

# Weight change patterns in breeding Great Tits (*Parus major*)

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Between 1993 and 1997 we weighed 12 Great Tit nests automatically using electronic balances for periods of 6-47 days during the breeding seasons. We used "The Visitor" software package for collecting and processing the data. In this paper we publish the results of the analyses of the day to day changes of morning and evening body weights of females and males.

1. None of the 12 males lost or gained weight during the observation periods.
2. Those two females whose weight was measured from the beginning of egg-laying until fledging had three different weight levels: average roosting weight during egg laying, during incubation and during late feeding differed. None of these females lost weight during egg laying, but one female's egg weight decreased. The females' morning weight levels were similar at egg laying and incubation.
3. Each female maintained her weight through incubation (N = 4). Females lost weight (10% on average, N = 4) after hatching, in the brooding period. Ten females maintained their body weight, while two others lost weight in the late feeding period.
4. We did not find any significant difference either in the average weight gained per hour during a day or in the average weight lost per hour during a night between the four periods of breeding (N = 5 females).

Based on other published data and on our own results we think that a substantial gain in weight before egg laying and some weight loss of females after hatching is a general phenomenon among Passerines. The substantial increase in body weight just before laying and its maintenance until the brooding period can partly be explained by the high energetic demands of laying and incubation. Reserves can serve as buffers against unfavourable conditions during these periods. Flight cost of high body weight makes weight loss before the peak feeding period adaptive but the exact timing and amount of this weight loss may depend on the actual energetic demands of brooding. Thus, optimal clutch size may depend on the amount of reserves a female can mobilise right after incubation.

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## 1. Introduction

There is a long-standing interest in understanding the breeding behavior of small Passerines and especially of Great Tits (Gibb 1950, Kluyver 1952, Noordwijk *et al.* 1995, Perrins 1996). Does egg laying, incubation or nestling feeding impose

some costs on the parents (*sensu* Williams 1966) or is parental effort always below the level that may influence parental survival (Gibb 1950, Lack 1947, Tuomi 1990)?

It is standard practice amongst field ornithologists that when birds are caught their body weight is also measured. Changes in body weight of the parents dur-



Tab. 1. An overview of the observed nests. The last 2 digits in the nest IDs give the year of observation. "Length" gives the number of days when a nest was actually measured. Thus, in the three cases denoted by \*, the time spans of the observations were longer than the number of observation days.

Nest ID	Nest data			Observation	
	No. Eggs	Hatched young	Fledged young	Length (days)	Beginning from
G50-93	8	8	8	12 *	brooding
G165-93	8	6	6	11	late feeding
G375-93	9	9	6	13	late feeding
G18-94	7	7	8	11	late feeding
G40-94	7	6	6	17	brooding
G16-95	10	10	6	43	egg-laying
G40-95	7	7	6	11	late feeding
G47-95	9	9	8	8	late feeding
G225-95	8	6	5	41 **	egg-laying
G231-95	8	7	7	6	late feeding
G231-96	7	4	4	26 *	incubation
G65-97-1	6	5	5	28	incubation

\* observation interrupted for 2 days

\*\* observation interrupted for 6 days

ing the breeding season is often considered as a good indicator of physiological condition and parental costs (Drent & Daan 1980, Nur 1984, Jones 1987a, Kacelnik & Cuthill 1990, Johnston 1992, Martins & Wright 1993, Merila & Wiggins 1997). Decreased body weight in enlarged broods is considered as a result of optimal allocation of energy between self-maintenance and reproductive effort and a sign of potential reduction in future survival (Stearns 1992). There is plenty of evidence that nestling body weight at fledging influences future survival of the nestlings (Perrins 1965, Garnett 1982, Lindén *et al.* 1992). Brood size manipulation experiments show that reduced body weight of the parents rearing enlarged broods corresponds with reduced parental survival (Stearns 1992).

Another approach to interpret weight changes during breeding is to consider weight changes on a longer time scale and to examine the changing ecological costs and benefits of fat storage (Witter & Cuthill 1993). Females gain weight just before egg laying (Witter & Cuthill 1993, Woodburn & Perrins 1997). The birds often lose weight during incubation or after the chicks hatch (Freed 1981, Ricklefs & Hessel 1984, Jones 1987a, Woodburn & Perrins 1997). A possible explanation for this pattern is that a bird needs her fat reserve during incubation as a buffer against long, unfavorable periods when she has to stay in the nest without self-feeding. The brooding birds lose these reserves before the peak feeding period when excess weight would increase their flight costs (Sanz & Moreno 1995).

Tab. 2. Comparison of the morning (MW) and roosting weights (RW) measured on the last day of incubation (Day -1) and the day before fledging (Day 18) for 4 females. The results of paired t-tests are shown (t and p values).

	Mean $\pm$ SD (g)	Day 18 MW		Day 18 RW	
		17.40 $\pm$ 0.46		18.47 $\pm$ 0.73	
Day -1 MW	19.31 $\pm$ 0.38	4.87	0.0166	1.64	0.1997
Day -1 RW	20.00 $\pm$ 0.78	4.88	0.0164	2.37	0.0985

Tab. 3. Daily body-weight changes expressed as percents of the morning weights (Mean  $\pm$  SD, No. of observations).

	Females	Males
Daily gain	6.53 $\pm$ 1.97% N = 178	7.46 $\pm$ 1.61% N = 103
Overnight loss	6.66 $\pm$ 1.76% N = 181	7.49 $\pm$ 1.49% N = 103

These two approaches to the interpretation of body weight changes throughout breeding can be combined. Body weight profiles (Fig. 1), or the amount of energy reserves during the course of breeding can also be considered as plastic traits that are optimized individually (Jones 1987a, Sanz & Moreno 1995). To solve this optimization problem each component of both the costs and benefits of gaining or losing weight at a certain time ought to be considered. By observing the entire weight profile we may also learn about the various components of costs and benefits of body weight change associated with different periods of breeding. For instance, if the birds regularly lose weight during the peak feeding period, weight loss can be

considered as the cost of heavy feeding activity, and not as an adaptation that reduces flight cost. If they lose weight just before the peak feeding period, the hypothesis that weight is lost to reduce flight costs cannot be excluded.

Timing of weight changes can be determined only by regular weighing of the birds. There is a major methodological problem of weighing the birds regularly during breeding, as catching them may influence their condition. Automatic weighing of nests solves this problem (Jones 1987b, Martins & Wright 1993, Szép *et al.* 1995). We used our own software package, called "The Visitor", for the automatic weighing of 12 nests of Great Tits and also for data processing (Tóth 1994). This made it possible to carry out the observation and to analyze the complete weight profiles and weight changes over a day and a night.

We found that all the measured females lost about 10% of their weight on average just after hatching and only a minority lost weight during the late feeding period,

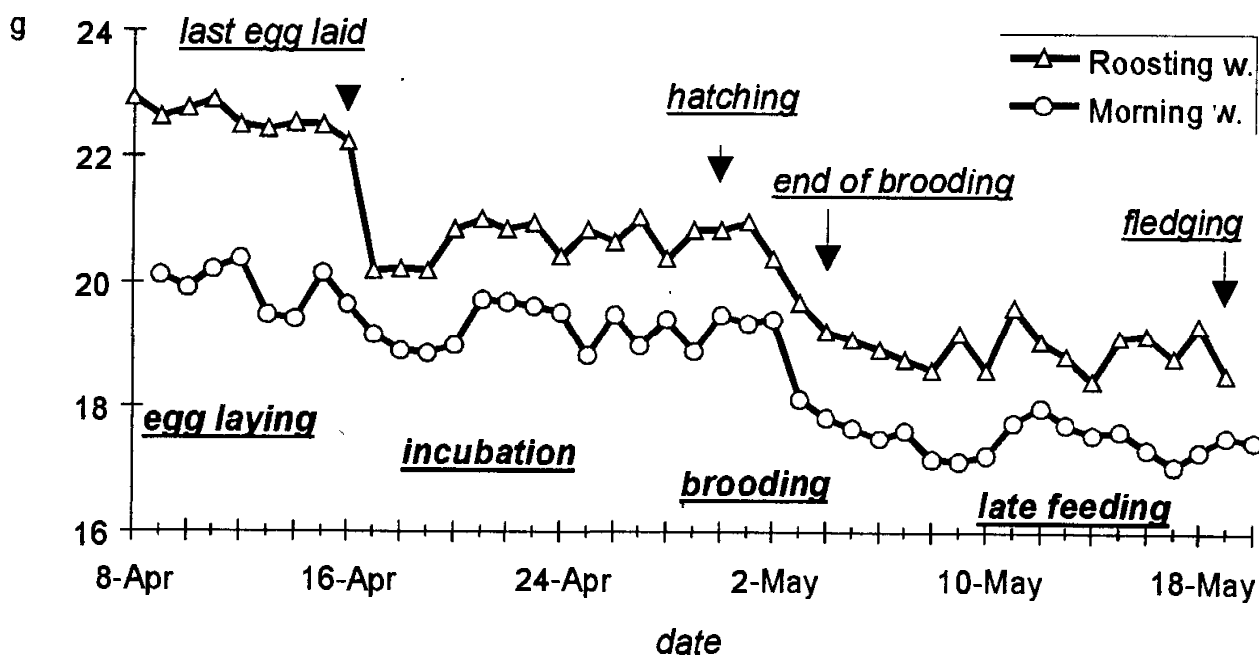


Fig. 1. A female's weight profiles (morning and roosting) during breeding (nest G16-95).

Tab. 4. Females' average weight gain per hour during daytime, in the four periods of nesting.

Nest	egg-laying	incubation	brooding	late feeding
G40-94	-	-	0.53 ± 0.09%	0.51 ± 0.07%
G16-95	1.08 ± 0.13%	0.61 ± 0.17%	0.54 ± 0.06%	0.56 ± 0.12%
G225-95	1.03 ± 0.16%	0.48 ± 0.14%	-	0.42 ± 0.10%
G231-96	-	0.33 ± 0.21%	0.34 ± 0.07%	0.43 ± 0.10%
G65-97-1	-	0.49 ± 0.15%	0.46 ± 0.18%	0.43 ± 0.17%
Average	1.05 ± 0.04%	0.48 ± 0.12%	0.47 ± 0.09%	0.47 ± 0.06%
Average time spent with daily activities (Hour: min: sec)	12:46:25	13:08:20	14:22:23	14:56:53

when brooding was over. The males' weight was stable without exception. In this paper we document all the weight changes we found and argue that flight cost reduction does not give a sufficient explanation for the observed weight change patterns.

## 2. Materials and methods

### 2.1. Subjects and study area

The Great Tit is a small, hole-nesting, resident Passerine that breeds commonly in all kinds of woods, in parks and gardens, and occupies artificial nestboxes readily. The female lays one egg daily, incubates alone and the male regularly feeds her during the two weeks of the incubation period. Both parents feed the young. The nestlings fledge about 18-20 days after hatching.

Fieldwork was carried out in the park of the Biological Research Station of Eötvös University in Göd. The area is a mixed habitat, with some parts having plantations of characteristic of a botanical garden. There are fragments of coniferous woods and riverine woodland of the river Danube, dense bushes and open fields. There were around 65 artificial nestboxes in the area, all fixed on tree trunks and some of them prepared for easy installation of an electronic balance. Data presented here were collected between 1993 and 1997.

### 2.2. Data collection

This study is based on data collected by a computerised weighing system. "Nest-Bug", the data collection module of "The Visitor" software package is used to monitor continuously the weight of nests mea-

Tab. 5. Females' average continuous weight-loss per hour overnight in the four periods of nesting.

Nest	egg-laying*	incubation	brooding	late feeding
G40-94	-	-	0.14 ± 0.03%	0.14 ± 0.05%
G16-95	0.14 ± 0.01%	0.13 ± 0.02%	0.14 ± 0.01%	0.14 ± 0.03%
G225-95	0.12 ± 0.02%	0.17 ± 0.04%	-	0.14 ± 0.06%
G231-96	-	0.11 ± 0.05%	0.12 ± 0.01%	0.09 ± 0.03%
G65-97-1	-	0.15 ± 0.03%	0.13 ± 0.09%	0.08 ± 0.00%
Average	0.13 ± 0.01%	0.14 ± 0.03%	0.13 ± 0.01%	0.10 ± 0.03%
Average time spent in the nest overnight	11:13:25	10:50:28	9:36:39	9:02:04

\* The egg-laying period's data are reduced with the average weight of the egg, laid overnight.

