

ON THE BIOLOGY OF THE LESSER SPOTTED EAGLE (Aquila pomarina)

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1. Introduction

Of all the eagle species breeding regularly in Germany, the Lesser Spotted Eagle is doubtless the most poorly investigated in regard to its biology. The reason for this is to be found in its being less conspicuous when compared with the Sea, Fish and Golden Eagles, and in its comparatively small and more easterly breeding distribution. On the other hand, this small attention is hard to understand, since the species is of particular interest because of two problems. Firstly there is the question of its systematic position with respect to the very closely related Greater Spotted Eagle (Aquila clanga) and secondly the problem of the inevitable death and complete disappearance of the second chick.

In Germany our knowledge of the way of life of the Lesser Spotted Eagle has been considerably increased in particular by SIEWERT (1932) and WENDLAND (1932, 1951, 1959). SIEWERT did the most thorough observation on the behaviour of the birds at the eyrie. Unfortunately, as he himself writes, they were unduly disturbed as a result, so that the behaviour in some respects was abnormal, such as the frequently prolonged absence of the female from the nest during incubation and the early nestling period. WENDLAND checked the largest number of eyries, as a result of which he approached above all a solution to the disappearance of the second chick. He summarized our knowledge of the Lesser and Greater Spotted Eagles in a monograph (1959). HOFFMANN (1931, 1932, 1938) was the only German ornithologist to have the opportunity to observe thoroughly both of these closely related species at their eyries in East Prussia. Unfortunately he does not go into detail on the results of his work. More recently GENTZ (1965, 1967) did observation at an eyrie in Mark Brandenburg.

Apart from incidental observations of Hungarian ornithologists - with the exception of SLADEK in Slovakia - systematic studies have been done especially by LICHATSCHEW (1957) and GOLODUSCHKO (1958, 1959, 1961). The works of both these Russian researchers were not taken into account by WENDLAND (1959) in his monograph or they were published later. Furthermore they are hard to come by and therefore hitherto almost unknown in the literature outside Russia. So they will be more extensively cited here - apart from their sections on feeding biology.

Because of certain statements, one must assume that some of the pairs which LICHATSCHEW (1957) was dealing with were Greater Spotted Eagles (Aquila clanga) (see 4.3.4.4.), although the author expressly talks of the "Lesser" Spotted Eagle. Because of the extensive data contained in this work I would, nevertheless like to quote it.

During several visits to Slovakia in 1968 and 1969, altogether totalling a period of four months, I was able to devote myself almost exclusively to the Lesser Spotted Eagle. 17 broods were investigated: I was able to watch two eyries from a hide for 268 hours. Altogether the investigations lasted 1200 hours in 112 days. The sites of the discovered eyries are shown in Fig. 1 (Abb. 1).

I was able to confirm many of the observations published in the literature. For this reason I shall not go into certain aspects such as egg colour, voice, development and behaviour of the young, etc., on which extensive descriptions exist.

One of the main aims of my study was to find out the possibility of rearing the second chick to flying age by means of some intervention, and in this way advance the status of the species. The results of these investigations have already been treated elsewhere (MEYBURG, 1971) and will only be briefly outlined here (see 7). The results of the studies on feeding will be published elsewhere (PALASTHY and MEYBURG, in preparation).

2. HABITAT AND NEST POSITION

A review of the literature shows the requirements of Lesser Spotted Eagles breeding biotope to be flat forests interspersed with swamps and bordering on moist

meadows and marshes. This statement is a generalization which applies to the flat lowlands of northern Germany and also to the flat parts of Russia and Poland, but it is not applicable to the large areas of the bird's range. For instance the Lesser Spotted Eagle breeds in the Balkans in mountain forests, without being bound to the presence of swamps or wet meadows.

In Slovakia too I found the birds breeding in fairly large forests at all elevations, although there was never moist ground in the vicinity. Furthermore its population density was in no way less than that given for the optional biotope in northern Germany (cf. 3.).

The Lesser Spotted Eagle is therefore - like the Black Stork - on the one hand more adaptable in its choice of habitat than many realised hitherto, but on the other hand there appear to be distinct regional variations in habitat requirements.

3. NESTING DENSITY

There are few statements on population density in the literature. WENDLAND (1959) found 4 breeding pairs in a 1200-hectare forest region of Mark Brandenburg every year. According to STEINFATT (1938), 25 pairs were supposed to breed in the 25,000-hectare Rominter Heide. GOLODUSCHKO (1959) found 19 breeding pairs in 1955 and 24 in 1956 in the Russian sector of the Byeloveshker Forest, so that there were respectively 3947 and 3125 hectares per pair, including the feeding territory. According to FEDIUSCHIN and DOLBIK (1967), this region supported 50-60 pairs in 1948-1952.

Since the eyries that I knew in Slovakia were widely scattered, and because I did not know the status of a definite area with exact boundaries, it is not possible for me to make accurate statements about the population density. Nevertheless it seems as if the minimal distances that I found between two occupied eyries were apparently no less in this completely dry, mountainous habitat than in the marshy habitats of northern Germany or White Russia. Thus, pairs 5 and 10 nested only 900m apart in 1968. The distance of these two eyries from those of pairs 8 and 9 were about 7 and 10 km. Possibly other pairs breed in between. In 1969 the eyries of pairs 4 and 11 were only 300-400m apart. In 1967 a third occupied eyrie was only 300-400m from these two (DANKO and SVEHLIK pers. comm.). Therefore I regard the estimate of the Slovakian Lesser Spotted Eagle status at 75-120 breeding pairs given by SLADEK (1955) as not too high. In eastern Slovakia the Lesser Spotted Eagle is the commonest raptor, with the exception only of the Buzzard and the Goshawk.

4. BREEDING BIOLOGY

4.1. Building time of the eyrie

As with most raptors - apart from the post-nestling stage - we know least about the nest-building period, the spring arrival and establishment of the territory. So far there are very few, if any, observations on many aspects, as for example the choice of the eyrie, the role of the sexes in building and the feeding of the female by the male. To this end one may make observations from a ground-hide at this time, without undue disturbances or difficulties. Unfortunately, for reasons of time, I have also had little opportunity to do more than brief notes on this interesting phase of the reproductive cycle.

4.1.1. Spring arrival

Next to the actual time of arrival at the breeding place, the most interesting question is whether the pair arrive together, or, in the case of separate arrival, which of the two partners gets to the eyrie site first. There are only a few conflicting statements about this in the literature.

HOFFMANN (1938) determined in one case the arrival of the female five days before the male. WENDLAND's (1959) observations also indicate arrival of the female before the male. SIEWERT's (1932) published observations on one pair are not clear on this point, but indicate asynchronous arrival. Also according to VON DOBAY (1934)

the pairs are said to arrive and depart together.

Unfortunately my own findings do not contribute to a clarification of this question either. I watched eyries 4 and 8 daily from 6 April 1969. On 10 April I heard from a distance soft shy Lesser Spotted Eagle calls from eyrie 8. A decidedly large-looking bird, probably a female, then flew out from the immediate vicinity of the eyrie. I could not establish the presence of a second bird. I encountered no eagle on the next few days. The eyrie had been decorated with two small green twigs, but subsequently not occupied at all.

At eyrie 4 I heard eagle calls for the first time on 13 April, but could not see any bird. Next day an eagle flew from the eyrie at my approach to a spot where I could not see it. The very excited calls that I heard immediately afterwards indicated copulation. Although I had seen only one partner, I assume that in this instance the eagles were already paired when they arrived at the breeding place.

It seems in the Lesser Spotted Eagle, as in the Black Kite, as if the adults sometime arrive at the breeding place already paired, sometimes singly, the females before the males. Which is more the rule must await further observations.

4.1.2. Territorial fidelity

As with all the larger raptors, the Lesser Spotted Eagle is very faithful to its territory and often uses the same eyrie for several years in succession. Many pairs, however, alternate for unknown reasons between several nests every year. Out of 8 eyries which were occupied in 1968, and which I checked in the spring of 1969, three were re-occupied. At one observation on 10 April 1969 an adult bird flew from the immediate vicinity of eyrie 8. As already mentioned, the eyrie was decorated with two fresh twigs. The pair must, however, have bred then in the same valley at another site. At eyrie 6 at Zvolen, SLADEK (1959) had already made his observations in 1957. Whether and how often the eyrie had been occupied in the meantime is not known. In 1966 eyrie 4 had been built by a Black Kite, but the Lesser Spotted Eagle bred in it in 1967, 1968 and 1969. Eyrie 11 was occupied by a Lesser Spotted Eagle in 1965, 1967 and 1969. (DANKO in litt. and pers. obs.)

Whether one is dealing with the same adults each year is a difficult question to answer. There is good evidence that the same applies to the Lesser Spotted Eagle as to the other raptors in which more is known of this problem; both partners return to the same nest site each year, but if one bird dies, it will very quickly be replaced by another. In this way nest sites are often occupied over much longer periods of time than the individual's age amounts to. At two of the three eyries (4 and 10) occupied in both years under observation, it seemed to me almost certain that the same females were concerned each time, since they were characterized by being especially tame (cf. 6.). Furthermore, in three successive years, I found only a single egg each time at eyrie 4.

WENDLAND (1932) established with certainty the same male at one and the same eyrie in two successive years. VON DOBAY (1934) also concluded on grounds of the great similarity of colouration, shape and size of the eggs that the same adults return to their old breeding places.

Since Lesser Spotted Eagles take over old raptor eyries whenever possible, they must sometimes become involved in fights with other occupants of the eyries. At the beginning of May 1969 DANKO and SVEHLIK (pers. comm.) found the fresh remains of a Booted Eagle not 100m from eyrie 12 - certainly the victim of such a conflict.

4.1.3. Eyrie construction and size

From the ground it is impossible to distinguish a Lesser Spotted Eagle eyrie - as one can that of a Fish Eagle - from that of a Buzzard for example, by size or site. Only a look over the nest rim provides certainty as to the owner, if one has not already seen it leave the nest.

According to WENDLAND (1951) the Lesser Spotted Eagle eyrie can be distin-

guished most characteristically from eyries of other raptors by its grass-lined bowl. As early as 1968 I realised that not a few eyries with eggs or small young lacked grass altogether. In 1969 I paid special attention to this. Out of nine eyries, of which I had photographs or diary sketches to show whether they were furnished with grass, this was so only in three cases (eyries 8 and 11). No eyries found by MAKATSCH (in litt.) were lined with grass.

One cannot therefore say that a grass lining is characteristic of Lesser Spotted Eagle eyries, but rather that a few Lesser Spotted Eagle pairs line their eyrie bowls with grass, as well as twigs, when they contain eggs or quite small young. The eyries of such pairs do not all have to be situated near pastures, because grass may also be found in eyries situated right in the middle of a forest. Most eyrie bowls were lined with fresh branches. They resemble other raptor species in this respect, as WENDLAND (pers. comm.) also confirmed when I showed him photographs of these eyries.

