The Spanish Imperial Eagle Aquila (heliaca) adalberti: its Biology, Status and Conservation

B.-U. Meyburg

ABSTRACT

The present paper summarizes results from ten years of fieldwork I carried out in Western and Central Spain as well as publications by various other authors. This eagle is the only European raptor to be regarded as 'endangered' (King 1981, Meyburg 1986).

INTRODUCTION

During the 1970s I was able to make a detailed study of this magnificent bird in Extremadura and neighbouring regions. I visited this area twelve times to study raptors over periods totalling ten months in all, during which I came to know this bird intimately, spending over 700 hours keeping watch on different nests from a hide or from nearby, not to mention the many hours spent searching for nest sites or making a census.

EARLY HISTORY

This species was first known to science and its taxonomy established only rather recently: in 1860 Pastor Dr. Ludwig Brehm (1861) described it from three specimens procured by his son, Dr. Reinhold Brehm, in honour of whose patron, Prince Adalbert of Bavaria, it was given the scientific name of *Aquila adalberti*. Brehm, however, only knew the reddish-yellow to -brown juvenile plumage, and it was not until ten years later that the adult plumage became known. For a long time thereafter the bird was aptly named the White-shouldered Eagle.

Although, following this first description, several authors questioned whether the bird was a new species (e.g. Rudolf von Österreich 1879) and it was frequently mistaken for a Tawny or Steppe Eagle, Brehm's view that it was a separate species from the eastern Imperial Eagle was generally accepted, and Dresser (1872) accordingly proposed the scientific name of *A. leucolena*. This view persisted until Hartert (1914) classified it, on the grounds of its similarity in adult plumage, as a race of the Imperial Eagle *A. heliaca*, which occurs from Slovakia to Lake Baikal. All authors since then accepted this attribution, although no further adequate research had taken place.

Then, a few years ago, three Spanish ornithologists undertook a critical comparison of 220 skins of both forms in various European museums, which led them to conclude that they were in fact two distinct species (Hiraldo *et al.* 1976). A decisive factor was the marked differences in their juvenile plumage.

It is presumed that the Iberian form became isolated from the eastern population during the Ice Age, during which the birds of the three great peninsulas along the Mediterranean were forced apart (Mountfort & Hosking 1965). After the end of the Ice Age, when it was probably warmer than today, the nominate form spread north as far as Leningrad.

PAST AND PRESENT DISTRIBUTION AND NUMBERS

Over a century ago the Spanish Imperial Eagle occurred over a major part of the Iberian peninsula and south through Morocco and Algeria as far as the Atlas mountains. Up to around 1920 sporadic occurrences in North Africa were by no means exceptional (Vaucher 1915). Since then it no longer survives on that continent (Ledant *et al.* 1981, Thévenot *et al.* 1982, Bergier 1987). True, birds have again been observed in Morocco, but these were only single individuals which had crossed the Straits of Gibraltar from Spain to winter there.

A study in Morocco in the spring of 1975 concluded that there was now no available suitable habitat left for these birds and that the species was extinct as a breeder (Mills 1976). In Algeria the eagle was clearly already rare by the middle of the last century. The British Museum has only two clutches from that country, collected on Mt. Edaugh in 1855 and in the Zeid forest in 1857 (M. Walters pers. comm.). More recently, there have been only very few sightings reported from Algeria (Ledant *et al.*).

The situation in Portugal is also very poor. Until recently there were practically no concrete data from that country. L. Palma (pers. comm. 1982) states that up to 1974/75 there were still approximately 15-20 breeding pairs. Agrarian reform, however, resulted in the abolition of private game preserves and the number of hunters increased enormously. In addition, much forest was cut down. There has been no clear evidence of breeding in recent years, although one solitary nest appears to have been active (Frazao 1984, Palma 1985, Rufino *et al.* 1985, Palma & Onofre 1986). Responsibility for the survival of this beautiful bird therefore lies almost entirely in the hands of the Spanish.

Until quite recently, its distribution and numbers in Spain were very little known. Even Valverde (1967), in his time regarded as the most knowledgeable ornithologist, could write: "Outside the Marismas of Guadalquivir, breeding is recorded only from El Pardo, the Sierra de Guadarrama and one specific part of the Tajo Valley." Accordingly the Coto de Dōnana was for many years regarded as the bird's principal refuge. Then, in the early 1970s, together with Spanish friends, we succeeded in locating around a dozen breeding pairs in the Extremadura and the Montes de Toledo.