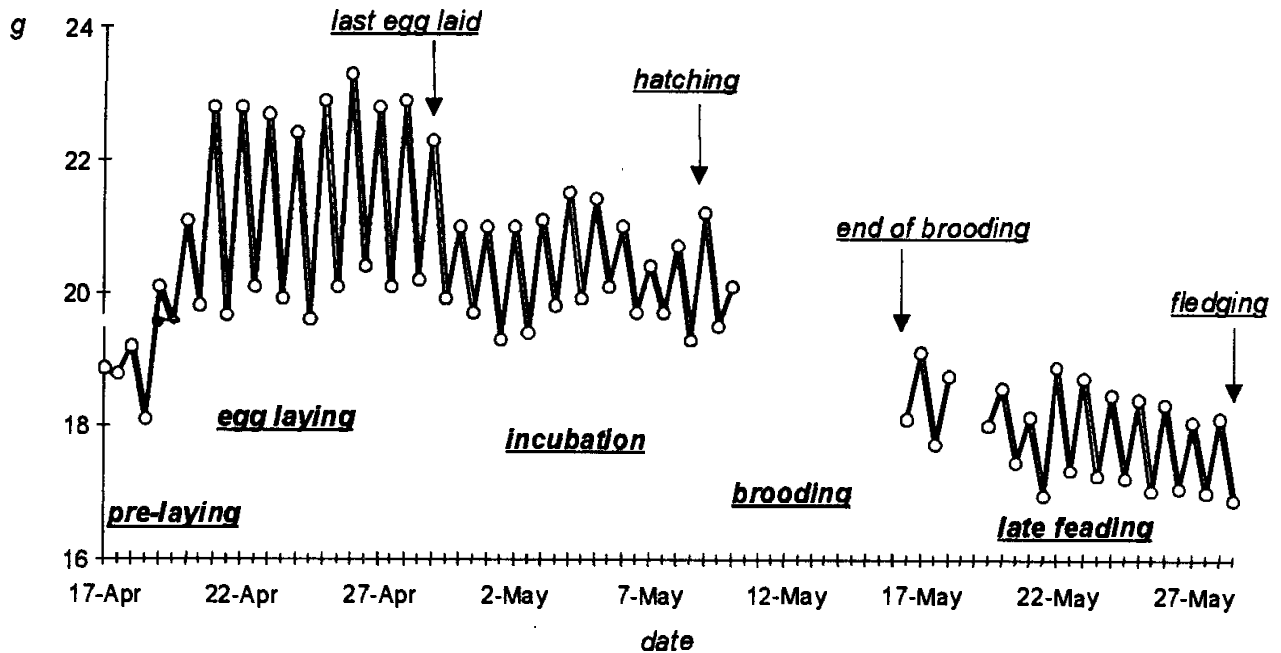


Fig. 2. A female's weight fluctuation during breeding (nest G225-95). The observed roosting and morning weights are connected to demonstrate the daily changes in weight during the whole season. On the first day of observation the female did not go roost in the nest. The observation was interrupted for 6 days.

sured by electronic balances connected to a central computer (Tóth *et al.* 1991, Tóth 1994, Szép *et al.* 1995). We used Mettler (PM4600, PM4800; Mettler-Toledo GmbH, CH-8606 Greifensee, Switzerland) and Sartorius (BA4100S; Sartorius AG, PO Box 32 43, D-3400 Goettingen) balances with an accuracy of 0.01 g and a capacity of 4000 g. One nest was partly measured with a Sartorius PT2100 that only has an accuracy of 0.1 g and a capacity of 2000 g.

Several nest boxes were pre-equipped with a shelf and a shielding outer box (called "windbox") to support the placing of a balance. The inner box containing the

nest was measured by the balance while the windbox protected the measurement from disturbance e.g. wind, rain, falling objects, and false visits by perching birds. This windbox makes it possible to obtain measurements with high accuracy (Tóth & Pásztor 1997).

Nests were regularly checked to determine laying date, clutch size, hatching date, number of eggs hatched, number of nestlings fledged. Also every evening in 1993 we measured manually the body-weight of each nestling in the measured nests with the "nestling weighing" function of NestBug.

Tab. 6. Females' average minimal faecal loss (g) in the four periods of nesting.

Nest	egg-laying	incubation	brooding	late feeding
G40-94	-	-	0.79 ± 0.09	0.74 ± 0.22
G16-95	0.36 ± 0.17	0.76 ± 0.12	1.03 ± 0.27	0.95 ± 0.16
G225-95	0.28 ± 0.12	0.53 ± 0.20	-	0.89 ± 0.23
G231-96	-	0.45 ± 0.41	0.58 ± 0.17	0.81 ± 0.23
G65-97-1	-	0.61 ± 0.36	0.51 ± 0.22	0.88 ± 0.34
Average	0.32 ± 0.05	0.59 ± 0.13	0.73 ± 0.24	0.85 ± 0.08
Average time spent away during the first trip (sec)	1992 ± 542	754 ± 217	369 ± 109	523 ± 177

We analysed data from 12 Great Tit nests. Nests were observed by the weighing system for a minimum of 6 and a maximum of 47 days. The measurements were started at different nest stages, but each nest was measured up until fledging. A set of analyses was performed only on the five nests with the longest periods of measurement, two of them monitored from egg-laying and two from incubation (Tab. 1).

### 2.3. Data processing

"NestBug", the data-collection module of "The Visitor" recognises arrival and departure events of the parents. It records the time of the event and relevant original weight data. "Estimate" is a data-processing module which estimates the two weight levels at each event: immediately before and after the event. "VisAna" is an analysis module which calculates weight changes and applicable variables at each event, builds up visit records, separates visits into those of each parent, based on their body weights, and supports manual correction of this identification on interactive graphs.

During the nestling feeding period we can determine the body weight of the visiting parent bird from the change in the nest weight at departure when the parent did not remove a faecal sac. Cases when a faecal sac was removed can be detected with high certainty, as a faecal sac is usually much heavier than a food load brought for the young (Woodburn & Perrins 1997 and our own unpublished measurements).

We collected the body-weights of the parents at the beginning and at the end of their "workday". We use the term "*morning weight*" (*MW*) for the departure weight at the first visit each day and "*evening*

*weight*" (*EW*) for the departure weight at the last visit. When a female spent the night in the nest her "*roosting weight*" (*RW*) was estimated by her last arrival weight after which she stayed in for the night, and we also collected her "*departure weight*" (*DW*) at dawn. Departure weights are usually higher than the respective morning weights as the female loses weight through defecation during her first trip.

We analysed changes in the parents' morning and evening (roosting) body *weight profiles* and tried to find significant trends (Fig. 1). We calculated the changes in weight from day to day, as well as separately for daytime and overnight (Fig. 2). For the females we divided the overnight weight-loss into two parts. The first part was calculated from the difference between the *roosting weight* in the evening and the *departure weight* in the morning. This is the weight lost during the night through respiration and evaporation (*continuous overnight weight-loss*). The second part was calculated from the difference between the *departure weight* (leaving nest after the night) and the *morning weight* (leaving the nest after her first visit). This difference slightly underestimates the weight of the female's *faecal weight-loss* as she may also eat during this first trip.

Comparison of subsequent morning weights of males was problematic, as the time of their first visit to the nest varied to a great extent from day to day, while the body weights of the parents typically show a rapid increase during the first few hours of the day. To take this into account, we corrected all the morning weights of the males to the same time (5.00 am) by regressing their body weight on their arrival

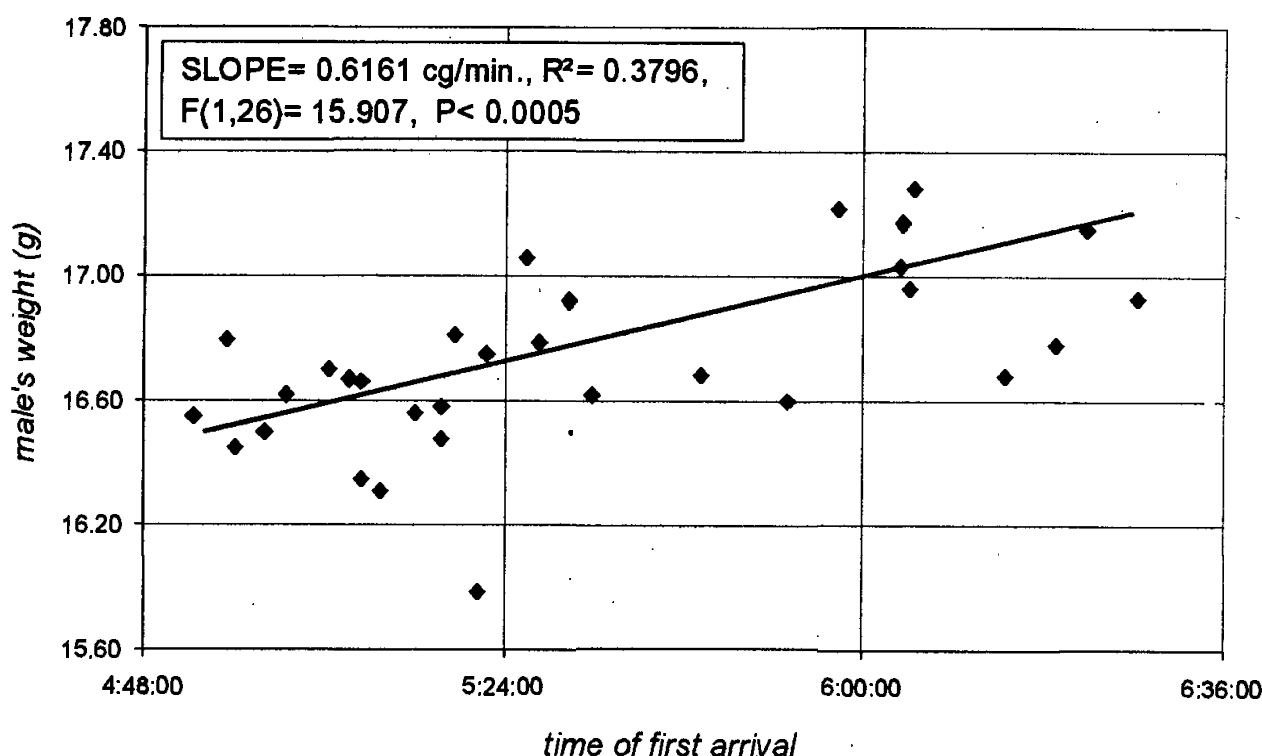


Fig. 3. Method of correction of the male's morning weight (nest G16-95). Each point on the graph represents the time of the first arrival and weight of the male on a certain day. The characteristics of the fitted line on the morning weight versus time of arrival diagram are shown.

time (Fig. 3). However, we could not include in the analysis those days when the male arrived after 7.00 am, as these arrival weights do not fit the "early morning line".

#### 2.4. Statistics

Linear regression was used to demonstrate trends in the weight profiles in the different periods and also for the correction of the males' data. After testing for the homogeneity of variances, we performed single classification ANOVAs to investigate any significant differences between the different periods. The brooding period was eliminated from the ANOVA, because its variance caused significant inhomogeneity of variances. We compared the mean weights of the different periods (egg-laying, incubation, late feeding) with Scheffe's-test. We used t-tests to investigate differences in the overnight weight-

loss between two periods. Mann-Whitney U-tests were performed on the time components. All tests were carried out using the software package Statistica for Windows v5.1 (StatSoft Inc. 2300 East 14th str. Tulsa, OK 74104, USA).

### 3. Results

#### 3.1. Weight profiles

We used linear regression for the initial tests. The fitted lines for the females' weight profiles of the whole measurement periods showed significant decreases in all the analysed cases. The slopes of the fitted lines ranged from -0.07 to -0.15 g a day and their slopes differed significantly from each-other (test of parallelism,  $df = 4, 121$ , *Morning weights*:  $F = 3.51, p < 0.01$ , *Roosting weights*:  $F = 7.34, p < 0.001$ ).

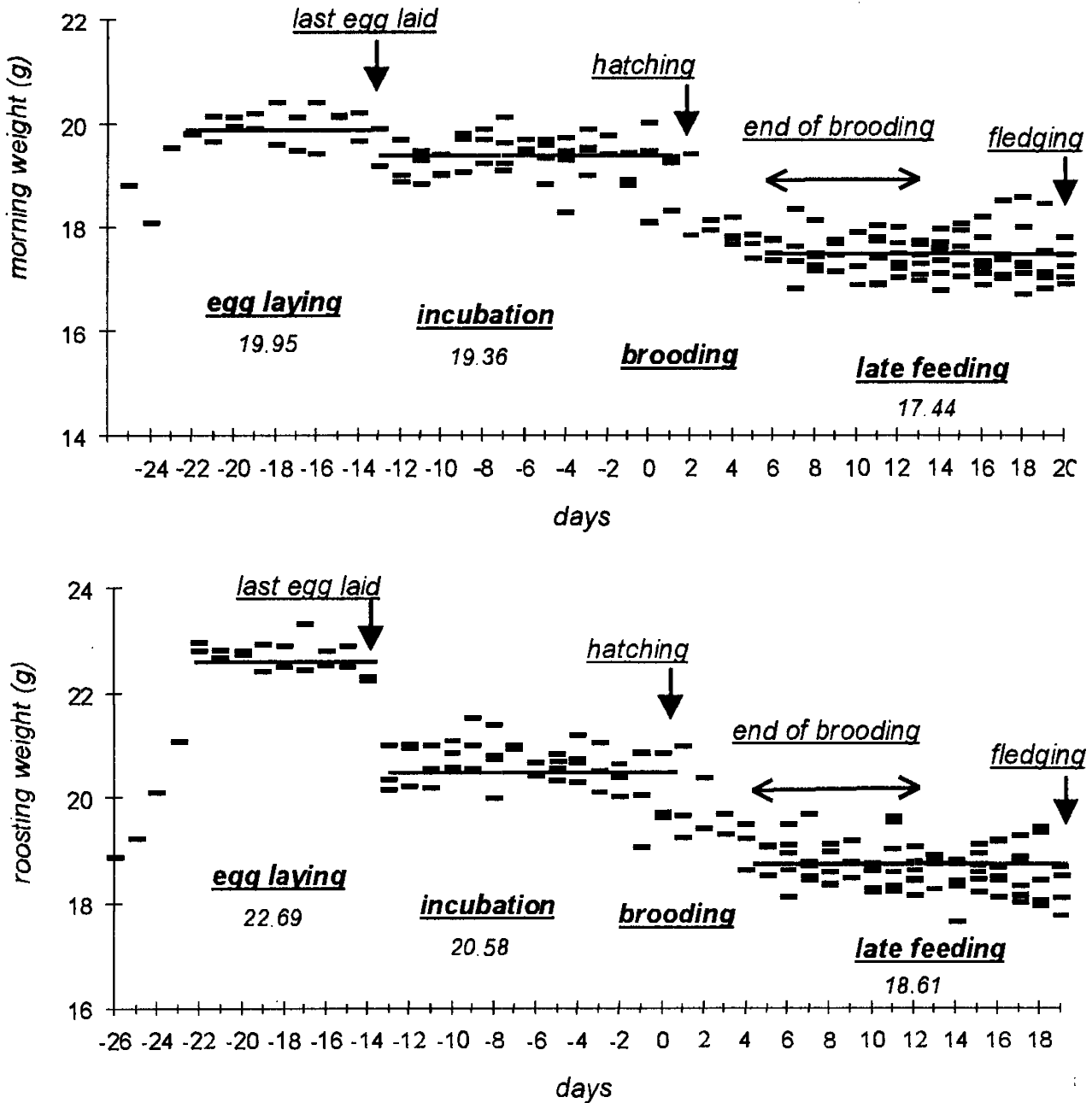


Fig. 4. Females' morning (above) and roosting weights (below). The data of the 6 nests are arranged according to the date of hatching. The average morning or roosting weights of all the females are shown under the periods' name. The length of brooding differed from nest to nest. The arrow under the "end of brooding" shows the period when broodings were finished.