As long as there are still eggs in the nest usually only the bowl is lined with twigs. Only with advancing age of the young are twigs also found on the nest rim. Eventually the hollow of the bowl disappears entirely and the eyrie resembles a platform. In both pairs 1 and 4 I saw only the female bring branches.

In only one eyrie did I find an egg without any underlying layer (eyrie 10 on 10 May 1969). Some time later even this nest was lined with branches.

Inordinately much has been discussed about the "decoration" of the eyrie with fresh branches, without any truly revealing declaration having been found. This discussion will not be continued here. That young Lesser Spotted Eagles develop well without this layer is shown by the successful rearing of two young eagles by two Black Kite pairs (cg. 7, and MEYBURG 1971), which are known to line their eyries with a completely different kind of material.

The exact measurements of two Lesser Spotted Eagle eyries appear in Table 2.

4.2. The breeding period

4.2.1. Time of egg-laying and beginning of incubation

According to the statements of practically all observers of Lesser Spotted Eagles, which agree in this respect, egg-laying starts usually at the beginning of May, or in a number of cases even in the last days of April. This applies also to Lesser Spotted Eagles in Slovakia.

In 1968 the first chick of the pair I observed at eyrie 4 hatched on 5 or 6 June. With an incubation period of about 40 days, the egg must have been laid about 26 April. In the same eyrie the chick hatched on 9 June 1969, so that egg-laying must have occurred about 30 April. In 1969 I found the first chick to hatch on 7 June; it had hatched either that day or the day before. Egg-laying must have been on 26 April. In eyrie 11 the chick emerged on 10 June, which indicated egg-laying on the 1 May. On 7 May I found the complete clutch of two eggs already in this nest.

In the pair watched by SIEWERT the female did not begin to incubate steadily immediately after the laying of the first egg, but remained for a few days close to the eyrie. Further observations would probably show that this is not the rule.

4.2.2. Incubation period

We do not yet have any reliable and accurate statements on the duration of incubation.

SIEWERT (1932) established by daily observation that the young hatched 43 days after egg-laying. Since the female of the pair studied by SIEWERT frequently interrupted her incubation for many hours, the resulting arrested development of the embryos would speak for a rather shorter incubation period by several days in normal cases. WENDLAND, who did not establish it accurately, estimated it to be about 40 days.

Unfortunately I also did not succeed in determining this exactly, since the

female of pair 4, which seemed because of her tameness during this investigation an ideal subject, and whose eyrie was observed daily after the laying of her first egg at the beginning of May, 1969, as also the previous year, did not lay a second egg.

In more recent summaries the incubation period is given as 38 days. It seems to me as if some clarification is needed here, as to how this value has been determined. The statements originate with WENDLAND (1959), who calculated this period from observational data of SLADEK (1957). This worker found in three observations on one eyrie one egg on 8 May, two eggs on 6 June and a two-to-three-day-old chick from the second egg on 19 June, thus 43 days after 8 May. The embryo in the first egg had died. WENDLAND arrived at the figure of 38 days apparently by subtracting the two days of the estimated age of the chick and the three days between the laying of the two eggs as shown by previous experience. Both periods of time are, however, estimated and could have been one or two days longer or shorter. Such a calculation of the incubation period does not seem tenable to me. Even SLADEK did not presume such a conclusion and wrote only that, in the eyrie observed by him, the incubation time must have been shorter by two days than that recorded by SIEWERT (43 days). Yet even this does not seem to me altogether substantiated; it is very doubtful that the first egg was in fact laid on 8 May and had not already lain in the nest for two or three days. Anyway SLADEK mentions nowhere any observation as early as 7 May at which the eyrie was still found to be empty. That he did make such an observation seems improbable, since he writes that he could not determine the egg-laying interval so as not to disturb the birds by frequent interruptions at the beginning of incubation. It is therefore even more unlikely that he did not consider an observation on 7 May worthy of mention.

Even if later observations do establish that the incubation period is 38 or 41 days, the above account will yet have shown that at present we cannot answer the question of the incubation in the Lesser Spotted Eagle with any accuracy.

4.2.3. Clutch size

Even today opinions differ about the number of eggs in the clutch of the Lesser Spotted Eagle. WENDLAND (1959) writes that the Lesser Spotted Eagle almost always lays two eggs; clutches of one are mostly second clutches or very rare exceptions. MAKATSCH (1959) on the other hand is of the opinion that the clutch consists of two, but also very often of one, eggs. In the same way, opinions of the old oologists varied, some of them claiming that the clutch usually consists of only a single egg (SZIELASKO 1895, RÜDIGER SR. 1903 and others). CHRISTOLEIT (1903) was the first to say that he could simply not entertain the opinion that the Lesser Spotted Eagle usually lays only one egg. He wrote further that he had examined quite a number of Lesser Spotted Eagle eyries and only found one egg in a single case. Unfortunately all the older authors express themselves equally inexactly about the actual number of eyries examined, so that one cannot calculate the percentage of single-egg clutches found. CHRISTOLEIT gives what is probably the correct explanation for the claim of many oologists that one-egg clutches are the rule in the Lesser Spotted Eagle: "if other careful observers found only one egg in naevia, I can account for this only by the fact that the clutch was not yet complete."

To get as objective a picture as possible of clutch size in the Lesser Spotted Eagle, I have amassed the available material in Table 3. More comprehensive figures have been given by only a few authors, and are sometimes not unproblematical, such as the statements of LICHATSCHEW (1957). Unfortunately it was also unprofitable to work through the older oological literature, since the older authors expressed themselves very generally and gave no accurate figures regarding the clutches collected by them.

Many incidentally mentioned clutches have therefore been included in the Table. In order not to distort the picture with incomplete clutches, I have admitted single-egg clutches only if they were recorded after 10 May, or if the eyrie had been observed with one egg on two occasions more than five days apart. I have not considered single-egg clutches without time of finding, except of those authors who have had much to do with the Lesser Spotted Eagle, such as WENDLAND, GOLODUSCHKO and others, and who would scarcely have included incomplete clutches. Incomplete clutches which were found after 10 May and are yet reviewed here, will be counterbalanced by those complete single-egg

clutches found before this date but not included in the count. Two downy young in an eyrie counted as a clutch of two eggs, since a third egg could not have been lost in the short time during which the second chick still survives. If only one downy chick was found, it was impossible to refer to the egg count. Statements on eyries from which two young have flown (HOFFMANN 1931, CHRISTOLEIT 1903 and others) have not been included, since there is a strong suspicion here of confusion with the Greater Spotted Eagle. Counts by authors who observed 10 or more clutches have been presented separately. Those of the remaining authors are grouped by regions. All records of clutches in which no comparison between one- or two-egg clutches was possible, such as those of older collectors, have not been treated. The statements by KRÜPER (1852) are dealt with by virtue of the very large total of observed clutches, even though these are unfortunately given as "approximately".

As the table shows, two-egg clutches comprise 81.5% of all clutches, or in other words, about four out of five broods contain two eggs. In 16.3% of the cases, the full clutch consisted of only one egg, while three-egg clutches may be expected in only two out of 100 Lesser Spotted Eagle eyries. The mean clutch is thus 1.8 and seems to have almost no geographical variations. An increase in clutch size eastward and a decrease southward, such as SLADEK (1959) supposed from data of SCHNITNIKOW (1913) and MAKATSCH (1950), was not established. Only the percentage of three-egg clutches seemed to increase eastward. Of altogether eight three-egg clutches known to me (KOLLIBAY 1906, SARUDNY 1911, SCHNITNIKOW 1913, VON DOBAY 1934, FEDIUSCHIN & DOLBIK 1967) six were found in Russia.

In Macedonia and Slovakia five and three single-egg clutches respectively were found in the same eyrie region and mostly even in the same eyrie, and so might have originated from the same females. This fact, as well as the statement of KRÜPER that one female laid one egg per clutch in two successive years, leads one to suppose that some Lesser Spotted Eagle females always lay only a single egg. The low total count of observed clutches explains the low mean clutch size in Macedonia and Slovakia.

4.2.4. Egg measurements

Recently HENRICI (1951) drew attention to the size difference between first and second eggs of the Lesser Spotted Eagle, a fact already known to the old ornithologists (KRUPER 1852, STERNBERG 1884). WENDLAND thereupon suggested measuring the two eggs separately so as to arrive at a more distinct separation of Greater Spotted Eagle clutches. The question of the average size-difference has a particular bearing on the death of the second chick, since a smaller chick naturally hatches out of a smaller egg, which means that it is still further at a disadvantage in addition to the age-difference.

In order to assess this factor in its context, it would be best to measure the mean of the fresh full weight or the volume separately for first and second eggs in as many clutches as possible. Unfortunately, I could not come by enough single data (Table 4) to allow of useful mean values. I have therefore given the mean of the usual length and breadth measurement of a total of 105 eggs. The mean weight was decided indirectly from this.

The egg measurements stem from the following sources: 42 eggs VON DOBAY (1934) 32 MAKATSCH (in. litt.) 10 W. RÜDIGER (cited in HARTERT 1912-1921) 5 DANKO (in. litt.) 3 SLADEK (1957, 1959), 3 KIRALY (1931) 2 SZEMERE (1920) 2 SIEWERT (1932) and 6 measurements of my own.

Clutches dealt with by HENRICI (1951) have not been included in the calculation, since he selected clutches with particular size differences which would give a false impression.

Of the 46 complete two-egg clutches, in seven cases (15.2%) the two eggs were practically identical in size, i.e. the second egg was either longer but narrower, or broader but shorter than the first. For instance the following examples are quoted:

64.4 x 53.2 and 63.0 x 54.0
62.8 x 50.5 and 46.5 x 48.0

61.6 x 51.6 and 62.2 x 50.7
61.2 x 51.3 and 62.0 x 50.1 mm

In such cases it is not very simple to differentiate which the first egg is. I then compared the respective lengths and breadths and from these deduced that the minimally larger egg was the first; in eggs of approximately the same length, width is the deciding factor. Since differences in breadth affect the egg size more than those in length, I took the broader egg as the first. The correctness of this was confirmed in each case by the eggshell weights, which were available in these critical clutches. Naturally it is assumed throughout that the first egg is the larger, even if only barely so. A final confirmation may only be obtained by direct observation at hatching time.

The maximal size difference of 61.6 x 59.1 and 55.6 x 46.7 mm in the 46 clutches was in a clutch found by me in eyrie 11.

The results of the calculations as well as the maxima and minima may be seen in Table 6. This shows that the second egg is on average 2.3 mm shorter and 1.8 mm narrower than the first.

