropoulos@hotmail.com](mailto:d_papandropoulos@hotmail.com)

<sup>3</sup> Hellenic Centre for Marine Research, Institute of Marine Biological Resources and Inland Waters, 46,7 Km Athens-Sounio Ave, Anavyssos, Greece, e-mail: [zogaris@hcmr.gr](mailto:zogaris@hcmr.gr)

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### Abstract

The diet of the lesser spotted eagle (*Clanga pomarina*) was studied in the area that is now the Amvrakikos Wetlands National Park during the Spring periods of 2000 and 2002 by analysis of pellets and prey remains found at two active nest sites, in two different territories. Among 155 prey items collected, in terms of biomass, the diet was 43% reptiles, 30% birds, 24% mammals, 3% amphibians and 1% arthropods. The most important prey taxa were brown rat (*Rattus norvegicus*) at 19%, water snakes (*Natrix* spp.) at 11% and moorhen (*Gallinula chloropus*) at 11% composition. Despite a wide availability of semi-natural and agricultural habitats around the immediate nesting areas, the species seems to have invested in foraging largely on water-dependent animals. The species maintained only one or a maximum of two pairs in the wider region during the study, this being at the southwestern margin of its global breeding range. Conservation insights and recommendations are presented.

**Key words:** pellets, prey remains, nests, distribution, conservation.

### Introduction

The lesser spotted eagle (*Clanga pomarina*) is a medium-sized migratory eagle, breeding in Eastern Europe and Western Asia and wintering in sub-Saharan Africa (Ferguson-Lees & Christie 2001). Its diet has been widely studied in Eastern Europe (Ivanovsky 1996, Haraszthy *et al.* 1996, Abuladze 1996, Treinys & Dementavičius 2004, Dravecký *et al.* 2008; Milchev 2010) but the only published study of its diet in Greece is in Dadia National Park, Northeastern Greece (Vlachos & Papageorgiou 1996). In Greece, the current breeding population is estimated at 67-90 pairs, with the overwhelming majority in northeastern Greece, and with some evidence that it is declining (Alivizatos and Handrinos 2009). Data on lesser spotted eagles is scarce west of the Pindos Mountain range, in the western margin of the species breeding distribution. In fact, in central-western and north-western Greece (Aetolia-Acarnania and Epirus) there seems to be less than a dozen breeding pairs of this species and next to nothing is known of its local breeding or feeding ecology (Hallman 1985; Grimmet and Jones 1989; Zogaris *et al.* 2003; Portolou *et al.* 2009).

In this study, data are presented for the diet of the species during nesting at Amvrakikos Wetlands National Park in western Greece, at the southwestern margin of the lesser spotted eagle's global breeding range. This work is especially interesting since we hypothesized that the diet may be quite different from

Eastern European populations, in the core of the species breeding range. Besides contributing to filling this important knowledge gap, studies of raptor diets may, among other things, help in recording many other species (prey items) in zoologically poorly-studied areas (Alivizatos *et al.* 2004; Xirouchakis *et al.* 2019). Through this study we also provide relevant conservation insights and recommendations concerning the lesser spotted eagle in this area.

### Study area and methods

The study area is situated in the wider peripheral zone of Amvrakikos Wetlands in western Greece (central location: 39° 07' N, 20° 48' E) which was enacted as a National Park on March 21st 2008. The National Park also includes a Ramsar site and it is included in a NATURA 2000 Special Protection Area (SPA) and Important Bird Area (IBA) (Portolou *et al.* 2009). The core of this protected area is a large double river delta wetland with extensive reed swamps, many lagoons and river floodplains (with riparian forest belts), surrounded by agricultural lands and dry hills covered in a mosaic of Mediterranean garrigue, scrub woodlands and oak forests (Sarika *et al.* 2005).



**Figure 1.** Aerial photo of Valaoritis mountain with *Quercus frainetto* forest in foreground, where a nesting territory of lesser spotted eagle was active in 2000 (Photo: S. Zogaris).