The males' corrected weight profiles showed no significant trends in any of the observed individuals ( $N = 12$  males). Therefore in this paper we shall concentrate on the females.

A standard method in bird studies is to catch the birds on certain days at various times and weigh them (e.g. Merila & Wiggins 1996). We checked whether

someone could still find a decrease in the females' weight between incubation and fledging by this method. We selected the morning and roosting weights of the last day of incubation (Day -1) and the last day before fledging (Day 18) from four nests. We used paired t-tests for comparison and we found significant difference only in half of the possible comparisons (Tab. 2).

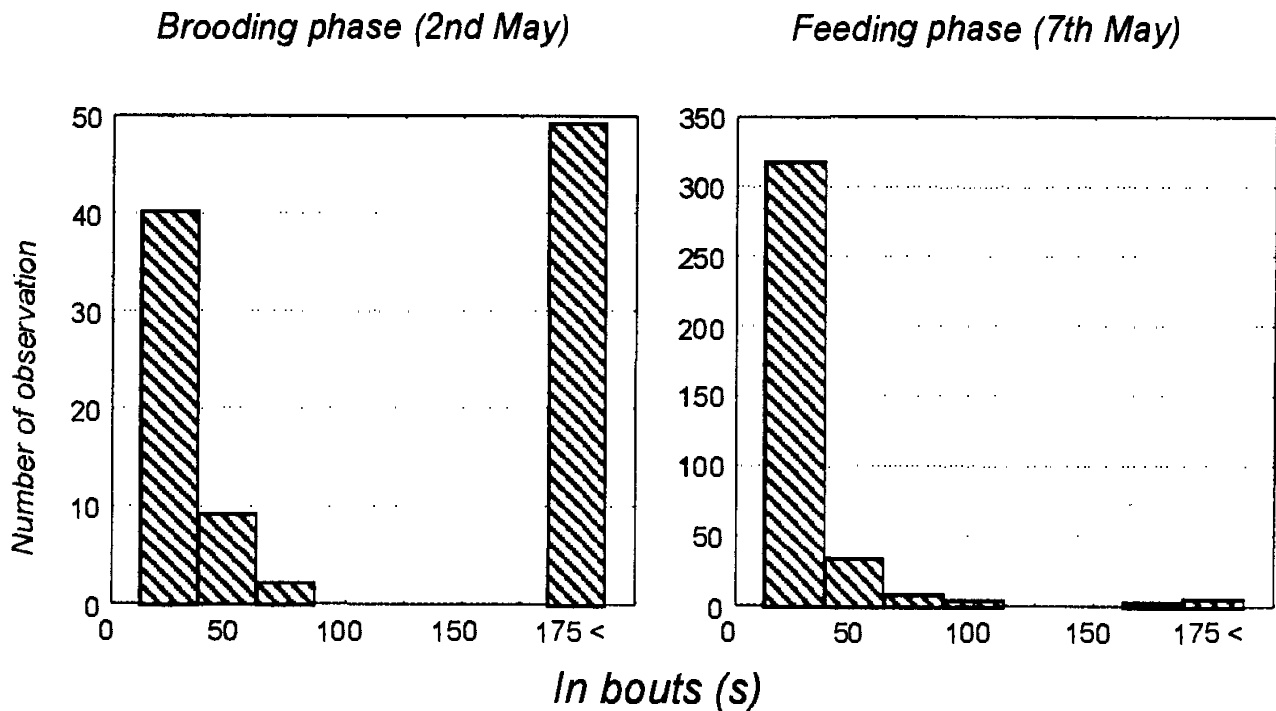


Fig. 5. Finding the end of brooding phase. The difference between the two histograms of length of visits is striking. The number of longer visits is decreasing throughout the brooding period. In the later feeding period we could hardly find brooding visits.

### 3.2. Four phases of breeding

Further analysis of the females' roosting weights showed three different weight levels and a transitional period. These weight levels can be related to the different periods of breeding: laying, incubation and late feeding (Fig. 4).

During the egg-laying period the female lays one egg each day, before she leaves the nest in the morning. During this phase she spends more of her day out of the nest.

We consider the incubation period from the completion of clutch although the female can start incubation earlier. Both females, measured in this period, started incubation after clutch completion.

The feeding period may be divided into two parts: brooding and late feeding (Freed 1981). During the brooding phase the nestlings are mostly unfeathered and need to be warmed by their mother. This

means that the female cannot leave them alone for long intervals. As the nestlings and their feathers grow, they become capable of regulating their body temperature, and both the frequency and the length of the female's brooding visits decrease gradually. In order to find the end of the brooding phase, we studied the distribution of visit length day to day (Fig. 5). We define the brooding phase to be over if the proportion of visits longer than 120 seconds is under 5% of the total number of visits per day. Thus the female's visits are nearly always short and serve only feeding purposes during the late feeding period. (The length of brooding varied between five and twelve days.)

By comparing the variances of weights in the four periods, we found that the brooding phase causes significant difference between the variances (Levene's tests,  $df = 3, 37$ ,  $p < 0.001$  for both weight profiles of nest G16-95). Excluding the

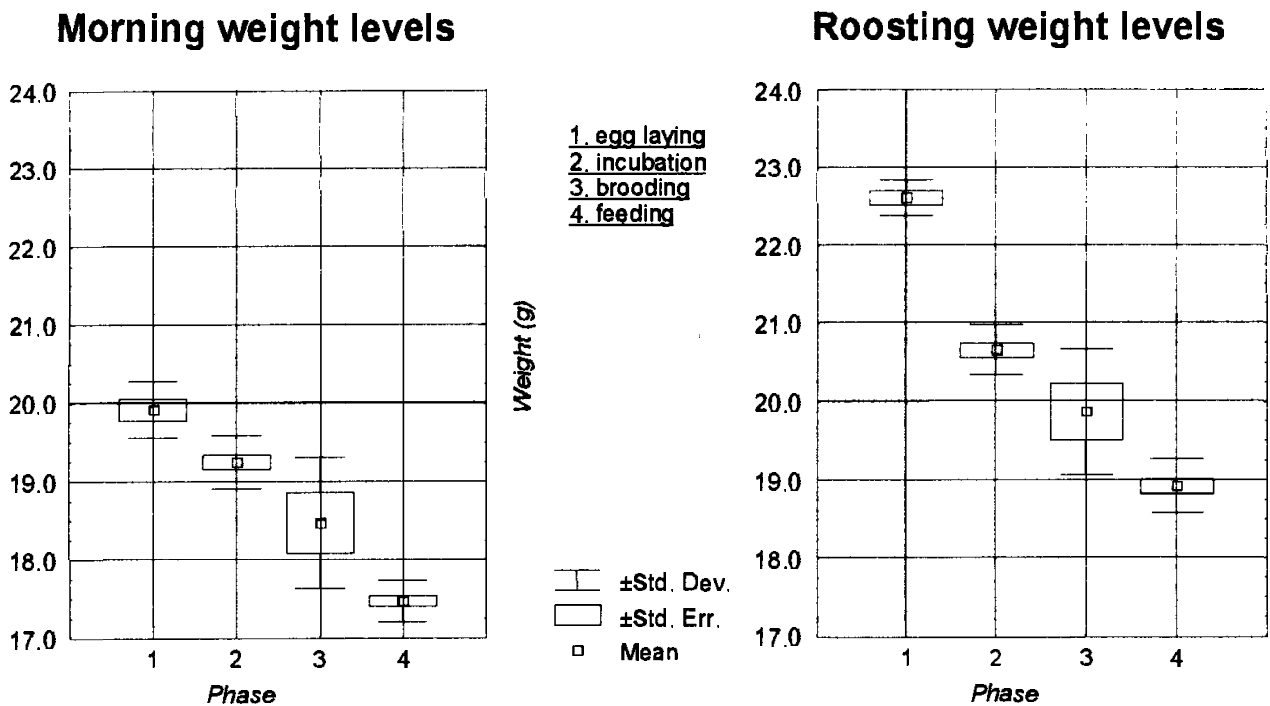


Fig. 6. Means, standard errors and standard deviations of the different weight levels (nest G16-95). For both weight profiles the standard deviation of the female's weight during the brooding phase is very high. This is due to the sharp decrease in body weight.

brooding phase from the analysis resulted homogeneity in the variances of the remaining three periods (Levene's tests,  $df = 2, 33, p > 0.15$ ). The analysis of the other two nests where appropriate data were available showed similar results.

By comparing the mean weights in the different periods, we found a significant difference between the incubation and the late feeding periods of each female (Fig. 6, Scheffe-tests,  $p < 0.001$  for both weight profiles,  $N = 4$  females).

### 3.2.1. Egg-laying

During the egg-laying period we found a significant decrease in the roosting weights but not in the morning weights in one of the two nests (slope =  $-0.07$  g/day,  $R^2 = 0.5570$ ,  $F(1,6) = 7.5442$ ,  $p < 0.0334$  for the *roosting weights*, nest G16-95).

We found a significant difference in the roosting weight profile between the egg-laying and the incubation phase

(Scheffe-test,  $p < 0.001$ ,  $N = 2$  females). The female collects the material required for the formation of the egg during the day and lays the egg at dawn. This explains the  $7.99 \pm 0.20\%$  (mean  $\pm$  SD,  $N = 2$  females) decrease in the roosting weight after clutch completion. In contrast this decrease is smaller (nest G16-95:  $3.35\%$ ,  $p < 0.01$ ) or not significant (nest G225-95:  $1.62\%$ ,  $p > 0.35$ ) in the morning weight profiles.

### 3.2.2. Incubation

Over the incubation phase there was no significant trend in the weight profiles in any of the observed cases (linear regression,  $N = 4$  females).

### 3.2.3. Brooding

Both the morning and roosting weight profiles of the brooding phase show a significant decreasing trend so we did not con-

sider it as a constant weight level. The slopes of the fitted lines ranged from -0.06 to -0.50 g a day and they differed significantly from each-other (test of parallelism,  $df = 3, 17$ , *Morning weights*:  $F = 7.48, p < 0.01$ , *Roosting weights*:  $F = 3.32, p < 0.05$ ). All measured females lost weight throughout the five to eight days in this phase. The females lost  $10.0 \pm 1.5\%$  (Mean  $\pm$  SD,  $N = 4$ ) of their incubation weight on average, that is about 2 g.

### 3.2.4. Late feeding

There was no significant trend in the weight profiles (linear regression) in the majority of cases. None of the females gained weight and only 2 of the observed 12 females lost weight in the late feeding phase. One of the females lost 0.76 g over 11 days and the other one lost 1.23 g over 13 days.

### 3.3. Daily mass changes

During daytime the males gained  $7.46 \pm 1.61\%$  (mean  $\pm$  SD,  $N = 103$  days) while the females gained  $6.53 \pm 1.97\%$  ( $N = 178$  days) of their morning weights. These averages do not include data of the egg-laying periods for the females, when the daily weight gain was  $13.73 \pm 0.13\%$  ( $N = 15$  days).

Overnight the males lost  $7.49 \pm 1.49\%$  ( $N = 103$  nights) while the females lost  $6.66 \pm 1.76\%$  ( $N = 181$  nights) in comparison to their following morning weights. (In comparison to their evening or roosting weights, males:  $7.06 \pm 1.32\%$  ( $N = 89$  nights), females:  $6.12 \pm 2.15\%$  ( $N = 174$  nights)) These means do not include data of the egg-laying periods when the females' overnight weight loss was  $12.09 \pm 0.17\%$  ( $N = 15$  nights) due to the laid egg.