A clutch whose measurements very closely approach the calculated mean values gives an estimated mean fresh full weight of the two Lesser Spotted Eagle eggs of 87 and 79 g. Since the second chick usually also increases its weight by 10-20g daily for the first days of its life (4.3.4.3.) it means that the lower birthweight is on average only a relatively small disadvantage. It should therefore be of great significance in the elimination of the second chick only when there is a marked size difference in the eggs and a long gap between the dates of laying.

4.2.5. Adult behaviour in the breeding season

The most interesting question concerning the adults in the breeding season is that of their roles in the incubation of the clutch. There is no clear answer to this in the literature.

WENDLAND wrote in 1958 that only the female incubates and is fed by the male. In his monograph (1959) it seems nevertheless that he believed he had seen the males on the eggs once or twice during his numerous observations at the eyrie. He did not apparently watch for any length of time at that time. The male incubated many times for about half an hour at SIEWERT's eyrie, where the female often left the eggs exposed for hours on end because of undue disturbance.

I myself have sat for a total of 37.5 hours over six days at eyrie 4, namely

- on 2 June 1968 from 1100-1900 hours
- 3 June 1968 from 0500-1330 hours
- 22 May 1969 from 1000-1115 hours
- 26 May 1969 from 0850-1745 hours
- 27 May 1969 from 1100-1615 hours
- 8 June 1969 from 1240-1815 hours

The most important results of these six days of observation can be followed from my diary entries:

On 2 and 3 June 1968 the female broods uninterruptedly for the entire period of observation without altering her position or turning the eggs once. She often rests her head on the rim of the nest, but does not close her eyes.

On 22 May 1969 the male lands without a sound on the rim of the eyrie at 1235 hours carrying a snake in his beak, but is ignored by the female. He lays the prey on the rim of the nest, remains perched for some minutes on a branch right next to the nest and finally flies off. Both partners remain completely silent.

On 26 May the female is not at the nest on my arrival, and comes at 0910 hours to the eyrie with a large green twig in her bill, stays some minutes sitting undecidedly on a branch, loses the twig, and then sits on the egg. After a few minutes she flies suddenly away, as if she were disturbed, but returns after three minutes with a green twig which she lays on the nest edge, and resumes incubation. At 1316

hours the male arrives at the nest with a snake, which the female grasps quickly this time even as she stands up from the clutch, and swallows it on the nest rim as she takes off. The male sits down on the clutch and takes up the same position as the female. She stays in the immediate vicinity of the eyrie until 1350 hours, as I recognize by her repeated calling caused by the uninterrupted mobbing of a Jay. From time to time I can see her as she preens and is harried by the Jay. After her return to the eyrie, the male leaves it only hesitatingly. The female turns the egg by rolling it backwards with her bill towards herself. Thereafter she incubates again without interruption until the end of the observation period. From time to time she sleeps with her head in her back feathers.

On 27 May the female interrupts her brooding twice during the period of observation in order to turn the egg (1500 and 1530 hours). At 1535 hours she flies from the eyrie and tries to break off a green twig nearby, but returns after 10 minutes of frustrated efforts.

On 8 June the female broods throughout the observation period without any interruption.

The observations agree with those of SIEWERT in that the male feeds the female during the incubation period and takes over incubation while the female is away from the nest dealing with the prey. There is therefore no real sharing of incubation in the Lesser Spotted Eagle, in which both sexes find their own food.

4.3. Nestling period

4.3.1. Hatching time

Young Lesser Spotted Eagles usually hatch in the first half of June. Fig. 2 shows the hatching time of the first or only chick in each eyrie. They are determined either directly i.e. by daily observation of the nest, or according to the weight of the chicks in those cases where the eyries were examined only every two, three or four days. In these cases there is a possible error of one day either way in the actual hatching date.

4.3.2. Duration of hatching

Only HOFFMANN (1938) has so far given accurate observations on the duration of hatching in the Lesser Spotted Eagle at the nest.

On 29 May he found a completely intact clutch, from the first egg of which the calls of the chick could be clearly heard. HOFFMANN wrote of further events: "The next day, thus on 30 May, one of the eggs was cracked at 1430 hours and a hole appeared at 1500 hours, through which the bill of the chick with its egg tooth became visible. However, only on 31 May, almost 24 hours later in the early afternoon on the last day of May, did the young eagle emerge. That was undoubtedly an abnormally delayed hatching."

My own observations on the hatching duration of three eaglets show that HOFFMANN's case was by no means "an abnormally delayed hatching". As evidence let me give the relevant extract from my diaries:

On 15 June 1968 at 0900 hours I find the second egg in eyrie 8 with a quite faint depression in the middle. It now weighs 63g. The chick is peeping quite audibly. At 0730 hours on 16 June the chick has cracked the shell into two almost equal parts. From the crack are protruding a leg and a wing, at which the older sibling pecks frequently with full strength. The second chick cries loudly and tries to break open the two shell halves further. Now and then it calls a halt to its exertions. At the next observation at 1830 hours that same day the chick has finally emerged and is already quite dry. Although still weak, it already opens its eyes. It weighs 45g. There is no more trace to be found of the eggshell.

I observed the second and third cases of hatching in 1969. At midday on 7 June 1969 eyrie 7 contained a chick weighing 67g and an undamaged egg of 62.3 x 52.2 mm with a weight of 82g. The chick can be heard clearly in the egg. Small fragments

of the first eggshell are still lying in the nest bowl, which perhaps shows that the shell is eaten by the female. Otherwise I have never found eggshell remains in a Lesser Spotted Eagle eyrie. I take the second egg and incubate it further artificially in a small electric incubator. Next day on 8 June, a tiny crack begins to be visible in the eggshell at 1230 hours. A small pip mark can be felt by feeling gently with the finger. At 1500 hours on 9 June the first small crack has reached a length of 1 cm. At 1715 hours the chick has fully emerged. It is still quite wet and only opens its eyes some time later.

At 1330 hours on 9 June, eyrie 12 contained two eggs, the first of which had a barely visible crack. At 0830 next morning the crack was scarcely larger. At 1400 hours on 11 June the chick already lay in the nest bowl, quite dry with open eyes.

To summarize one might say that the hatching of a Lesser Spotted Eagle egg takes 24 to 48 hours, as HEINROTH (1933) also confirms, of which the actual breaking open of the egg takes two hours. The remaining time extends from the start of hatching to the opening of a small air hole.

4.3.3. The number of young hatching

The answer to the question of how many successfully incubated two-egg clutches produce two chicks is of interest, not only per se, but, in connection with a method I have developed for rearing the second chick (cf. 7.) and therefore for the protection of the Lesser Spotted Eagle, as the success of this conservation measure is largely dependent upon it. Unfortunately there are only a few comprehensive studies on this question.

WENDLAND (1951) watched 11 two-egg clutches to hatching. Two chicks hatched from all clutches. GOLODUSCHKO (1961) watched 25 two-egg clutches through to hatching, from all of which two young seem to have hatched. This cannot be deduced with certainty from his accompanying table, but emerges indirectly from the text (cf. 4.3.7.). Only 13 out of 35 clutches of the Greater Spotted Eagle/Lesser Spotted Eagle population studied by LICHATSCHEW (1957) contained two eggs. Only four times out of 30 broods observed to hatching did two young hatch. Unfortunately it is not apparent from this work whether there were any two-egg clutches among the five remaining broods. Even if this was not the case, there was an infertile egg in nine of the 13 two-egg clutches.

Out of eight two-egg clutches I watched, two chicks hatched in five cases. In two clutches the second egg was added; I could not say for certain if a second chick hatched in the third instance. When on 14 July 1968 I climbed a tree 3m from the eyrie-tree, which itself was very difficult to climb, I could see only one newly-hatched chick with certainty. There was no clue as to the disappearance of the second egg or chick. The chick seemed anyhow not to have reached the age at which the second chick normally dies and disappears.

Apart from the Greater Spotted Eagle/Lesser Spotted Eagle population of LICHATSCHEW, which apparently lived under extreme conditions, both chicks seem to hatch from two-egg clutches in most cases. One may indeed assume that two chicks hatch in an average of three out of four Lesser Spotted Eagle eyries in which the clutch has been completely incubated - counting in single-egg clutches too.

Only SARUDNY (1911) has so far recorded three hatched young in one eyrie.

4.3.4. The problem of "Cainism"

Undoubtedly the most interesting problem in the breeding biology of the Lesser Spotted Eagle is the quite regular death and traceless disappearance of the second chick a few days after hatching. The exact sequence of events and the development of this peculiar, and at first sight apparently somewhat paradoxical occurrence cannot be regarded as fully clarified even today. WENDLAND (1958b) used the pertinent term "Cainism" for this occurrence - derived from the Biblical story of the murder of Abel by Cain - since the elder Lesser Spotted Eagle chick doubtless causes the death of its smaller sibling.

4.3.4.1. Investigations to date

The problem was recognized only relatively recently, since nearly all the older authors were of the opinion that the Lesser Spotted Eagle normally lays only one egg, or on the other hand that the second egg is usually addled. W.A. VON HOMEYER (cited in KOLLIBAY 1906) was the first to find an eyrie with two young in 1865, and GERICK (1929) was the first to put forward the opinion that this was the rule. It is the particular service of WENDLAND (1932, 1951) to have been the first to explain in principle the phenomenon of the regular disappearance of the second chick. On the basis of his observation made at the eyrie, he came to the conclusion (1951) that the cause of death of the smaller Lesser Spotted Eagle chick is to be found in its being squeezed by the older chick. The older chick has the remarkable trait of continually climbing on top of its smaller sibling, as a result of which the latter, at the same time as being prevented from being fed regularly and gradually losing its strength, is slowly crushed to death. As WENDLAND (1958a) writes, he sees this as "apparently the only case of its kind in avian biology in which one sibling is squeezed to death by another," a regular phenomenon, as it were a "birth control", which "may not be placed on the same level as, for example, the premature death of young Buzzards," since he excludes fights between siblings and a shortage of food as causes. In confirmation of his opinion he quotes the observations of HEINROTH (1933) made on two young eagles raised by hand, in which "the older scrabbled about on the electric warming-pad, with which both were covered, and in this way killed its sibling".

All other authors who have yet expressed themselves on this question have only been able to put forward theories. SLADEK (1959) observed how the larger chick worked on the smaller by pecking at it, and he assumed that the latter could not obtain any food during its short life. GERICK (1929) wrote: "Unintentional ejection through the restless crawling about of the older chick seems most likely to me." SIEWERT (1932), in whose eyrie only one chick hatched, supposed the cause to lie in the large interval between egg-laying - he established the almost certainly abnormal interval of 10 days in the eyrie studied by him - and the rapid growth of the first chick in its second week of life. GENTZ (1965) indeed proposed: "Possibly the premature death of the second chick is caused by the fact that it requires regurgitated food for the first or even second day, while the female is already feeding the older chick on small fragments of meat from frogs, mice, etc." HENRICI (1951) finally pointed to the factor of size-difference between the first and second eggs, about which there has already been some discussion (cf.4.2.4.).

