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Habitat selection by Black kite breeders and floaters: Implications for conservation management of raptor floaters

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ABSTRACT

Preserving large predators is important but challenging because these species are typically wide-ranging, select multiple habitats at different scales and often present spatial or habitat separation between the breeder and floater sectors of a population. In addition, most of our knowledge on raptor floaters' habitat requirements comes from large solitary species, whose floaters often occupy temporary settlement areas spatially separate from breeding locations. Here, we examine space and habitat use by a loosely colonial, wetland-dependent raptor, the Black kite (*Milvus migrans*), in a population where floaters co-exist with territory holders, enabling a direct comparison of their habitat preferences. The study was conducted in Doñana National Park (South-Western Spain), a seasonally drying marshland currently surrounded by intensive agriculture and rice-fields. Intensive radio-tracking revealed that breeders and floaters selected and avoided the same habitats despite a radical, four-to-eight fold difference in their home-range dimensions: all kites over-selected open habitats suitable for their aerial foraging modes and avoided woodland and farmland. These results suggest a continuum of raptor population structures ranging from solitary species whose floaters select different habitats than breeders and are concentrated in spatially separate settlement areas, to colonial and semi-social species whose floaters fully coexist with breeders with shared habitat preferences. Both extremes of this continuum will pose challenges for conservation management. In solitary species, special conservation efforts may be required to identify and manage temporary settlement areas, while in gregarious species, the larger ranges of floaters may expose them to different threats than breeders, whose occurrence and consequences may be subtle to identify.

1. Introduction

Preserving and managing large vertebrate predators is becoming increasingly important as a way to maintain high levels of biodiversity (Estes et al., 2011), but poses special challenges for several reasons. First, these species are characterised by large home-ranges, which cannot be easily encompassed within protected areas (e.g. Newton, 1979; Clark et al., 1999; Ray et al., 2005). Second, they frequently select habitat features at multiple scales, from the micro-scale to the landscape-level (Sánchez-Zapata and Calvo, 1999; Thompson and McGarigal, 2002; Ciarniello et al., 2007), which requires broad-level management plans (e.g. Whitfield et al., 2006a). Third, they may use different habitats at different times of the year (Boal et al., 2005; Schmitz et al., 2010). Finally, the populations of large predatory vertebrates are frequently composed of a sector of territorial breeders, often concentrated in resource-rich sites, and a sector of non-breeding individuals, frequently located far away from the breeding grounds (e.g. David Smith, 1993; Ferrer and Harte, 1997; Crabtree and Sheldon, 1999; Balbontín, 2005). The latter adds complexity to strategic management targeting long-term population persistence, especially because non-breeding animals are difficult to study due to their cryptic behaviour, differential habitat selection, spatial separation from breeders, or potential long-distance dispersal (e.g. Zack and Stutchbury, 1992; Rohner, 1997; Whitfield et al., 2009a; Penteriani et al., 2011). As a result, there is little knowledge on the differences in habitat choices between the breeders and floaters of a population, and conservation planning is often biased to protect the habitats preferred by the breeding sector of predator populations (e.g. Real and Mañosa, 1996; Whitfield et al., 2006a). Also, most of the (scarce) available knowledge is heavily biased towards large species of solitary birds of prey, whose floaters are typically concentrated in so-called "temporary settlement areas", where they select different habitats than breeders (Ferrer and Harte, 1997; Balbontín, 2005; Caro et al., 2011; Penteriani et al., 2011). As a result, little is known of smaller species with different social systems, such as colonial or loosely colonial species.

Because of all the above, there is a high need for further multi-scale habitat selection studies on both breeding and non-breeding

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individuals of predatory vertebrates, particularly of gregarious or semi-gregarious species. Here we provide such a study by examining the space and habitat requirements of the breeders and floaters of a semi-social raptor, the Black kite (*Milvus migrans*). In particular, we use data from a 3-year radio-tracking study on the Black kite population of Doñana National Park (South-Western Spain), one of the most renowned and biodiversity-rich reserves of Europe.

Our study system is a good model for the goals presented above due to several reasons. (1) The Black kite is a semi-gregarious raptor, which in Doñana mainly breeds in loose colonies (Sergio et al., 2005). (2) In this population, floaters coexist with breeders (Blas et al., 2009; Sergio et al., 2009, 2011a). This allows the study of habitat selection by the two status categories while controlling for differences in habitat availability, avoiding the problem of comparing the decisions by groups of individuals occupying separate areas characterised by different landscapes. (3) Doñana National Park is an island of semi-natural vegetation subject to dynamic habitat management and transformation. Outside the park, drainage of the seasonal marshes in the second half of the 20th century has generated a matrix of intensive farmland, dominated by rice fields to the north-east, whose suitability for wildlife species is largely unknown. Inside the protected area, all habitats are traditionally actively managed (e.g. Fernández-Delgado, 2005). For example, large patches of forest have been recently thinned or removed, while the hydrology of the seasonal marshes that characterise the park is subjected to a recently implemented large-scale restoration program (Project "Doñana 2005": García Novo and Marín Cabrera, 2005a), which included the restoration of various sites totalling more than 50 km^2 of seasonal marshland which had been originally converted to agriculture (García Novo and Marín Cabrera, 2005b; Santamaría et al., 2005; Martín-López et al., 2011). The above described habitat changes and active management inside and outside the park call for more solid knowledge of the habitat preferences of key species such as Black kites, which are the most abundant large predators in the park and which depend heavily on woodland for nesting and marshland for hunting (Sergio et al., 2011b). Understanding habitat preferences of key indicator species could be fundamental to forecast future impacts of habitat management and to implement more efficient post-intervention monitoring.