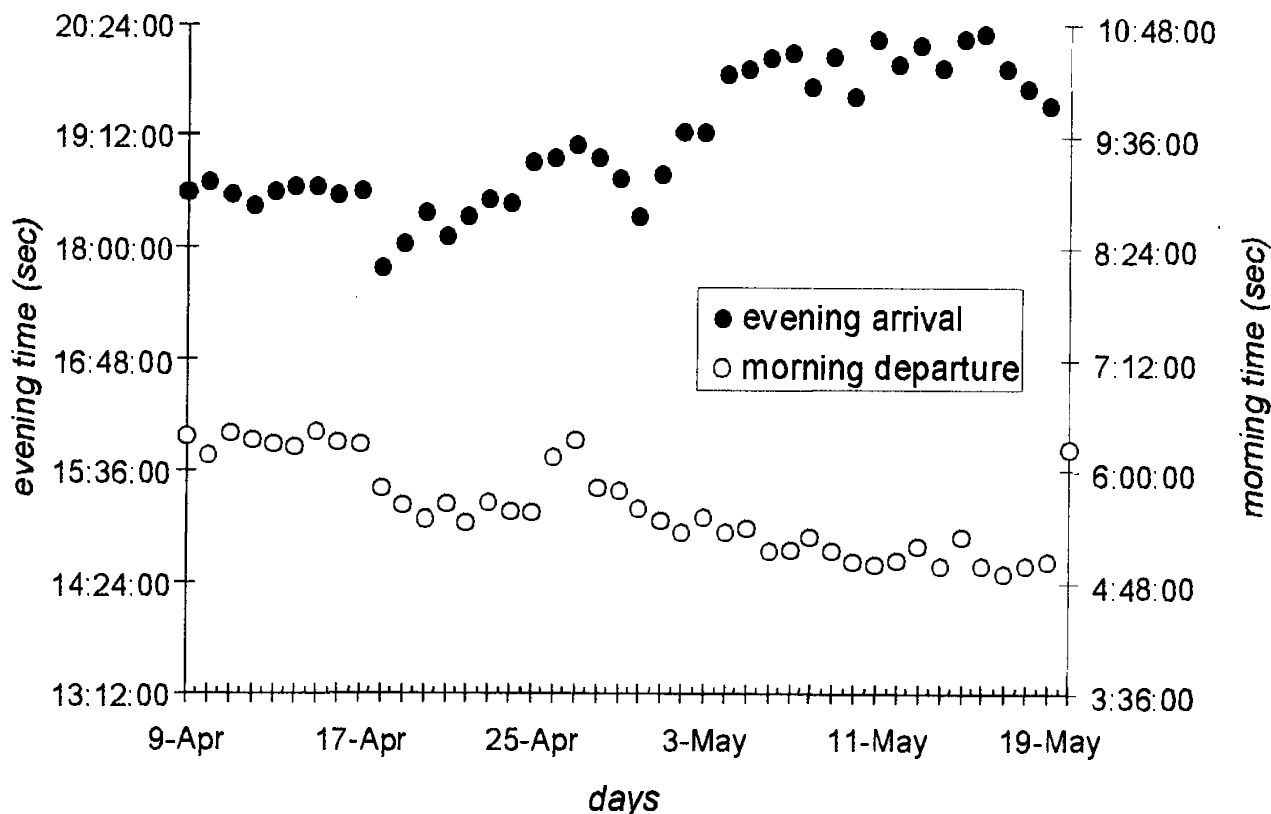


Fig. 7. Female's daily timetable (nest G16-95). As the breeding season proceeds the days become longer and the nights get shorter for the female.

We found no difference between the average daily gains and overnight losses of either the females (t-tests,  $df = 357$ ,  $p > 0.62$ ) or the males (t-tests,  $df = 204$ ,  $p > 0.92$ ). However, we found that the males lost and gained more weight than the females (t-tests,  $p < 0.0001$ ).

As the energetic demands of incubation, brooding and late feeding may differ, we compared the average weight gained or lost per hour in the four periods. Both the lengths of the working days and the duration of roosting vary throughout the breeding season (Fig. 7). We calculated the difference between the time of the first departure in the morning and of the last arrival for each female for each day. We calculated the body-weight increase per hour as the ratio of the proportional gain in body-weight from morning until night and the duration of the working day. We determined the proportional continuous weight-loss per hour similarly. To our surprise, we could not show any differences in the rate of body-weight change between the periods (Tab. 4, 5).

We also calculated the weight lost during the first foraging trip. This usually gives a minimum estimate for the weight of the faeces as the female defecates after her first departure in the majority of cases but she also eats during these foraging trips (Tab. 6). The apparent difference in the average faecal loss between the periods is partly due to the difference of the average length of the first foraging trip. These foraging trips were significantly the shortest on average and had the smallest standard deviation during the brooding period, while it was by far the longest during egg-laying.

## 4. Discussion

### 4.1. Male weight levels

In our sample the males maintained their weight throughout the observation periods. Males are on average heavier than females outside the breeding season (Kluyver 1952, own unpublished data). The male was heavier than the female in five pairs while the female was heavier in seven pairs during the observation periods. The weight profiles belonging to a pair never crossed during the observation period. As before hatching the males do not visit the nest early in the morning we have no opportunity to determine their exact morning weight in the beginning of the breeding season by weighing at the nest. It would be interesting to study whether the males lose weight in those early days when they feed the females before and during laying. In the case of non-incubating, non-brooding males the energetic demands are probably more evenly distributed than on the females.

### 4.2. Female weight levels

#### 4.2.1. Egg-laying

The females start to increase their body weight some days before the first egg is laid (Woodburn & Perrins 1997). The only female whose weight was measured in the pre-laying period also showed a large increase in weight during the four days before laying (Fig. 2). This increase in weight is mainly due to the increase of body water content (Woodburn & Perrins 1997). The function and fate of this water are unclear. Both Mertens (1987) and

Woodburn & Perrins (1997) report water loss at the beginning of incubation and after hatching.

Egg production is energetically costly for small birds. During a breeding season Great Tits have to produce an egg, weighing nearly 10% of their own weight, on each day. To collect the required materials, the pair must co-operate, and the supplementary or courtship feeding by the male (Royama 1966, Krebs 1970) may have an important role in achieving the target: a clutch of 6 to 13 eggs.

The requirements of the laying period are high and thus the environment can affect its characteristics to a great extent. Food availability is the main signal for the timing of egg laying (Nilsson & Svensson 1993, Nilsson 1994, Nager *et al.* 1997), which may be influenced by temperature. When laying has already started, poor feeding conditions, due to bad weather or high population density, can cause laying interruptions in Great Tits (Dhondt *et al.* 1981). There was no such interruption in our two nests.

Poor feeding conditions may also be reflected in either decreasing body weight or decreasing egg weight in the course of the laying period (Nager & Noordwijk 1992, Ramsay & Houston 1997). In one of the two nests the female's roosting weight decreased but her morning weight remained stable in the laying period. This suggests that egg weight decreased, although we did not measure the eggs separately. It is important to keep in mind that besides other nutrients the availability of calcium for the egg-shell could also be a limiting factor (Graveland *et al.* 1994). The calcium comes mainly from small snails (Graveland & van Gijzen 1994). The females usually go roosting with a snail in their gizzard

(Perrins 1996) because they digest it slowly overnight and thereby their digesting capacity is maximised during the day (Woodburn & Perrins 1997).

Similarly to others (Jones 1987c, Woodburn & Perrins 1997) we found that the female's body weight is greatest in this period.

#### 4.2.2. Incubation

After the last egg is laid (sometimes earlier) the female starts to incubate the eggs. The start of incubation is also influenced by food availability (Nilsson & Svensson 1993, Nilsson 1994, Nager *et al.* 1997).

After clutch completion the reproductive organs regress and some water is lost, while the weight of the carcass, carcass fat and flight muscle increase (Mertens 1987, Woodburn & Perrins 1997). Woodburn & Perrins (1997) found that this caused considerably higher weight loss after egg-laying than the average egg weight in Blue Tits (*Parus caeruleus*). However, the difference between the roosting weights of the two females observed in our sample was not much bigger (0.07 g and 0.26 g) than the average egg weight. The maintenance of fat reserves may help the females to continue incubation at lower temperatures when their energy expenditure grows considerably (Mertens 1987) and when they need to stay longer on the eggs. Besides relying on their fat storage, females may count on the males' supplementary feeding.

None of the females in our sample (N = 4) lost weight during incubation. In two of three years Mertens (1987) found that Great Tit females lost more than 1 g during incubation; similarly Woodburn & Perrins (1997) also found decreases in the weight

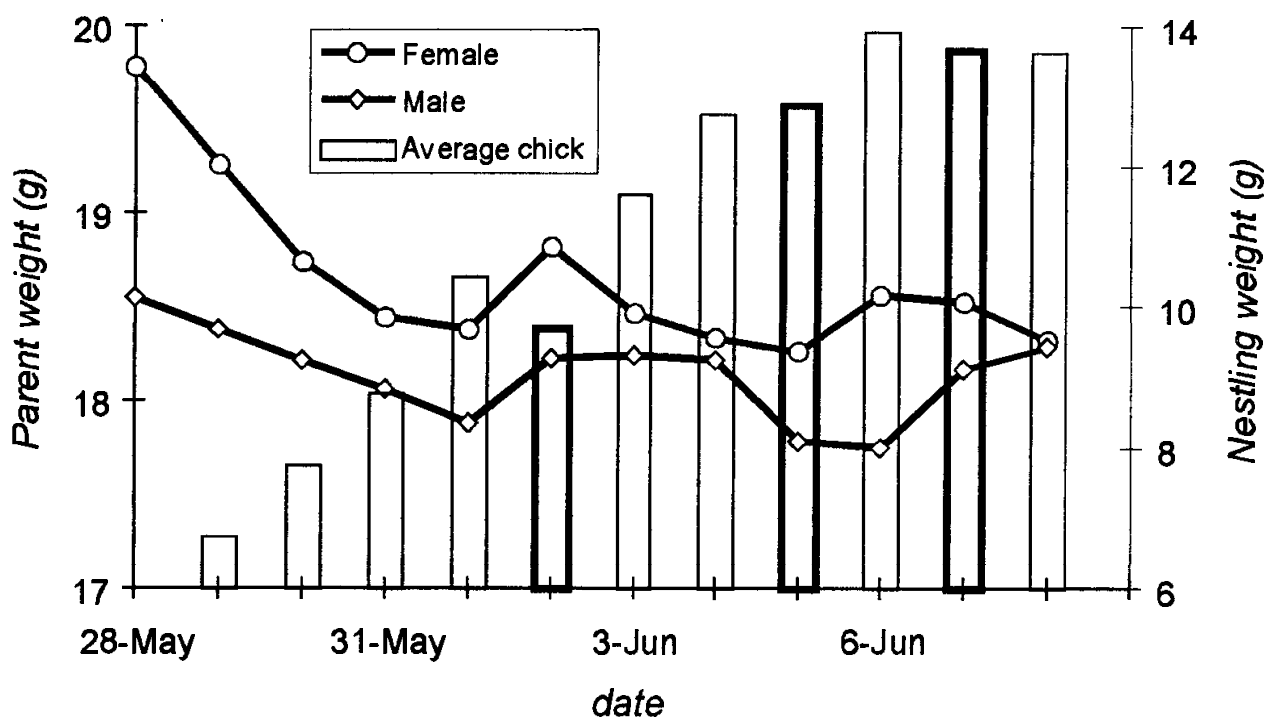


Fig. 8. A "disaster-struck" nest (nest G375-93), where 3 chicks have died one after the other (the last on 1 June) and 6 fledged. There were several rainy days when the nestlings lost weight (darker bars). On those days the parents maintained or gained weight. This example suggests the shortage of fat reserves.

of four Blue Tits. Ricklefs & Husell (1984) reported weight decrease in female but not in male Starlings (*Sturnus vulgaris*) though both sexes take part in incubation. While short-term weight changes of incubating Swallows (*Hirundo rustica*) were related to the prevailing weather, Jones (1987c) did not find long-term weight-loss during incubation (N = 5 females). These different results suggest that the body weight of incubating females is sensitive to the prevailing conditions yet females are always heavier during incubation than during nestling rearing. Females typically do not lose all their reserves by the end of incubation.

#### 4.2.3. Brooding

All the females lost weight over five to eight days after hatching (N = 5). Freed (1981) described the same phenomenon in

House Wrens (*Troglodytes aedon*), Jones (1987a) in Swallows, Ricklefs & Husell (1984) in Starlings, Moreno *et al.* (1991) in Collared Flycatchers (*Ficedula albicollis*) and Woodburn & Perrins (1997) in Blue Tits. Merila & Wiggins (1997) showed that the rate of re-growth of feathers removed earlier correlated negatively with the amount of weight loss, which could indicate stress in this period. There is accumulating evidence that female weight loss immediately after incubation may be a general phenomenon among Passerines, though data are still scarce. The magnitude of this weight loss may depend on the incubation weight of the females and the number of nestlings (Jones 1987a, Johnston 1993, Merila & Wiggins 1997).

There is a long-standing discussion in the literature over whether this weight-loss represents some costs of reproduction

or is a pre-adaptation to diminish the forthcoming increase in flight-costs (Drent & Daan 1980, Norberg 1981, Freed 1981, Ricklefs & Husel 1984, Merila & Wiggins 1997). Gosler (1991) showed that females declined in protein reserves while feeding a brood. The proper timing of this weight-loss must be crucial for the female, as if she loses her reserves too early she may not survive unfavourable periods. If she is too late she unnecessarily keeps predation risk higher (Gosler *et al.* 1995) or retards nestling growth by inefficient energy utilisation. As the females lose most of their weight just after or during hatching, and not right before the peak feeding period (unpublished data), we think that flight-cost reduction does not have a major role in timing their weight loss. Houston (1993) showed in simple time budget models that the efficiency of mass loss, i.e. the value of the energy released by mass loss in terms of the increase in energy delivered to the young is lower than 1 if the bird loses weight during the peak feeding period. However, during brooding any saving of energy by the female can be given more directly, i.e. more effectively to the nestlings by brooding than in the late feeding period by decreased food demand.