Formerly the species must have been much more widespread in Spain, and also more numerous in its present-day range. Irby (1895) wrote that the population had markedly declined between 1869 and 1894, mainly due to collectors. Today it is other factors which threaten the bird's long-term survival: chief among these is the so-called "repoblación forestal" ("reafforestation") with eucalyptus and pine. This is not done on treeless waste land but is replacing the few remaining forests of typical Mediterranean cork and holm oaks, a measure to which the Spanish national Institute for Nature Conservation (ICONA) subscribes, improbable as this may seem (Meyburg 1976). This wholesale destruction of the habitat not only deprives the tree-nesting Spanish Imperial Eagle of its breeding sites, but also the entire typical Mediterranean flora and fauna are suffering severe damage. Further reasons for the decline are direct persecution by illegal shooting, collision with high-tension cables, illegal robbing of eggs and young and poisoning by strychnine and poisoned eggs put out for foxes in nature reserves. A further factor must be pesticides: concentrations of up to 19.9 ppm have been found in eggs. Finally, the decimation of rabbits through myxomatosis must also have played a part in the species' decline, since rabbits form the basic diet of this eagle. A population census was conducted at national level between 1981 and 1986 (Garzón et al. 1984, Veiga et al. 1984, González et al. 1987). 104 breeding pairs were located, and in 92 cases breeding was confirmed. 32% of these breeding pairs inhabit the mountains of Toledo and Extremadura, whilst 27% are concentrated in three areas totalling only 1,050 km², namely El Pardo (Madrid

Province), the Nature Park of Monfragüe (Cáceres) and the Dõnana National Park (Huelva). A previous census carried out in the 1970s and less complete had located 39 pairs and estimated the total population to be 50 pairs. The total population is thought to have increased by around 50% since then.



During the past ten years the eagle's geographical distribution has remained practically unchanged. Occupied nests were plotted on 44 squares (each representing a map 1:50,000). In ten others, nesting was considered probable and in only three was the presence of isolated individuals noted. From five squares which had contained pairs at the start of the 1970s, these birds had now disappeared. The species' range has shrunk in the north-east and the west. It has been impossible to find any breeding pair in Portugal. In 1983 birds were observed in only two squares during research work for the "Atlas of Breeding Birds in Portugal" (Frazao 1984).

The overall range is therefore very small. Only 5% of the squares on Spanish territory are occupied. The factors governing this reduced range and low numbers are habitat destruction and persecution past and present. The most critical period for the species was between 1950 and 1980, when the threat of extinction seemed imminent. To-day it is certainly possible to view the situation of the Spanish Imperial Eagle with greater optimism. The increase in the population is also confirmed in the three well-studied areas (El Pardo, Monfragüe and Dõnana), where 19 pairs were counted in 1972-74 and to-day there are 30. All the new pairs have established themselves within the known range, most often in the immediate neighbourhood of the main nesting areas. 22% of all pairs inhabit protected zones and it would be highly desirable for this proportion to increase to 50%. To this end, a number of "critical habitats" are being designated, that is to say areas where there is a high density of pairs and where the habitat is still well preserved but remains unprotected. Four of these areas comprise 40,000, 15,000, 25,000 and 35,000 ha respectively.

One task of urgent priority is also to reduce the high mortality rate among juveniles in their wintering quarters. These unfortunately lie in parts of Spain where hunting pressure is greatest. Four of these regions have been identified: in the north of the province of Toledo, the south-east of the province of Badajoz, the south-east of the province of Ciudad Real and the east and south-east of the province of Cadiz.

The principal pray of the Imperial Eagle is the rabbit, whose numbers have been decimated by myxomatosis, so a reintroduction programme would also help. One such programme has already been started at Monfragüe.

BREEDING BIOLOGY

Breeding in Immature Plumage

Spanish Imperial Eagle pairs spend the whole year in the neighbourhood of their nest, whilst the young disperse in all directions after reaching independence. Occasionally an immature may also be seen in spring near an active nest. On such occasions I never observed any sign of aggression on the part of the adults. Now and then a bird in juvenile plumage will take a mate and breed. I observed such a case in 1975, when a still very light-coloured female was incubating two eggs. The male in question was in adult plumage. Unfortunately, after a time this nest was abandoned. Suetens and Van Groenendael (1971) photographed and studied one such pair, which succeeded in rearing young. Cases of mixed pairs are also known from the Marismas of Guadalquivir. This is most likely due to the lack of unmated adults in the population.

Attainment of Adult Plumage

In one case I was able to study the plumage development of a bird illegally taken from the nest in 1971 and kept captive in Cáceres: when I first saw this bird in the spring of 1972 it was in the typical tawny juvenile plumage. The following year this became slightly darker, the upper side of the wing being dotted with small, darker feathers. When four years old the plumage was heavily speckled, with light and dark feathers on belly, breast and back. White feathers were already showing on the lesser upper wing-coverts but still lacking on the shoulders ('braces' around mantle). A year later the bird was virtually in full adult plumage, with just a few pale feathers still showing on belly, legs and back, and the band of golden-yellow running from above the eye to the nape was not yet fully developed. At the age of six, the bird was finally in full adult plumage with conspicuous white leading edges to inner forewing and noticeable 'braces' on sides of mantle.

