A Preliminary Demographic Approach to the Bonelli's Eagle *Hieraaetus fasciatus* Population decline in Spain and France

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INTRODUCTION

Bonelli's Eagle is a species whose most important numbers in Europe are found in the Iberian Peninsula and on the Mediterranean coast of France (Cramp & Simmons 1980), where there are about 800 pairs. According to the most recent census in Spain (Arroyo 1991), the highest densities are reached in the mountain ranges along the Iberian Mediterranean coast, where 3-9 pairs can be found per 1,000 km². In spite of this, the population is decreasing, even in optimal areas with high densities. The comparison of the Spanish censuses of 1986 (Equipo de Estudio del Aguila Real y Perdicera *in press*) and 1990 (Arroyo 1991) show that in this period the species has become extinct in six provinces, is declining in 12 and is stable or in slight increase in 24. In France only 30 pairs remain, from an original 80 pairs in 1960 (Cugnasse 1984; Cheylan & Simeon 1984). The aim of the present report is to show demographic parameters in different populations and their importance for eagle conservation.

STUDY AREA, MATERIAL AND METHODS

Five study areas in Languedoc-Roussillon and Provence, both in France, and Catalonia, Alacant and Murcia in Spain (Figure 1) were carefully monitored to assess population trends and demographic parameters. In each area, population size and the average number of young fledged per pair were recorded annually. Moreover, adult mortality was estimated in each area according to replacement of breeding adult birds by non-adult birds, and from the disappearance of breeding birds.

Pre-adult mortality is being studied by means of wing-tagging (Kochert *et al.* 1983) and ringing. From 1986 to 1991, 101 young were wing-tagged and ringed in the nest with PVC and metal rings when between 40 and 55 days old.

Wing tags did not cause any physical or behavioural damage to young or adult birds. Mortality of young before independence was estimated by the proportion of

Figure 1. Location of study areas. 1: Provence. 2: Languedoc-Rossillon 3: Catalonia. 4: Alacant. 5: Murcia.

dead birds from 31 birds followed intensively from fledging to independence. Young mortality in the first year of life after independence was estimated from the proportion between sightings or recoveries obtained in the second year of life and the first year of life. For each population, the percentage of annual population change was calculated according to corresponding demographic parameters, following Ferrer and Calderón (1990), by means of the formula:

% of annual change = 100 (R-1) where $R = S_a + (S_j(P/2))/R^2$

S_a: Adult survival rate.

S_j: Pre-adult survival rate.

P: Production of young.

RESULTS AND DISCUSSION

Population Trends: Population changes in the study areas are shown in Figure 2.

All populations are declining, but two patterns emerge. A sharp decline in Murcia and Alacant and a more moderate decline in French and Catalonian populations.

Production of Young: The number of fledged young per territorial pair in each population is shown in Table 1. The highest average productivity was found in Alacant and Murcia, with 1.32 and 1.27 fledged young per pair, which are high levels for a species with a clutch size of one or two eggs. The production in the other populations is close to one young per pair.

Table 1. Demographic parameters and percentage of annual change for the studied Bonelli's Eagle populations.

(For pre-adult mortality we use a minimum preliminary estimate).

	MINIMUM PRODUCTION OF YOUNG	ADULT MORTALITY (%)	PRE-ADULT MORTALITY (%)	PERCENTAGE OF ANNUAL POPULATION CHANGE
Provence	1982-91 0.97 (N = 146)	1977-91 5.2 (N = 248)	90	-0.3%
Lan.-Rouss.	1966-91 1.04 (N = 199)	1971-91 8.8 (N = 68)	90	13.2%
Catalonia	1971-90 1.04 (N = 129)	1971-90 9.4 (N = 201)	90	-.3.8%
Alacant	1984-92 1.32 (N = 113)	-	90	-
Murcia	1979-91 1.27 (N = 138)	1985-91 16.3 (N = 276)	90	-8.7%

Adult Mortality: Adult mortality is highly variable between populations, ranging from 16.3% in Murcia to only 5.2% in Provence (Table 1). The causes of adult mortality were studied by recording dead birds found in Murcia and Catalonia. In both areas shooting is the main factor. Power lines are the second cause of mortality in Catalonia, while trapping is the second cause in Murcia (Table 2).