4.3.4.2. Own observation and experiments

My intention to observe this interesting occurrence in its entire sequence from a hide in the neighbouring tree fell through in both 1968 and 1969. In 1968, in eyrie 5 selected for that purpose, the second egg or chick suddenly disappeared without trace on 14 June, after I had not been able to watch this eyrie for several days because of a defect in my vehicle. In 1969, in eyrie 11 selected for these observations the second egg was unfortunately infertile. Since it was the most important purpose of my Lesser Spotted Eagle studies to find a way of rearing also the second chick to flying age, in order to be able to exercise a positive influence on the status in this way (cf.7.), I had to give up the idea of letting things run their normal course in the remaining eyries. Even so the experiments conducted to this end yielded some interesting results, which one would certainly not have obtained from simple observation. I am as a result now of the opinion that further interesting conclusions may be expected from supplementary experimentation, apart from direct observations from a hide in the neighbouring tree.

Next I am going to give the most important observations briefly and chronologically from diary notes in order to present and discuss the result conjointly. For simplicity I have named the first-born "Cain" and the second-born "Abel". Thus, for example "Abel 7/68" means the second chick from eyrie 7 in the 1968 brood. The weight given after the numbers of the young are their weights for the corresponding day.

14 June 1968: Eyries 7 and 2 contain two young each. Cain 7 is about 6-7 days old and weighs 165g, the approximately 3-day old and equally lively Abel 110g (!).

The second equally intact chick in eyrie 2 weighs 70g. The two Abels are removed from their eyries.

15 June: Observed eyrie 6 in company with J. SLADEK and J. HRONCOM. I see only one chick from the neighbouring tree - the eyrie tree is very difficult to climb. We find the second one later dead but uninjured under the eyrie tree. It has a weight of 128.4g ! Unfortunately it was lost in a burglary from my vehicle before it could be dissected.

16 June: Abel 8 has finally hatched and weighs 45g. The older sibling, which I removed from the eyrie, weighs 140g.

Abel 7 has meantime reached a weight of 130g and is placed in a Black Kite eyrie (eyrie A), from which the young kite is removed at the same time.

18 June: Abel in eyrie 8 now weighs 53g, Abel 2 and Cain 8, which I am raising by hand, 135 and 180g.

19 June: Abel 8 - meantime 200g in weight - is placed in eyrie 1, in which the chick from a single egg clutch weighs 240g.

21 June: Abel 2 now weighs 180g.

22 June: Observation at eyrie 1: the added Cain 8 has fled to the nest rim and has apparently not been brooded by the female since it is quite cold when compared with the original chick from this eyrie, which is sitting in the nest bowl, and Cain 8 has by contrast an empty crop. It has lost weight and weighs only 176g, while the other chick is considerably larger and is very aggressive toward Cain 8. All the down was torn from an area of about 15 sq.cm. on the back of Cain 8. As soon as I placed it in the nest bowl, it was set upon by the other chick with pecking and fled to the rim where it was safe from attack. I again take it out of the eyrie, since it would certainly have died within a few days.

Abel 8 in the eyrie now weighs 117g, Abel 7 in the kite eyrie A 420g and Abel 2 in my care 235g.

23 June: I put Abel 2 (250g) and Cain 8 (212g) at the same time into Black Kite eyrie A, removing Abel 7 (420g) at the same time. I put Abel 7 with the 340g chick in eyrie 1. It was at once attacked by the latter, but proceeded to defend itself. They both peck strongly at each other for several minutes, always at the opponent's head. The somewhat smaller young of eyrie 1 always ends the short fighting pauses. After both chicks have pecked at each other for a while, the larger added Abel 7, although probably somewhat weakened by being transported, suddenly lies flat and allows anything to happen to itself. The belligerent chick 1 pulls at its dorsal down with shaking head-movements. Since Abel 7 faces the same as Cain 8 I remove it again from the eyrie and put it next day in Black Kite eyrie B where it was reared by the adult kites until I removed it a few days before it flew and put it into eyrie 1 (see August 6).

24 June: Several hours of observation from the hide reveal that the much larger Abel 2 shows no aggression toward the smaller Cain 8 in Black Kite eyrie A. Both are well.

26 June: Abel 2 and Cain 8 in kite eyrie A weigh 415 and 290g, Abel 8 in its own eyrie 270g.

1 July: Abel 2 and Cain 8 in kite eyrie A now weigh 580 and 335g. Since the kites apparently cannot provide the two Lesser Spotted Eagle chicks with enough food, I place Cain 8 with its younger, but meanwhile larger sibling (450g) in eyrie 8 from which it originated.

4 July: Observation at eyrie 8. Cain (450g) has been terribly set upon by its younger sibling (680g). It has large wounds on back and dorsal surface of the wings. It has fled to the outermost branches on the rim of the eyrie. I place it with its sibling in the nest bowl again. When I return to the eyrie two hours later to take some photographs of both young, Cain has once again fled to the outermost rim of the eyrie. For that reason I take it from the eyrie, since it would certainly die after a few days, and place it again in the kite eyrie.

6 July: 6 hours of observation at Black Kite eyrie A. Although Abel 2 (850g)

is now more than twice the size of Cain 8 (350g) it is not aggressive. There are colour slides showing the two chicks together in the eyrie. But as the far smaller Cain 8 is not adequately fed he has to be removed from the eyrie and reared by hand.

24 July: The young bird (1125g) from eyrie 9, which I had to take to any eyrie (cf. 4.3.7.) is placed with the young bird (1350g) in eyrie 1. Although both are already six weeks old, they still fight vigorously. One of the young is thrown several times onto its back, at which it strikes at its opponent with its talons. Since there is an acute danger that one of the young will topple from the nest, I remove chick 9 again in the evening, raise it by hand until shortly before flying and place it then in eyrie 8.

6 August: Abel 7 is removed from Black Kite eyrie B and placed with the young bird in eyrie 1. Neither shows any aggression any more. Sometimes they lie peacefully side by side in the nest bowl (cf. Fig. 8 in MEYBURG 1971). Abel 7 flew on 11 August, about 20 hours before its nest companion, chick 1.

4.3.4.3. Results and discussion

The following seems to arise from my observations:

1. The second chick is not hindered from being fed in all eyries. It can develop uninfluenced in the first days of life, as if it were alone in the nest.

Evidence for this is given by the weights of Abel 6 and Abel 7/68. Abel 6 weighed 128.4g at death; Abel 7/68 weighed 110g when it was removed from the eyrie and was still very healthy.

According to the few available measurements, the second newly hatched chick weighed an average of 48.9g (see Table 7). Thus Abel 6 gained 79.5g up to its death, which indicates a weight gain of about 20g a day in an average life span of 4 days in the second chick. Abel 7/68 could increase its weight by about 61.1g up to its removal from the nest. Even if one takes the birth weight of Abel 6 to be the maximum 63g, it could still have gained 65.4g (= 16.3g a day). It follows from this that SLADEK's (1959) opinion that the second chick could not get any food during its short life is - at least in a certain percentage of the eyries - certainly incorrect. Abel 8, whose larger sibling was removed from the nest the day it hatched, reached a weight of 128g only on the 5th day, thus at the same age at which Abel 6 should already have died at a similar weight of 128g. The single young in the eyrie watched by SIEWERT (1932) only weighed that much on its 7th day. Its daily weight gain was thus only 9.2g (see in this connection the curves for weight gains of these young in MEYBURG, 1971, Fig. 5).

2. The urge, described by WENDLAND (1951) for the older chick to climb on top of the younger and thereby squeeze it to death, has not been confirmed.

Against the existence of this drive described by WENDLAND, is the fact that I have no observations to indicate such a drive. There was one first-born chick (Cain 8) among the four Lesser Spotted Eagles that I reared by hand for a longer or shorter period. I had this bird in my care from 16 June 1968 onward. This was the day on which its younger sibling hatched - as already mentioned several times. Abel 2 and Abel 7 were partly reared at the same time as Cain 8. Abel 2 was distinctly smaller than Cain 8. Both were kept together in an artificial nest at just the same time the second chick would normally have died. Although I often watched both chicks for hours uninterruptedly, I could never see that Cain 8 tried to climb on to Abel 2. Yet another consideration throws doubt on the existence of such behaviour. As WENDLAND himself writes, this is the only drive in the animal kingdom, comparable only to that of the Cuckoo, in which all objects and nest occupants are dispatched. In the Cuckoo, however, this behaviour disappears after a few days, thus when all nest mates have been dispatched and the purpose of the behaviour pattern has been fulfilled. One would expect the same from the Lesser Spotted Eagle. My observations show, however, that artificially reared young eagles returned to the eyrie are still endangered long after the time when they should normally have died in the nest. Finally the question arises as to why nature should have adopted such an involved method as the development of a completely new behaviour pattern, when it seems enough to allow the intrinsic aggression of apparently all young raptors to manifest itself more strongly among themselves to achieve the goal of population reduction.

Now the question to be answered is how so conscientious an observer as WENDLAND could have come to the conclusion, which he stated expressly, that he was not dealing with a more or less occasional phenomenon during his observations. Perhaps this may be explained as follows: During the first days of life, young Lesser Spotted Eagles, like other young raptors, are very sensitive to cold and are commonly brooded by the female. Should one approach the nest, the female leaves, exposing the chicks to ambient temperatures, which are nearly always below their favoured temperature. Until the observer has fastened his climbing irons and reached the eyrie, the female might have been away for 10-20 minutes. In order to counteract heat loss and to present as small a surface area as possible to the outside, the two chicks instinctively crowd together as closely as possible. That the larger chick should come to lie partly on top of the smaller in a bowl is natural, especially when the size-difference between the two is considerable. WENDLAND (1959) himself speaks in one place of the smaller chick as a living warming-pad.

This supposition is completely supported by my observations on the artificially raised Cain 8 and Abel 2. If I lowered the warming lamp close to the artificial nest, the two young lay side by side. If it was extinguished by a short circuit, the two young pressed close together. By deliberate repetition I could repeatedly observe that the small Abel 2 tried to push itself right underneath Cain 8, but was unable to do so because of their comparatively small size-difference.

In the same way the accident of the young reared by HEINROTH may be explained. The older one got too warm under the warming-pad and, because it had no way of getting out of the narrow box, it crawled on top of the warming-pad. The smaller one suffocated under the weight of both.