The females still need some energy reserves because of the high and unpredictable energetic demands during brooding. In the first days of brooding, a female still spends much time in the nest, which imposes a heavy time constraint on her (Tóth & Pásztor 1997). She cannot leave the nestlings alone for too long while she also has to provide food for both them and for herself. This means that by minimising self-feeding she can gain valuable time that can be used for the other two activi-

ties. Both parents feed the young in this period and it is likely that the male gives less food to the female than earlier. Thus, it is possible that brooding is energetically even more demanding for the female than incubation and she is in need of her reserves. The energetic demands imposed by brooding on the parents may vary with the environmental conditions. We found that the length of the brooding period varied among nests. It ranged from 5 to 12 days in our sample.

As the first days after hatching may be critical for both the nestlings and their parents, the optimal number of nestlings may depend on the amount of reserves possessed by the female at hatching. We think that in order to understand the role of brooding in the optimisation of clutch size we need more studies, which concentrate on this period.

#### 4.2.4. Late feeding

The feeding frequency reaches its maximum in the late feeding period. By that time the parents possess reduced reserves. When unpredictable bad weather causes limited food availability the parents have to decide whether to feed themselves or the chicks (Fig. 8). Restriction to self-feeding may be the only option in many cases, causing weight loss in the nestlings and reduced juvenile survival. The decision of the parents, and in turn their body weight, may depend on the number of nestlings, i.e. on the value of the brood (Smith *et al.* 1988).

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## Összefoglalás

### Költő széncinegék testtömeg-változásai

Automatikus elektronikus mérlegek segítségével 12 széncinege testtömeg változását követjük nyomon 6-47 napon át a költési szezonban 1993 és 1997 között. A "The Wisitor" szoftver csomagot használtuk adatgyűjtésre és adatrendezésre. Tanulmányunkban a tojó és hím madarak reggeli és esti testtömeg változásának napról napra történő változását elemeztük.

1. A vizsgált 12 hím széncinege közül egyiknél sem következett be testtömeg változás.

2. Két tojónál sikerült a testtömeg változást a tojásrakás kezdetétől a kirepülésig követni. Esetükben három testtömeg szintet tudunk elkülöníteni: átlagos éjszakázási tömeg a tojásrakás, kotlás és etetés alatt. A tojásrakás alatt egyik tojó sem veszített a tömegéből, bár az egyik egyed tojásainak súlya csökkent. A tojók reggeli testtömege hasonló volt a tojásrakás és kotlás alatt.

3. A tojók egyikének sem csökkent a tömege a kotlás alatt ( $N = 4$ ). A testtömegük azután kezdett el csökkenni (átlagosan 10 %-al,  $N = 4$ ), hogy a fiókák kikeltek. A késői etetés alatt tíz tojónak a tömege nem változott, kettőnek pedig csökkent.

4. Nem találtunk szignifikáns különbséget a napközbeni óránkénti tömegnövekedés, illetve az éjszakai óránkénti tömegcsökkenésben a négy költési szakasz között ( $N = 5$ ).

Eredményeink és publikált adatok alapján úgy gondoljuk, hogy az énekesmadarakra általánosan jellemző a kotlás előtti jelentős tömegnövekedés és kisebb tömegvesztés a kotlás után. A jelentős testtömegnövekedés a tojásrakás előtt, és a tömeg megtartása a kikelés utánig részben magyarázható a tojásrakás és kotlás nagy energia igényével. A tartalékok előse-

gítik az esetleges kedvezőtlen időszakok átvészelését. Az etetés előtti tömegcsökkenés adaptív, mivel a nagy tömegű egyedek számára a repülés nagyobb befektetést igényelne, de a tömegcsökkenés időzítése és mértéke az adott fészekalj igényeitől függ. Az optimális fészekalj méret tehát attól is függhet, hogy a tojó mennyi tartalékot képes mobilizálni a kotlás után.

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# Status of Kentish Plover (*Charadrius alexandrinus*) in Hungary

Tamás Székely

Székely, T. 1997. Status of Kentish Plover (*Charadrius alexandrinus*) in Hungary. – Ornis Hung. 7: 19-26.



Population size, distribution and reproductive success of Kentish Plovers in Hungary are summarised. 105-140 pairs bred in 1988-1992. Two breeding sites (Miklapuszta and Southern Hungary) contained the bulk of the population, with 60-80 pairs and 35-40 pairs, respectively. The number of breeding pairs has declined in recent years. Kentish Plovers have disappeared from some of their traditional breeding sites such as Hortobágy-puszta, and their numbers have dwindled in other areas such as in Southern Hungary and Vásárhelyi-puszta. I suggest two reasons for the reduction in number of breeding pairs: loss of breeding habitat and low reproductive success. First, the loss of breeding habitat may be due to reduction in grazing pressure by sheep flocks. I argue that sheep grazing is important in maintaining short vegetation and bare ground in these alkaline grasslands. Short vegetation and bare grounds may attract Kentish Plovers to settle. In addition, Kentish Plovers prey upon the insects following sheep flocks and they may feed on insect larvae which develop in sheep dung. Second, the breeding success of Kentish Plovers was poor: 28% of eggs hatched and 29% of chicks that hatched reached fledging age. I estimate that new recruits replace only 17% of adults which die each year. To prevent the disappearance of Kentish Plover from Hungary urgent measures are needed, such as to increase hatching success by stricter control of stray dogs and cats, erect protective fences around some nests and maintain, or preferably increase, the current intensity of sheep grazing.

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## 1. Introduction

Kentish Plovers *Charadrius alexandrinus* are cosmopolitan and in most parts of their range they breed on the coast. Nevertheless, in the Carpathian Basin they breed in alkaline grasslands ('puszta') and at the edges of alkaline lakes. The Kentish Plover is one of the characteristic birds of the Hungarian alkaline grasslands (Udvardy 1941, Sterbetz 1965), and thus any change in their distribution or population size may indicate a change in overall quality of this habitat.

In this paper I report on the current status of Kentish Plover in Hungary, illustrate

recent changes in breeding numbers, investigate the causes of the reduction and suggest measures for the protection. Much of the data is based upon my field study in Southern Hungary (1988-1990) and Central Hungary (1991-1994). The study sites, field work and statistical analyses are described elsewhere (e.g. Székely 1991, Székely 1994).

## 2. Breeding sites

The bulk of the Hungarian population bred in Miklapuszta, Central Hungary (near the

villages of Harta and Akasztó): 60-80 pairs in 1990-1992; and in Southern Hungary (near the towns of Szeged and Kistelek): 35-40 pairs in 1988-1990. Miklapuszta was an extensive alkaline grassland whereas several patches of alkaline grasslands and cultivated fish-ponds made up the breeding sites in Southern Hungary. The number of breeding pairs was 3-12

I. & A. Széll pers. comm.) and one pair in 1992 in Sárkány Lake near the village of Sárkeresztur (Fenyvesi, L. pers. comm.). Thus approximately 105-140 pairs of Kentish Plovers bred between 1988 and 1992 in Hungary.

Kentish Plovers also bred in neighbouring countries such as Austria, Croatia and Serbia. 12-19 pairs of Kentish Plovers

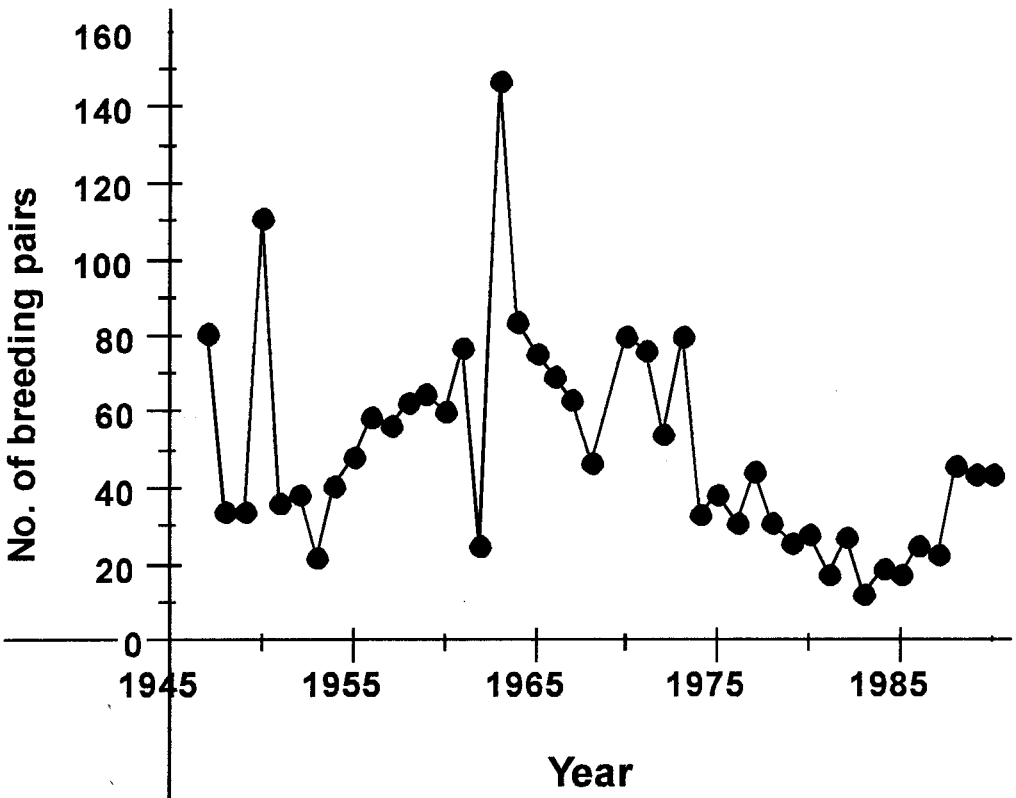


Fig. 1. Number of breeding pairs in Southern Hungary including Vásárhelyi-puszta (based on Sterbetz 1963, 1992, Tajti 1992).

pairs in the Nagyszék alkaline grassland (near the town of Balmazújváros) between 1980 and 1989 (Kovács 1984, Ecsedi, Z. & L. Szondi pers. comm.), 3-4 pairs in Kelemen-szék alkaline grassland of Kiskunság National Park in 1990-1992 (Bankovics, A. pers. comm.), three pairs in Kardoskút alkaline grassland in 1990-1991 (Sterbetz,

bred on the Austrian side of the Neusiedler-See (Rauer & Kohler 1990) and Glutz von Blotzheim *et al.* (1975) estimated 35-45 breeding pairs in Burgenland, Austria. Bartovsky *et al.* (1987) reported that 44-71 pairs of Kentish Plover bred in the former Yugoslavia (Voivodina, Slovenia and Croatia).

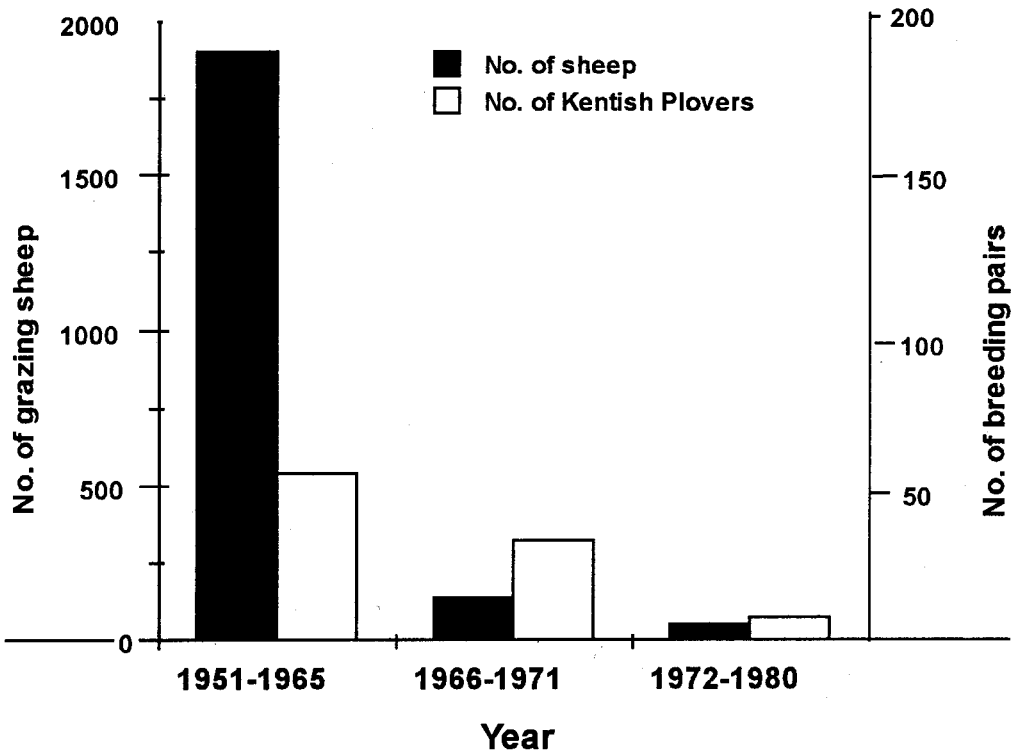


Fig. 2. The reduction in number of breeding Kentish Plovers coincided with the reduction in number of grazing sheep in Vásárhelyi-puszta (based on Sterbetz 1992).

