

# Clutch size, nestling aggression and breeding success of the Spanish Imperial Eagle



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**T**he Spanish Imperial Eagle *Aquila (heliaca) adalberti*, which was ranked as a distinct species by Hiraldo *et al.* (1976), is the only European raptor classed as 'endangered' in the ICBP Red Data Book (King 1981) and by the World Working Group on Birds of Prey (Meyburg 1986). Its productivity, an important parameter in assessing the capacity for survival of any threatened species, is little known; moreover, the data in the literature are derived almost exclusively from the Coto Doñana region (Valverde 1960a, b; Vielliard 1974), which is not typical habitat for this eagle. Elsewhere in Spain, Suetens & van Groenendael (1971) studied a single pair in the Extremadura, and Veiga *et al.* (1984) studied three pairs in the Sierra de Guadarrama. The present paper presents results from ten years of fieldwork in Western and Central Spain.

## Methods

On 12 visits totalling ten months between 1970 and 1980, I monitored 14 nest sites and checked a total of 60 broods. Altogether, over 700 hours' systematic watching was kept on the nests, either from a nearby hide or from a greater distance. Whereas the breeding success of many pairs could be followed over consecutive years, this was not always possible. Several nest sites were destroyed by clearance of the cork oak *Quercus suber* woods and replanting with eucalyptus and pine; other nests were abandoned for various reasons or were no longer present. The range and preferred habitat of the Imperial Eagle in Spain have already been described (Meyburg 1975,

1976; Meyburg & Meyburg 1978). Previously published data on the species' breeding behaviour (Meyburg 1975) from the same study do not include clutch size, nestling aggression or breeding success.

## Results

### *Clutch size and hatching success*

Of 35 clutches, the mean size was 2.6 eggs (seven clutches of one, seven of two, 16 of three and five of four). An average of 2.4 chicks hatched from 33 successful broods (ten of one, four of two, 14 of three and five of four). In four cases where only one egg was laid, this was infertile or the embryo died.

Tables 1, 2 and 3 give the figures for clutch size and hatching and fledging success for those ten nests/territories where nests were found in more than one breeding season. In three-egg clutches, the first two nestlings often hatched on the same day and the third about four days later, suggesting that incubation began with the laying of the second egg.

### *Nestling aggression and nestling mortality*

In broods with more than one chick, the nestlings are very quarrelsome in the early stage during the daytime. Because the eggs hatch over several days, the youngest chick generally falls victim to the aggression of the larger ones and dies during the first weeks after hatching. With one pair (pair 1), in Cáceres Province, this aggression was studied in detail over a succession of years; incidental observations on other pairs confirmed our findings at this nest. The literature contains insufficient data on this behaviour for either the Spanish or the eastern 'form' *A. (h.) heliaca* of the Imperial Eagle (Švehlík & Meyburg 1979).

On 24th April 1971, I first climbed to the nest of pair 1, which contained three downy chicks weighing, respectively, 820 g, 780 g and 340 g; the two

152. Clutch of three eggs of Spanish Imperial Eagle *Aquila (heliaca) adalberti*, Spain, April 1979  
(B.-U. Meyburg)



**Table 1. Clutch size in territories of Spanish Imperial Eagles *Aquila (heliaca) adalberti* in which nests were found in more than one breeding season, 1971-79**

Year	TERRITORY/PAIR									
	1	2	3	4	6	7	8	9	10	
1971	3						3			
1972	3	1	1	2	2	3	3		3	
1973	3	2	2		3	4				
1974	3	2				4				
1975		1	1			4			3	
1976	3	1	1			4	1	3		
1977	2									
1978										
1979	3					3				

**Table 2. Number of eggs hatched in territories of Spanish Imperial Eagles *Aquila (heliaca) adalberti* in which nests were found in more than one breeding season, 1971-79**

Year	TERRITORY/PAIR									
	1	2	3	4	6	7	8	9	10	
1971	3									
1972	3	0	0		1	3				3
1973	3	1	2			4				3
1974	3	1				4				
1975		1	1		0	1			3	
1976	3	1	0			4	0	2	4	
1977	2	1	2	0		3		1	3	
1978										
1979	3					3				

**Table 3. Number of young fledged in territories of Spanish Imperial Eagles *Aquila (heliaca) adalberti* in which nests were found in more than one breeding season, 1970-80**