After extensive search-find operations within the monitoring actions of a LIFE-Nature project (1999-2003), two active nests of the lesser spotted eagle were located in mature Hungarian oak (*Quercus frainetto*) forest in the hills neighboring the lowland wetlands. These nest sites will not be mapped here due to their sensitivity to human disturbance (and poor conservation and enforcement in the area); they were located generally in the wider areas of the Valaoritis and Zalongo mountains in the northwestern part of the Amvrakikos Gulf at elevations of approximately 500 and 350 m. above sea level, respectively. The Valaoritis nest site during the time of study was within high Hungarian oak forest but near the limestone mountain ridgeline (Fig. 1) dominated by Jerusalem sage (*Phlomis fruticosa*) phrygana scrub on limestone and garrigue thickets with open dehesa-like wood pastures of scattered Valonia oaks (*Quercus ithaburensis*). Although cattle and goat-grazing are practiced close to the nest-site, no other human activity influenced the site (when the nest was active in 2000); and the nearest road access was a seldom-used dirt track about 500 m. from the nest site. The Valaoritis site is only 4 km in a tangent from the Louros river floodplain; a wide frequently flooded area about 12 river kilometers from the river-mouth, known as an important foraging site

for these eagles (Zogaris *et al.* 2003). The Zalongo mountain site is about 8 km west-southwest of the Valaoritis site and 9 Km from the Louros river floodplain (Fig. 2). The Zalongo nest site is also in a mature Hungarian oak stand and also on a fairly high mature oak in a richly wooded landscape with a mosaic of regenerating Hungarian Oak woodlands and varied maquis thickets and evergreen sclerophyllous woodlands (it was less open than the Valaoritis site at the time of study). Road access was about 500 m from the nest tree and the land-uses here are extensive goat grazing and selective wood-cutting.



**Figure 2.** The Louros river floodplain at the village of Petra bridge with the Valaoritis mountain in the background (at Right) and Zalongo Mountain in the distance (at Left) (Photo: S. Zogaris).

At the time of study it was estimated that a single pair nested in the Amvrakikos area (the two active nests were not found concurrently on the same year); however a maximum of two pairs in the entire Amvrakikos area may have been possible (Zogaris *et al.* 2003). Pellets and prey remains were collected under the nests in the late spring periods of 2000 (Valaoritis) and 2002 (Zalongo). These were later analyzed with the help of suitable guides and identification keys (Arnold & Burton 1980, Brown *et al.* 1987, Chinery 1993, Macdonald & Barret 1993). Statistical analyses were performed with the SPSS statistical package. The proportion of the main prey groups in the samples were compared with the  $\chi^2$  test at the <0.05 significance level.