### 3. Population trends

Several ornithologists have warned that the size of the breeding population has declined recently in Hungary (Bankovics 1984, 1989, Sterbetz 1992), and current evidence supports this view. For example, the number of breeding pairs declined between 1947 and 1990 in Southern Hungary (Fig. 1). Although these estimates are based upon casual observations and reports, they suggest a general decline over the investigated period (Tajti 1992). The first thorough counts were carried out in 1988; thus the increase between 1987 and 1988 could have been caused by the increased precision of surveys - rather than by a real in-

crease in the number of birds. Sterbetz (1992) described a reduction in numbers of Kentish Plovers between 1951 and 1980 in Vásárhelyi-puszta (Fig. 2). In Eastern Hungary the stronghold of the Kentish Plover used to be the Hortobágy (Udvardy 1941). Whereas in 1965 25 pairs bred in Hortobágy, the number of breeding birds gradually declined (1969: 10-15 pairs, Sterbetz 1965) and since 1984 Kentish Plovers no longer breed there (Sterbetz 1965, Kovács 1984). Glutz von Blotzheim *et al.* (1975) estimated that in 1969-1971 150 pairs bred in Hungary, but this estimate did not seem to include the breeding population in Miklapuszta. Assuming that the number of breeding pairs have not changed in Miklapuszta since then (60-80 pairs), I

Tab. 1. Hatching success (% of nests or eggs that hatched) and fledging success (% of chicks fledged) of Kentish Plovers in Southern Hungary (Székely, T. unpubl. data). Successful nests hatched at least one chick. Only fresh clutches were included and only the ones which were known to hatch or fail. Disappeared chicks presumably died.

Year	Hatching success of nests			Hatching success of eggs		Fledging success		
	Hatched %	Predated or failed %	No. of nests	Hatched %	No. of eggs	Fledged %	Predated or disappeared %	No. of chicks
1988	37.5	62.5	8	37.5	24	13.6	86.4	22
1989	23.5	76.5	17	18.0	50	37.5	62.5	24
1990	31.6	68.4	19	31.6	57	34.8	65.2	23
All	29.5	70.5	44	27.5	131	29.0	71.0	69

estimate that the total number of breeding pairs was approximately 210-230 pairs in 1969-1971 in Hungary. Thus the number of breeding pairs could have been reduced from 210-230 pairs to 105-140 pairs over 20 years i.e. a reduction of 40-50 %. The negative trend coincided with the marked decline of Kentish Plover in several other

European countries (Tucker & Heath 1994, Meininger & Arts 1997).

#### 4. Causes of decline

I suggest that a loss of breeding habitat and a reduced reproductive success are both re-

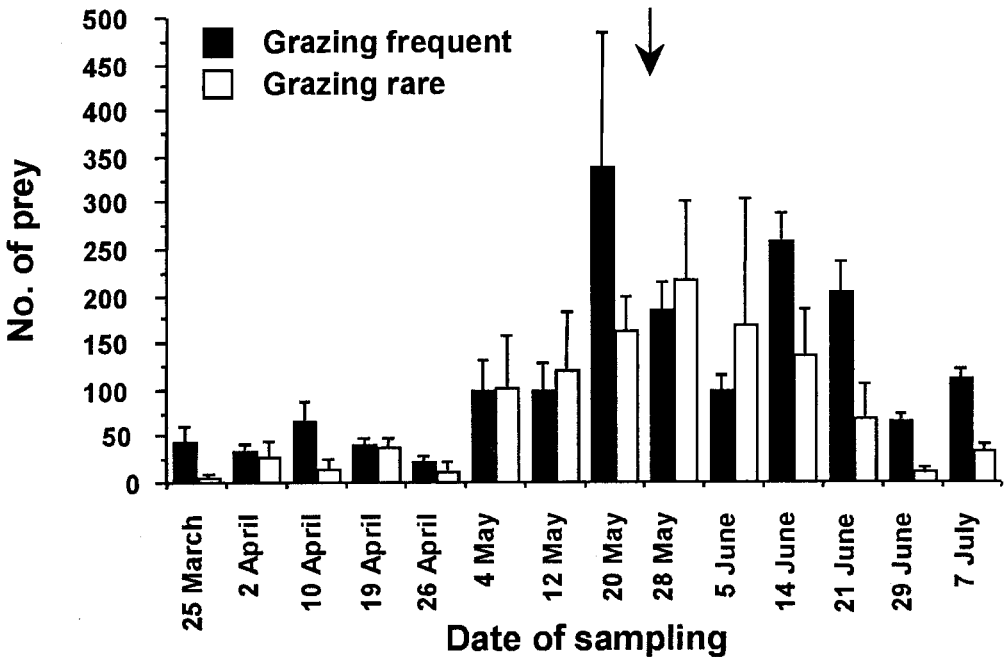


Fig. 3. The insect density (no. of prey items / 100 cm<sup>2</sup> of trap ± SE) is higher where sheep grazing pressure is high than where it is low (two-way ANOVA between 'grazing frequent' and 'grazing rare' areas with sampling date,  $F_{1,112} = 37.94$ ,  $p < 0.001$ , Székely *et al.* 1993). The arrow indicates the mean date of hatching of Kentish Plover eggs.

sponsible for this decline in Hungary, although other potential explanations such as increased over-winter mortality can not be ruled out (Szép 1995). Kentish Plovers have lost several breeding grounds during the last 40 years or so. Before 1953 the most important breeding site was probably an alkaline lake in Southern Hungary (Fehértó, 9 km north of Szeged), which harboured more than 100 pairs of Kentish Plover (Weisz 1935, Sterbetz 1963). This lake was drained and converted into fishpond between 1953 and 1955. By 1955 most Kentish Plovers left Fehértó and some of them dispersed into neighbouring alkaline grasslands and lakes (Sterbetz 1963).

Another threat comes from fertilisers which are used to improve productivity of grasslands. Short vegetation and large patches of bare ground seem to be necessary for breeding Kentish Plovers; thus increasing density and height of vegetation by these chemicals destroys the suitability of such habitats for Kentish Plover breeding (Sterbetz 1992). Reduction in grazing livestock may also be a significant threat. Sterbetz (1992) showed in Vásárhelyi-puszta that as the number of grazing sheep declined so did the number of breeding Kentish Plovers (Fig. 2). Extensive sheep flocks may be important in maintaining habitat quality for Kentish Plovers. These flocks typically contain several hundred sheep and they are attended by a shepherd. First, grazing sheep leave short grass behind thus intensive grazing and trampling by sheep may prevent vegetation from covering bare patches of grasslands. As soon as grazing stops or the intensity of grazing reduces the plants overgrow bare ground patches (Sterbetz 1992). Second, Kentish Plovers often feed in sites which

were grazed by sheep flocks several times a day. We found that the density of arthropods were higher in one such area than in less intensively grazed sites (Fig. 3). Insects may be attracted to sheep flocks, and/or they may use sheep and sheep dung to breed. These advantages of grazing are probably higher than the cost of sheep trampling nests (Székely 1992). Nevertheless, a specific study on the impact of sheep grazing on breeding birds would be most rewarding in the alkaline grasslands.

The other reason for the decline in numbers of breeding birds may be low reproductive success. Breeding success of Kentish Plovers is often low, even if their habitat quality does not deteriorate. 28% of eggs hatched and 29% of hatched young reached fledging age in Southern Hungary between 1988-1990 (Tab. 1). The major reason for nest failure was predation: 70.5% of failed nest were predated either by birds or mammals such as Marsh Harrier *Circus aeruginosus*, Montagu's Harrier *Circus pygargus*, Rook *Corvus frugilegus*, Hedgehog *Erinaceus europaeus*, Fox *Vulpes vulpes*, and stray dogs and cats (Székely 1992). It is likely that some of these predators took chicks as well, although the only chick whose predation was witnessed was taken by a Kestrel *Falco tinnunculus*.

Based on these values one may calculate whether the current rate of reproduction is sufficient to maintain population size. To maintain a stable population size the number of female young recruitment ( $r_f$ ) should be at least as large as the number of adult females which die each year ( $\mu_f$ ) i.e.  $r_f \geq \mu_f$ . An offspring has a probability  $0.28 * 0.29 * 0.53 = 0.043$  of surviving from the beginning of incubation until

reproducing approximately one year later (Tab. 1, Cramp & Simmons 1983). On average a female produces 2.96 eggs in a nest and lays 1.18 clutches in a breeding season; thus on average a female produces 3.49 eggs in a breeding season (Székely 1994, Székely, T. unpubl. data). Therefore a female is expected to produce  $0.043 * 3.49 = 0.15$  young each year which are recruited into the breeding population. Approximately half of these young will be male which leaves  $r_f = 0.075$ . The mortality of adult females is  $\mu_f = 0.43$  based on local returning rate of females between 1988 and 1994 in Southern Hungary and Miklapuszta (Székely 1994). Thus the recruitment seems to replace only 17% of adult loss. Even if we consider that each of these estimates have large confidence intervals, the rapid decline of Hungarian Kentish Plovers seems inevitable.

The Hungarian population does not decline that fast (see 'Population trends'). The discrepancy between the estimated rate of reduction and recruitment rate may derive from several sources. First, female mortality was based on the local returning rate; thus the real mortality of adults may be overestimated. Second, females may change breeding site between re-nesting (Stenzel *et al.* 1994, Székely 1994), thus the production of 3.49 eggs in a breeding season probably underestimates the real number of eggs laid over a breeding season. Third, immigration may compensate for some of the losses. Kentish Plovers are known to move between breeding sites over hundred kilometres (Stenzel *et al.* 1994, Székely 1994). However, I do not know the whereabouts of a population that might provide the immigrants to the Hungarian breeding sites.

## 5. Recommendations for conservation

Kentish Plovers have been protected since 1901 in Hungary and their most important breeding sites such as Miklapuszta and Southern Hungary are also under protection. However, protecting the species or the habitat by law does not circumvent the major threats: the low reproductive success and habitat loss.

There are several ways to improve the reproductive success of Kentish Plovers. First, stray dogs and cats can be controlled on breeding sites. For example, in Makraszék (Southern Hungary) Kentish Plovers bred less than 100 m from farms; thus their nests could easily be preyed upon by dogs wandering away from the farm. It is illegal to let a dog or cat roam on its own in nature reserves such as Makraszék, but stricter pest control would probably help to eliminate some of the nest predators. Second, nesting success can be increased by fencing around nests. Nest protective exclosures have been successfully applied in several plovers (Nol & Brooks 1982, Rimmer & Deblinger 1990). Following Jönsson (1993) we surrounded eight nests of Kentish Plovers in 1994 by a garden fence (Castro, M., Noszály, G. & T. Székely unpubl. data). Plovers easily squeezed through the fence whereas most predators were unable to do so. The exclosures were successful in protecting the nests. Six nests out of eight fenced nests hatched 16 chicks, whereas three nests out of eight control (unfenced) nests hatched only seven chicks. One of the two fenced nests which failed was predated probably by a small mammal, and the other nest was abandoned by both parents.

The other important action should be a better management of breeding habitats (Molnár 1996). Maintaining or increasing current grazing pressures on breeding grounds of Kentish Plover is very important. According to some sheep owners sheep-breeding is no longer profitable in Hungary, and thus they have reduced the size and the number of their flocks. Conservation authorities should find the way to encourage sheep-breeding especially on the traditional breeding sites of Kentish Plovers.

Kentish Plovers first bred on the bottom of drained fish ponds in 1970, and since then the number of breeding pairs appears to have increased in fish-ponds (Tajti 1992). Although hatching success of nests is lower in fish-ponds than in alkaline grasslands (Székely 1992), the fledging rates appear to be higher; thus the overall reproductive success appears to be higher in fish-ponds than in grasslands (Noszály *et al.* 1995). Fish-ponds which are drained in May and June attract several shorebirds such as Avocets *Recurvirostra avosetta*, Lapwings *Vanellus vanellus* and Little Ringed Plovers *Charadrius dubius*; particularly in Southern Hungary (Székely 1992). However, the bottom of drained fish-ponds are often cultivated and they may be filled up 2-4 weeks after drainage thus causing the loss of shorebird nests which are still being incubated. The interest of conservation is then to prevent or restrict the activity of fish-farms during the breeding season. Thus conservation authorities should pay attention not only to the alkaline grasslands and edges of alkaline lakes, but to fish-ponds as well. Perhaps grasslands and fish-ponds managed chiefly for conservation purposes would significantly improve the chance of

this small plover surviving over the next century in Hungary.

