

Short communication

# Differential composition in the age of mates in Bonelli's eagle populations: The role of spatial scale, non-natural mortality reduction, and the age classes definition

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## Abstract

Monitoring of the age of mates, a method proposed to detect early warning signals for demographic trends in long-lived bird populations, showed different patterns when the study was performed on a single Bonelli's eagle subpopulation of Andalusia (South of Spain) than when the whole region is taken into account. In this respect, we discuss the role of the spatial scale, the origin of reduction in non-natural mortality and the definition of the used age classes. For a correct monitoring of the age of mates in the Bonelli's eagle, we propose the two age classes previously suggested, adult and non-adult, but paying particular attention to the late subadult individuals, specially when the monitoring is performed in a wide region by different field work groups. Likewise, it is necessary for monitoring age of breeders in long-lived species with deferred maturity to collect data from a sample well distributed over space, taking regularly into account pairs from the edge and from the centre of population. Besides, it is important to monitor those subpopulations with different known threats, providing them their relative importance among the whole population. Finally, conventional monitoring of the age of mates seems to generally be a reliable way to predict viability changes of bird populations, except when adult by adult replacements take place by reduction in juvenile mortality.

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## 1. Introduction

Bonelli's eagle (*Hieraetus fasciatus*) is a threatened raptor in the European countries (Garza and Arroyo, 1996; Real et al., 1996). The main population of this species in Europe inhabits the Andalusia region (87,268 km<sup>2</sup>, southern Spain; Fig. 1), with 325 breeding pairs (Madero and Ruiz-Martínez, 1991; Balbontín et al., 2000; Bautista

et al., 2003; Gil-Sánchez et al., 2004; J.R. Benítez, per. com.; F. Martín, per. com.; P. Dobado-Berrios, per. com.; A. Menor, per. com.; personal data), >30% of European pairs (Real et al., 1996). Although this population remained stable at least for the last 10 years, an increasing of occupation of territories by non-adult birds has been detected at the end of the nineties basing on data from some parts of Andalusia, and it has been suggested as an early warning signal of changes in long-lived bird population trends (Balbontín et al., 2003). Decreases in the age of breeders carried negative consequences in demographic tendencies, since breeding success decreased

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Fig. 1. Location of the study area. The Bonelli's eagle pairs distribution in Granada (Gr) and Málaga (Má) provinces are showed.

for mixed pairs (Balbontín et al., 2003). Moreover, it could point out unnatural adult/juvenile mortality events, as shooting and electrocution (Real et al., 2001), among other reasons causing increases in turnover rates, as sex deviances (Ferrer et al., 2003).

Intensive monitoring of Bonelli's eagle population of eastern Andalusia is carried out from 1994 for Granada province (12531 km<sup>2</sup>, Gil-Sánchez et al., 2004) and from 2001 for Málaga province (7276 km<sup>2</sup>, Bautista et al., 2003; Fig. 1). Both provinces have about 130 breeding pairs (40% of Andalusia population) (Bautista et al., 2003; Gil-Sánchez et al., 2004). However, results of these two monitoring programs do not seem agree with those previously conducted by Balbontín et al. (2003), therefore no variations in mixed pairs proportion have been detected.

Data of monitoring and a discussion about results offered by Balbontín et al. (2003) are presented in this paper, whose specific goals are: (1) to compare Bonelli's eagle trends from two different sources (scales) of data (Balbontín et al., 2003 for Andalusia, and present study for Granada province), (2) to check if the negative tendency suggested by Balbontín et al. (2003) has acted during the recent years in the provinces of Granada and Málaga, (3) and to determine the causes of the expected different results between scales, in order to propose guidelines for developing an accuracy monitoring program of the age of mates in the Bonelli's eagle and other long-lived birds with delayed maturity elsewhere.

## 2. Methods

A description of the study area and method for monitoring of Bonelli's eagle is available in Bautista et al. (2003) and Gil-Sánchez et al. (2004). Pairs composition is expressed as percentage of adult pairs (Balbontín et al., 2003).

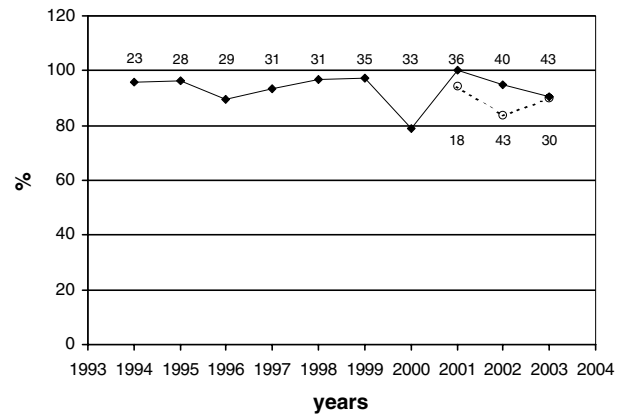


Fig. 2. Annual variation in the percentage of adult pairs in the populations of Granada (solid line) and Málaga (broken line). Number of monitored pairs per year is also indicated for Granada (above) and Málaga.