The Breeding Biotope

Like its eastern relative, the Spanish Imperial Eagle nests only in trees, and depends on mature stands of these. The birds nest predominantly in cork oaks – *Quercus ruber*, but will also adopt other trees so long as they provide a good view of their surroundings and easy access to and from the nest. Most frequently in Central Spain nests are found in stands of primeval cork oaks interspersed with holm and Lusitanian oaks, with an often barely penetrable undergrowth of *Cistus, Phillyrea, Erica, Arbutus*, etc. 200-300m up on the plateau (ca. 400-600m a.s.l.) projecting from the mountain range. These forests, rich in game and for the most part undisturbed, are, apart from cork extraction, generally only used as hunting preserves and known traditionally as "mancha". More rarely nests are found on the gently undulating plain with dense scrub and scattered trees. Such plains in general are typified by the "dehesa", which above all serves as pasture. Here the ground is covered with grasses or maquis. For the most part there are rather widely spaced-out stands of evergreen oaks whose acorns provide pig-food in autumn. Every ten or twelve years the ground between these scattered oaks is ploughed up and sown with wheat or barley. These strips make an important hunting ground for the Imperial Eagle and almost all other birds of prey as well.

A pair of eagles usually has from two to four nests 0.1 to 2-3 km apart and between which they alternate, although one nest may often be used three or four years in succession.

The Pre-Egg-Laying Period

In February and March 1975 I spent over 128 hours observing the behaviour of one pair(Pair No. 1). Whereas in the previous year this pair had already proceeded to egg-laying on 22 February, in 1975 this only began on 8 March. Most other pairs also produce eggs during the first half of March.

By mid-February the building of the new nest was already completed. We do not know how much time is spent on this and whether, as for example with the Sea Eagle, nest repairs are begun in the autumn of the previous year. During the last three weeks before egg-laying I saw green sprigs brought to the nest only nine times, six of these by the female. To give an idea of the nest size, the one used by this pair in 1971 measured 160 x 130 cm and was 85 cm deep, situated 8 m above the ground; the tree (a cork oak) was 54 cm in diameter at ground level and 13 cm immediately below the nest.

In the first days of March the female began to spend more time at the nest and passed a total of over four hours in a brooding position in it. It has been observed in other birds of prey that during the last days leading up to egg-laying they already spend much time in this position.

Whereas in many other raptor species the female, prior to egg-laying, is already regularly supplied with prey by the male and no longer hunts herself, this was not the case with the pair under observation. The female regularly flew off to hunt and was only once fed by the male.

Prior to egg-laying I saw 13 copulations, with up to four on one day, but none on eight other days. Two of these took place on the nest, two others close by it and the remainder on a crest of the mountain 200-400m above the nest. Mating was preceded only on two occasions by a typical circling courtship flight. Once both birds flew round together for about five minutes, after which the female settled in a tree on the crest, and the male flew down directly onto her back. In each case when mating took place on the crest, the male swooped down on the female in a steep dive with half-closed wings and outstretched talons from a great height (50m or more), first braking sharply and then landing mostly directly on her back. The actual mating lasted between 6 and 10 seconds. The male flapped his wings violently to maintain his balance on the female. Very characteristic were the deep, hoarse cries frequently given three times in succession during the mating on several occasions. Mating continues to occur after the eggs are laid, and I even saw it after the young had hatched and photographed it at the nest.

Prior to egg-laying the male spent 3.2% of the time it was observed at the nest, 62% perched nearby and 34.8% flying. The female spent 17.3% of the time flying round, 30.8% on the nest and 51.9% perched close to it.

Incubation

During incubation of the eggs I could undertake only few observations as compared with all other phases of the breeding cycle, namely only 19 hours altogether spread over three days. The interesting data we established need further confirmation: compared with almost all other species of the genus *Aquila*, the male played a considerable part in the incubation and did not feed the female. Whilst he took his turn at brooding the eggs, the female procured her own food. The eggs were not incubated during 2.7% of the total period of observation. The intervals between incubating shifts ranged from seven minutes to five hours.

Hatching

The hatching process in four observed instances lasted about two days. The chicks could open their eyes very shortly after and weighed between 78 and 84g. When a clutch consists of three or four eggs, there is an interval of up to three days between the second, third and fourth egg's hatching, whereas the first two chicks hatch almost simultaneously, indicating that incubation begins after the second egg is laid. In Central Spain hatching occurs between early April and early May.