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## Összefoglalás

### A széki lile *Charadrius alexandrinus* természetvédelmi helyzete Magyarországon

A hazai széki lile populáció nagyságát, elterjedését és szaporodási sikerét foglalom össze ebben a dolgozatban. 1988 és 1992 között 105-140 pár széki lile fészkel Magyarországon. A lilék két legfontosabb fészkelőterülete Miklapusztá (60-80 pár) és a Dél-Alföld volt (35-40 pár). A fészkelő párok száma erősen csökkent az utóbbi évtizedekben. A széki lilék eltűntek az egyik fő tradicionális fészkelőterületükről, a Hortobágyról, míg számuk alaposan megcsappant a Dél-Alföldön és a Vásárhelyi-pusztán. A csökkenés legfőbb oka a fészkelőterületek átalakulása és az alacsony szaporodási siker. A fészkelőterületek átalakulása nagyrészt a birkalegeltetés visszaszorulásának tulajdonítható. Véleményem szerint a birkák legelése jelentős a rövidfűvű, vakszikfoltokkal tarkított puszták fenntartásában. A rövidfűvű, kopáros szikespuszták fontos feltételét adják a széki lile fészkeléséhez. Továbbá, a széki lilék jelentős táplálékát képezik a birkákat követő és a birkatrágyában fejlődő rovarok. További vizsgálatok szükségesek annak felmérésére, hogy a legelő lábasjószágok

hogyan befolyásolják a sziki madarak fészkelését. Azonban a széki lilék alacsony szaporodási sikere is hozzájárul a populáció csökkenéséhez. A liletojások csupán 28 %-a kelt ki, míg a kikelt fiókák csupán 29 %-a repült ki a Dél-Alföldön. Becslésem szerint a hazai lilepopuláció nem képes az önnfentartásra, mivel az évi szaporulat csupán egyötödét pótolja az éves pusztulásnak. Sürgős intézkedések szükségesek a széki lilék további csökkenésének megakadályozására, a szaporulat védelmére és az élőhelyek további romlásának megakadályozására.

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# Nesting success of the Red-backed Shrike (*Lanius collurio*) in a cultivated area

R. Farkas, R. Horváth and L. Pásztor

Farkas, R., Horváth, R. and Pásztor, L. 1997. Nesting success of the Red-backed Shrike (*Lanius collurio*) in a cultivated area. – Ornis Hung. 7: 27-37.

We studied a stable population of Red-backed Shrikes in the Aggtelek National Park on an area which is a mosaic of arable lands with different degrees of cultivation. We analyzed the effect of cultivation on nesting success. We defined three types of land use: intensively cultivated plough-lands, extensively cultivated meadows or pastures, and uncultivated areas. Based on regular observations from several points on a transect, we made a map showing the location of the nests, the territories of the observed pairs and the land types. The observation period lasted 50-55 days a year between 1991 and 1996. We found that the decisive majority of nest failures were caused by predators. The nesting success was higher in the intensively cultivated and uncultivated lands than in the extensively cultivated areas. Bush size also affected nesting success, the risk of nest failure was lower in large groups of bushes than in lonely bushes. Human disturbance may have increased nest failures. We did not find any effect of bush type and distance from forest-edge on nesting success. We neither found any difference between the densities of pairs from different land-use types.



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## 1. Introduction

The breeding population of Red-backed Shrikes (*Lanius collurio*) have shown a marked decrease in some of its traditional habitats in Northern and Western Europe. Nowadays several projects try to reveal the possible causes of this trend all over Europe. According to the general view this population decline may be the result of the intensive, large-scale agricultural cultivation, especially the use of pesticides and the disappearance of breeding sites (Reuven & Lohrer 1995). We studied a stable population in an area cultivated by traditional agricultural methods. By analyzing the causes of nesting failure we

would like to reveal the factors relevant to the maintenance of local Red-backed Shrike populations on cultivated areas.

## 2. Methods

The study was conducted in the Aggtelek National Park (Northern Hungary), in the valley of the Jósva-stream, between Jósavfő and Szinpetri (Visnyovszky & Márkus 1993). The 107 ha study area is surrounded by xerotherm oak forests (*Quercus pubescens*, *Quercus petraea*), hornbeam forests (*Carpinus betulus*), spruce plantation (*Picea abies*) and the two villages. A stable Red-backed Shrike

Tab. 1. Relationship between breeding density and nesting success in the Red-backed Shrike.

Years	number of pairs	breeding density (pairs / 10 ha)	intensively cultivated		extensively cultivated		uncultivated		nesting success (%)
			success	nest failure	success	nest failure	success	nest failure	
1991	41	3.83	11	3	10	7	7	3	68.2
1992	35	3.27	8	1	12	3	7	4	77.1
1993	34	3.18	8	4	6	7	8	1	64.6
1994*	40	3.74	8	7	5	11	5	4	45
1995*	46	4.3	9	6	10	11	8	2	58.6
1996	54	5.05	12	4	15	12	8	3	64.8
Total	250		56	25	58	51	43	17	

Years marked by \* took part only in the analysis of the densities of territories

population lives in the valley, with 35-54 territories per year (Tab. 1). Between 1991-1996 we collected data on 50-55 days a year (except 1994: 15 days), during the whole breeding season from the middle of May until the middle of August. From the beginning of June until mid July we made observations every day. Data on the amount of precipitation was measured at the local station of the Hungarian Meteorological Service.

We used a 5 kilometer long path for making observations and transect-counts in the valley. Boundary of a territory of a pair was established by synchronous observations of the neighbours. We defined three types of cultivation: intensively cultivated lands (plough-lands), extensively cultivated lands (meadows, pastures) and uncultivated or ruderal areas. We used a map with the scale of 1:5000. All observations, territories, found nests and land usage types were indicated on this map. To estimate the size of the area of each land type we cut around the areas from the map and weighed them on an electronic balance of 0.01 g accuracy. In the first two years nests were systematically searched and checked regularly.

All the statistical analyses were carried out by the software BIOM PC. All tests are 2-tailed except when it is stated otherwise.

### 3. Results

#### 3.1. Habitat selection

The area of the different land types changed year to year depending on whether the local people started cultivation on new, previously uncultivated lands or they left the land uncultivated. We determined the number of pairs that seemed to have a territory in each land type in each year and calculated the population density. We did not find any significant difference between the population densities of different land types (One-way ANOVA  $F_{(2,15)} = 1.714$ ,  $df = 2$ ,  $p > 0.05$ ).

#### 3.2. Components of breeding success

We measured nesting success by the proportion of successful nests. We considered a nesting attempt successful if we recorded at least one juvenile bird on the parents' territory soon after the expected time of fledging. This study does not differentiate between first and second broods.

We did not find significant difference in nesting success between the years ( $G = 3.284$ ,  $df = 4$ ,  $p < 0.5$ ) and we neither found any significant difference between any

Tab. 2. The most frequented plant species used for breeding

Species	Number of nests	% of total nests
blackthorn ( <i>Prunus spinosa</i> )	38	26.39
dogwood ( <i>Cornus sanguinea</i> )	19	13.19
willow ( <i>Salix sp.</i> )	18	12.51
wide rose ( <i>Rosa canina</i> )	17	11.81
elder ( <i>Sambucus nigra</i> )	14	9.72
hawthorn ( <i>Eunonymus sp.</i> )	10	6.94
others (10 species)	28	19.44
sample size	144	100

combination of year groups. On average nesting success was 68.7%.

The average clutch size was 4.62, the size of clutches ranged from 2 to 7. Fifty-two percent of the clutches were destroyed entirely from the nests found in 1991 and 1992. Only 64.9% of the laid eggs hatched. The average hatching success/nests was 46.6%. Average hatching rates of eggs was 96.2% in the non-destroyed nests.

To find the effective factors we have to take a closer look at the causes of unsuccessful breeding attempts. We examined 42 destroyed nests found in four years (1991, 1992, 1993 and 1996).

Twenty-seven nests with eggs and 11 nests with nestlings were destroyed. We could not identify the stage of destruction in 6 cases, when the content of the nest disappeared 1-2 days before or after the ex-

pected date of hatching. Although more clutches were destroyed in the egg-stage than with nestlings, we could not show a significant difference from the 1:1 ratio (Goodness of fit test,  $G = 3.558$ ,  $df = 2$ ,  $p < 0.1$ ). It is not possible to reveal significant difference either between the nesting success of the two stages (test of independence,  $G = 2.765$ ,  $df = 1$ ,  $p < 0.1$ ).

Thirty-four nests (80.9%) were destroyed by predators and 6 (14.3%) by rainfall. The cause was unknown in two other cases (4.8%), thus predators caused the decisive majority of clutch-destructions (Fig. 1). Jays (*Garrulus glandarius*) are suspected to be the most important nest-robbers but there are other species whose visibility is much lower, because they move on the ground hidden by the vegetation. We saw beech-martens (*Mar-tes foina*), grass snakes (*Elaphe longissi-*

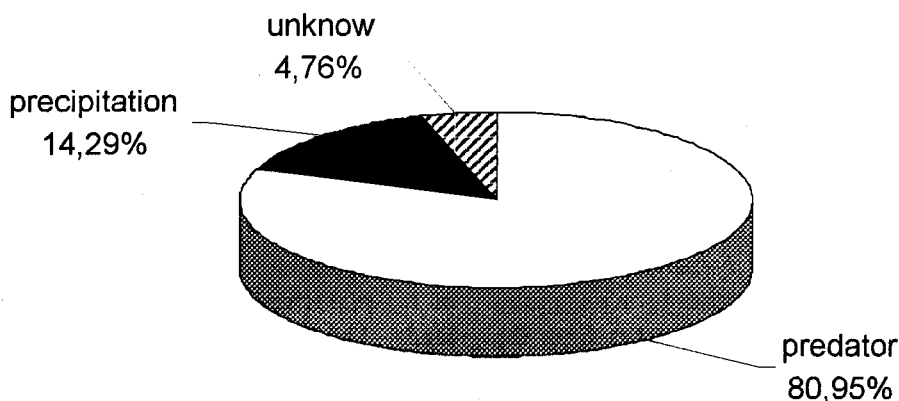


Fig. 1. Causes of clutch destructions in the Red-backed Shrike. Decisive majority of clutches were destroyed by predators.

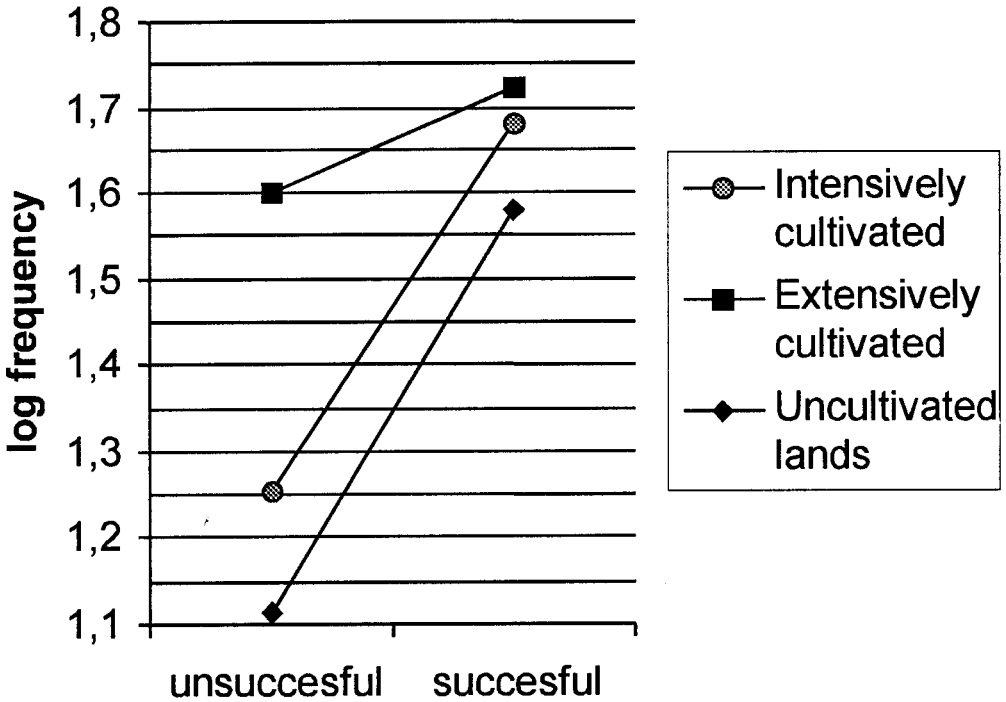


Fig. 2. Habitat-success interaction (interaction plot). The compared categories (unsuccessful and successful nests) can be found on x axis, frequency of nests are shown on y axis. (See also the text.)

*ma*) and dormouses (*Glis* spp.) in the area. These are also potential nest predators.

### 3.3 Effects on nest failure

#### 3.3.1. Habitat

We compared the nesting success of breeding pairs in the three land usage types. The proportion of successful nests was the lowest in the extensively cultivated areas (test of independence,  $G = 6.351$ ,  $df = 2$ ,  $p < 0.05$ ).

The three types can be classified into two categories. The intensively cultivated and the uncultivated lands form one group and the extensively used areas form the other one. This classification is justified by the interaction plot (Fig. 2). The figure shows the natural logarithm of the number

of nest failures and of the successful nests in the three different habitat types. Thus the parallel lines show that the proportion of unsuccessful and successful nests is nearly the same in the intensively cultivated and uncultivated areas. The level of significance increased by repeating the test with the two new groups ( $G = 6.305$ ,  $df = 1$ ,  $p < 0.02$ ) (Fig. 3).

In order to give the magnitude of the effect we can express the difference in the proportional losses as odds ratios. We took the proportion of successful and unsuccessful nests in the extensively used lands and divided them by the same ratio of the intensively used and uncultivated lands. This odds ratio shows that how much times the first proportion is higher than the second. In our case the odds on success is 2.1 times better in intensively

used and uncultivated regions than in extensively used regions ( $\omega = 2.094$ ).