## Results

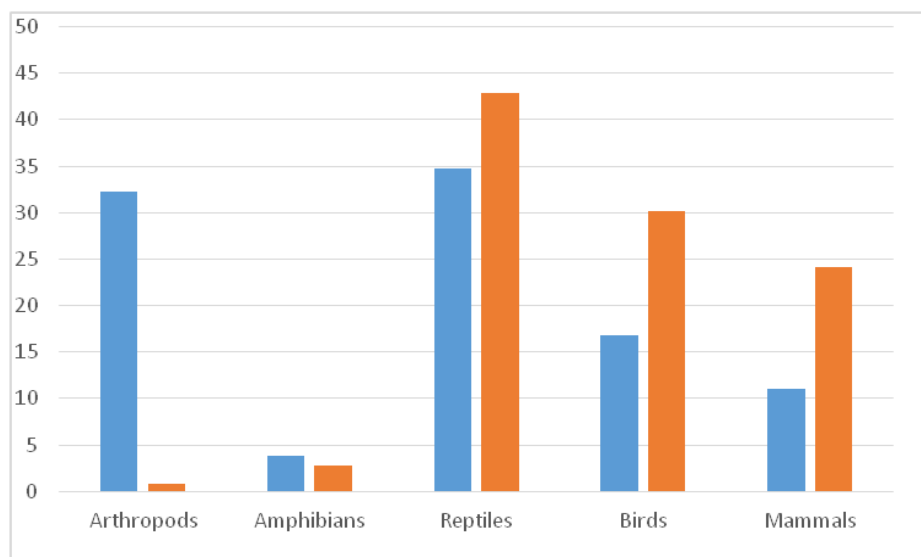
In total, 155 prey items were identified (80 and 75 in each nest respectively). The diet was varied, including reptiles, birds, mammals, amphibians and arthropods (table 1, Fig. 3). By numbers, reptiles were the most important prey (35%), followed by insects (32%), birds (17%), mammals (11%), amphibians (4%) and crustaceans (1%). In terms of biomass, reptiles were again the most important prey (43%), with the most important taxa being water snakes belonging to the genus *Natrix* (11%), eastern Montpellier snake (*Malpolon insignitus*) and large whip snake (*Dolichophis caspius*) (7%); and four-lined snake (*Elaphe quatuorlineata*) (5%). Birds were also important (30%), with the most important species being the moorhen (*Gallinula chloropus*) (11%) and the squacco heron (*Ardeola ralloides*) (5%). Mammals made up 24% of the prey biomass, with by far the most important species the brown rat (*Rattus norvegicus*) (19%). Less important prey were amphibians (3%) and insects and crustaceans (both <1%). Thus the most prominent single prey taxa were water snakes, brown rats and moorhens. Estimated prey biomass ranged from 1 to 500 grams, with an average of 73 grams.