Rearing the Young

I kept watch for several hundred hours at various nests during the nestling period. The most remarkable aspect is the share the male takes in rearing the young. He not only feeds them regularly - some of the time jointly with the female - but also on occasion broods them. This is never, or at most very rarely, seen with other eagle species. One joint feeding of two 60-day-old young lasted for 33 minutes, with each parent feeding one of them. Throughout another instance, lasting for 35 minutes, the female shielded the nestlings almost constantly, with only the heads of the young protruding from her warm feathers. This was in fact the longest joint feeding by the parents observed during 174 hours' observation of Pair No. 1 during the second half of the nestling period: on average, feedings lasted barely 15 minutes, and took place 1.5 times on each day of observation.

Up to the time of fledging, prey were pretty regularly torn up and fed to the young in small pieces, even when these were quite capable of feeding themselves. This was true for two-thirds of the days spent observing Pair No. 1 during the second half of the nestling period. At this time prev were brought to the nest on average 2.2 times per day, i.e. every five hours. The parents would arrive with prev at any time between 7.38 and 20.04 hrs, but most frequently between 9 and 10 a.m. and 5 and 6 p.m. At most they brought prev four times per day, but once seven times during one day's observation. On two occasions I saw the parents arrive simultaneously with prey, in one instance a mammal and a lizard respectively. Indeed the female occasionally flew off hunting when the young were only two weeks old, but prev were predominantly brought by the male, whilst the female remained at the nest or close by. On 16 May 1971, for example, when the young were around 42 days old, I had her in view for nearly 60% of the time; 27.3% of this time she spent on the nest, 34.3% perched nearby and 18.4% flying. On that same day I had the male in view 30.3% of the time, of which he spent 35.3% flying or perched near the nest, the remaining 29.4% at the nest. On many days the male spent longer at the nest than the female, as, for instance, one hour and 47 minutes on 2 May 1975. The chicks were mostly brooded, during the day, betweeen 60% and 71% of the time during the first week after hatching, after which this percentage rapidly decreased, depending on the weather. Whilst the young were soon left exposed to the heat of the sun, the female would return virtually at once to the nest directly it began to rain, and try to cover the fast-growing young, although by now scarcely able to conceal more than their heads in her feathers. At least up to the 46th day the female spent the night in the nest.

As with other raptors, sprigs of greenery were brought to the nest throughout the nestling period, with Pair No. 1 altogether ten times during six out of 15 observation days.

In the days leading up to leaving the nest, the young would exercise their wings impressively in a way I have never seen with other eagle species: if the wind was suitable, they would spring into the air and hover flapping up to four metres above the nest. Occasionally this would last a surprising length of time, in gusty weather leading one to wonder if the birds would not be blown away. Similar flight training is only known to me with the Osprey. One determining factor is the freedom of access to and from the nest. In a nest with three full-fledged young eagles this not infrequently led to quarrels when two of the young sought to practice flying simultaneously and got in each other's way. Quite often one would then peck its sibling's head with loud and agitated cries.

Breeding Success and fostering of young

The breeding rate is an important parameter in reckoning the chances of survival of a threatened species. On 12 visits totalling ten months between 1970 and 1980, I monitored 14 nest sites and checked a total of 60 broods. 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.

35 clutches produced an average of 2.6 eggs (7x1, 7x2, 16x3 and 5x4). Out of 33 clutches, an average of 2.4 chicks hatched (10x1, 4x2, 14x3 and 5x4). In four cases when only one egg was laid, this proved to be infertile or the chick was dead in shell. The number of eggs laid and of young fledged ranged between one and four, the results obtained by each pair remaining markedly constant over 260

the years. Whereas two pairs laid only one or two eggs respectively and often failed to rear young, others laid three or even four eggs each year and reared two or three young. No pair occupying a territory has been known to fail to lay. During the first weeks, the chicks are highly aggressive towards each other, which often leads to the death of the youngest. The eldest chick has even been observed to kill, first the youngest and then, two days later, the second youngest. 39 out of 57 breeding attempts were successful. 71 young fledged, i.e. 1.8 per successful attempt (12x1, 23x2, 3x3 and 1x4). This corresponds to 1.3 young fledged per pair per year (Meyburg 1987).



