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COMMUNAL ROOSTING IN YOUNG BONELLI'S EAGLES (*AQUILA FASCIATA*)

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Communal roosting behavior implies many ecological and evolutionary consequences in birds (Zahavi 1971, Allen and Young 1982, Eiserer 1984, Beauchamp 1999). Among raptors, communal roosts—small sites where various individuals of the same species gather to spend the night (Newton 1979)—have traditionally been associated with social species (or those social in at least one stage of their lives). However, Muñoz et al. (2010) recently showed that even eminently solitary species can aggregate around roosts under certain conditions. Consequently, communal roosts can be found in a wide variety of situations, from winter quarters (e.g., Sánchez-Zapata et al. 2007) to migration stopovers (e.g., Muñoz et al. 2010), and even breeding areas in the case of young or nonbreeding mature birds (e.g., Donázar 1993, Lambertucci et al. 2008). However, this meeting behavior has been rarely reported for highly territorial, long-lived raptors with deferred maturity during the typical juvenile dispersal period, i.e., the period in which juveniles settle in dispersal areas that are clearly defined and separated from the breeding range (Ferrer 2001). Communal roosting also entails conservation concerns. Roosting sites have repeatedly been identified as highly vulnerable places (Riley et al. 1983, Donázar et al. 1996, Lambertucci et al. 2008, Muñoz et al. 2010) as they usually concentrate many birds outside of protected reserves.

Bonelli's Eagle (*Aquila fasciata*) is a long-lived, territorial, nonmigratory raptor with a genuine juvenile dispersal stage preceding sexual maturity (at 2–5 yr of age; Real 2004). This species, distributed irregularly throughout the Mediterranean basin, the Middle East, the Indian subcontinent, and Southeast Asia (Ferguson-Lees and Christie 2001), is currently classified in Europe as ''endangered'' (SPEC 3 level; BirdLife International 2004), with Spain holding 75% of the European population (del Moral 2006). Maintenance of the floater population is thought to be critical for the long-term stability of the continental Bonelli's Eagle population (Real and Mañosa 1997, Soutullo et al. 2008), as explicitly noted in the Spanish Red Data Book (Real 2004). However, many biological aspects of Bonelli's Eagles' dispersal are still unknown, although limited basic data have been recently reported (e.g., Mañosa et al. 1998, Real and Mañosa 2001, Bautista et al. 2004, Balbontín 2005, Moleón et al. 2009a, Cadahía et al. 2010).

We here describe the communal roosting behavior of young Bonelli's Eagles in dispersal areas in southern Spain and also assess the level of legal protection of roosting sites.

STUDY AREA AND METHODS

The study area comprises two of the most important concentration areas for dispersing Bonelli's Eagles in Europe: the Cadiz-Seville (36°33′N, 5°55′E; 30–410 masl) and the Guadalcanal (38°10′N, 5°49′E; 400–960 masl) regions in Andalusia, southern Spain. Andalusia contains the primary Spanish—and hence European—breeding population for this species; Moleón 2006). These two areas, particularly the Cadiz-Sevilla region, receive tens of dispersing individuals yearly, not only from Andalusia, but from many other parts of western Europe (Consejería de Medio Ambiente 2008). Both areas are primarily devoted to agriculture, stock-rearing and small-game hunting, and the habitat is dominated by a mixture of nonirrigated crops and Mediterranean scrub patches, with small stands of nonnative *Eucalyptus* spp. scattered throughout.

Fieldwork was conducted in two main phases. In the first phase, a broad-scale preliminary investigation conducted 2004–06, we searched the areas with the highest concentration of young birds within the Cadiz-Sevilla and Guadalcanal dispersal areas to determine the sites selected by eagles for roosting. We observed at dusk during principal dispersion period (September–February; Bautista et al.

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2004). After we sighted an eagle or eagles, we followed the birds by vehicle, using 10× binoculars. This allowed us to locate, and then record on a map, the locations where eagles perched to spend the night.