**Table 1.** Diet of the lesser spotted eagle (*Clanga pomarina*) in Amvrakikos Wetlands.

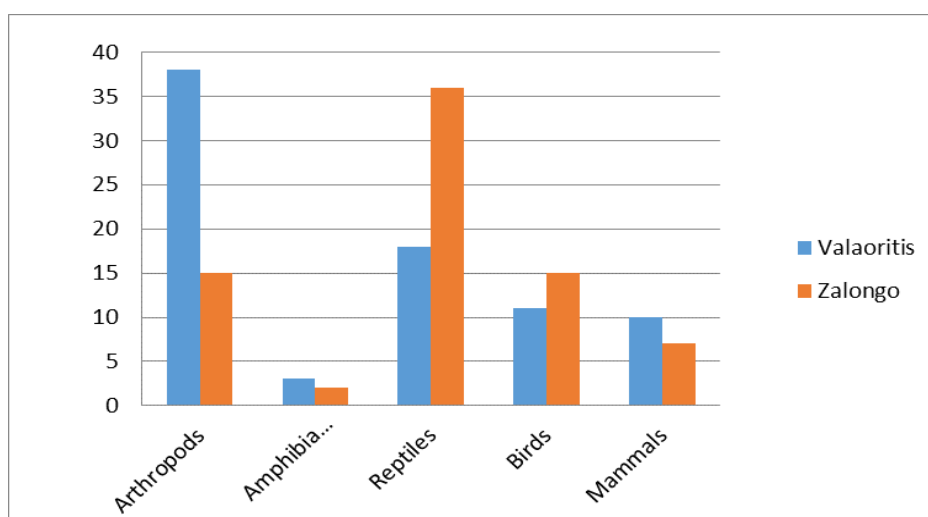
Prey	Number	% number	% biomass
<b>CRUSTACEA</b>	<b>1</b>	<b>0.6</b>	<b>0.2</b>
<i>Potamon fluviatilis</i>	1	0.6	0.2
<b>INSECTA</b>	<b>49</b>	<b>31.6</b>	<b>0.3</b>
Tettigoniidae	27	17.4	0.2
<i>Gryllotalpa</i> spp.	5	3.2	<0.1
Acrididae	1.	0.6	<0.1
Carabidae	15	9.7	<0.1
Cerambycidae	1	0.6	<0.1
<b>AMPHIBIA</b>	<b>5</b>	<b>3.2</b>	<b>2.8</b>
Ranidae indet.	2	1.2	1.4
Anura indet.	3	1.9	1.4
<b>REPTILIA</b>	<b>54</b>	<b>34.8</b>	<b>42.9</b>
<i>Lacerta</i> spp.	7	4.5	1.5
<i>Malpolon insignitus</i>	5	3.2	8.1
<i>Dolichophis caspius</i>	4	2.6	7.0
<i>Elaphe quatuorlineata</i>	3	1.9	5.2
<i>Natrix</i> spp.	27	17.4	11.0
Colubridae indet.	8	5.2	10.1
<b>AVES</b>	<b>26</b>	<b>16.8</b>	<b>30.2</b>
<i>Ixobrychus minutus</i>	1	0.6	0.9
<i>Ardeola ralloides</i>	2	1.3	5.3
<i>Porzana</i> spp.	2	1.3	1.1
<i>Gallinula chloropus</i>	4	2.6	10.6
Rallidae indet.	8	5.2	7.0
<i>Otus scops</i>	1	0.6	0.8
<i>Passer</i> sp.	1	0.6	0.2
Passeriformes indet.	2	1.3	0.5
Aves indet.	3	1.9	2.9
Aves indet. ova	2	1.3	0.8
<b>MAMMALIA</b>	<b>17</b>	<b>11.0</b>	<b>24.2</b>
<i>Erinaceus roumanicus</i>	1	0.6	4.0
<i>Microtus</i> spp.	2	1.3	0.4
<i>Apodemus</i> sp.	1	0.6	0.2
<i>Rattus norvegicus</i>	11	7.1	19.0
Mammalia indet.	2	1.3	0.6
Total	155	-	-