The high rate of loss due to "Cainism" or fratricide (Meyburg 1974) gave birth to the idea of increasing the reproduction rate of this endangered raptor by removing chicks likely to die and placing them in other nests. Starting in 1972, I placed one chick - the youngest in a nest where the youngest of three had regularly vanished - in another nest which contained only one infertile egg. This chick condemned to die was immediately accepted and reared to fledging. In the following years this protective measure was again carried out for several pairs (Meyburg 1977, 1978a, b, Meyburg & Garzón Heydt 1975). This activity was resumed in the 1980s by a group of Spanish ornithologists (Gonzáles et al. 1986). Between 1984 and 1986, thanks to their intervention, 16 chicks from 14 nests which would otherwise have perished from fractricide were removed from their nests of origin. They comprised two second-born, twelve third-born and two fourth-born, varying in age between two and 18 days. To enable them to build up their strength, they were held in captivity for periods of up to 25 days and then placed in nests with foster-parents (in 14 cases) or put back in their own nests (in two cases). Seven of the adopted nests already contained one chick, four contained two chicks and the other three only infertile eggs. The age of the chicks ranged from 10 to 30 days. The nests in which they had been placed were regularly monitored and three of the adopted chicks were fitted with radio transmitters, in order to verify normal survival after leaving the nest. Thirteen of the 16 young adopted eagles survived without difficulty, representing a survival rate of 81.75%. Without such intervention, the parent Imperial Eagles would have lost 13 young

and would have raised only 1.0 young per successful breeding attempt. This adoption technique resulted in the fledging of 26 young, thereby achieving an average of 2.0 eaglets per successful breeding, and so doubling the reproduction rate of the controlled pairs - a result even better than that obtained by Meyburg & Garzón (1973) during the 1970s.

This technique of fostering of young raptors to increase the breeding success has afterwards been widely applied to several other raptor species. However, it was not known whether introduced young survive as well as true young after leaving the nest and after reaching independence, since an intensive tracking of the fostered young had never been carried out. Heredia *et al.* (1987) verified that two fostered young went through a normal process of transition to independence, surviving the post-fledging period and dispersing from the study area. These results show that fostering is a valuable technique in increasing the breeding success and survival rate of Spanish Imperial Eagles.

The Post-Fledging Period

Few eagle species have been adequately studied during this interesting phase of the breeding cycle, from the time of leaving the nest up to independence of the young. In the summer of 1977 my wife and I were able to make systematic observations of this stage in the course of 180 hours.

On 24 June one young eagle left the eyrie when we were still 80 m away. It flew so adroitly that this could not have been its first flight. Its sibling remained quietly in the nest. On 4 July both young had flown. In the course of just under 11 hours' observation, both of them made five flights of under 100m and two of 100-500m. They spent much time sitting on a patch of scree immediately above the nest, where they would hop clumsily from stone to stone. Only once did one of the young stray further than 100m from the nest. Prey were brought twice to the nest by the parents, which the young ate there. They most probably spent the night in the nest, since they returned to it at 16.32 and 17.43 hrs respectively and remained there up to the time observation ceased.

On 5 July, for the first time, the young which first left the nest flew up to a greater height for a short time, part of which it spent soaring. Hitherto the young eagles had confined themselves purely to guided flight. Six times during the day one of the two came to the nest, but in the main for only a few minutes, although once for 40 minutes and once for two hours.

Three days later the young had extended their activities over 500m and perched mainly on the crest above the nest. Both could now soar almost as well as their parents, and would indulge in aerial play, with the higher bird stooping on the lower and attempting to deflect it with outstretched talons, whilst the latter would turn on its back and stretch out its talons in opposition. This was observed seven times in succession. Later on the young played the same game with their parents. Both young eagles stayed remarkably close to each other, as a rule huddled together and taking wing simultaneously. During these days for the first time also, a delivery of prey occurred away from the nest, although the parents continued to bring prey there as well.

Eight days later we watched six deliveries of prey, one of these to the nest, four others to a cliffledge on the mountain crest above the nest and the last one seen, on 16 July, over 2 km from the nest down in the plain. This last was so interesting as to merit fuller description: at 17.22 hrs one young took off, glided left along the mountain slope and then with half-closed wings let itself fall in a seemingly perpendicular dive towards a spot some 2 km distant on the plain. At 18.21 hrs it was followed by its sibling, emitting repeated begging calls, to the same spot, over which the parents flew six minutes later. At 18.52 hrs both young also flew up again, one of them with a noticeably full crop, and returned to the nest area. All four birds had evidently eaten some prey at that spot, where it must have been killed. Possibly it had been too heavy to be transported by the parents. This was the first time since leaving the nest three weeks earlier that the young eagles had ventured further than 1 km from the nest.

On 26, 27 and 28 August (about 2 months after fledging) we again visited this nest site and spent altogether 17 hours of observation. Both the adult birds were present, one of them visiting the nest

for four whole minutes on one occasion. The young, however, were neither seen nor heard. In this case, therefore, the post-fledging period lasted perhaps less than ten weeks. In two further breeding territories (No. 3 and No. 7), where two and three young respectively were fledged, the young eagles were still present at the end of August. In both these cases, however, the young had left the nest two to three weeks later.