Year	TERRITORY/PAIR									
	1	2	3	4	6	7	8	9	10	
1970				0						
1971	2	0	2	1		2	0			3
1972	2	0	0	0	1	2	1			
1973	2	1	1	0	2	2				
1974	2	1	0	0		2				
1975	1	1	1	0	0	2			2	
1976	2	1	0	2		2	0	2	4	
1977	2		2			3				
1978	2					3				
1979	1									
1980	2									

larger chicks were about 20 days old, and the smallest about 16 days. Since I knew that the fledging of three young had occurred in the eastern 'form' of the Imperial Eagle, and as the third chick appeared healthy, I judged that the latter had a reasonably good chance of surviving and left it in the nest; two days later, it had disappeared. On 7th April 1972, I found two chicks each weighing 88 g in the nest, together with one egg (which I removed). Two days later, this egg hatched in an incubator and, on 11th April, the chick was placed in another nest containing only one infertile egg; it was



153. Male Spanish Imperial Eagle *Aquila (heliaca) adalberti* arriving to join female at nest with young, Spain, April 1979 (B.-U. Meyburg)

immediately accepted by its foster parents, which reared it successfully. The two chicks in the original, 'parental', nest also fledged, although the younger one suffered considerable aggression from the older (on 27th April, a greater part of the down on its back had been torn out); the third chick, had it been left to hatch in that nest, would probably not have survived the first week.

In 1973 and 1974, three chicks hatched from pair I; in each year, the youngest was removed and placed in a nest in the Doñana Reserve. In 1975, it was not possible to climb the nest; only one chick was reared to fledging and it might have killed one or even two of its siblings.

In 1976, there were again three young; on 17th April, the two larger ones each weighed 272 g, while the third weighed 175 g. During 24th-27th April,

my wife and I kept watch over the nest for a total of 31 hours from a hide in a neighbouring tree. Between 09.43 and 09.58 hours on 24th, the female was feeding her young as we approached; when we reached the nest, the two larger chicks (*a* and *b*) both had full crops, whereas the smallest (*c*) was repeatedly cheeping from hunger. At a further feed, between 12.55 and 13.22 hours, chick *c* received 57 morsels from the female, *b* received 75, while *a* took no food. At the next feed, which began at 14.47, chick *a* attacked chick *c*, which immediately retreated to the edge of the nest and no longer tried to take food; chick *b* was also unable to procure more than seven morsels as it was constantly attacked, whereas *a* consumed 45 items. At the last two feeds on that day, chick *c* managed to obtain 29 morsels, while *a* and *b* consumed somewhat less. Altogether, the smallest chick was attacked three times by the largest.

On 25th April we watched two feeds, during which totals of 81 morsels of flesh were fed to *a*, 75 to *b*, and 78 to *c*. On this date, *c* was attacked four times by *a*, but two of these occasions were provoked by its own aggressive behaviour. During the first attack, at 13.14 hours, *c* received 21 beak-blows and had down torn off its back. During four feeds on 26th April, the largest chick consumed 186 items, the second chick 124 and the smallest chick 75; on this date, the largest chick attacked the second five times and the smallest six times.

On 27th April, a very cool and rainy day, chick *c* was obliged to spend most of the time on the rim of the nest. Its back was blood-stained from chick *a*'s beak-blows and the down had been torn away over a large area. It was attacked six times by *a*, during which it received 33 beak-blows, as well as 11 from chick *b*, which also attacked it now and then. Occasionally, both larger chicks nibbled at *c*'s bleeding back as if it were a prey item. Chick *b* was also attacked by *a* 12 times and received 48 beak-blows. At the two feeds which took place, *c* was unable to procure any food, while *a* devoured 94 morsels and *b* took 37.

During 31 hours' observation between 24th and 27th April, chick *a* attacked chick *b* 20 times and inflicted at least 63 beak-blows on it. Chick *c* was attacked by *a* 19 times and must have suffered at least 93 beak-blows, in addition to a total of 11 beak-blows from *b*. Chick *a* seized hold of *c* only twice, and chick *b* attacked *a* once. During the 12 feeds observed, the largest chick consumed at least 432 morsels of flesh, whereas *b* obtained 359 and *c* only 240. Chick *a* increased its weight during the three days by 120 g, *b* by 70 g and *c* by only 30 g, so that *a* finally weighed almost twice as much as *c*.

