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THE FOOD HABITS OF EURASIAN EAGLE-OWLS IN SOUTHERN PORTUGAL

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KEY WORDS: *Eurasian Eagle-Owl*; Bubo bubo; *diet*; *Mediterranean habitats*; *Portugal*; *principal component analysis.*

Knowledge of the food habits of a predator is essential for its conservation because diet may influence survival (Hakkarainen et al. 2002) and breeding performance (Viñuela and Veiga 1992, Arroyo 1998, Penteriani et al. 2002), or reveal possible conflicts with human activities (Thirgood and Redpath 2000). Moreover, the analysis of the diet of top predators may be particularly useful for species conservation when intraguild predation is occurring (Sergio et al. 2003).

The Eurasian Eagle-Owl (*Bubo bubo*) is a large predator with a Palearctic distribution and the diet of European populations has been widely studied in several countries (Penteriani 1996). However, the information on the diet of this species in the Iberian Peninsula is only available for Spanish regions (e.g., Hiraldo et al. 1975, Donázar 1989, Serrano 1998, Martínez and Zuberogoitia 2001), and no information is available for Portugal.

Lagomorphs, and more specifically European rabbits (*Oryctolagus cuniculus*), play an important ecological role in the food webs of western Mediterranean ecosystems (Delibes and Hiraldo 1981, Iborra et al. 1990). Iberian eagle-owls are rabbit specialists (Hiraldo et al. 1976, Donázar et al. 1989) and, due to the abundance of this prey, attain locally high population densities (Delgado et al. 2004, Ortego and Díaz 2004). In recent decades, myxomatosis and rabbit hemorrhagic disease were responsible for the large decline of rabbit populations in the Iberian Peninsula (Villafuerte et al. 1995). Consequently, rabbit-dependent species such as the Spanish Imperial Eagle (*Aquila adalberti*) and the Iberian lynx *Lynx pardinus* are presently in need of conservation action (Ferrer and Negro 2004). Although the large scale effects of rabbit diseases on Iberian eagle-owl populations have never been evaluated, rabbit declines have been shown to influence negatively both this owl (Martínez and Zuberogoitia 2001, Penteriani et al. 2002) and other raptors through direct and indirect effects (Tella and Mañosa 1993). The objective of this study was to describe the diet of eagle- owls in southern Portugal, and to analyze possible intrapopulation differences in diet.

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Table 1. Mean percentage contribution by number and by mass for prey items collected at 23 Eurasian Eagle-Owl territories in southern Portugal.

	N	MEAN FREQUENCY	PERCENT BIOMASS
Mammals	**1701**	**64.5**	**77.9**
Hedgehog (*Erinaceus europaeus*)	127	4.9	7.7
Southern water vole (*Arvicola sapidus*)	160	5.6	2.7
Rats (*Rattus* spp.)	100	3.9	1.5
Iberian hare (*Lepus granatensis*)	234	9.4	21.7
Rabbit (*Oryctolagus cuniculus*)	441	16.7	29.3
Iberian hare/rabbit	560	20.5	13.9
Other mammals[a]	79	3.5	1.1
Birds	**862**	**32.1**	**21.7**
Little Grebe (*Tachybaptus ruficollis*)	22	1.1	0.4
Red-legged Partridge (*Alectoris rufa*)	207	8.7	9.2
Common Moorhen (*Gallinula chloropus*)	80	3.1	2.0
Eurasian Thick-knee (*Burhinus oedicnemus*)	15	0.6	0.7
Rock Pigeon (*Columba livia*)	88	2.8	2.0
Barn Owl (*Tyto alba*)	20	0.7	0.5
Little Owl (*Athene noctua*)	41	1.3	0.6
Azure-winged Magpie (*Cyanopica cyana*)	104	2.9	0.5
Eurasian Jay (*Garrulus glandarius*)	21	1.0	0.4
Other birds[b]	264	9.9	5.4
Other prey[c]	**103**	**3.4**	**0.5**

[a] Includes (in order of numeric importance): unidentified rodent (*N* = 20), garden dormouse (*Eliomys quercinus*; 14), wood mouse (*Apodemus sylvaticus*; 14), Mediterranean pine vole (*Microtus duodecimcostatus*; 12), house/Algerian mouse (*Mus* spp.; 11), greater white-toothed shrew (*Crocidura russula*; 3), Iberian mole (*Talpa occidentalis*; 2), genet (*Genetta genetta*; 1), domestic cat (*Felis catus*; 1), unidentified carnivore (1).