Post-fledging behaviour and dispersion of young eagles were studied in the National Park of Doñana (SW Spain) during the summer of 1984 with the aid of radiotelemetry (Alonso *et al.* 1987, Gonzales *et al.* 1985, Heredia *et al.* 1985, 1987). 11 young were wing-tagged and 10 of them were provided with solar-powered transmitters shortly before leaving the nest. During the study period (15 July-30 October) 4 young and 2 adults died. Electrocution was found to be the main cause of mortality in the Doñana area. In the early post-fledging period the eaglets stayed for 3-6 weeks in an area of 5.6-36.7 ha. close to the nest (0-1,100 m.). Their flight activity accounts for 6% of the total diurnal activity, flying only perch to perch and flapping. In the next 1-4 weeks the home range was gradually increased and soaring flights were started. At the age of 96-129 days the juveniles travelled up to 150 km, away from the nesting area, with a home range of 950-37,250 ha., staying several days outside. Final dispersion took place between 1 September and 31 October, at an age of 123-126 days. Though dispersal may occur in any direction, most of the birds showed a tendency to travel southeast, towards the Gibraltar area. The young were fed by their parents throughout the post-fledging period, with an average of 0.4 feeding per nest and day. Hunting skills were developed gradually and first kills did not take place until the end of the post-fledging period.

PREY AND HUNTING METHOD

Hitherto the diet of the Spanish Imperial Eagle had been studied virtually only in the Marismas of Guadalquivir (Valverde 1967; Delibes 1978). Our own researches in Central Spain are still in need of analysis. Up to the time of myxomatosis (autumn 1957), the rabbit formed the basic prey in the Marismas (ca. 40% - 58%). At the start of the infection's spread, rabbits were particularly easy to capture and through 1958 and 1959 formed 77% of the prey. Five years later these animals were much rarer and in the Marismas had largely been replaced by waterfowl (*Anas spp.* 30%). This is, however, an atypical biotope for the population as a whole. In the Sierra Morena and in Central Spain the eagles were compelled to switch in part to small birds, which now form between 40% and 60% of their prey and at least half of which weigh less than 200g. Rabbits here still form the most usual prey, and mammals make up 44.4% of the prey, birds 41% and reptiles 14.6%. Prey weight in 45% of cases ranges from 600 to 1,800g; larger prey (fully grown hares, bustards, geese etc.) are exceptionally taken, whereas 25% of the prey weigh less than 200g. Myxomatosis must have been responsible for a marked decline of the Spanish Imperial Eagle population.

As with most eagle species, the actual hunting is difficult to observe, and only extremely rarely does one ever see a kill. In the Extremadura I frequently saw the eagles on hunting flights. They would circle about 100m above the plain and often hang against the wind if they spotted something below. In this way they could hang practically stationary for a long time, using only the tail and wing-tips to balance themselves. In attacking prey, the wings are partly or tightly folded, so that the bird can swoop down at the requisite speed almost perpendicularly with outstretched talons. I have often seen this same hunting technique used by other members of the genus *Aquila*, e.g. Lesser Spotted and Golden Eagle. The actual strike is scarcely ever seen, the view in Extremadura being largely obscured by the oak trees scattered about the pasture-land.

On 10 July 1977 we had an excellent view of a just-killed hare or large rabbit being brought back: at 10.30 hrs the male approached the nest from around 6.5 km distant, flying laboriously between the oak trees. The four dangling legs of the still intact prey were clearly recognizable. The female flew in close attendance on the severely hampered male. A Griffon Vulture flying past was immediately attacked by her. The male's flight and silhouette were clearly changed: the tail was spread out fanwise and the wing-beats became shorter and rounder than before. The male's stretches of gliding were very brief, since it lost height very rapidly, the more so since it was struggling upwind. He therefore was constantly obliged to circle round in order to gain height. He took 35 minutes in all

to cover the 6.5 km back to the nest, making an average speed of 11 kmph. Since this arduous return flight lay roughly parallel to a country road, we were able to follow it more or less closely from our car the whole time. Any much larger prey would have been beyond the eagle's power to carry.

Often, however, the eagles only need to spend a short time hunting. Thus, for instance, on 16 May 1971, the male flew off at 9.30 a.m. and was already back with prey in 24 minutes.

In the Marismas the eagles will consume prey on the spot if it is too large to be transported. Thus a pair would frequently team up to attack Greylag Geese, generally in the following manner: Eagle A would stoop from a great height at a pack of geese on the ground, at which the latter would immediately fly up. The resulting confusion was exploited by A to grab hold of one of the geese, whilst Eagle B flew up high to repeat the same manoeuvre if possible. The stricken geese were then consumed by both together on the ground.