After perching sites were located, and based on the fact that most of the birds we found were grouped into communal roosts (see Results), we proceeded to a second, more detailed, investigation phase. We counted the number of eagles present to evaluate the utilization of roosts in the middle of the 2007 dispersal period (November—first fortnight of December). We planned censuses to assess spatial and temporal variations in roost usage. Thus, we made one visit per roost (''spatial survey''), except for two roosts, which we visited seven and five times, respectively, to assess daily fluctuations (''temporal survey''). We surveyed the roosts from a distance using binoculars (10×) and spotting scopes (20–60×) to minimize disturbance. Although observations normally started before midday, counts were always done at dusk. We recorded both the number and age of all the individuals seen, as well as the presence of any other raptor species in the roosts. Following several authors (Parellada 1984, Forsmann 1999, Gil-Sánchez et al. 2005), we classified non-adult Bonelli's Eagles as ''juveniles'' (birds in their first calendar-year), ''immatures'' (second calendar-year) or ''subadults'' (third calendar-year), based on progressive changes in plumage characteristics. On some occasions, we noted eagles using the roosts during the day (especially in midday) for resting and feeding. Some of these birds may stay in the roosts until nighttime; thus, our dusk counts should be considered a minimum estimate, as some eagles may have been undetected.

To obtain an indication of the size of the trees used by eagles, we randomly chose a subset of three trees in each of 10 different roosts. For each such tree, we measured the trunk diameter (DBH) at 1.3 m aboveground and the tree height (TREEH). These measurements were made after the primary eagle dispersal period had finished.

We digitally mapped (ArcGIS 9.0) the location of each roost site, and calculated the percentage of roosts falling within the Andalusian Network of Natural Protected Sites (RENPA) or Sites of Community Interest (SCIs).

RESULTS

We located 18 communal roosts within the central and southern sectors of the Cadiz-Seville dispersal area, and two in Guadalcanal ($n = 20$ total roosts). All roosts were used in all subsequent years after their first detection. All the roosts were found in small (<1 ha) isolated stands of *Eucalyptus* spp. (mean DBH = 72 cm, range: 40–210 cm, $n = 30$ trees, and mean tree height = 21 m, range: 15–40 m, $n = 30$ trees) within a matrix of cereal crops crossed by scattered hedges of *Chamaerops humilis* and other Mediterranean shrubs. The habitat supported high densities of rabbits (*Oryctolagus cuniculus*; 3.0–4.7 rabbits/ha; Moleón et al. 2009a), the main prey of the Bonelli's Eagle in western Europe (Moleón et al. 2009b).

Between 2 and 11 eagles (mean = 5.3 ± 2.7 [SD]) per roost were observed in the spatial survey ($n = 20$ total counts at 20 roosting sites, $n = 105$ total birds). Similar numbers were found in the two roosts included in the temporal survey (mean = 4.7 ± 3.2, range: 2–9, $n = 7$ total counts, $n = 33$ total birds; and mean = 5.0 ± 1.0, range: 4–6, $n = 5$ total counts, $n = 25$ total birds, respectively). Using the global (i.e., all counts in all roosts) mean of 5.1 ± 2.6 birds per roost per d, we estimated an average of 102 (range 50–153) young Bonelli's Eagles using these communal roosts daily during the peak dispersal period.

We aged 103 birds during the spatial survey. Among them, 91.3% ($n = 94$) were juveniles, 6.8% ($n = 7$) were immature, and the remaining 1.9% subadults ($n = 2$). For comparison purposes, of a sample of 128 Bonelli's Eagles observed in random transects made outside the roosting sites in the same season and region between 1997–2006 (Consejería de Medio Ambiente 2008), 55.5% were juveniles ($n = 71$), 25.8% immatures ($n = 33$) and 18.7% subadults ($n = 24$); similar proportions were found by Bautista et al. (2004) for another Andalusian dispersal area. Thus, juvenile eagles were proportionately more frequent inside roosts than outside them ($\chi^2 = 36.59$, $P < 0.001$).

In 91.7% of our visits, we observed that Bonelli's Eagles were sharing the roost with young individuals of another large raptor, the Spanish Imperial Eagle (*A. adalberti*). In these cases, each species used a different part of the stand so that the individuals of each species remained grouped and separated from the others (minimum interspecific distance = 12 m). Other species, including most frequently Black Kite (*Milvus migrans*) and Common Buzzard (*Buteo buteo*), also used the same roosts, although to a lesser extent (<5% of both the visits and the total number of roosting birds), typically as single individuals of each species.