[b] Includes (in order of numeric importance): unidentified Passeriformes (*N* = 81), starlings (*Sturnus* spp.; 36), unidentified dove (28), Tawny Owl (*Strix aluco*; 16), thrushes (*Turdus* spp.; 14), Common Wood-Pigeon (*Columba palumbus*; 12), Northern Lapwing (*Vanellus vanellus*; 8), unidentified crow (8), unidentified duck (7), Cattle Egret (*Bubulcus ibis*; 6), Eurasian Magpie (*Pica pica*; 6), Mallard (*Anas platyrhynchos*; 3), domestic chicken (*Gallus gallus*; 3), Eurasian Coot (*Fulica atra*; 3), unidentified Rallidae (3), Eurasian Turtle-Dove (*Streptopelia turtur*; 3), Carrion Crow (*Corvus corone*; 3), unidentified birds (3), Little Egret (*Egretta garzetta*; 2), Black-shouldered Kite (*Elanus caeruleus*; 2), unidentified wader (2), Long-eared Owl (*Asio otus*; 2), Common Kingfisher (*Alcedo atthis*; 2), Green Woodpecker (*Picus viridis*; 2), Eurasian Teal (*Anas crecca*; 1), Red Kite (*Milvus milvus*; 1), Eurasian Kestrel (*Falco tinnunculus*; 1), Little Bustard (*Tetrax tetrax*; 1), Eurasian Woodcock (*Scolopax rusticola*; 1), Hoopoe (*Upupa epops*; 1), European Bee-eater (*Merops apiaster*; 1), Southern Gray Shrike (*Lanius meridionalis*; 1), Corn Bunting (*Emberiza calandra*; 1).

[c] Includes: reptiles (1), amphibians (39), fish (17), and arthropods (46).

STUDY AREA AND METHODS

The study area is located in Alentejo and Algarve provinces (southern Portugal), in the Meso-Mediterranean and Thermo-Mediterranean bioclimatic belts, characterized by a hot, dry Mediterranean climate (Rivas-Martínez et al. 2002). The landscape is dominated by plains or low hills with the elevation ranging from sea level to 1000 m above sea level. The main habitats are agricultural fields (cereal steppes, olive groves, and vineyards) and Mediterranean scrublands, as well as holm oak (*Quercus rotundifolia*) and cork oak (*Quercus suber*) pastoral woodlands (montados).

Eagle-owl territories were searched from 1997 to 2004 by combining listening and playback sessions during the prelaying period (November–February in the study area). From March to June, all suitable areas were visited to search for nests, roost sites, and feeding perches.

The diet of eagle-owls was studied in 23 territories and, in order to reduce disturbance, we only visited collecting sites at the end of the breeding season. During each visit, all prey remains (i.e., recent and old pellets, prey remains, and accumulated bones) were collected from recently used nests and feeding perches. The minimum number of individuals was determined following recommendations of (Marchesi et al. 2002) in order to avoid bias. Prey items were identified by comparison with the collection of the Laboratory of Archaeozoology (IPA - Portuguese Institute of Archaeology), and using identification keys for bones and feathers.

Principal Components Analysis (PCA) was used to examine variation in diets and place the different territories into subsets in terms of diet tendencies, based on the frequencies of 14 prey classes. In this analysis, the compo-

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nents (axes) revealed the correlations among variables (prey classes), and each territory was then related to these components (Tabachnick and Fidell 2001). Data in the cross-products matrix were centered by columns (variance/covariance), so that the variables contributed to the analysis in proportion to their variances (Jongman et al. 1995). Scores for column variables were calculated by weighted averaging (McCune and Mefford 1999).

RESULTS

The 23 territories yielded 2666 prey items, belonging to 64 different species (Table 1). Lagomorphs (rabbit and Iberian hare [*Lepus granatensis*]) were the most frequent prey in the majority of the territories, ranging from 27–67% ($\bar{x}$ = 47%). Among the other mammal species, the most frequent prey species were rodents ($\bar{x}$ = 13%) and Hedgehogs *Erinaceus europaeus* ($\bar{x}$ = 5%). Birds were present with frequencies ranging 14–48% ($\bar{x}$ = 32%), of which passerines ($\bar{x}$ = 9%), pigeons and doves ($\bar{x}$ = 4%), owls ($\bar{x}$ = 3%), the Common Moorhen (*Gallinula chloropus*; 91% of the overall Gruiformes, $\bar{x}$ = 3%), and the Red-legged Partridge (*Alectoris rufa* ; 99% of the overall Galliformes, $\bar{x}$ = 9%) were the most frequent.