The weight of the Spanish Imperial Eagle's prey can thus range between 20g and over 3 kg, although under optimum conditions warmblooded vertebrates of between 600 and 1,200g are preferred.

INTERSPECIFIC BEHAVIOUR

I saw aggressive behaviour repeatedly by Pair No. 1 against the somewhat larger Golden Eagle and smaller Bonelli's Eagle. Thus on 23 February 1975, for example, I watched both birds excitedly calling 1.5 km from the nest, stooping constantly at an immature Golden Eagle, which made off as fast as it could. On 5 March 1975 the female was lying in a brooding position in the nest when she suddenly flew up and rapidly headed straight for an immature Golden Eagle about 1 km distant which at once veered off. The male, perched near the nest, took no notice. This pair displayed the same behaviour several times on the appearance of a Bonelli's Eagle; in one case the male alone reacted, whilst on other occasions both partners attacked.

There are clearly differences between individuals, in which habituation must play some part. In one area of the Tajo, where several pairs of Golden and Spanish Imperial Eagles nest, sometimes less than 1 km apart, I repeatedly saw Golden Eagles fly past an occupied Imperial Eagle's nest at a distance of less than 100m without any consequent reaction.

Smaller kinds of birds, particularly raptors, for their part regularly mob the eagle, the most persistent being jay and raven. If the latter are too importunate, the eagle will often turn the tables. Thus on 18 February 1975 I watched an Imperial Eagle in Salamanca Province violently chase a raven which had previously been molesting it and was now shrieking out in terror. Similar behaviour can occur with smaller raptor species. Thus, for example, on 13 April 1977, we saw the male of Pair No. 1, up to then peacefully brooding, suddently attack a Booted Eagle.

Against the substantially bigger Black Vulture (*Aegypius monachus*) the eagle would also frequently display aggression, even when occupied Black Vulture nests were less than 100m away. Usually these attacks were more or less playful, and the vulture would often turn on its back and extend its talons to the attacker swooping down. On other occasions I saw, on 12 April 1972 for example, how an eagle would strike at the back of a vulture for two or three seconds, producing a spray of feathers. Of special interest was an incident on 21 May 1971, when I was seated in a hide by a Black Vulture's nest containing one three-week-old young. At 17.40 hrs an immature Spanish Imperial Eagle appeared, settled about 20m above the nest, facing into the wind, and then dropped vertically down onto it with outstretched talons. The adult vulture was however waiting for this with outspread wings which it beat violently as the eagle approached. The latter ventured no nearer than 1.5m from the nest, but repeated its attack several times. After five minutes the second vulture which had been flying round all the while close by landed at the nest. Both birds stood at the nest in typical greeting posture for a full two minutes, but then suddenly flew up, possibly due to some careless movement by myself in the hide. The adult which was originally in the nest immediately realized the danger to its now unprotected young and attacked the eagle in the air. Striking viciously at each other, they drifted a few hundred metres away. The vulture then appeared to recognize the danger that the eagle might swiftly fly to the nest, abandoned the pursuit for its own part and returned to the nest with a rapidity never before or since seen in this species. The young Imperial Eagle thereupon resumed a few further ineffective attacks, doubtless aimed at the vulture chick, and finally flew away.

ESSENTIAL CONSERVATION MEASURES

Certainly the most important and urgent requirement is habitat protection. At present there are two major reserves in which the birds breed in impressive density: the Doñana National Park and the Monfragüe Nature Park. The former is so well known that it needs no further comment. In this connection it is worth mentioning, however, that the Spanish Imperial Eagle may be regarded as one of the direct causes for the foundation of the World Wildlife Fund (WWF), deriving from Guy Mountfort's Doñana expeditions and Eric Hosking's first photos of this bird (Mountfort 1957) and following which the establishment of this reserve was one of the first projects to be funded. The second of these reserves, which Jeśus Garzón and I first visited in 1972 and for the protection of which we thereafter canvassed (Meyburg & Meyburg 1978), was officially established in 1979. It covers about 18,000 ha and was the first nature reserve in Spain to protect typical Mediterranean flora and fauna. It would be a fallacy to think that a bird with such an extensive range of activity could be saved from extermination in just a few self-contained reserves. It is vital to persuade the governments of Spain and Portugal to reconsider their so-called reafforestation programmes and to take into account the ecological factors. Resolutions to this end were adopted at the world conferences on birds of prey in 1975 (Vienna), 1982 (Thessaloniki) and 1987 (Eilat).