Given all the above, here we: (1) examine the home range and habitat selection of kites of different sex and status (breeders vs. floaters) and (2) propose potential management guidelines based on the obtained results.

2. Methods

2.1. Study species

The Black kite is a medium-sized, monogamous, migratory raptor. It is an opportunistic, aerial predator typical of open habitats (Viñuela and Sunyer, 1992; Blanco and Viñuela, 2004), adept at exploiting temporary situations of overabundance of relatively easy prey (Hiraldo et al., 1990). In our study population, all individuals are migratory and remain in Doñana from March to August, where they mostly breed as monogamous pairs (Sergio et al., 2007). The local breeding density can be very high (from 1 to 30 pairs/km^2, Sergio et al., 2005, 2011b; authors' unpublished results) and most pairs could be considered to nest within a very large, loose colony. Diet composition is very heterogeneous and dominated by wetland birds and their nestlings, crayfish, rabbits (*Oryctolagus cuniculus*) and carrion (Hiraldo et al., 1990; Viñuela and Veiga, 1997). Floaters are generally young birds (1–7 years old, Blas et al., 2009) physiologically capable of reproducing but apparently displaced from the breeding sites by older, more dominant conspecifics (Sergio et al., 2009; Blas and Hiraldo, 2010; Blas et al., 2011). Sexual role division during reproduction follows the usual scheme for raptors (Newton, 1979): the male provides most of the prey for the female and offspring while the female performs most of the incubation, brooding and nest guarding.

2.2. Study area

The study was conducted in Doñana National Park, located within the estuary of the Guadalquivir river, along the coast of the Atlantic Ocean in South-Western Spain (6°12′–6°40′W, 36°48′–37°20′N). The five main macro-habitats observed in the park include: (1) seasonally drying marshland (hereafter "marshland"), (2) Mediterranean scrubland or grassland with scattered cork oaks (*Quercus suber*) (hereafter "dehesa"), (3) extensive scrubland on sandy soil (hereafter "scrubland"), a mixture of different degradation stages of autochthonous Mediterranean scrubland (Castroviejo, 1993), including patches dominated by *Pistacia lentiscus* and *Myrtus communis* or by *Halimium halimifolium*, *Ulex* spp., *Stauracanthus genistoides* and *Erica* spp.; (4) mobile sand dunes along the ocean coast, and (5) extensive forests of stone pine *Pinus pinea* and smaller woodlots dominated by Cork oaks or *Eucalyptus* spp. trees (Castroviejo, 1993). A mosaic of intensively cultivated lands and rice fields surrounds the park.

2.3. Field methods

Between 2007 and 2009 we trapped 38 Black kites by cannon-netting (Fig. 1) and equipped them with a conventional backpack transmitter (TW-3 of 15 g; life expectancy = 1.4 years; Biotrack Ltd., Wareham Dorset, UK), which was fitted with a Teflon harness (Kenward, 2001). The sex, status and sampling period of tracked kites are specified in Table 1. Kites were monitored every 3–4 days and all locations, obtained by triangulation, were GIS mapped through the software ArcView 3.2 (ArcView GIS, Redlands, CA, USA). In each tracking day, all marked kites were searched simultaneously while driving along a network of paved and dirt roads covering the entire park and its surroundings, thus sampling areas both close and far from nest concentrations. Also, the starting point and sequence of survey roads were varied each time, in order to avoid biasing the tracking data towards certain areas (e.g. towards nest concentrations). Using an area accumulation curve, we found that locations sampling saturation was reached for an average threshold of 40 fixes per individual and all individuals were radio-located more than 40 times.

Radio-tracking and the intensive demographic monitoring of the breeding and non-breeding sectors of the population (Sergio et al., 2009, 2011a) allowed us to determine the breeding status of all radio-tagged individuals. These included 12 breeding males, 12 breeding females and 14 floaters (eight males and six females). Breeders were defined as individuals holding a territory with a partner and building a nest. All trapped birds were sexed by molecular analysis of a blood sample (Ellegren, 1996).

2.4. GIS and statistical analysis

For each kite, we estimated the home range size and configuration through the following three indices: (1) the Minimum Convex Polygon (MCP), (2) the Kernel Density Estimator (KDE) at 95%, 75% and 50% contours, calculated with a least-squares cross-validation (LSCV) procedure and a smoothing factor (Seaman and Powell, 1996) and (3) the mean distance of all fixes from the home-range centroid (hereafter "distance to centroid"), calculated through the Animal Movement extension for ArcView (Hooge and Eichenlaub, 2000). However, to avoid reporting redundant results, for the analyses of habitat selection we only show the models based on the