SLADEK (1959), to whom WENDLAND's conclusion was known, also mentioned nowhere in his work, which dealt with the problem of Cainism in the Lesser Spotted Eagle, a crushing of the smaller chick by the larger. It is questionable whether the smaller cannot suffer harm from lying under a sibling almost three times heavier, in those cases in which the older is substantially larger, as for example in eyrie 8 (45g and 140g on 16 June 1968). It is, however, certainly not a real factor in the elimination of the second chick.

3. Characteristic of young Lesser Spotted Eagles is their extraordinarily intense aggressiveness among one another. The weaker chick is thereby so intimidated that it no longer dares to eat any more. It is in this tendency to be intimidated that the real reason for the death of the second chick is to be seen in those cases where the size difference between the siblings is small.

The aggressive behaviour has also been described by other authors (HOFFMANN, SLADEK). The young indulge in it with pecks aimed at the head and back of the sibling. The long hair-like down is often pulled and shaken. The older chick is almost invariably the initiator, although this behaviour is innate also in the younger chick which defends itself as well as possible. This behaviour seems innate in the young of all raptors, even those in which nestling mortality is very rare, such as the kites. The difference lies in the intensity with which the young fight.

If a weaker chick receives blows on its head during a fight, and is visibly subdued, it lies flat and lets come what may. This resembles strongly a "submissive posture" or "akinesis" (Translator's note: "akinesis" is an accepted behavioural term for the absence or cessation of motion). But this behaviour does not in any way lead to a let-up of the attacks by the stronger on the submissive chick. The longer both Lesser Spotted Eagle chicks live together and the more often the younger chick sees the dominance of the larger sibling, the sooner does the younger adopt this attitude, eventually even when it becomes aware of the other chick. Thus after a short while it was no longer possible to feed Abel 2 when Cain 8 was visible, even when I had placed the two more than a metre apart. Abel 2 lay flat and could not be induced to eat at all. However, when I removed Cain 8 from sight, it allowed itself to be fed at once. The same sort of thing must have happened in eyries 8 and 1 when I put Cain 8 and Abel 7 in experimentally.

This posture is also adopted when the dominance of the other chick is small, or even when dominance is apparent as a result of greater aggression of one young, (see observations for 23 June 1968). In this way the submissive chick undoubtedly harms

itself, since this posture affords its no protection - as already mentioned - from the attacks of its sibling, but instead prevents its being fed.

My observations thus agree fully with those of HEINROTH (1933), who wrote about the matter as follows: "Since sibling-eggs are involved, the proof was again provided that one of the eggs did not always need to be infertile at all and there were other reasons for finding only one young in the eyrie of the Lesser Spotted Eagle later on. As we mentioned earlier the quite small young of some raptors fight ferociously without the intervention of the parents. The subdued member dares not move again, so that it starves to death".

This behaviour certainly has a very real meaning in the elimination of the second chick in cases where the size difference between the two siblings is small (example, eyrie 7/68, 69), and where this difference alone is not sufficient to place the younger chick at such a disadvantage that it slowly starves. As evidence of this also is the often substantial size difference between siblings in the eyries of other raptor species, without the smallest chick always dying. That a Lesser Spotted Eagle chick could be seriously injured by another at this tender age is most unlikely. This sort of thing is possible only some time later when two larger young are experimentally placed together by human agency. On the other hand this seems to occur more often in the Golden Eagle under natural conditions.

4. In cases where the size difference between siblings is small, the second chick probably flees from the attacks of the older to the nest rim, from where it possibly falls off as a result of the careless movement of an adult, or from weakening. It might also freeze, since it cannot be brooded there.

Particular proof of this was the finding of Abel 6 under the eyrie. If the chick starves in the nest bowl, it would either be used as food or carried away from the eyrie by the adult, in which case it would hardly come to lie right under it.

How does it happen then, that these second chicks which develop normally for the first few days, as in eyries 6 and 7, suddenly die at the age of about five days? Perhaps this may be explained as follows:

The young are almost continuously brooded during the first days of life and the larger has therefore hardly an opportunity to attack the smaller. If the latter is barely smaller, it can partake of feeding. When the first chick is about ten days old, the female interrupts the brooding sometimes for quite a long time. From now on the second chick can escape from the attacks only by flight to the nest rim. It cannot be brooded there any more and is probably not fed any more. Whether it eventually dies from cooling or malnutrition, or by falling from the eyrie must be determined by further observation. It is true that I have seen only in those young Lesser Spotted Eagle experimentally put together when they had already passed the age at which the second chick would normally have died, that one always fled to the nest rim, yet this seems to me the only possible explanation as to how those young that develop quite normally at first suddenly disappear. This supposition is supported by observations on a Golden Eagle in eastern Slovakia: The second chick sat right on the nest rim and was in contrast to the larger chick in the nest bowl, cold - the brooding female had flown away at my arrival - and had, unlike the other, an empty crop. All the down on its back had been pulled out over a large area.

5. The size difference between siblings is sometimes so significant that it alone is enough to prevent the development of the second chick, since it is hardly able to obtain anything when the older chick is being fed, is then too exhausted to induce the female to go on feeding.

An impressive example of this was brood 8 in which Abel weighed 45g on 16 June when it hatched, while its larger sibling already weighed 140g, thus more than three times as much. On regarding these two chicks, I doubted that the smaller had any chance of survival, even without any particular aggressiveness on the part of the larger sibling.

In a review of the literature on the problem of neglect of runts in the nest among raptors, one encounters some inconsistency which, in my opinion, requires further

clarification. One often reads that the first bird to hatch will oust the smaller one during feeding or as SCHÜZ (1957) expresses it, "ousts it and claims everything". On the other hand, all observers of the Lesser Spotted Eagle agree that it is during the first nestling days that there is generally abundant prey in the eyrie, a fact I can only confirm. Since the ability of the first chick to take food is naturally limited, it is not immediately comprehensible why the female does not continue to feed the second chick after the first is replete, when there is still enough food in the eyrie. Perhaps an explanation is offered by an observation I made several years ago from a hide situated 8m from a Black Kite eyrie: two out of three young of a few days old were almost equal in size, while the third was by contrast clearly smaller. At the feeds this youngest one got only about every tenth morsel. Feeding ceased with the repletion of the two larger young. The smaller and still hungry chick then begged only very feebly, without vigour and chilled through, with its head swaying back and forth. Often, however, it had even lain down long before. These feeds, which lasted on average 14 minutes (max. 25 minutes, min. 10 minutes) in five accurately documented cases had made too great demands on its strength to be able to beg further, or else its now very weak begging was insufficient to stimulate the meanwhile "impatient" female to feed any more. It also happened in the Black Kite that the two larger chicks pecked at the smaller, thereby intimidating it.

Which of the three factors, intimidation by aggression, weakening after a feed, or inattention of the female to the weak begging, applies to the Lesser Spotted Eagle can only be determined by further observations. But probably no single factor is generally critical, but more often one or another applies according to the age and size difference of the young.

6. The aggression of the young a few days old is directed against everything, but particularly against moving objects of about the size of a child's fist within a range of about 50cm. The chick scrabbles determinedly towards it, up to 10 times as shown experimentally. The chick does not react any more to objects more than half a metre away.

This behaviour was impressively shown by Cain 8 during his upbringing in captivity. It was always astonishing with what tenacity and determination this chick attacked and pecked other chicks or a fist presented over the edge of the table. When removed a little way, it immediately crawled again towards it. WENDLAND's observation that the larger chick would scramble on to the smaller and oppress it probably rests on this behaviour. In the nest this behaviour is no doubt further intensified by the struggle to keep as close to the middle of the nest as possible. The precision of the distance at which the chick no longer concerned itself with that sort of object, varying according to the substrate (about 50cm - this distance was greater on a flat surface like a table top -) raises the possibility that it has to do with some sort of territorial behaviour. The subdued chick can in large measure save itself from these attacks by fleeing as far as possible to the nest rim, as I observed in Cain 8 on 22 June 1968 in eyrie 1 and on 4 July in eyrie 8. I have seen the same thing in the Golden Eagle and it has been described in the Buzzard (e. g. MEBS 1964).

7. Except in its smaller size, the second chick differs in no way at hatching from its older sibling, nor is it any less aggressive. This aggressiveness seems to be eliminated after only a few days of living together with a larger chick. Thereafter such a chick is no longer aggressive when placed experimentally even with a much smaller one.

As has already been shown by earlier observations, the chick hatching from the second egg is completely raised when the first egg fails to hatch, (SLADEK 1957). It develops just as fast as the chick hatching from the first egg in a clutch of two. That the aggressive behaviour of the second chick is just as well developed as that of the first is shown most impressively by the behaviour of Abel 8 towards its sibling (see observations for 4 July 1968).

This aggressive behaviour is, interestingly, apparently eliminated if a chick lives with another stronger one for several days. This is in a certain way reminiscent of the peck order behaviour of social animals, with the difference that the non-aggressive chick does not display any further aggressive behaviour throughout its whole nestling period, even when later it comes together with a significantly smaller chick (see e. g. observations on 6 July: Abel was quite indifferent towards Cain 8, who was not

half as big). I have never even seen Abel 7 attack one of the other two clearly smaller chicks during its artificial rearing.

It would be an interesting experiment to place two non-aggressive young of this kind and of equal size in a Lesser Spotted Eagle eyrie. If the correctness of my observation is to be confirmed, it could be tested at the same time whether a Lesser Spotted Eagle is in a position to provide enough food for the rearing of two eaglets, a fact doubted by GROTE (1936).

8. The aggressiveness of normally brought up Lesser Spotted Eagles remains of long duration in comparison with that of most of other raptors. When placed together experimentally, they tolerate each other only two weeks before flying.

The intensity with which the two chicks fought when placed together in eyrie, 1 at the age of 6 weeks on 24 July 1968 clarified to me how improbable it is that two young are ever raised in one eyrie under natural conditions.

Regarding the question of how the corpse of the second chick disappears, WENDLAND supposed that it is used as food by the female. Thereupon INGRAM (1959) took it as proven that the Lesser Spotted Eagle belonged to the list of raptors in which fratricide and subsequent "cannibalism" occurred. MÄRZ (1969) regarded this problem as one of the few for which it would be rewarding to conduct research into food remains. He writes: "Thus the problem of 'cannibalism' is not solved and one does not know whether the parents or the siblings kill the young."

As is clearly shown by my work, the second chick is not directly killed by the older sibling, since the latter is too weak at that tender age to do it any serious injury. That sort of thing may, it seems, occur in the Goshawk, the harriers and probably now and then in the Golden Eagle. In most raptors the runt nestlings die mainly from malnutrition. Cronism (Translator's note: this is the anglicised version of the original German word "Kronismus" coined by Schüz in 1957) being killed by the parents may be regarded as abnormal in raptors, if it occurs at all. At most a chick that was no longer moving could be used as already dead food for the other chick.

