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Prey density, prey detectability and food habits: the case of Bonelli's eagle and the conservation measures

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Abstract

In the diet of raptors the presence of prey-species is influenced by their abundance and the ground-level vegetation in territories, this situation being analysed for the Bonelli's eagle (*Hieraaetus fasciatus*) in south-eastern Spain. First, the minimum number of prey-items for the reliability of results was tested, obtaining between 15 and 30 prey-items depending of pair. Second, differences in prey frequency and productivity among pairs was analysed, finding an interpair shift in both variables, but there was no relationship between the frequency of prey-species in the diet and productivity. Third, it was found that the percentage of European wild rabbit in the diet was less correlated with its abundance in territories than with the surface of open land in the same. This suggests that accessibility to rabbits would be more important for the Bonelli's eagle that the absolute abundance of this prey type. Thus, open land is the single variable selected by a multiple multiple-regression analysis explaining the frequency of rabbits in this raptor's diet. Birds as prey complemented the diet when open-land scarcity in the territories implies low rabbit detectability and consumption. Conservation measures proposed concerning the increase of prey availability in this declining population should consider both the absolute prey density and prey detectability, avoiding extensive reforestation in territories and favouring vegetation structure suitable for prey detection by eagles.

Keywords: Bonelli's eagle; Conservation measures; Prey detectability; European wild rabbit; Southern Spain

1. Introduction

One of the principal functions of territoriality in non-colonial birds, especially raptors, is to supply adequate resources, usually food and nest-site (Cody, 1985; Newton, 1997). Many studies have investigated the food habits of Palearctic raptors (Cramp and Simmons, 1980), some revealing differences among seasons (Watson et al., 1992; Mañosa, 1994), biases in methods used to study the diet (Marti, 1987; Real, 1996), and differential reproductive success among habitats corresponding to variations in prey densities (Newton, 1997; Janes, 1985). Nevertheless, few studies have included tests to evaluate biases involved in a scarce number of prey items in the analysis, or the relationships between prey density, prey detectability and food habits (but see Jaksic and Soriguer, 1981; Janes, 1985).

Food availability is one of the most important factors influencing the quality of raptor habitats, which is determined not only by prey density, but also by the accessibility to prey by predators (Widen, 1994). While absolute food abundance may certainly be of great importance, various habitat features may affect either accessibility of food or the time and energy expended in securing it. In this way, ground-level vegetation can affect the ability to detect prey and hence may influence the success of particular foraging behaviours (Bechard, 1982; Janes, 1985). This is the reason why prey accessibility has been proposed to be more important to

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reproductive success than absolute prey density (Janes, 1984). As a consequence, some authors emphasized the importance of analysis of resources of raptors (Rosenberg and Cooper, 1990), although in studies of avian foraging difficulties invariably arise in measuring resource availability (Smith and Rotenberry, 1990).

Among Mediterranean raptors, Bonelli's eagle (*Hieraaetus fasciatus*) is suffering one of the most severe population declines (Rocamora, 1994). This eagle has a highly disjointed global distribution (Cramp and Simmons, 1980), 80% of the European population being located in Spain (Real et al., 1997). In this country the nesting population has declined by 25% during the period 1980–1990 (Arroyo et al., 1995). In Andalusia (Southern Spain), the last stronghold of the Bonelli's eagle (Balbontín et al., 2003), we have previously found that absolute prey density in territories does not affect the distribution and breeding success of the eagle (Ontiveros and Pleguezuelos, 2000). Nevertheless there are no studies available analysing either the influence of prey detectability or diet composition in the breeding success of pairs, such information being crucial in the designing of conservation measures concerning the increase of prey densities for the Bonelli's eagle.

In this study, we analyse the minimum number of prey items per territory necessary for a reliable dietary analysis, prey density, and prey detectability (through habitat features), and their relationship to the breeding success of Bonelli's eagle.

2. Study area and methods

The study was conducted in eastern Andalusia (2°40′–4°13′ W; 36°45′–37°49′ N) a largely mountainous region, although pairs here considered are located in a rather clumped population (52 km for the most distant pairs), nesting between 800 and 1400 masl. The climate in the territories of this population is Mediterranean, with mean annual temperatures ranging between 13.3 and 16.9 °C and annual rainfall between 351 and 639 mm (30-year standard meteorological averages) and typical Mediterranean vegetation (Rivas-Martínez, 1985).

For the present analysis, we selected eight Bonelli's eagle pairs from which we obtained a high number of prey items for the dietary analysis; the difficulty of collecting many prey items in the mountainous territories of Bonelli's eagle, prevented a larger sample size for the number of pairs. The diet of the pairs was analysed in the breeding season (February–June) during the 1997–1998 period. For dietary analysis, we used pellets and remains to avoid underestimating mammals and reptiles and overestimating birds (Oró and Tella, 1995; Ontiveros and Pleguezuelos, 2000).

Line transects were used to provide an index of relative prey density in each territory. This method has proven effective to determine prey-species abundance of raptors, and to compare the densities of abundant species between different zones (Fitzner et al., 1977), being less difficult to perform than absolute-density methods, and equally useful (Caughley, 1977). Prey density was measured as the mean of individuals per km of census. Because of methodological constraints, we analysed only the abundance of the main prey species of the Bonelli's eagle in the study area (rabbits, partridges and pigeons) representing 90.2% of the diet of the eagle in terms of biomass (Ontiveros and Pleguezuelos, 2000).

One census per year was taken along a 5-km stretch each, during two consecutive years (1997 and 1998), in different zones within territories (providing the independence of the data), and grouping main prey species in a single census, which is advantageous in enabling greater precision in data over time (Watson et al., 1992; Guix et al., 1997).

The length of the censuses was distributed proportionally over the surface of the habitats in each territory (Caughley, 1977). The censuses were performed by an observer on foot, between 06.00 and 09.30 h., on days of good visibility, walking at a speed of 1.5–2.0 km/h (Bibby et al., 2000), during the period February–April. Censuses during May were avoided, when demographic explosions of rabbits occur in the Mediterranean area (Soriguer, 1981). Line transect is the most accurate method for censuring rabbits (Palomares, 2001), and diurnal censuses proved to be useful (Soriguer et al., 1997; Serrano, 1998; Palomares et al., 2001), since this prey-species, although primarily nocturnal, also shows substantial diurnal activity (Soriguer and Rogers, 1981; Moreno et al., 1996); thus, we deemed the diurnal rabbit census to be a more realistic estimate of prey density for a strictly diurnal raptor such as Bonelli's eagle.

The same territory shape and size for each pair was considered, circular and with a radius equal to half the average distance between nests of neighbouring pairs in a clumped population (5.0 ± 1.2 km; mean ± SD), according to previous data for this region (Ontiveros, 1999). In accordance with field observations of the authors, hunting areas detected for the eight pairs were included in this territory surface area. No territories overlapped in the population considered.

Different habitat features can influence the detectability of prey by raptors, such as the number and dispersion of perches, the presence of cliffs, and the ground-level vegetation (Janes, 1985). Nevertheless, the area occupied by Bonelli's eagle in the study area is largely mountainous, with a great abundance of cliffs and perches. Therefore, we tested the prey detectability through the low opportunity to conceal – that is, the amount of open lands in the territory, including grasslands, cereals crops, olive orchards, and scrublands (except dense scrubs of evergreen oak). In the semiarid study area, grasslands, low-height scrub and cereal crops, are not high and dense