## 3. Results

No decreasing over time in pairs composition ( $R_s = -0.17$ ,  $p = 0.711$ ,  $n = 10$ ; Fig. 2) was observed for the population of Granada province. For Málaga province, any tendency was observed between 2001 and 2003 ( $R_s = -0.50$ ,  $p = 0.729$ ,  $n = 3$ ; Fig. 2). Adult pairs for Málaga (mean = 87.91%) was near the mean value for Granada province (93.31%), one of the highest values for Bonelli's eagles cited within Spain by long-term studies (Real and Mañosa, 1997). All non-adult birds incorporated to the breeding population were late subadults (Parellada, 1984; Forsmann, 1999). No cases of territories held by a single eagle for more of three months were registered, since replacement of lost birds was fast (Gil-Sánchez et al., 2004). Likewise, any pair with two non-adult members were observed (Gil-Sánchez et al., 2004), as it is expected in declining populations (Newton, 1979; Balbontín et al., 2003). No important changes in population trends have been observed between 2000 and 2003, with no lost known breeding territories, and two new breeding territories in Granada. Moreover, in this province it has been an increased trend since 1994 ( $n = 7$  total new pairs; Gil-Sánchez et al., 2004).

## 4. Discussion

In contrast to Balbontín et al. (2003) for the whole region of Andalusia, we have not observed any negative tendency for the age of mates and population trends in Granada between 1994 and 2003, and any warning signal was detected in Málaga between 2001 and 2003. These contradictory results may pose a question of spatial distribution of the data. Usually, some areas of a whole population, that may take up the edge, the centre or be randomly distributed (Channell and Lomolino, 2000; Virgós, 2002), may suffer different threats and mortality lev-

els, and here is where the declining warning signals mainly become apparent (Real and Mañosa, 1997; Carrete, 2002). Besides, non-natural mortality in the Bonelli's eagle differs among geographical regions (Real et al., 2001). This should be the cause of the different results of us with respect to the whole Andalusia region (Balbontín et al., 2003), provided that Granada and Málaga were provinces with relative lesser mortality events. However, the three of the eight andalusian provinces with highest non-adult proportion detected in Balbontín et al. (2003) are Cádiz, Málaga and Granada. This suggest that the previous hypothesis is not important, at least in our case. So, it is possible that the data of Balbontín et al. (2003) were not regularly distributed over the whole Andalusian population (not as much in space as in number of data by territory). Therefore, they could have a major data set in the last years for territories with highest proportion of non-adults.

On the other hand, in Andalusia is taking place the protection of power lines in dispersal areas to avoid electrocution since 1987 (Ferrer, 1993). As is well known, electrocution has been the main mortality factor for juvenile Bonelli's eagles, affecting females more frequently than males (Ferrer and Hiraldo, 1992; Real et al., 2001) at the end of the 1980s and, at least, the first years on the 1990s (Real et al., 2001). The progressively partial solution of this mortality factor could also contribute to explain both the presence of warning signal before and the non-negative trend after the end of the 1990s. So, adult by adult replacements in the last years could become more frequent. In addition, last researches have been showed that territorial Bonelli's eagles can regularly visit dispersal areas (Bautista et al., 2004; Real, per. com.; Sánchez-Zapata, per. com.) and therefore is possible that protection against electrocution in these places had decreased mortality rates not only in the juvenile but in the breeder eagles, consequently diminishing turnover rates. However, still being these two explanations non-mutually exclusive, both differ in their conservation and warning signals monitoring implications. While the second one implies a reduction in the mortality events that can be detected by a conventional monitoring program of the age of mates (this is the mechanism because should be different the trends from Balbontín et al. (2003) and from us), it is necessary to have marked and individualized the breeder population in order to perceive mortality events through adult by adult replacements. In this last case, conventional monitoring loses its predictive capability because it cannot detect the mortality of mates.

Anyhow, we recommend that for monitoring the age of mates for wide populations, where the large scale prevent the monitoring of the total of breeding territories, is necessary to collect data from a sample well distributed over space, taking regularly into account pairs from the edge and from the centre of population. Besides, it is important

to monitor those subpopulations with different known threats and providing them their relative importance among the whole population, since as most of population attributes, the age of the breeders could be influenced by the heterogeneity of the population (Ferrer and Penteriani, 2003; Ferrer and Bisson, 2003; Penteriani et al., 2003). It may be interesting for further studies to determine the minimum sample in the space and time to detect accuracy changes in the age of mates, taking into account situations where the different subpopulations show differential density and mortality rates.

On the other hand, the consideration of the two age classes proposed by Balbontín et al. (2003) (adult and non-adult) seems to be adequate to avoid subjectivity and standardize criterions among different field work teams where the study was performed in areas as large as Andalusia, where the monitoring by a single work group is unviable. However, it is necessary to be careful discriminating the late plumage of subadult, that is closer to adults (whitish underparts with dark streaking) than to juveniles and early subadults (tawny breast) (Parellada, 1984; Forsmann, 1999). So, it is very difficult to differentiate this plumage in the field and therefore, it may usually be bad classified as an adult. Moreover, late subadults are the birds that more frequently join the breeding population (Carrete, 2002; present study). This fact must carefully be taking into account for monitoring age of mates, specially when it is performed over a wide region by different field work groups, since the evaluation of the subtle differences between late subadults and adults may vary among observers.

Differentiation between the adult and non-adult age-classes by plumage characteristics has been a relatively recent study subject for the Bonelli's eagle (see Parellada, 1984). Thus, Balbontín et al. (2003) may be underestimating the non-adult age-class in the early 1980s and considerate some late subadults as adults. This also may contribute to the contradictory trends observed by these authors and us.

Any way, we still believe that the measure of the age at first breeding may potentially be an useful early warning signal to predict viability changes in long-lived bird populations (Ferrer et al., 2003), as it is recommended by Balbontín et al. (2003), in spite of the fact that the present data do not seem support this hypothesis for the dynamic of the Bonelli's eagle population in the whole Andalusia region. The only exception for the usefulness of this method is, as we said before, when adult by adult replacements take place by reduction in juvenile mortality.

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