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A Contribution to Knowledge of Territorial Behaviour of the Imperial Eagle *Aquila heliaca*

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INTRODUCTION

The Imperial Eagle is rare in Czechoslovakia, with a population of about 25 pairs (Mrlík & Danko 1989, 1990). This species is considered endangered worldwide and is included in the Red List of Threatened Animals (IUCN 1988; Meyburg 1986). Basic data on the biology of *Aquila heliaca* are widely available in the literature but to my knowledge, there are no works devoted solely to its behaviour. The situation is different with the Spanish Imperial Eagle *Aquila adalberti*. A number of authors (e.g. Alonso *et al.* 1987; Ferrer 1990; Ferrer *et al.* 1990; Gonzalez 1988; Meyburg 1974,1975,1981-82,1987) studied the behaviour of this species at least to some extent. Thus, the biology of the extremely rare and endangered *Aquila adalberti* is now much better known compared to *Aquila heliaca*.

MATERIAL AND METHODS

The present work is based on field observations between 1977 and 1991. Over a period of 15 years a total of 296 days were spent in the breeding territory of the eagle pairs studied. Time sampling lasting almost 688 hours was used for a detailed data analysis. Data on behaviour were collected using an "*ad libitum* sampling method" and between 1984 and 1991 also a "*focal animal* sampling method" was used (Altmann 1974; Lehner 1979). To date, a time sample comprising 133 h 16 min of observation has been collected using this method.

An original "*ad libitum* sampling method" was applied in an area of about 12.5km^2. The observation of focal animals (i.e. "*focal animal* sampling method") was made from a hide located 12m above ground in a tree. From here, we could observe an eyrie from a distance of 600m as well as the birds' movements in an area of approximately 8.5km^2

Sixteen behaviour patterns were distinguished during movement and

resting activities. From the viewpoint of this work, two of these patterns were analysed: attack and display flight. As an *attack* I considered the purposeful flight of an individual or breeding pair of eagles towards other individuals of the same or other bird species. This purposeful flight need not necessarily, but could, change into deliberate pursuit or into a threat posture in flight. The attack resulted in driving the "enemy" or "rival" away from the vicinity of the eyrie or from the protected breeding territory. This description corresponds to the term aggression (e.g. Heymer 1977; McFarland 1987). As a *display flight* I considered demonstrative flights, typical of which were unusual and very conspicuous flight activities, forming a mixture of an intense sliding dive with rapid loss of height followed by a slower rise without wing-flapping. Sometimes we observed a peculiar swaying sideways flight. These flight activities are called typical undulating display, pot-hooks without wing-flapping. They are apparently a part of territorial and sexual behaviour and can be characterized as territorial displays (McFarland 1987).

The collected data were evaluated by non-parametric statistical Kolmogorov-Smirnov test for one selection (KS).

RESULTS

A) *Aggressivity: dependence on the breeding cycle.*

The significant majority of aggressivity patterns in eagles were observed in April and May (27.2% and 24.2%; KS test = 0.1637, $P > 0.01$, see Fig.1).

This behaviour was observed most often from May to August, i.e. at a time when young were in the eyrie (60.6%), rather than in the pre-breeding period or during incubation (February-April, 39.4%).

For calculation of the frequency of aggressivity the precise length of time was recorded during which this behaviour was studied (687 h 50 min). A total of 33 aggressivity patterns were observed in the course of 133 time samples. (In this case, observations from Febuary and August are not included in the statistical evaluation due to the small number of time samplings: in February one, in August two). The monthly average frequency of aggressivity from March to July was 0.0442 events/hour ($s = 0.023$, $n = 5$); its value reaching its peak significantly in April (0.081/hour, KS test = 0.11402, $P > 0.01$). It is clear from Figure 2 that the eagles were most often observed attacking other birds during April and May (58.6% from $n = 29$ during March-July, or 51.5% from $n = 33$ during February-August). The frequency of aggressivity was highest during the late incubation period and when the young were very small (less than about 25 days of age), corresponding to April and May in Czechoslovakian conditions.