At 17.40 hours on 27th April, I left the hide and climbed to the nest. Chick *c* was soaked through and lying huddled on its back, while *a* was raining blows on it. Since, in my view, it had no chance of surviving the night, I removed it from the nest; it soon recovered in an incubator, and on the following day was placed in another nest containing only one chick of the same size.

In 1977, for the first time, we found only two eggs in the nest of pair *I*. On 14th April, the two chicks weighed 82 g and 88 g respectively; the smaller one had only recently hatched, since there were still pieces of eggshell in the nest. On 19th and 20th, we watched from a hide for an unbroken period of

12 hours: during four feeds, both chicks procured a substantial amount of food; we saw them attack each other on six occasions, on some of which the smaller chick was the aggressor. Both young subsequently fledged.

In 1978, we could establish only that two young fledged. In 1979, between 19th and 27th April, observations were again made over a period of 40 hours from a hide in a nearby tree. On 15th April, the three chicks weighed 206 g, 166 g and 104 g respectively. The largest chick was exceedingly aggressive towards the other two. On 19th, it attacked the second largest 15 times and the smallest eight times; and, during feeds, it devoured over 46 morsels of flesh, whereas the second largest obtained only about 20 and the smallest only four. On 21st April, the chicks weighed 430 g, 250 g and 110 g respectively. On this day, the second largest chick suffered about 20 beak-blows from the largest and the smallest received three beak-blows from the largest and one from the second largest; in order to evade these attacks, both chicks retreated even farther to the rim of the nest, where as a rule they were not offered any food by the female. It was usually enough for the largest chick to threaten attack by raising its head to its full height for both smaller ones to be cowed. Frequently, the dominant chick not only struck with its beak, but would also tug and tear at its subordinate's down with vigorous head-shaking, and would even repeatedly pick up the smallest chick by its head and shake it, let it drop and pick it up again. The largest nestling demonstrated this behaviour not only at feeding times or when hungry, but also when its crop was full.

On 23rd April, the smallest chick procured 20 morsels at one feed, after

154. Such broods of four Spanish Imperial Eagles *Aquila (heliaca) adalberti* are not infrequent: Spain, April 1973 (B.-U. Meyburg)





155. Pair of Spanish Imperial Eagles *Aquila (heliaca) adalberti* at nest with young, Spain, April 1979 (B.-U. Meyburg)

the largest chick, fully satiated, had fallen asleep. Still diminutive in comparison with the other two, the smallest chick was now faced with an additional problem in that it was often offered morsels that were too large for it to swallow: the parents had adapted their feeding to the larger and more adept chicks. At a further feed, 49 items were offered to one of the smaller chicks (unfortunately, the male parent hid the young from view, so that we could not establish which of the two received the food).

On 25th April, during the only feed observed, when the female was standing in front of her chicks, probably neither of the smaller chicks received food. On this day, the smallest chick had to endure over 115 beak-blows from the largest: once again, it was seized by the head or wing, lifted up and shaken, then dropped, picked up again and so on. At 17.00 hours, when I climbed to the nest, it lay dead and flattened, still warm, in the bowl of the nest; it weighed 100 g, while the two larger chicks weighed 750 g and 290 g respectively. On the following day, the dead chick was attacked five times with beak-blows by the largest chick, which on one occasion picked it up and shook it as before for a period of ten minutes; on another occasion, the second largest chick was attacked by the largest 11 times in seven minutes, and was forced to spend most of the time completely intimidated on the rim of the nest. During the only feed observed (17.42-18.25 hours), the largest chick consumed 103 morsels while the other obtained none. At 16.45 hours, the female grasped the dead chick in order



156. Spanish Imperial Eagles *Aquila (heliaca) adalberti*. Spain, April 1979: oldest nestling lives youngest by its head, while second-oldest flees to edge of nest, watched by adult female (B.-U. Meyburg)

to feed it, plucked something to offer it, but the largest chick snatched this away and again vented its aggression on the dead chick. At 17.03 and 18.25 hours, the female again grasped the dead chick, but released it both times. I had the impression that the female now had an 'inhibition' towards feeding the dead chick, a phenomenon which I first observed among eagle species when watching the nest of a Lesser Spotted Eagle *A. pomarina* (Meyburg 1974).