I regard it as equally possible that those young Lesser Spotted Eagles that are ousted at feeding times and starve, are later treated as prey by the female, but there is still no proof of this. But in cases in which the second chick can develop normally for the first few days of life - this may be the majority - it seems to me questionable whether these nestlings do not die sooner from falling down, as already suggested. The find of 15 June 1968 is indeed to be regarded as evidence of this.

My work should have made it clear how little we still know about the disappearance of the second Lesser Spotted Eagle chick in particular. Many of my statements are of a hypothetical nature and definitely need confirmation, 1. by direct observation from a hide, 2. by daily weighing of the young in as many eyries as possible, and 3. by special experiments such as have already been suggested.

4.3.4.4. Rearing of two eaglets

Even in the most recent comprehensive works one finds the opinion expressed that Lesser Spotted Eagles raise two young in rare cases. Thus BROWN and AMADON (1968) write: "Few nests rear two young, even when food is abundant", and GEROUDET (1965) remarks that the Lesser Spotted Eagle raises only one offspring except in the rarest cases.

This doubtless stems from a case mentioned by WENDLAND (1959) in his monograph, in which two young Lesser Spotted Eagles were supposed to have left the nest (HOFFMANN 1931). Although HOFFMANN, more than anyone else, had and used the opportunity to observe Lesser and Greater Spotted Eagles thoroughly at the eyrie on a comparative basis, it seems to me, after a thorough and accurate study of his publications, that a case of confusion with the Greater Spotted Eagle cannot altogether be ruled out. I shall name only the most important criteria that indicate the possibility of such a confusion: 1. The eyrie in question is the very first Lesser or Greater Spotted Eagle eyrie to which HOFFMANN climbed. 2. HOFFMANN saw the two eaglets close up for the last time when they were four weeks old, and could not therefore establish the presence or absence

of the yellow nape spot, the only characteristic by which the two species may be distinguished with certainty. 3. Only 600m away HOFFMANN found another eyrie in 1930, which he described also as a Lesser Spotted Eagle eyrie (1931). In his Greater Spotted Eagle work which appeared only a little later (1932) it is quite evident, however, at the top of p.260, that he was dealing with Greater Spotted Eagles at this second eyrie in 1930, thus in the same year that the two eaglets left the other eyrie, a sure sign that he could not distinguish with certainty between the two species at this time.

LICHATSCHEW (1957), who did very thorough studies on raptors from 1938-1953 on a 3800 - hectare forest at Tula, about 200km south of Moscow, established in 1938, 1945 and 1949 the departure of two "Lesser Spotted Eagles" from one eyrie. The sum of some conspicuous statements, which cannot be discussed here in detail, indicates that he was likewise dealing, in the case of most breeding pairs, with Greater Spotted Eagles. Here I may name in particular: 1. the weight of the eggs, of which 3 out of 8 weighed more than 100g, which is never the case in the Lesser Spotted Eagle; 2. the egg measurements - leaving out one clear Lesser Spotted Eagle clutch, the mean values of the remaining eggs agree almost exactly with those given in "Hartert" for the Greater Spotted Eagle; 3. the nestling period, which in the case of one second eaglet lasted 66-67 days (!); 4. the weight of the fledged young (up to 2100g) and 5. the large number of birds (35%) and the insignificant number of amphibians (4%) in the food, quite apart from the fact that the observation area lies about 100km east of the eastern limit of the distribution of the Lesser Spotted Eagle given by DEMENTIEW and GLADKOW (1951).

According to RIECK (1962), two Lesser Spotted Eagles were supposed to have left an eyrie in the Schorfheide.

In summary it can indeed be said that almost every account of the departure of two Lesser Spotted Eaglets from one eyrie given in the literature is the result of confusion with the Greater Spotted Eagle, in which this does not constitute a decided exception. According to WENDLAND (pers. comm.) this is known in at least 12 definitely established cases. For this reason I did not quote data of this kind mentioned in the older literature - e.g. KRÜPER 1852, CHRISTOLEIT 1903. Nevertheless the departure of two young in the Lesser Spotted Eagle may perhaps occur quite exceptionally even today, but proof of this is still lacking.

4.3.5. Behaviour of the parents during the rearing of the young

One may expect the most interesting and impressive experiences with the Lesser Spotted Eagle during the nestling period from observations from a hide in the neighbouring tree with a view into the eyrie. I put my prefabricated hide, whose erection took scarcely an hour, 14m from eyrie 1 at a height of about 18m on 30 June 1968. The hide frame made of light metal has a height of 1.20m and a floor area of 0.6 x 1.0m. It is covered with a double layer of green material, on the outside with finer and on the inside with coarser sacking. Suitable large holes cut in the inner layer allow a practically unrestricted view to the outside, while the coarse mesh of the outer layer prevents one from being seen. The great advantage of the construction lies in the short assembling time needed when the attachment can only be done during the nestling period. Working in two stages, danger of disturbance to the parents can be cut to a minimum. On the first day the hide, which is brought fully assembled, is simply pulled up quickly on a rope. Looking from a ground hide at a greater distance, it can be seen whether the old birds accept it. If so, it is finally attached some days later, otherwise it must quickly be taken down the same day.

Pair 1 accustomed themselves quickly to the hide, and after a short while, showed not the slightest fear of it. For example, the female frequently sat on a branch only 4m from it.

I spent 216 hours in this hide on 17 days, sometimes up to 15.75 hours a day, from the beginning of the fourth week of the eaglet's life until its departure. At first I entered my hide very early in the morning, often between 0300 and 0400 hours. Since the parents never became active before 0600 hours, I later began the observations at this time.

In relation to the relatively few hours spent at the eyrie by other authors during the nestling period (WENDLAND 31, GENTZ 51, SIEWERT and HOFFMANN not accurately

determinable), I may be permitted to report on the most important results of my observations. In order to present these as clearly as possible and to avoid tedious and superfluous diary entries, I have presented the most important behaviour patterns and events at the eyrie by means of symbols arranged chronologically in Fig.3. Unfortunately I could not make any thorough observations for the first three weeks of the chick's life. This was not possible on the one hand because of lack of time, since I gave preference to my experiments on the rearing of the second chick (cf.7.), which initially caused considerable expense, and on the other hand since the female of pair 5, at whose eyrie I had also erected a hide, discovered me in the hide on the third or fourth day of the chick's life (cf. 6). I could therefore not count on uninhibited behaviour in this bird and I quickly removed my hide. For this reason I could watch only pair 4 on two days during the first week of life.

The following account treats mainly of the frequency of individual events, thus more of the frequency of bringing prey or twigs, and less on the behaviour of the birds in particular, since other authors have reported exhaustively on this already (WENDLAND, SIEWERT, HOFFMANN, GENTZ), and my observations agree overall with them.

4.3.5.1. Brooding of the young

During the first week of life the young Lesser Spotted Eagles are brooded almost continuously by the female parent, except for a few minutes when they are being fed, when the female undertakes short flight movements. The male has been seen brooding only by SIEWERT (1932) and it is open to question whether this does not represent an exception resulting from disturbances. In the course of the second, and especially the third, weeks of life brooding is increasingly interrupted, especially in warm weather. From the fourth week the chick is kept warm during the day only exceptionally in cold wet weather, but possibly still regularly at night. The advanced age at which the chick is still brooded exceptionally by the female during the day is seen from Fig. 3. If the behaviour of the female to brood the chick is initially released by the sight of it, it is the chick itself that later approaches the female waiting on the nest edge, by soliciting and sticking its head under her feathers. One cannot actually speak of "brooding" at this time, since the chick has now grown much too big to be covered adequately by the female. It is more that only the head is tucked under the parent's fluffed belly plumage, which really looks amusing to the observer. The chick at eyrie 1 is still being "brooded" in this way at the age of 43 days. At night it probably solicited the female to a still later age, since she spent the night at the eyrie until at least two weeks before it left the nest.

4.3.5.2. Standing guard at the nest

The female remains almost constantly at the eyrie until the chick is 3 weeks old. Even thereafter she remains perched on the edge of the nest for many hours during the day, but gradually takes up sentry post more and more in the close vicinity. From then on it is hard to tell if she stays continuously in the vicinity of the eyrie (thin long lines in Fig. 3), or if she also makes a hunting flight now and then, since she changes her perch from time to time and cannot be kept in view uninterruptedly. It is also worth stating as WENDLAND (1951) very correctly remarked, that the female's drive to guard the young is slowly lost with rather frequent disturbance, which is unavoidable when observing from a hide in the neighbouring tree, and replaced by the hunting drive which normally reawakens only much later. The female of pair 1 brought prey twice to the eyrie only on the 32nd day of the chick's life; she seemed to have caught it herself. During the first week of the chick's life the female is undoubtedly fed by the male, because she mostly feeds herself at the feeds. The female of pair 1 came almost every day to the eyrie up to the 51st day of the chick's life in order to tear up prey for it. It is certain that the amount of food it took by itself would not have been enough to keep it alive. Up to this day she brought food to the eyrie only 7 times, but I could not establish that she got it from the male. It would no doubt be possible that it could have been given to her by the male and that she could also be provided for by the male until the young flies and does not leave the immediate vicinity of the eyrie. It is more likely that she gradually feeds herself more and more after the fourth week, but carries prey only now and then to the eyrie herself.

Apart from the time needed to hunt for her own food, she remains practically constantly in the neighbourhood of the eyrie until the eaglet's departure. This was evidenced by the constant calling which betrayed the female's presence every time, as soon as the male appeared near the eyrie with prey (cf. 4.3.5.6.). Until the chick was 49 days old, and perhaps even after this, the female spent the night in the eyrie. According to SCHROOT's observations (1938) the female is supposed to spend the night at the eyrie until the chick's departure.

4.3.5.3. Bringing of twigs

It is a well known and much discussed fact that Lesser Spotted Eagle eyries are continually lined with fresh twigs by the parents during the nestling period. At the two eyries that I observed I never saw the males carrying twigs. They came to the eyrie exclusively to hand over prey.

I could often watch and photograph the females breaking off the twigs at short range. To do so they walked along a thin branch which usually bent under their weight, as far as possible to the tip, beating their wings to maintain a balance, and sought a side twig to break off with the bill.

During the entire period of observation the female of pair 1 brought 39 twigs to the eyrie (symbolized by triangles in Fig. 3). 31 of them were freshly foliated (triangle solid black), the rest dry (triangle open).

In the course of 14 days, during which I encompassed the entire daily activity, the bird brought 38 branches, an average of 2.7 per day, maximally 9 in one day and none at all on 4 days. The number of branches brought daily to the nest decreased on average with the advancing age of the chick, but they were nonetheless brought practically to the time of its departure.