Figure 1. Distribution of agressivity in Imperial Eagles

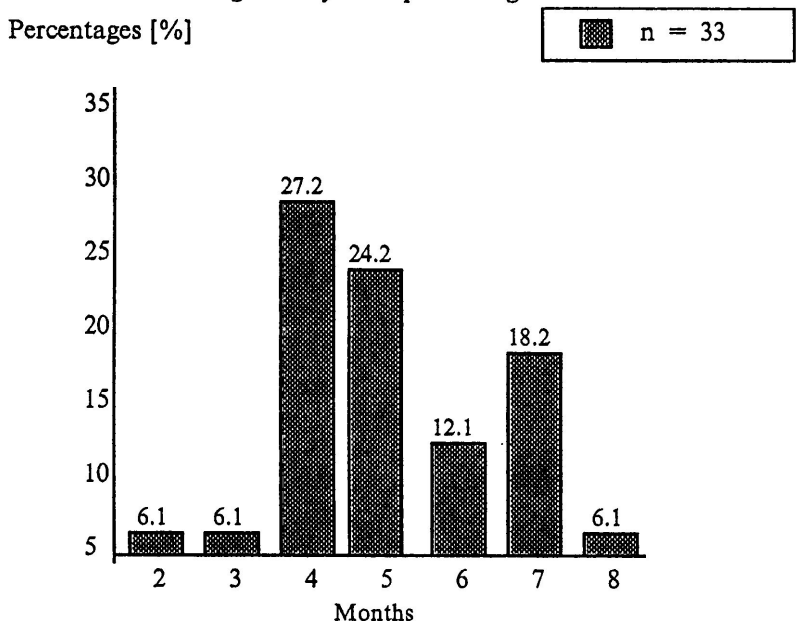
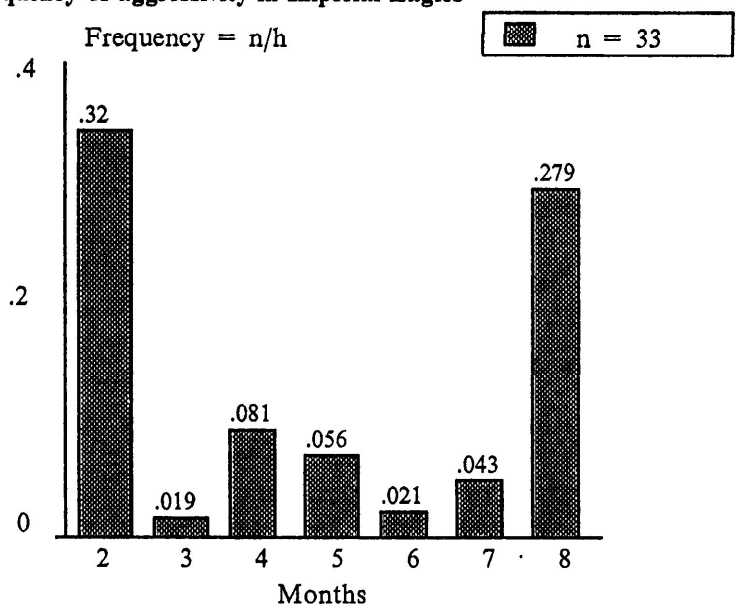


Figure 2. Frequency of aggressivity in Imperial Eagles



B) *Aggressivity: dependence on the size of species attacked and distance from eyrie.*

A total of 12 cases of aggressivity were analysed in which the distance from the eyrie was precisely measured using the map. The eagles attacked at an average distance of $x = 1079.8$ m from the eyrie ($s = 766.8$; $n = 12$). The dependence on the breeding cycle can be elucidated at least to some extent by the following data. We recorded an isolated attack at a distance of 1348.5 m from the eyrie in March. In April, i.e. during the incubation period, the average distance was longest, $x = 1870.5$ m ($s = 522.0$; $n = 2$). No data were obtained in May, nevertheless in June, during intensive parental care for their young, this distance was shortest, $x = 403.0$ m ($s = 145.7$; $n = 3$). In July the eagles again attacked other birds at an average distance of $x = 1109.8$m ($s = 789.9$; $n = 6$).