Pre-adult Mortality: During the post-fledging period, before independence, four out of 31 birds died, giving a young survival rate for this period of 87.2%. Predation, starvation and electric power lines are the main causes of mortality during this period

Table 2. Causes of adult mortality (%).

|	Catalonia	Murcia
Shot	50.0%	68.0%
Trapped	0.0%	10.5%
Power Lines	38.0%	5.2%
Starvation	6.0%	0.0%
Uncertain	6.0%	15.8%
Number of Cases	16	19

(Table 3). A preliminary estimate for the survival rate in the first year of life after independence is given by the quotient between tagged individuals sighted or recovered in their second plumage and those sighted or recovered in their first. This gives an estimate of $5/34 = 0.147$ (14.7%) survival rate. So, global survival rate from fledging to one year later may be only 12.8%. Bonelli's Eagles reach sexual maturity at three or four years old. We do not have enough data to give a preliminary estimate for survival rates for the second and third year of life, but if the figures obtained for the first year are accurate, pre-adult survival rate rate should not be above this value. So, the maximum pre-adult survival rate for Bonelli's Eagle is 12.8%, but the actual value may be below 10%. Main causes of mortality during dispersal are direct persecution and electric power lines (Table 3).

Table 3. Causes of non-adult mortality (number of cases).

	Before Independence	After Independence
Shot	0	3
Trapped	0	1
Power Lines	1	10
Starvation	1	1
Predation	2	0
Uncertain	1	0

Conclusions and Management Recommendations: Percentage of annual change is negative in all the populations studied (Table 1). Production of young is found to be at acceptable levels for the species, for which the highest median productivity ever recorded in the world is 1.44 (Bergier & Naurois 1985). In some areas (Murcia, Alacant), the decline of Bonelli's Eagle populations seems to be a consequence of high adult mortality, leading to an abrupt decrease in population size (Figure 2). In other areas, where adult mortality is lower, decline is moderate and is mainly as a consequence of high pre-adult mortality and habitat destruction. Each breeding population needs a particular set of management activities to ensure its conservation. However, a non-local set of conservation measures may be taken in order to protect non-adults during dispersal, when the birds cross the local boundaries of their original breeding population. High non-adult mortality is a common feature in all Bonelli's

Figure 2. Population trends in the five study areas. Top to bottom: Murcia, Alacant, Languedoc-Rosslló, Provence, catalonia.
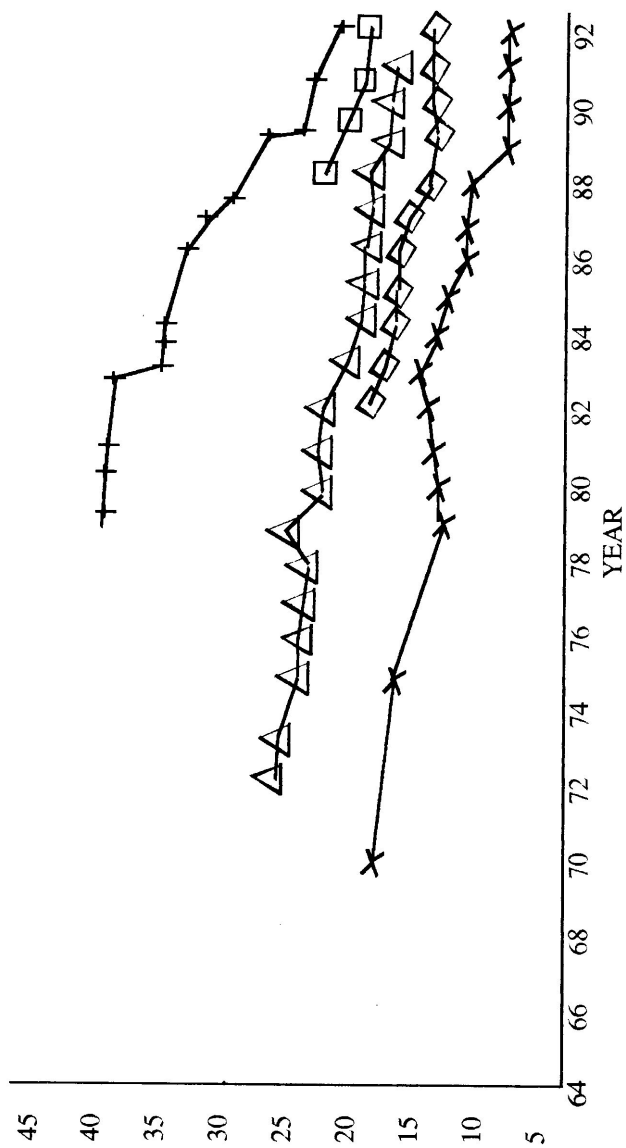
Eagle populations and requires a global approach. In consequence, several management recommendations can be proposed:
a) Eliminate direct persecution by hunters or pigeon fanciers.
b) Detect and eliminate dangerous power lines in breeding and dispersal areas.
c) Locate and improve quality of dispersal areas.
d) Create natural reserves in the most important dispersal areas.
e) Improve our knowledge of dispersal behaviour.
f) Create natural reserves in the most vulnerable breeding territories.
g) Increase prey abundance by habitat improvement and hunting regulation.
h) Regulation of disturbing activities (climbing, aerial and mountain sports) in the breeding areas.

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