

LONG-TERM CHANGES IN NEST DEFENCE INTENSITY OF THE SPANISH IMPERIAL EAGLE, *Aquila adalberti**

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ABSTRACT This paper deals with the variations recorded in the nest defence of the Imperial Eagle, *Aquila adalberti* after the declaration of Doñana as a national park (Parque Nacional Doñana, SW Spain) and the cessation of strong human pressure. Increases have been detected in the defence and number of attacks during the reproductive cycle as well as over the years. The latter is interpreted as behaviour learned by adult eagles having long reproductive lives whose defensive conduct has been positively reinforced by numerous nest visits made by investigators.

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INTRODUCTION

In Europe, aggressive nest defence against humans by large raptors is scarcely observed (Newton 1979). In fact, we do not know of any attack carried out by any species of the genus *Aquila* on the continent. Geographic differences in the frequency of attacks against humans in some species of raptors have been recorded. According to some authors, these are related to the intensity of human persecution suffered (Newton 1979). This is the case of the Bald Eagle *Haliaeetus leucocephalus*. Over most the American continent, the Bald Eagle maintains a distance of at least 70 m from the observer (Greir 1969), the Bald Eagles in Amitchikta (Aleutian Islands) which have not had contact with firearms stay only a few meters away and occasionally attack directly (Sherrod *et al.* 1977). In other birds, such as the American Crow *Corvus brachyrhynchos* differences in nest defence relative to the human pressure to which they were subjected have also been described (Knight 1984).

The Spanish Imperial Eagle *Aquila adalberti** is a large, territorial and sedentary raptor. Its longevity is approximately 21 to 22 years. Reaching sexual maturity at 5 years of age, it has an average reproductive life of 16-17 years (Ferrer 1989). From 1870 to 1910, the Spanish Imperial Eagle population in Doñana National Park was severely reduced to 2-4 pairs, mainly due to human persecution. In 1965, a section of the park was declared a scientific reserve.

When the present day national park was created in 1974, there was a stable eagle population of 15 pairs.

The Spanish Imperial Eagle is a highly threatened species; it has been the object of special attention ever since. Its reproduction has been well observed in Doñana National Park by effecting 4 nest visits per year throughout the breeding cycle. This paper aims to determine whether the cessation of human pressure and the protection of the park have affected the defence behaviour of the Spanish Imperial Eagle.

METHODS

Observations were made while visiting the nest to determine clutch size, hatching rate and the number of fledglings. Only those nests containing eggs or chicks were taken into account. The visits were carried out by 2-3 people. These visits involved one person climbing to the nest. During the visit the distance at which the two adults remained and their defence response, i.e. whether or not they attacked, as well as the breeding stage were recorded. The proximity of the eagles has been divided into three groups: less than 20 m, 21-50 m, and more than 50 m.

The analysis of the data is done with the NAG programm Generalised Linear Interactive Modelling system (GLIM), using a Poisson regression (Royal Statistical Society 1985).

RESULTS

During this twelve-year study, a total of 403 nest visits were made (approximately 4 visits to 7-10 pairs per year). In 170 occasions data of valid observations were obtained. From these, the distance at which the parents remained throughout the visit was calculated. The results of the 170 valid

Table 1. Number of nest visits and distances maintained by the Spanish Imperial Eagles during the visits, grouped according to reproductive stage and in three years periods.

Distance	Years	Eggs	Chicks	Fledglings	Total
>50 m	1977-79	10	10	9	29
	1980-82	6	5	3	14
	1983-85	11	8	5	24
	1986-88	11	5	3	19
	Total	38	28	20	86
21-50 m	1977-79	0	1	1	2
	1980-82	1	5	3	9
	1983-85	2	7	6	15
	1986-88	2	15	12	29
	Total	5	28	22	55
<20 m	1977-79	0	0	1	1
	1980-82	0	1	2	3
	1983-85	1	2	5	8
	1986-88	2	5	10	17
	Total	3	8	18	29
Total		46	64	60	170

Table 2. Summary of interactions among the factors distance (D), year (Y) and breeding stage (S).

Factors	two factor effect			linear interaction		
	G^2	df	p	G^2	df	p
D-Y	38.58	6	<0.001	29.79	1	<0.001
D-S	35.32	4	<0.001	25.84	1	<0.001
Y-S	3.15	6	>0.5	1.81	1	>0.1

Table 3. Number of attacks against man by the Spanish Imperial Eagles during nest visits (E when eggs, C when chicks, Fl when fledglings).