Out of 39 cases, the eagles attacked the Common Buzzard 19 times (48.7%). Much less frequent were attacks against Goshawk (5 times, 12.8%), Golden Eagle (3 times, 7.7%) and Black Stork (3 times, 7.7%). Those against other bird species were sporadic (Fig. 3). Worth mentioning is the fact that in one instance we observed intraspecific aggressivity; the breeding female drove away an adult Imperial Eagle which was apparently passing by incidentally (28.08.1991).

We found that the eagles attacked 10 bird species (Fig. 3). These may be divided according to their size into three groups - small-sized (Sparrowhawk, Rook), medium-sized (Common and Honey Buzzards, Goshawk) and large (eagle, stork). We found that smaller birds were attacked at a significantly shorter distance from the eyrie compared to larger birds (KS test = 0.06510, $P > 0.01$, $n = 12$). This distance was in small-sized birds $x = 825$m ($s = 524.3$, $n = 2$), in medium-sized birds $x = 1159$m ($s = 795.7$, $n = 6$) and in large birds $x = 1089$ m ($s = 796.6$ $n = 4$, Fig.4).

C) *Display flights: dependence on the breeding cycle and on distance from the eyrie*

We are unable to evaluate the frequency of display flights using the data obtained. However, its very low value is documented by the fact that we observed display flights 41 times during 33 days of observation, while the total number of observation days was 296.

We observed these flights from February to August, significantly the most frequent being recorded in April (39%, KS test = 0.0635, $P > 0.01$, $n = 41$, Fig.5).