The twigs were not usually built in, they were simply dropped into the nest bowl. One day the chick was completely covered as it lay in the nest bowl after the female had brought several large branches one after the other to the eyrie.

The arrivals with twigs were, on average, a steady occurrence between 0600 and 1800 hours. Only between the period of 1800 and 1900 hours was a clear increase noted in the bringing of 9 twigs, apparently associated with the female spending the night at the eyrie, as she was more often seen in the neighbourhood of the nest shortly before dawn than during the rest of the daylight hours.

4.3.5.4. Feeding of the chick

A few hours after hatching, the young Lesser Spotted Eagle opens its eyes and is then immediately in a position to take small pieces of meat presented to it. Since the prey animals - mostly frogs and mice - brought by the female are comparatively small, the chick is soon in a position to feed itself insofar as it swallows them whole. The astounding feats performed by young Lesser Spotted Eagles in this way have already been graphically described (WENDLAND, HOFFMANN). The chick is still quite dependent on the female for a long time when the prey is larger. As can be seen from Fig. 3 the female tears up the prey for the chick until it is 51 days old. The most fully grown eaglet, to which the female presents pieces hardly larger than to a newly hatched chick, often gives a really "impatient" impression. The frequency and duration of feeds can be deduced from Fig. 3.

4.3.5.5. Frequency of bringing prey and consumption of food

As can be seen from Figs. 3 and 4, prey was brought to the eaglet 65 times in the course of the 216 hours I spent at the eyrie. Of this, the male brought 49 items, the female 16. Four of the 16 prey animals had certainly been taken from the male by the female shortly beforehand, so that she seemed only to have brought 12 animals altogether that she had killed herself.

Under the very difficult conditions of observation - prey animals were mostly already partly eaten or plucked and usually visible only for fractions of a second - the following were identified: 44 small mammals, mostly fieldmice, 3 frogs, 2 mouse-

-weasels and one bird; also 7 larger mammals - already half eaten - which were recognizable only as rather large bloody lumps of meat, and contrary to the other prey animals, mostly carried in the talons. In 8 cases I could not identify the prey items at all.

The daily distribution of arrivals with prey appears in Fig. 5: As it shows, the birds - and mostly the male - were actively hunting mainly between 0700 and 1100 hours and again between 1200 and 1600 hours. No prey was brought to the eyrie before 0600 hours and after 1800 hours. Only a short time elapsed between striking smaller animals and the arrival of the bird at the nest, since the male often came to the nest with mice at intervals of only a few minutes and made at such times a definitely exhausted impression. Afterwards he sat panting for a few minutes near the eyrie before flying away again. Only the devouring of the head end of larger prey animals seemed to delay a little the appearance at the eyrie. One cannot be too far wrong in equating the moment of hunting and bringing in the prey.

The minimal interval of time between the bringing in of two prey animals by the male was sometimes amazingly small, in one case only 11 minutes, in several others 15-20 minutes. If one reviews the time taken for the to and fro flight to the hunting grounds, the male must have needed only a few minutes for a successful hunt.

In the course of 14 days on which I watched throughout from morning to evening 56 prey animals were brought, thus an average of 4 a day, maximally 12, minimally 1 on one day (cf. Figs. 3 and 4).

It seems rewarding to undertake the attempt to calculate approximately from this the food consumption of a young Lesser Spotted Eagle during its nestling period and furthermore that of a Lesser Spotted Eagle pair during its stay in the breeding area.

For this purpose the mean weights are given of single prey animal groups from prey collected by me in 1968 at different eyries:

1. Small mammals 25g. (This refers mainly to field mice Microtus arvalis. To 39 field mice collected at eyries, there were only two yellow-necked mice Apodemus flavicollis, and one each of house mouse Mus musculus, dwarf mouse Micromys minutus, large vole Arvicola terrestris and hamster Cricetus cricetus).

2. Large mammals 150g. (This refers almost exclusively to juvenile hares Lepus europaeus. Remains of 5 hares found in eyries weighed 700g. I could not of course determine how much had already been eaten by the male and female, and how much had been fed to the chick. I obtained the impression from direct observation at eyrie 1 that the male had already eaten the bulk thereof. Since all these animals were brought to the eyrie at a time when the female was still tearing up food for the chick and was also eating some herself, 150g is hardly too low an estimate for the eaglet.).

3. Mouse-weasel 100g. (Both animals were completely undamaged when brought to the eyrie. Four other mouse weasels found at eyries gave approximately this value on average.).

4. Birds 30g. (The only bird brought seemed really small to me. A field sparrow found at an eyrie weighed 30g.).

5. Frogs 15g. (Mean weight of 6 grass frogs Rana temporaria.).

6. Unidentified prey animals 25g. (These were apparently mostly field mice.).

The prey animals found at some eyries at the start of the nestling period in 1968, with their total weight, are presented below for review. It must be remembered that the female also fed on these, for reasons given. Later on one seldom finds prey animals in the eyrie.

Eyrie 7 on 14 June: 1 juv. hare, 1 large vole, 1 yellow-necked mouse, 4 field mice and 1 juv. chaffinch, altogether 355g.

Eyrie 8 on 15 June: 2 juv. hares and 1 yellow-necked mouse, together 232.6g.

Eyrie 8 on 18 June: 1 juv. hare, 160g.

Eyrie 1 on 19 June: 3 field mice, 1 adult partridge, together 411g.

Eyrie 1 on 23 June: 1 juv. hare, 1 adult quail, 1 dwarf mouse, 2 field mice and one grass frog, altogether 268g.

Eyrie 4 on 26 June: 1 adult mouse-weasel and 1 juv. chicken, together 117g.

This gives a total weight of 2345g for the above 56 prey animals, from which a food requirement of 167.5g per day per eaglet can be calculated, a value that one can regard as average from the 10th day of life to flying age. Assuming a mean food requirement of 80g during the first ten days of life, a young Lesser Spotted Eagle would need 8840g of food from hatching to flying.

Compared with the common Buzzard, a young Lesser Spotted Eagle would, on average, take as much food as two young Buzzards during its nestling period. However, it seems to me that the mean weight of daily needs of 75g for a Buzzards nestling given by UTTENDÖRFER (1952) and THIOLLAY (1967) is rather low.

In order to get an approximate idea of the food requirements of a Lesser Spotted Eagle family during its stay in the breeding area, another short calculation is given. Taking the daily food needs of one adult and of the eaglet after flying as 150g and that of the female during the breeding season as 80g, a value of 56.3kg is obtained during the stay of the birds from 10 April to 10 September and the departure of the eaglet on 10 August. That would amount to about 2250 field mice.

4.3.5.6. Other behaviour patterns

GENTZ (1965) described a distinct greeting ceremony in the female Lesser Spotted Eagle, of which he had known nothing from the literature. As soon as the male appears in the vicinity of the eyrie she adopts a horizontal attitude, bowed forwards, and follows the mate with her eyes, her neck strongly drawn inwards and soliciting continuously. SIEWERT (1932) described very similar behaviour that he saw before egg-laying as a "mating-ceremony". I have also seen and photographed the behaviour described by GENTZ, very often at the time of handing over the prey. It seems to give the impression of sexual excitement in the female, although no more copulation takes place during the nestling period. The biological significance of this behaviour, especially of the great variety of call notes accompanying it, seems to me to lie in the stimulation of the male to bring the prey with which he has landed near the eyrie, actually to the eyrie and to hand it to the female and later directly to the chick. I have seen equivalent behaviour also in the Black Kite, both before matings and feedings of the female by the male and later when prey is handed over during incubation and nestling periods. This quite flexible behaviour does not cease in any way, as GENTZ writes, as soon as the female no longer stands guard at the eyrie, but remains until the departure of the eaglet. The only later difference is that the female calls from any place in the neighbourhood of the eyrie and the prey is generally given directly to the eaglet by the male. It was often possible to determine the presence of the female in the nesting territory only by the commonly prolonged calling, for which GENTZ knew no explanation. It could immediately be determined from its intensity and nuances whether the male had prey and how far he still was from the nest. If I could see the female, it was often most impressive to watch her increasing excitement at the approach of the male carrying prey to the eyrie. As soon as the eaglet had taken the prey, the female again adopted a relaxed attitude. By watching at the same time the shy behaviour of the male, which sometimes approached the eyrie only very hesitantly I could not escape the impression that he required the "moral support" of the female to dare to come near the eyrie. Since one could determine without difficulty the domination of the female over the male at "nest relief" during the breeding season, it is possible to assume that the same situation obtains as in the Fish Eagle, in which both partners defend different territories; the female the eyrie and its immediate vicinity, the male only the further environs of the eyrie. Perhaps the shyness of the male Lesser Spotted Eagle at the nest results from this. If he is further disturbed by human intrusion, he will eventually not trust himself to come to the nest at all, or else will do so only intermittently. If the female has called in vain for some time, she flies to the male and brings the prey to the nest herself. If she had not been spending the time at the nest beforehand, it would easily create the impression in the observer that she had been hunting by herself. But even when the male is not disturbed, the female grows "impatient" if she waits too long for the prey to be handed over, and she then flies to the male.

4.3.6. Duration of the nestling period

At an eyrie watched closely by SLADEK (1957) the eaglet flew at the age of 55 days when the nest was checked.

The second chick in eyrie 8 hatched at 0900 hours on 16 June 1968 and on 11 August, at the age of 57 days, was perched on a branch 1m from the nest, and flew at my approach. Both young would probably only have attempted the flight several days later had they been undisturbed. The nestling period thus normally lasts about 58 days on average. The second young from eyrie 2 raised by a pair of Black Kites flew by itself, however, at the age of 51 days and was quite flightworthy.

SLADEK (1957) has already published on the development of the Lesser Spotted Eagle from hatching to flying, and above all watched the succession of feathering by means of photographs, while I have presented the weight gain elsewhere (MEYBURG 1971).

4.3.7. Reproductive rate

Out of a total of 17 Lesser Spotted Eagle broods studied by me, 4 failed. This means a recruitment rate of 0.76 fledged young per pair per year.

This corrected value may actually be placed somewhat lower, since not all the eyries were watched through to the fledging of the eaglet. On the other hand the two chicks to hatch second have not been included in the calculation; they would normally have died after hatching with absolute certainty, but were reared through my experimentation (cf. MEYBURG 1971, and Section 7.).

On 15 May 1968 I found half an eggshell under eyrie 3. The nest itself was empty, but the fresh lining in the bowl showed that the disturbance must have been recent. The incubating female might have been shot, since I encountered only one Lesser Spotted Eagle near the eyrie on several days. At a Goshawk eyrie not many hundreds of meters away I found the female shot dead on her four partly destroyed eggs.