The first two axes of the PCA explained 76% of the variance, and axis 1 was positively correlated with lagomorphs and negatively with birds, while axis 2 was positively correlated with lagomorphs and negatively with rodents (Fig. 1). No obvious subgroups in terms of diet tendency were apparent, and most territories were found along a gradient between diets dominated by lagomorphs, and diets based on lagomorphs and birds.

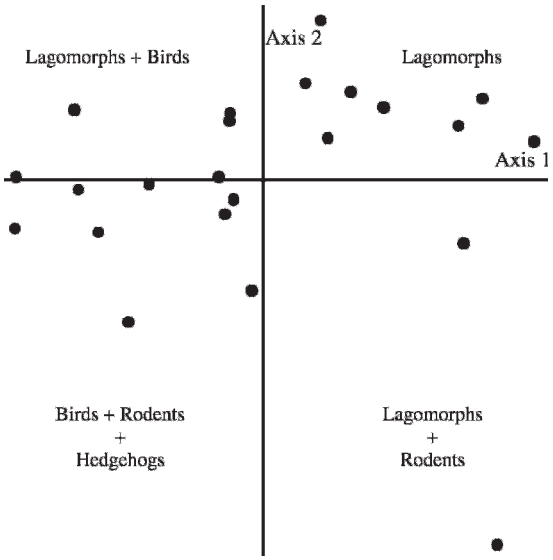


Figure 1. PCA scatter plot of prey remains found in 23 Eurasian Eagle-Owl territories in southern Portugal, analyzed using the frequency of the following 14 prey classes: mammals (all species), insectivores, rodents, southern water vole (*Arvicola sapidus*), rats (*Rattus* spp.), lagomorphs, Iberian hare (*Lepus granatensis*), birds (all species), Galliformes, Gruiformes, Charadriiformes, Columbiformes, Strigiformes, and Passeriformes.

DISCUSSION

The eagle-owl is considered a generalist top-predator that specializes in the most advantageous food and is therefore able to occupy several biomes (Donázar et al. 1989). In southern Portugal, as in other Mediterranean habitats, lagomorphs were the most common prey of this owl, probably due to their abundance and size. However, in this region, Iberian hares made up a significant fraction of the lagomorphs in the diet, and had a higher mean frequency (9%) than in most Spanish regions (e.g., Hiraldo et al. 1975, Donázar 1989, Serrano 1998, Martínez and Zuberogoitia 2001). On the other hand, some pairs showed more diverse diets, which included small mammals and birds, possibly as a response to lower availability of lagomorphs, as previously shown by other authors for this opportunistic predator (Serrano 1998, Penteriani et al. 2002).

The frequency of owls recorded as prey of the eagle-owls in this study may be relatively high, compared to values documented in a review of intraguild predation in Mediterranean eagle-owls (Serrano 2000). Such predation may indicate possible food limitation in some areas.

In the PCA analysis, food composition varied continuously along a gradient, and no major subgroups with specific dietary tendencies could be clearly discerned, probably as a consequence of the gradual landscape changes found in southern Portugal. At this regional scale, the observed gradient in diet did not coincide with a geographical gradient, which might indicate that habitat characteristics at the home-range scale are the main factors influencing eagle-owl food habits. However, further investigation will be needed to understand the role of these factors.

HÁBITOS ALIMENTICIOS DE *BUBO BUBO* EN EL SUR DE PORTUGAL

RESUMEN.—El principal objetivo del presente estudio consistió en llevar a cabo una descripción de la dieta de 23 territorios de *Bubo bubo* en el sur de Portugal. Fueron analizadas 2666 presas, que representaron un total de 64 especies. Las presas principales fueron aquellas pertenecientes al grupo de los lagomorfos, destacando entre ellos el conejo *Oryctolagus cuniculus*. La frecuencia de rapaces nocturnas encontrada parece indicar niveles relativamente elevados de depredación de miembros del mismo gremio. Se llevo a cabo un análisis de componentes principales para ver las posibles diferencias entre los territorios, situándolos en un gradiente que va desde aquellos en los que la dieta se basa en lagomorfos hasta otros en los que las presas como aves y pequeños mamíferos representan un porcentaje importante. Los resultados apuntan a que la dieta

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de *Bubo bubo* está más influenciada por las características del hábitat que por las propias variaciones geográficas.

[Traducción del equipo editorial]

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