Figure 3. Species spectrum of birds attacked by Imperial Eagles

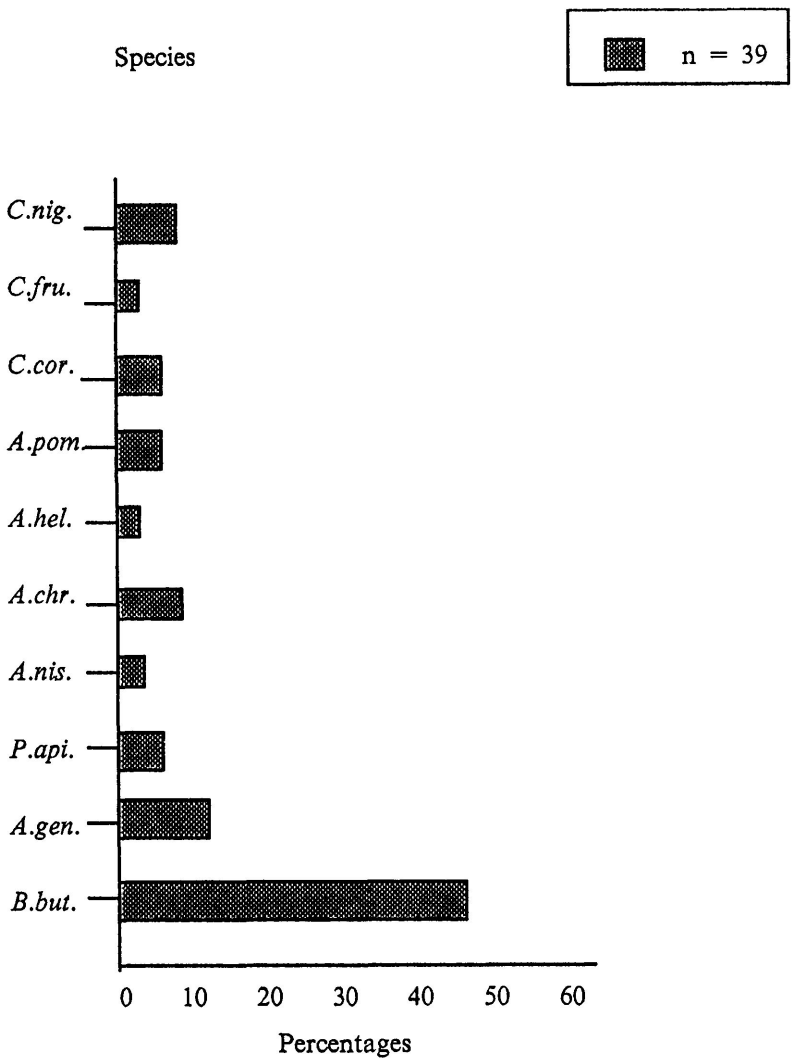
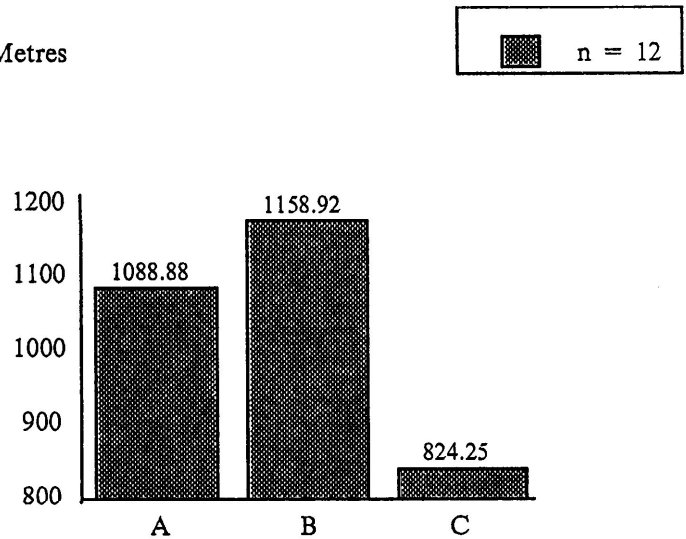
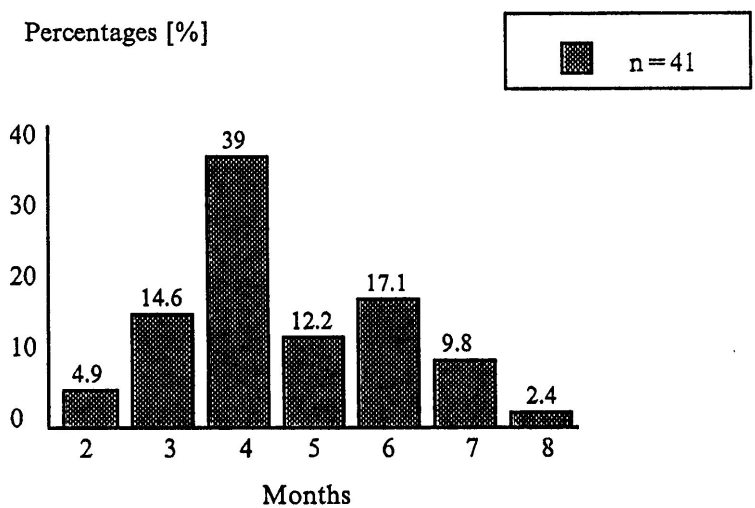


Figure 4. Attacks by Imperial Eagles depending on distance from nest and size of intruder.



A: Size of *Aquila* sp., *Ciconia* sp.
B: Size of *Buteo* sp.,*Pernis* sp.,*Accipter gen.*
C: Size of *Corvus* sp.,*Accipiter nisus*

Figure 5. Display flights of Imperial Eagles.



A total of six display flights were observed in which the distance from the eyrie was determined. These took place at an average distance of x = 796 m from the eyrie (s = 737.5, n = 6), four of them being expressed by a male and two by a female. However, it is probable that in some instances the eagles intentionally used display flights for the intimidation and repulse of intruders. Dispay flight where this fact was excluded, i.e. genuine courtship flight with no intruders nearby, was observed at an average distance of 398m from the eyrie (s = 101.4, n = 3). Display flights were observed significantly in the vicinity of the eyrie (KS test = 0.2058, P > 0.01, n = 6). We observed 66.7% out of six display flights less than 500m from the eyrie, marginal values were 174 and 2306m.

CONCLUSION

1 - Most aggressivity patterns (attacks) were observed in April (27.2%, n = 33). A statistically significant difference compared to values observed in other months of the year was found (KS test). Similarly, the frequency of these interactions was significantly different depending on the stage of the breeding cycle (KS test). Monthly average between March and July was only 0.0442/ hour (s = 0.023, n = 5), in April 0.081/hour.