There were some differences between the two samples. There were significantly more arthropods in Valaorit, sampled in 2000 and more reptiles in Zalongo, sampled in 2002 ( $\chi^2 = 17.1825$ ,  $p < 0.002$ ) (Fig. 4 & 5). The Shannon index, evenness and Berger-Parker dominance index at the level of class were 1.94, 0.84 and 0.48 for Valaorit and 1.97, 0.76 and 0.48 for Zalongo. At species level, they were 3.18, 0.81 and 0.35 for Valaorit and 3.34, 0.80 and 0.36 for Zalongo. At class level, Pianka's index = 0.76, while in species level = 0.11.

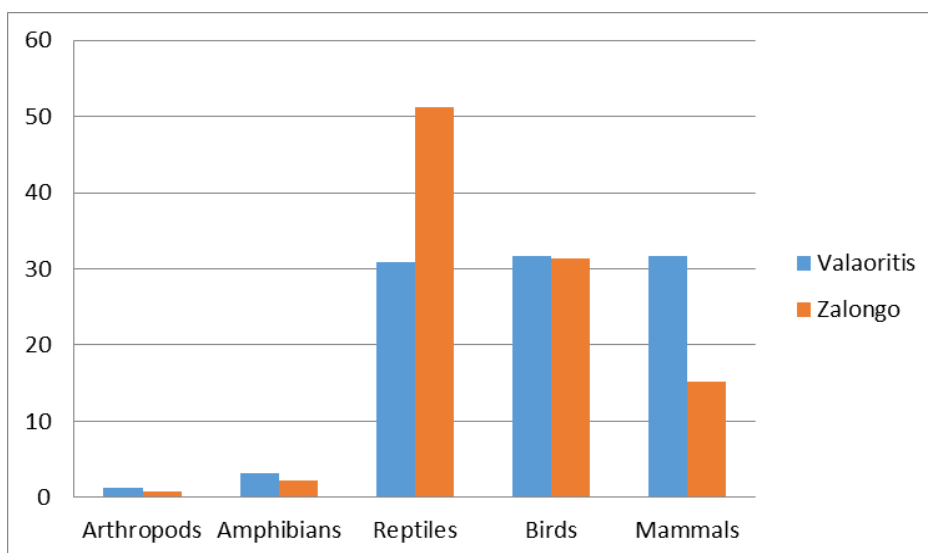




**Figure 3.** Diet of the Lesser Spotted Eagle by numbers (blue) and biomass (red).



**Figure 4.** Comparison of the main prey groups between Valaoritis and Zalongo by numbers (%).



**Figure 5.** Comparison of the main prey groups between Valaoritis and Zalongo by biomass (%).

## Discussion

The present study took place in the southwestern edge of the species' European breeding distribution, within a Mediterranean climate-region differing from most of the species' global breeding range (Väli *et al.* 2004). The diet of the lesser spotted eagle in Amvrakikos was quite varied, but reptiles (particularly snakes), birds and small mammals made up most of the biomass. However, it is possible that amphibians were underestimated by pellet and prey remains analysis, as they often leave few identifiable remains. Frogs were often recorded being carried away by the eagles in the study area. Results here are similar with that in Dadia National Park, Northeastern Greece, in the predominance of reptiles in the diet (Vlachos & Papageorgiou 1996). Dadia and Amvrakikos do differ in some landscape aspects although both are located in Mediterranean climate areas; however, the diurnal raptor population is much lower in the Amvrakikos (Zogaris *et al.* 2003; Poirazidis *et al.* 2011).

Perhaps the most important finding of the present study was the fact that the dominant prey species, particularly water snakes, brown rats, moorhens and other water birds, occur primarily or exclusively in wetland habitats. This is important because the eagles did not nest immediately next to the wetland but in upland hill forests overlooking the delta plain and surrounding upland landscapes. Indeed, the birds were often recorded hunting in river-side marsh habitats and floodplain riparian open field habitats, particularly within and adjacent to the Louros river floodplain (Zogaris *et al.* 2003, Zogaris *et al.* 2008). Interestingly, although the species is considered to have opportunistic feeding habits based on what prey species are easily available (Zub *et al.* 2010); here we document a prevalence of wetland prey species and this also confirms our habitat-use observations during this study. A concentration of foraging activity was recorded in wetland and riparian areas; particularly near the Louros river and adjacent reclaimed agricultural land (hayfields, irrigated animal-fodder crops) in this riparian area (Zogaris *et al.* 2003). We conclude that the species is a quite opportunistic generalist predator from the data we present here; and further study in wetland-adjacent Mediterranean populations of this species would be instructive.

The difference in the proportion of reptiles and arthropods between the pair in Valaoritis and that of Zalongo is probably due to the fact that the former foraged more often in drier and more open habitats that are common immediately around the Valaoritis general area (i.e. areas rich in arthropods). This is supported by the occurrence in their diet of several lizards (*Lacerta* spp.), which are typically found in open scrub and other relatively dry habitats. In summary, the diet of the species in the study area was notable for the predominance of wetland species, the high importance of snakes and the very low importance of small rodents (such as *Microtus*). While reptiles are important food items in southern Europe, in central Europe the lesser spotted eagle feeds mainly on small rodents, and secondarily on birds and amphibians (Treinys & Dementavičius 2004, Dravecký *et al.* 2012). The importance of reptiles in southern Europe's lesser spotted eagle diet is likely due to their greater availability in drier open habitats and due to high reptile densities within Mediterranean-climate wetlands as well. Snakes were especially abundant along the river embankments and within the Louros floodplain during this study.

## Conservation implications

In recent decades habitat change may be affecting the lesser spotted eagle nesting patterns and populations in Western Greece as it has in some other areas of Europe; this species being particularly sensitive to cultural landscape abandonment, forest homogenization, nest-site habitat loss and human disturbance (Treinys 2004; Poirazidis *et al.* 2019). At Amvrakikos, this raptor was targeted for conservation actions among six threatened bird species within the LIFE-Nature Project during the study period (Zogaris *et al.* 2003; Theocharis *et al.* 2004). At Amvrakikos, the riparian woodland areas, wet meadows and floodplain wetlands that are often used by breeding pairs have experienced serious anthropogenic pressures and disturbance, including tree-cutting, agricultural water pollution, water abstraction, salinization of wetlands and disturbance from poaching and hunting (Zogaris *et al.* 2008). However, apart from this, food availability should not be a limiting factor for this species at Amvrakikos. Although specific studies of terrestrial non-avian vertebrates are scant for the area, our observations show that many reptiles, amphibians and large rodents thrive here and these are important prey items for other raptor species in this area as well (Alivizatos *et al.* 2004, 2005).