Years	E	C	Fl
1977-79	0	0	0
1980-82	0	1	0
1983-85	0	0	0
1986-88	1	3	8

observations are grouped according to breeding stage and divided into three-year periods (Table 1). A greater proximity of the adults, which is observed as the breeding cycle advances, has proven to be highly significant (Table 2). There is also a rise in the number of attacks. A very significant increase in the adults proximity throughout the years has been noted (Table 2). In addition, the number of direct attacks against observers has risen over the years. The first occurred in 1981; there were three in 1986, three in 1987 and six in 1988 (Table 3). The differences in attack frequencies between years are highly significant ($\chi^2 = 29.0$, $df = 3$, $p < 0.001$). The proportions of visits over the years in the three different stages of the breeding cycle was similar (Table 2).

DISCUSSION

A marked rise in nest defence as the breeding cycle advances has been observed in several bird species (Espirino 1968, Barash 1975, Curio 1975, Andersson *et al.* 1980, Greig-Smith 1980, Biermann & Robertson 1981, East 1981, Blancher & Robertson 1982, Röell & Bossema 1982, Merritt 1984). This behav-

our has been interpreted in two ways: firstly, in accordance with the hypothesis that the greater the progenitor investment, the greater the nest defence demonstrated (Barash 1975, Andersson *et al.* 1980, Biermann & Robertson 1981) as an extension of Triver's concept of parental investment (Trivers 1974) and, more recently as a behaviour learned by those parents whose nests were visited various times. In this case, the defence behaviour against the supposed predatory attack was reinforced being that the offspring were unharmed (Knight & Temple 1986).

Our data show a rise in nest defence as the breeding cycle progresses. A decrease in distances from the observers and an increase in the frequency of attacks. Nevertheless, it is impossible to distinguish between the two hypotheses since each nest was visited on at least three occasions during the same reproductive period.

The rise in nest defence over the years, however, cannot be predicted by the hypothesis of greater parental investment. In our opinion, this increase can be attributed to experienced adults whose defence behaviour has been positively reinforced upon not losing their offspring after a hypothetical predatory attack.

Theoretically, it is possible that there were highly aggressive adults whose nest defence including direct attacks against man, fell within the normal range of defence behaviour. In this case, these individuals would be the ones most likely to be eliminated under strong human persecution (a target less than 20 meters away is an easy shot). This could explain that there are no accounts of large raptors striking humans in densely populated areas.

With the creation of the scientific reserve and the declaration of Doñana as a national park shortly afterwards, selective pressure against defensive conduct disappeared. From this point onward, not only were those individuals displaying strong defensive tendencies not eliminated, but their behaviour was vigorously reinforced each year by multiple non-destructive nest visits. This change in selective pressure, coupled with the fact that the Spanish Imperial Eagle is a raptor possessing a long

reproductive life, has facilitated the increase in defence behaviour and the occurrence of direct human attacks.

Other explanation for the increase in nest defence over the years could be that as result of relaxed persecution the mean age of the breeding population in the park had increased. If nest defence behaviour is related to age, independent of experience, effects of age and experience could not be distinguished. Nevertheless, the existing data support the claim that the Doñana Imperial Eagle population remained stable in age structure for at least the past 10 years (Ferrer & Calderón 1990).

It is also possible that the highly defensive attitude of one member of the pair reinforces the behaviour of the other. The only case of adult male aggression recorded was in a pair whose female had been carrying out attacks for three years. In this male, a rapid decrease in the distance from the research workers leading to direct attacks was observed. Taking into account that the replacement rate of this population is low, it is highly improbable that the two members of the pair would be replaced at the same time. Thus, this could have had an influence on the rapid increase in defence recorded.

In conclusion, we can predict that the defensive behaviour and, in particular, direct attacks against man will carry on increasing in the following years if the numerous nest visits are continued. In addition, it is expected that similar rise would be observed in any other scientific reserve where human pressure formerly existed.

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- * Editorial note: many handbooks (cf. Cramp, S. & K.E.L. Simmons (eds.) 1980. *The birds of the western Palearctic*, Vol. II. Oxford University Press, Oxford.) still refer to the Spanish Imperial Eagle as the Iberian race, *Aquila heliaca adalberti*, of the Imperial Eagle.

SAMENVATTING

Dit artikel gaat over het nestverdedigingsgedrag van de Spaanse Keizerarend (door sommige beschouwd als aparte soort). In dit gedrag traden veranderingen op nadat de Coto de Doñana in ZW Spanje tot een nationaal park werd verklaard (gedeeltelijk in 1965, in 1974 tot huidige oppervlakte) en sterke vervolging ophield.

De afstand waarop de Keizerarenden tijdens een bezoek aan het nest zich ophielden nam gemiddeld af en het aantal aanvallen nam toe tussen 1977 en 1988. De frequentie van aanvallen neemt ook toe in de loop van het voorplantingsseizoen.

De toegenomen neiging tot nestverdediging in de 12 onderzoekjaren wordt geïnterpreteerd als aangeleerd gedrag. De volwassen arenden zijn gedurende een lange periode van hun leven geslachterijp. Talrijke, niet meer fatale nestbezoeken (voor onderzoek) door de mens versterken het defensief gedrag. - HWdN.