2 - The eagles attacked at an average distance of 1080m from the eyrie (range 300-2393 m, s = 766.8, n = 12). This distance was longest in April and shortest in June (1871m in April, 403m in June).

3 - Attacks against smaller birds (Sparowhawk, Rook) were performed at a significantly shorter distance from the eyrie compared to larger birds (KS test, n = 12). Birds of Buzzard size were attacked at an average distance of 1100m from the eyrie (n = 6).

4 - We were unable to evaluate the frequency of display flights. However these most often were observed in April (39.0%, n = 41). A statistically significant difference was found compared to values in other months of the year (KS test).

5 - Display flights were observed at an average distance of 796m from the eyrie (s = 737.5, n = 6). They were performed four times by a male and twice by a female. A significant difference was found in these individual behaviour patterns depending on the distance from the eyrie (KS test): 66.7% of display flights were performed within 500m from the eyrie (n = 6), marginal values were 174m and 2306m from the eyrie.

DISCUSSION

Selected behavioural patterns were observed in a breeding territory of the Imperial Eagles; however, they were very rare. Using the Kolmogorov-Smirnov statistical test, we were to confirm the original hypothesis suggesting that attack and display flight are "building", i.e. the basic elements of territorial behaviour in eagles. Unfortunately, the demarcation of the territory based on observed behavioural patterns is questionable. Firstly, the patterns studied were very scarce. The furthest distant "marked" sites of the territory were located 2393m (attack) and 2306m (display flight) from the eyrie. Out of the observed behavioural patterns, 38.9%, 16.7% and 44.4% were recorded within 500m, 500-1000m and over 1000m from the eyrie respectively (n = 18, i.e. six display flights, 12 attacks). The results also suggest that the defence of breeding territory was most intensive in April, during which we observed most aggressivity patterns (27.2%) and the frequency of these interactions was significantly highest (0.081/hour). In April the eagles also attacked intruders located at the furthest distance from their eyrie (1871m). Display flights were most often observed in April as well (39%).

As stated, behaviour is little studied in either race, but more in *Aquila (h) adalberti* than in the nominate *Aquila (h) heliaca*. Perhaps the most detailed study was carried out in Spain: a pair of *adalberti* observed by Meyburg (1975), prior to egg-laying (and at times later in the cycle), was travelling several km from the eyrie. Typical *Aquila* undulating Sky-dance display-flight was observed mostly low over the eyrie but also up to 2-3km away. These facts correspond very well with our own observations. From this point of view, this behaviour appears similar in both *adalberti* and *heliaca*.

There is little information available about antagonistic behaviour. Serious attacks were observed by Meyburg (1975) directed against *Aquila chrysaetos*, *Aegypius monachus* and Raven *Corvus corax*, including repeated dive-bombing and calling. We observed serious attacks directed against 10 species of birds (*Buteo buteo, Accipiter gentilis, Ciconia nigra, Aquila chrysaetos, Pernis apivorus, Aquila pomarina, Corvus corax, Accipiter nisus, Corvus frugilegus*, with only one case of aggression against a conspecific *Aquila heliaca*). We assume that the spectrum of bird species that can be attacked depends on the composition and population density of bird species within the eagles' breeding territory. Certain habituation to frequent presence of other raptor species within the breeding territory is surely also of great importance. This corresponds to the data published by Meyburg (1975), when one Golden Eagle often flew within 1km of an Imperial Eagles' eyrie without being molested.

It is not the aim of this contribution to solve general problems of Sky-dance motivation and its behavioural classification. However, according to our observations it is probable that in several instances the eagles used display flights intentionally for the intimidation and repulse of intruders. Where this fact was excluded, courtship flight, (i.e. genuine display with no intruders nearby) was observed in 34 instances out of 41 observations of display flights (83%). Meyburg (1975) wrote that it seemed quite clear that the display flights were sexually motivated and could not be interpreted as a dispersion mechanism. Cramp & Simmons (1980) comment on this problem as follows: "Sky-dance, thought by some to be basically aggressive and of territorial significance" (see also Glutz *et al.* 1971). According to our observations, we assume that these Sky-dance display-flights are motivated sexually but they have evident territorial significance.

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