On 27th April, during a day-long watch from the hide, I could see only the largest chick. That evening, when I climbed to the nest, the dead chick has disappeared and the second chick now lay dead, out of my reach, on the rim of the nest. The sole survivor weighed 900 g. This is, to my knowledge, the first direct observation of one eagle chick killing both its siblings.

During the grand total of eight feeds observed, the largest chick took at least 305 morsels, the second largest 21, and the smallest 76. During the 40 hours' observation, the second largest chick was attacked 45 times by the largest and received at least 77 beak-blows. Up to the time of its death, the smallest was attacked 21 times by the largest and received at least 152 pecks, the fewer number of attacks on it being accounted for by the fact that it had most often retreated out of reach to the rim of the nest; at the time of its death, it weighed 7.5 times less than the largest chick.

Among other *Aquila* species, in particular Lesser Spotted Eagle,



157. Spanish Imperial Eagle *Aquila (heliaca) adalberti*, Spain, April 1979: oldest nestling killing youngest; second-oldest has now retreated over rim of nest. towards right (B.-U. Meyburg)

Verreaux's Eagle *A. verreauxii* and Spotted Eagle *A. clanga*, the number of young is regularly reduced from two to one by 'Cainism' soon after hatching, irrespective of food supply (Meyburg 1974, 1978, Gargett 1977, 1982), to which the hypothesis of Skutch (1967) of 'readjusted reproduction' corresponds. The Spanish Imperial Eagle, however, reflects Lack's (1947) theory of 'maximum reproduction' (unpredictable food shortage leading to adaptive brood reduction). Usually, more young hatch than are reared, and the difference in their sizes caused by asynchronous hatching results in only those chicks for which adequate food is available being reared.

#### *Breeding success*

Altogether, the results of 57 breeding attempts were recorded. Of these, 39 (72.2%) succeeded in fledging at least one young. In all, 71 young fledged: an average of 1.8 per successful attempt (12 of one, 23 of two, three of three and one of four), corresponding to 1.3 young fledged per breeding pair per year. It is notable that there was no evidence that any pair which occupied a territory failed to attempt breeding.

Only in three cases was it not possible to check breeding results: pair 9 (which hatched one young in 1977), pair 7 (which hatched three in 1979), and pair 10 (which hatched three in 1973). The fact that these three pairs bred successfully in all other years of the study leads one to assume that in these years, too, they were successful.

An additional five young may have been reared by pair 7, which hatched three chicks in 1972 and four in each of the four years 1973-76. Since the

rearing of three young was, however, unknown for the Spanish Imperial Eagle, it was feared that not all the chicks in one nest would have survived; only two chicks, therefore, were left in the nest in each case, the remainder being transferred to other nests, chiefly in the Coto Doñana. In 1977 and 1978, and possibly also in the following years, this pair reared three young. Nevertheless, it seems extremely unlikely that all four young would regularly have been reared to fledging; the only such possible occurrence, veith another pair, has not been fully confirmed, since the final check was made a relatively long time before fledging.

When analysing these results, no account was taken of those last-hatched chicks which fledged from nests containing only one infertile egg and to which they had been transferred. This method, whereby the rate of reproduction can be increased, has already been described (Meyburg 1978). In one case (pair 4, 1973), moreover, a chick from pair 7 which was placed in a nest that had been robbed some 14 days earlier was successfully reared.



158. Female Spanish Imperial Eagle *Aquila (heliaca) adalberti* with only surviving (oldest) nestling which had killed both its siblings, Spain, April 1979 (B.-U. Meyburg)

The causes of failure of the 15 unsuccessful breeding attempts were as follows: five nests were robbed by human beings; in four, the eggs were infertile; in three, the nest collapsed; and in one, a female in juvenile plumage abandoned her eggs. In two other cases, cause of failure was unknown.