In this connection it is important that as complete a census as possible be made of all breeding pairs. This has been under way since 1970. When an area is found to contain a high breeding density, efforts must be made to have it protected also. Apart from this, an individual strategy has to be devised for each single breeding pair. Most important in this respect is the attitude of the landowner: in many cases he is the best guarantee of the bird's protection. And if possible, the pair's breeding success should be monitored annually. This differs from pair to pair, some showing consistently good results whilst others show none. The reasons for failure in the latter could in many cases be eliminated, e.g. by wardening the nests.

If the logging of a forest cannot be prevented, artificial nest-trees with platforms should be erected well in advance, as is done in many countries for Ospreys and White Storks. That the Spanish Imperial Eagle is adaptable in this respect is shown by the repeated breeding of one pair on a pylon in Province Madrid (Barajas 1981). The management potential in accustoming the birds to artificial nest sites is certainly great and perhaps the only way of maintaining an appreciable population in the long term in some areas. This should be a prime concern in future.

Nestling mortality through "Cainism" has already been dealt with. Here, too, is a great management potential. Since one pair can hatch three or four chicks, whilst others have at most only one or even infertile eggs, it costs relatively little to apply this method, especially if in conjunction with a study of the breeding biology and population monitoring. Should there be insufficient nests with infertile eggs to accommodate the removed chicks, these can be raised in captivity and later released into the wild or kept for captive breeding (Meyburg 1983).

Since the erection of the first electric cables in 1974, over 200 km of medium-tension cables (16kv-20kv) now encircle the Doñana National Park. And in this region, where raptor density is particularly high, the number of birds electrocuted has been alarming in recent years (Anon. 1984). Accordingly in 1982 a study was undertaken to determine the true impact of electric cables on the avifauna. A section of 100 km of cable, comprising 1,127 poles of different types passing through a variety of biotopes, was checked at regular intervals (Ferrer & de le Court 1988).

To-day, the chief cause of mortality in the Imperial Eagle in this region is electrocution. This above all affects juveniles: 72.2% of these eagles found dead under poles are immatures, whereas the pro

portion of immatures observed in the population is only 20%. Electrocution therefore affects the species in its most critical stage - the dispersion of the young.

The adults are therefore less affected than the young by the problem of electrocution; nevertheless the death of an adult has an extremely important impact on the population, since it means the loss of a breeding bird. Juvenile mortality is immense: during the first year of dispersion it reaches practically 100%: none of the 17 young eagles ringed since 1982 has survived more than one year. The principal reason for this is the electric cables surrounding the park (Ferrer & de le Court 1988).

There are a number of solutions to this problem which would not be costly and which might prove surprisingly simple, such as isolating those parts of the cable alongside which the bird perches. The poles are not all of the same type, and there is a differential in mortality according to the structure of the pole. Generally speaking, those types which oblige the bird to perch close to the cable are the most dangerous. Such poles should never be erected in areas particularly rich in raptors. To-day a thorough study is being conducted throughout Spain, which gives rise to hopes that this alarming situation is now appreciated.

Captive breeding is the ultimate method whereby one can seek to help a doomed species. Spanish Imperial Eagles are very rarely kept in zoos. There are, on the other hand, a considerable number of birds which have by illegal means come into private hands in Spain and several other countries. It would be rewarding, albeit very difficult, if these scattered and solitary birds could be collected together in one or two centres for breeding purposes. In the wild, only those nestlings should be taken which are otherwise doomed (Meyburg 1983)

Just as illegal shooting must finally be reduced and if possible stopped altogether through education of the public (all birds of prey have been protected by law in Spain throughout the year since 1966), so, clearly, must steps be taken against the putting out of poisoned bait for foxes and wolves, which can equally destroy the birds.

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B.-U. Meyburg Herbertstr. 14 D-1000 Berlin 33 Federal Republic of Germany

Table 1. Different causes of mortality in 70 Spanish Imperial Eagles recorded since 1974 in Andalucia (after Ferrer & de le Court 1988).

Cause of death	Number	Percentage
Electrocution	31	44.2%
Unknown	14	20.0%
Disappeared	11	15.7%
Starvation	7	10.0%
Accident	2	2.8%
Other causes	2	2.8%
Disease	1	1.4%
Poison	1	1.4%
Collisioh	1	1.4%

Table 2. Causes of mortality registered in Spanish Imperial Eagles in Extremadura (after Garzón et al. 1884).

	ADULT	Y-I	U.A.	TOTAL	
Shot	14	12	9	35	53.03%
Poison	5	1	-	6	9.09%
Electrocution	3	8	-	11	16.67%
Trap	2	-	_	2	3.03%
Flight Incapacity	-	2	-	2	3.03%
Unknown	2	8	-	10	15.15%
Total	26	31	9	66	100.00%

Y-I= young or immaturs; U.A.= unknown age

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