The chick from eyrie 2 disappeared without trace during June 1968. Apparently this loss was attributable to human agency, since the eyrie was generally known in the neighbouring village.

Destruction of the clutch in eyrie 10, in which I found only fragments of eggshell at the end of May 1969, may not have been of human account. Pine-martens had possibly been at work here.

The chick in the very low eyrie 9 was taken in June 1969 by a young boy. Fortunately I was able to lay my hands on it. After a time of intensive care I placed it with the chick in eyrie 8, from which it also flew. It has likewise not been included in my calculation, since it would normally have been lost to the population.

Also included in the calculation would be those pairs which apparently did not breed at all. Thus I found several typical Lesser Spotted Eagle eyries that were in fact lined with greenery, but were not occupied. HOFFMANN (1938) made similar observations. It is in any event very difficult to estimate the number of such pairs.

For comparison the results of the few other more comprehensive investigations are given: out of 12 broods observed by WENDLAND (1932) from 1929 to 1931, 8 young flew, thus 0.66 young per pair per year. In a later work (1951) he wrote only that two pairs watched for over 20 years in Mark Brandenburg could rear their brood mostly undisturbed.

GOLODUSCHKO (1961) studied 35 Lesser Spotted Eagle broods, containing 64 eggs, in the Russian part of the forest of Bialowies. Of these, no young hatched out of 14 eggs (= 21.9%). Among them were all 6 single-egg clutches. Of the 50 young that hatched, 29 died (= 58%). Therefore 0.6 young flew per pair per year. Unfortunately it is not apparent from this work why nothing hatched from the 6 single-egg clutches; whether the 8 remaining eggs that did not hatch consisted of 4 two-egg clutches, a conclusion one can make indirectly from the text; and why both young died in 4 eyries.

Finally LICHATSCHEW (1957) made interesting observations on a Greater Spotted Eagle/Lesser Spotted Eagle population at Tula. An average of 4 pairs a year were

studied from 1938-1954. In many years of poor food supply a number of pairs did not breed. In some years no eagles bred at all, as in 1939, 1941, and 1942. In 1940 four out of five clutches were abandoned - probably as a result of shortage of food. In 1949 the chicks died in two out of four broods. Out of 35 complete clutches, 22 (62.9%) had 1 egg and only 13 (37.1%) two eggs. At hatching there were 26 broods with one chick (86.7%) and only 4 broods of 2 chicks (13.3%). 24 nests produced 1 flying young each (88.9%) and 3 nests (11.1%) produced 2 each! Altogether the number of fledged young was 0.93 per pair per year, including those pairs that did not attempt to breed at all.

4.4. Post-nestling dependent period

(Translator's note: this is known in German as the "begging-flight" period)

Within the total reproductive period, the time from departure until independence of the young is, as with most raptor species, the most poorly known.

According to WENDLAND (1951) the eyrie is still rather often used as the site of prey-transfer. When he was examining an eyrie for food remains, a young bird that had left the nest 3 weeks earlier suddenly arrived on the eyrie at the call of an adult in the distance. I regard this as an incidental observation or a rare exception. The chick of pair 8, which left the nest several days before the added chick from eyrie 9 (cf. 4.3.7.) had to go hungry until the latter also left the eyrie, since the adults were busy up to then bringing prey (cf. also MEYBURG 1971). If it had flown back to the eyrie itself, it could have been assured of its share, since it was somewhat stronger than the added young one. Even my other, if rather scanty, observations show that the young Lesser Spotted Eagle does not return to the eyrie after its departure, either to spend the night or to get prey. They agree in this respect completely with the conclusion of SCHROOT (1938).

According to WENDLAND (1951) the young Lesser Spotted Eagles are supposed to be fed by the adults for at least another 3-4 weeks. PORTENKO (1928) claims to have seen an eaglet, departed on 4 August, hunting independently on 12 August.

Whether the young eagles accompany the parent on migration to the winter quarters, or whether the birds depart separately, has still to be determined.

5. HUNTING METHODS

I have not observed hunting Lesser Spotted Eagles systematically, but I have seen 12 hunting flights at closest proximity from a car. Of these, only one was successful. In these flights the birds circled over the fields and meadows at a height of about 30-50m. When they spotted a prey animal, they turned into the wind in order to locate it exactly. If the situation was favourable, they simply dropped vertically on to the prey by more or less closing the wings to regulate the speed of fall, which must be quite considerable. Shortly before reaching the ground, at a height of about 10m, the talons are extended forwards, as one of my photographs clearly shows. I also saw a Golden Eagle in eastern Slovakia hunting in exactly this way without success. I have never seen the characteristic hunting on foot described from northern Germany (SIEWERT 1932). They would hardly have been guaranteed any success in dry eastern Slovakia where the field mouse is the most important prey, quite contrary to the moist hunting grounds of northern Germany where hunting is rather for live frogs occurring in fairly high density along the margins of ditches.

6. BEHAVIOUR TOWARDS MAN

In a rare and threatened species of bird like the Lesser Spotted Eagle, it seems fitting to go into the behaviour of the birds towards man, for the chances of survival of the species are largely dependent upon the animals' ability to adapt their way of life to the ever-increasing population of the countryside.

On the whole, the Lesser Spotted Eagle pairs studied by me in Slovakia were

hardly shyer than the Common Buzzard. Most of the incubating and brooding females left the nest only when one tapped the nesting tree. Only a few had a greater flight-distance.

The females of pair 4 and 10 sat especially closely. Both eyries were on really steep cliffs, so that one could look into the eyries from the top. Female 10 flew hesitatingly away when one looked over in this way with field glasses for some time. Female 4 did not even allow herself to be flushed in this way, even when I watched for 5 or 10 minutes or sang or shouted loudly, although the distance was only 50m. Both females behaved in exactly the same way in 1968 and 1969, so that one could be sure that the same birds were involved in both years (cf. 4.1.2.).

I watched at eyrie 4 for a rather long time during the incubation period (cf. 4.2.5.). The female stayed on the nest even during construction of the observation tent. As soon as I disappeared into the tent, she popped her head up, laying it flat on the nest rim as soon as she saw me and behaved quite unconcernedly. If I wanted to leave the tent, I had to start talking and singing loudly shortly beforehand so as to prepare her for the appearance of a person. If I did not do this and appeared suddenly, she took fright and left. The behaviour of this female resembled in some ways that of one described by WENDLAND (1959). The female discovered him as he climbed to the hide and became most excited. Nevertheless she returned to the eyrie 20 minutes after he had disappeared into the hide. WENDLAND concluded from this that the Lesser Spotted Eagle "can never, as could a person, make the following deductions: 1. a person has climbed into the hide, 2. he has not climbed out, therefore 3. he is still inside." The female of pair 5 showed me greater "intelligence" than this in a most impressive way. I had erected one of my prefabricated hides in a tree next to her nesting tree and it had been immediately accepted by the eagles. On the first day of observation the female soon came to the eyrie and began to brood the chick of a few days old. She did not concern herself further with the telephoto lens that protruded a little from the hide. Unfortunately I had a hole in the material of the hide rather too large for the telephoto lens, so that there was a 1-cm wide gap between the lens and the hide, which I used as an observation hole. Since I still had the camera in front of me, I sat half a metre from this gap. For several hours the female had stayed on the nest quite unconcernedly, when suddenly I noticed that she had caught my eye behind the gap. I do not know which of us got the greater fright at that moment. For a fraction of a second she stood immobile and then flew like lightning from the eyrie. When she had not returned after several hours, but only called from time to time nearby, I left the hide. The day after next a companion accompanied me to the eyrie and went away singing loudly and with conspicuous movements after I had disappeared into the hide. I waited in vain for several hours but the female did not come to the eyrie. Only the male brought a mouse now and then. A further two days later I came to the eyrie at 0200 hours at night. Since I waited again in vain, I removed the hide and did not bother the pair again. At the times when I was not in the hide, the female must have cared for the chick, since it could not manage by itself the prey brought by the male. However, it gave a healthy impression and later left the nest successfully. I cannot explain the behaviour of this female except that she was quite capable of making the deductions described by WENDLAND.

Pair 1 which I watched the longest had its eyrie only 80m from a road. If woodsmen or berry-pickers passed along it, the female hardly noticed them, but flew away only when they left the road. Once a thermos flask slipped out of my hands in the hide and fell clattering loudly on to the metal floor. The female looked in all directions for the source of this sound, but appeared not even to have considered the hide.

These and many other little observations made it clear to me how well the Lesser Spotted Eagle is able to fit in with man and his technological civilization.

7. PROTECTION OF THE LESSER SPOTTED EAGLE

One of the main aims of my Lesser Spotted Eagle investigations was to test the possibility of preventing the regular death of the second chick and to rear it to fledging for the conservation of the species. Since a positive result can be

expected from such a possibility only if a large number of eyries are treated, it must fulfil the requirements of being conducted with as little disturbance as possible by a very few experienced specialists in the shortest possible time. I have outlined and discussed fully elsewhere the experiments in this direction and their results (MEYBURG, 1971). Therefore I shall go into this only briefly here. The only possible method is to be conducted in the following way:

One of the newly hatched chicks, or the second egg, which can then be incubated artificially, must be removed from the Lesser Spotted Eagle eyrie and placed in the eyrie of another large raptor, whose own chick must be removed at the same time. The young Lesser Spotted Eagle reared by the foster-parents must be returned to a Lesser Spotted Eagle eyrie shortly before it flies, in order to be fed further by the Lesser Spotted Eagle adults after it leaves the eyrie. The young removed from the nests of foster-parents are to be placed in other nests of the same species.

In 1968 I gave the second chicks to two Black Kite pairs to rear. The one flew prematurely and could not be captured. I put the other one in a Lesser Spotted Eagle eyrie, from which it flew a day before its nest mate. In 1969 I put a second chick into a Buzzard eyrie. It was also adopted by the adults, but unfortunately disappeared suddenly without trace after some time.

Since two chicks hatch in an average of 3 out of 4 nests of the Lesser Spotted Eagle (cf. 4.3.3.), it would be possible to raise the reproductive rate of the Lesser Spotted Eagle by about 75% if the competent nature conservation authorities decided to have the necessary measures taken by the raptor-specialists. Since only a few climbs need to be made altogether to each eyrie, the necessary expense is very small - at least in comparison with the permanent watch on Sea Eagle and Peregrine eyries - quite apart from the greater success that can be expected.

In view of the world-wide decrease in raptors, it seems fitting to test the possibility of taking corresponding conservation measures with other threatened species. I have already begun this sort of investigation in the Golden Eagle. In this connection it has been mentioned that the second chick of a Black Eagle (Aquila verreauxi) in which two chicks always hatch, but are never both reared, has been successfully reared to fledging in the Matopos National Park in Rhodesia in 1969 (GARGETT 1970).

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