### Discussion

Until recently, the Marismas of Guadalquivir ranked with the Coto Doñana as the largest secure area of habitat for this species, ensuring the



159. Some pairs of Spanish Imperial Eagles *Aquila (heliaca) adalberti* regularly fledge three young: three well-grown nestlings, Spain, June 1977 (B.-U. Meyburg)

birds' survival. This concept must now be revised in view of the threat to this region, but more particularly since the discovery of a considerably larger population in other parts of Spain. Also, the contention that the Spanish Imperial Eagle has a lower reproductive capacity than the eastern 'form' *A. (h.) heliaca* (Géroudet 1979) can no longer be upheld in the light of data presented here. The earlier view was based on observations by Valverde (1960a, b) on seven pairs in the Marismas, where an average of only 0.75 young per pair per year fledged; in one year, however, three pairs built no nest at all, in another three pairs occupied nests but failed to lay, and three clutches were infertile. Failure to breed in many years, which Vielliard (1974) also confirmed for three pairs in the Coto Doñana in 1964, contrasts strikingly with the results which I obtained in Western Spain. In two of the cases reported by Vielliard (1974), however, failure was attributed to human disturbance, while the third pair had become too old and infertile. In Western Spain, the territory kept under the longest period of unbroken observation (pair 1), over ten consecutive years, produced 18 young (eight broods of two, and two of one) (table 3).

Although the Coto Doñana offers ideal conditions for study of the species, no new encouraging data have emerged since the creation of the Reserve in 1964, which, as Vielliard (1974) stated, is disappointing. In 1973, for instance, 13 eggs were laid in six nests, from which only four chicks hatched. In the same year, in Western Spain, also in six nests, 17 eggs were laid from which 16 chicks hatched (Meyburg & Garzon Heydt 1973). In 1972 and 1974, in the Coto Doñana, one of five nests contained, respectively, two and four addled eggs, and a further nest fell down.

Whether breeding success in past years was really so much lower in the Marismas than in Central Spain remains open to question. In 1962, Vielliard (1974) recorded a breeding success of 1.3 young per pair, which corresponds quite closely with the average for Central Spain, and in his opinion this should have been normal before the creation of the Reserve. This region is not a typical habitat for the species, and is probably also suboptimal. A population of the eastern 'form' of Imperial Eagle, on the edge of its range in southern Slovakia, had a breeding rate of 0.76 young per breeding pair per year (Švehlik & Meyburg 1979), slightly above that in the Marismas.

One remarkable fact is the consistency of breeding success or failure, respectively, in individual territories of Spanish Imperial Eagles in Central Spain. According to local inhabitants, most of the nest sites have been occupied since living memory, and pairs 1 and 7, for example, also bred successfully before the time of my studies. A decisive factor in this is not only the plentiful supply of food, but also the protection enjoyed by these pairs on the extensive private estates in this region. This breeding success should not, for all that, obscure the fact that changes can easily take place in these circumstances which could bring about the disappearance of many pairs/territories within a short space of time. This has occurred in Portugal, where the agrarian reforms of 1974-75 led to the extermination of the whole population of 15-20 pairs (L. Palma *in litt.*).

At least two of the former resident pairs in Central Spain which we checked (pairs 2 and 6) were driven away during the period of our study by the clearance of the cork oaks and replanting with eucalyptus and pine. Pair 3 bred in an area already planted with eucalyptus. All breeding attempts in these trees repeatedly came to grief through the collapse of the nests. Pair 4 ultimately bred near a road, and their nest was constantly robbed.

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### Summary

During 1970-80, clutch size, nestling aggression and resultant nestling mortality, and breeding success of the Spanish Imperial Eagle *Aquila (heliaca) adalberti* were studied in Extremadura

and neighbouring regions of Western Spain. The number of eggs per clutch and the number of young fledged varied between one and four, with remarkable consistency shown by most pairs over several years. Whereas two pairs regularly laid only one or two eggs and frequently failed to rear young, others laid three or four eggs every year and reared two or three (even four) young. There was no evidence for any pair which occupied a territory not attempting to breed. Nestling aggression considerably reduced the number of chicks during the first weeks after hatching; this phenomenon was previously not known for the Spanish Imperial Eagle. In broods with several nestlings, aggression by older chicks almost always led to the death of the last-hatched; in one instance, the way in which the oldest chick killed first the youngest and, two days later, the remaining chick was observed in detail. Whereas, among some other *Aquila* eagles, nestling aggression (or 'Cainism') almost invariably leads to the death of the second chick independently of the food supply, with the Spanish Imperial Eagle food supply does have an influence on nestling survival.

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