After 2003 when the LIFE-Nature project ended, observations by the Amvrakikos Management Body show that at least one breeding pair of lesser spotted eagle still survived and probably nested in the vicinity of the studied area in the northwestern part of the Amvrakikos Gulf. In 2008 a single small-sized individual was repeatedly spotted in the same area, the species frequented the Louros river floodplain (below the former nest sites of Mount Valaoritis) but during that year no confirmation of breeding was documented (Zogaris *et al.* 2009). In the 2010s, there were indications of a single pair holding territory near the above locations, but details are unpublished (S. Floudas, M. Katsiskatsou, personal observations). A single pair probably still breeds in the area and may be related to the very small breeding population in the lowland river valleys of Epirus immediately north of the Amvrakikos. However, detailed studies of this species have not continued and concrete conservation measures in recent years have not been pursued.

A specific conservation problem concerns the preservation of breeding sites and their surrounding landscapes, since the species is sensitive to landscape scale disturbances, as in other parts of its European range (Treinys 2004, Väli *et al.* 2004). Further conservation policy applications (strict protection zones) at nesting sites and potential nesting sites may be required at Amvrakikos; this particularly concerns mature woodland preservation within traditional cultural landscapes. Since these upland landscapes are near or on the boundaries of the newly created National Park they fall into a "shadow" of poorly enforced protection and monitoring. This "shadow effect" is a problem in many protected areas in Greece, where conservation resources and actions concentrate on high-profile core-areas or habitat types (e.g. wetlands) and ignore critical hotspots nearby or less-studied areas and landscapes on the fringe of protected areas (Vlami *et al.* 2017).

We have evidence at the Amvrakikos nesting sites that the eagles have reacted to human disturbance during this study. During 2001 (April-May), the pair originally found at Valaoritis did not breed at the oak stand, most probably due to disturbance from a new road construction and the creation of a rock quarry nearby; approximately 600 m. from the former nest tree site; and within view of the nesting tree. Attempts by conservationists to stop the rock quarry works failed and the pair did not breed on Valaoritis in 2002 and 2003 when the small quarry was in full operation (Zogaris *et al.* 2003). In fact, Valaoritis seems like an optimal nesting site for this eagle because it is so close to the species foraging hotspot, the Louros floodplain, yet this mature forest relic is not within the Special Protection Area (SPA) NATURA 2000 site of Amvrakikos. This is an example of the conservation area "shadow effect"; where an important hotspot (the eagle's nesting-site habitat) is ignored although immediately adjacent to a high-profile conservation area.

In 2002 and 2003 the pair breeding at nearby Zalongo Mountain which is much farther away from the Louros floodplain was also frequently recorded foraging at this floodplain wetland (Zogaris *et al.* 2003). We observed flights to-and-from the nest site and the Louros floodplain on many occasions during the study. However, the legal conservation of Zalongo's landscape has also not fared well. Although Zalongo was once delineated within an Important Bird Area (Grimmet and Jones, 1989, "Vouna Zalongou, site 054", p. 294), this site is no longer within Greece's revised IBA list (Portolou *et al.* 2009); and not in a NATURA 2000 area, although it marginally lies within the current peripheral boundary of the Amvrakikos Wetlands National Park. In our opinion, the National Park peripheral zone (which now includes Valaoritis also) currently affords little protection or structured monitoring of conservation relevance for this species. We urge authorities to show greater concern for this species' potential breeding habitats at both Zalongo and Valaoritis; these areas should be further investigated and efforts made for more effective conservation zonation and enforcement (i.e. consideration for inclusion inside the Amvrakikos SPA). It goes without saying that efforts for further ecological research (i.e. species-habitat study), in order to better inform conservation actions, are also required for this lesser spotted eagle population.

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