All roosts we studied were located outside protected areas in Andalusia, on privately owned agricultural land that was extensively farmed.

DISCUSSION

In many long-lived, territorial species with deferred maturity and a juvenile dispersal period, young individuals aggregate in relatively small but dense concentrations within dispersal areas. In this social life-stage, communal roosting is thought to be fairly common, as we found here for Bonelli's Eagle. In fact, we also documented that another similar raptor, the Spanish Imperial Eagle, frequently shared the same roosts.

Several hypotheses, mainly relating to thermoregulation, predation avoidance, and foraging efficiency, have been proposed to explain the origin of communal roosting behavior in birds (Beauchamp 1999). In our case, thermoregulation benefits are unlikely to be important due to the mild weather conditions in the study area (even in winter) and the relatively low number of birds per roost. Furthermore, predation avoidance seems a negligible strategy in Bonelli's Eagle, which is a super-predator (Moleón

et al. 2009b) with very few natural enemies. In contrast, some elements of foraging efficiency, i.e., ''information transfer,'' ''conspecific attraction'' and ''patch sitting'' (Beauchamp 1999) may be related to the communal roosting behavior of young Bonelli's Eagles. According to Ward and Zahavi (1973), unsuccessful birds should follow companions to profitable foraging patches, although attraction of nearby conspecifics to food sources (Buckley 1996) and simple aggregations of eagles near rich prey patches (Caccamise and Morrison 1988, Penteriani et al. 2006) would also be plausible explanations for congregation. The fact that the age-ratio in communal roosts compared to that outside them was biased toward juveniles (i.e., the most inexperienced birds) suggested that some component of the foraging information might be important. Thus, the youngest birds may need to stay together until they acquire enough experience to roost independently of the group. Additionally, young eagles should choose those places with a lower risk of human disturbance for roosting. In this regard, the scarcity of stands of trees (i.e., relatively safe refuges) within the study area may force birds to aggregate in the few available. Nonetheless, other causes underlying the decision of roosting close to conspecifics cannot be excluded, particularly considering that Bonelli's Eagles typically perched separately from Spanish Imperial Eagles and from other raptors in roosts.

One striking finding from our study was that the Bonelli's Eagles' communal roosting sites are completely legally unprotected in Andalusia. Protection of these consequential places would favor the conservation of the least experienced and largest cohort of the dispersing population, the youngest individuals, whose communal behavior makes them especially vulnerable to direct human persecution. In addition, the small size and very simple structure of the roosts confer a distinct vulnerability to human disturbance and habitat alteration, which is even more worrying considering the interannual stability in roost usage. The provision of safe havens for the Bonelli's Eagle floater population through protection of Andalusian communal roosts seems crucial, not only for local or regional populations, but also for the continental population. We additionally encourage periodic monitoring and preventive protection of all isolated stands of mature trees in the primary dispersal areas for Bonelli's Eagles, as these may also serve as future roosts.

DORMIDEROS COMUNALES EN ÁGUILAS *AQUILA FASCIATA* JÓVENES

RESUMEN.—Rara vez se han registrado dormideros comunales en aves rapaces territoriales de vida larga y madurez sexual retardada durante su dispersión juvenil. Aquí describimos este comportamiento para el águila *Aquila fasciata*, una rapaz territorial amenazada de vida larga con una genuina etapa dispersiva previa a la madurez sexual. De acuerdo a muestreos efectuados entre 2004 y 2007 en dos de sus más importantes áreas de dispersión juvenil europeas (Andalucía, sur de España), encontramos 20 dormideros comunales que acogieron una media de 5.3 ± 2.7 águilas jóvenes por dormidero y noche durante el periodo central de la época de dispersión. En consecuencia, estimamos que 102 (rango: 50–153) águilas usaron diariamente los dormideros. Ciertos componentes de la teoría de forrajeo óptimo, así como la elección de lugares alejados de interferencia humana, podrían explicar el comportamiento de dormir comunitariamente en esta especie. Debería proporcionarse protección urgente tanto a estos bosques-isla como a otros similares que podrían también actuar como dormideros.

[Traducción del equipo editorial]

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