### 3.3.2. Precipitation

We classified years according to the amount of precipitation measured in the local meteorological station. Years with less than 100 mm of rainfall during May and June were put into the first group whereas years with more than 100 mm were put into the second group. We did not get significant difference between the nesting success of the rainy and non-rainy years (test of independence,  $G = 2.376$ ,  $df = 1$ ,  $p < 0.1$ ).

### 3.3.3. Nest sites

#### 3.3.3.1. Bush size

We classified the potential breeding sites in the valley into two categories. Lonely bushes with small diameter got into the first group and groups of bushes with a

larger extension got into the second group. We found a significant difference between the success of nests in these two bush size types ( $G = 4.521$ ,  $df = 1$ ,  $p < 0.05$ ) (Fig. 4). The found bush size effect is strong as the odds on nesting success is four times better in the groups of bushes than in the lonely bushes ( $\omega = 4.00$ ). When we excluded the nests destructed by rainfall from the analysis, although the sample size decreased, the value of  $G$  increased ( $G = 5.333$ ). The effect of land usage on success cannot be explained by the effect of bush size as there is no difference in the distribution of bush types in the 3 land usage types ( $G = 2.189$ ,  $df = 1$ ,  $p < 0.2$ ) (Fig. 5). Obviously, the chosen type of cultivation does not depend on the size of the bushes in an area.

#### 3.3.3.2. Bush type

We registered 16 plant species in the valley used by shrikes for nesting. These plants were usually shrubs or trees, there

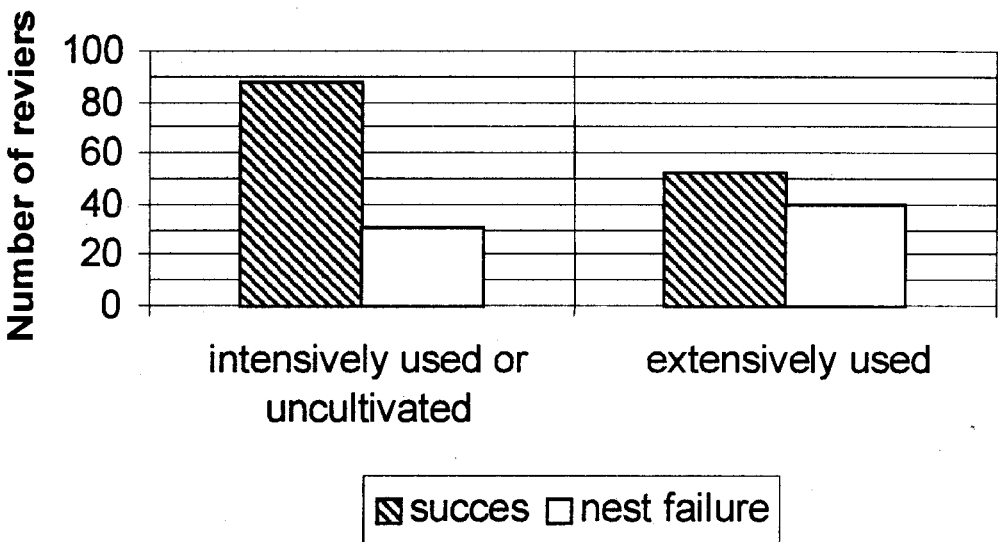


Fig. 3. The effect of habitat on nesting success of the Red-backed Shrike.

were only two occasions when we found a nest on soft-stalked plants. The most frequent plant species are shown in Tab. 2.

We studied whether the type of the nesting bush affect nesting success or not. Therefore we divided the 16 plant species into two classes. Open, thornless type was represented by such species like the willow (*Salix* spp.) and elder (*Sambucus nigra*), while closed, thorny bushes formed the second group among others with blackthorn (*Prunus spinosa*) and wide rose (*Rosa canina*). We could not show any difference between the success of these two groups of nests ( $G = 0.219$ ,  $df = 1$ ,  $p < 0.7$ ). Repeating the calculation of the G statistics again only for the 6 most frequent plant species, its value increased but did not get significant ( $G = 2.020$ ,  $df = 1$ ,  $p < 0.2$ ).

### 3.3.3.3. Location

The cross-section of the Jósua-valley can be easily divided in three sharply separated breeding areas. A nearly five kilometer long bushy stripe extends along the Jósua-stream. Another unbroken bush stripe runs at the edge of the bordering forest between the two villages. Between these two stripes a wider area can be found with different sized bushes. In the last class we separated nests on lonely bushes from groups of bushes. Comparing these four types there was no significant difference between the nesting success ( $G = 4.83$ ,  $df = 3$ ,  $p < 0.2$ ).

### 3.3.4. Three-way interactions

Beside the series of tests of independence we also used log-linear models to reveal

three-way interactions. First, we examined the interactions among nesting success (successful and unsuccessful), quantity of rainfall (under 100 mm and above 100 mm) and habitat types (intensively cultivated and uncultivated contrary to extensively cultivated areas), but only the success-habitat interaction proved to be significant ( $G = 1.845$ ,  $df = 1$ ,  $p < 0.2$  for the 3-way interaction) (Fig. 6).

Three-way interaction could not be detected either among the size of bushes, nesting success and the two habitat types (in the latter case using the above defined categories) ( $G = 0.987$ ,  $df = 1$ ,  $p < 0.5$ ).

### 3.3.5. Effect of observer's disturbance

In 1991 and 1992 we explored the valley for nests systematically and checked them regularly so they suffered from regular disturbance. In 1993 and 1996 we examined only the nests found by accident and checked them more rarely. There was a significant difference between the success of these two classes of nests ( $G = 2.064$ ,  $df = 1$ ,  $p < 0.05$ , one-tailed test).

However, we also compared the nesting success of checked nests and success of those non-disturbed breeding pairs whom we observed from a distance. First, we supposed that already the first breeding attempt of each pair was effective in the second group. In this case, the test of independence showed significant difference between the nesting success of disturbed and undisturbed pairs ( $G = 3.299$ ,  $df = 1$ ,  $p < 0.05$ , one-tailed test) (Fig. 7). The odds on success is 1.7 times better at the undisturbed pairs than at disturbed ones ( $\omega = 1.726$ ). However, when we

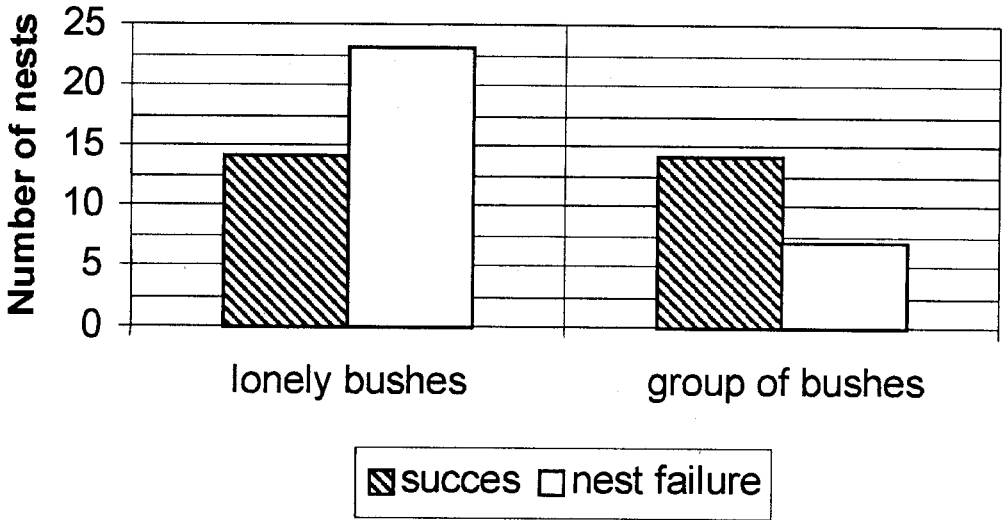


Fig. 4. The effect of bush size on nesting success of the Red-backed Shrike.

checked for the second attempts, we found at least 8 pairs whose fledglings came from a second nesting attempt with a high probability. Taking this into account, the difference between the disturbed and undisturbed groups disappeared ( $G = 1.35$ ,  $df = 1$ ,  $p < 0.15$ , one-tailed test)(Fig. 8).

#### 4. Discussion

The density of breeding pairs did not differ considerably from densities in other Central European regions (Kuzniak 1991).

Nest failures are caused mainly by predators in the majority of open nesting Passerine species. Though the rainfall

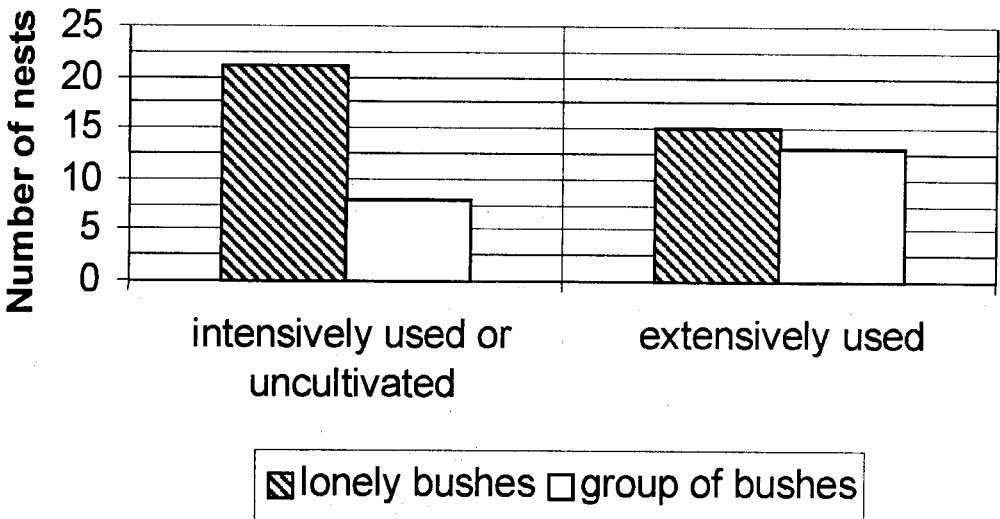


Fig. 5. Habitat is independent from bush types.

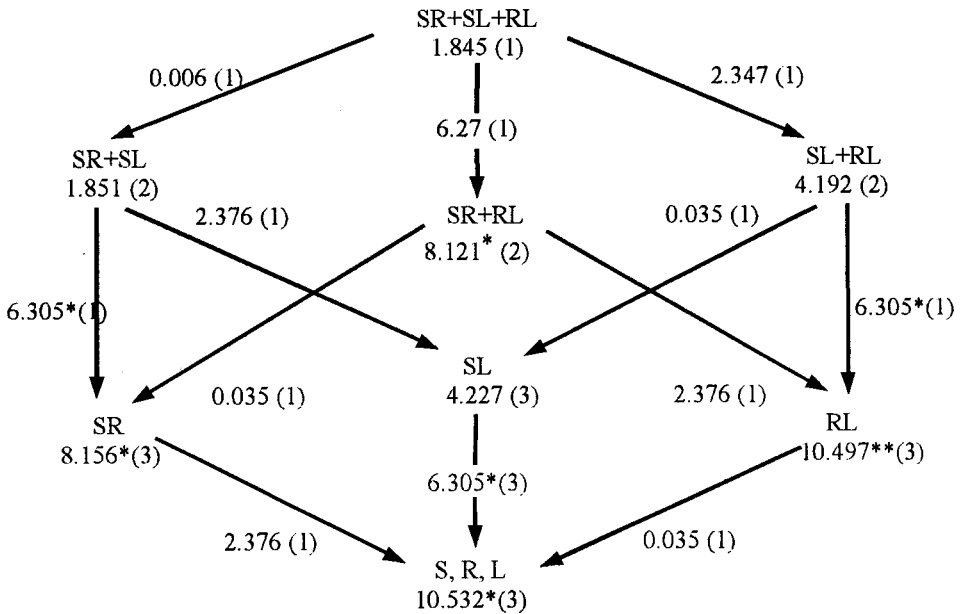


Fig 6. Success (S), rain (R) and land type (L) interaction. G values corresponding to model selection are given. The degrees of freedom are given in parentheses. The \* shows the level of significance (\*:  $p < 0.05$ ; \*\*:  $p < 0.001$ ).

also causes nest failures, in our sample there are only a few drenched nests, therefore it is impossible to analyze the effect of rainfall. The amount of rainfall may have an indirect effect on the density of the resource populations and might decrease fledging success, but we do not have data to verify this assumption.

Similarly to others we did not find significant difference between the risk of predation in egg and nestling stages (Matyjasiak 1995). However, our sample size is small and we did not make comparison on daily predation rates. The nesting failure is rather high (52%). Fuisz *et al.* (1997) found that only 31.3% of nest failed, Kuzniak (1991) related that 40.4% of eggs and nestlings had lost and Rozgonyi (1993) also found nesting success higher.

Red-backed Shrikes in our population were less successful in the extensively

used areas than in the intensively cultivated and uncultivated lands. Söderström *et al.* (1996) also found that nest predation rate was 2 times higher on grasslands than on other areas in a Swedish population. The reason of this effect may lay in the type of vegetation. As the result of regular mowing and grazing the vegetation is much shorter and scarcer in the extensively cultivated lands than in the intensively and uncultivated areas. This may increase the effectiveness of ground-predators. The predators moving on the ground may catch sight of the feeding male or female easier and find the bush where the nest can be found. Jays are important and well-visible predators but there are others like martens, grass snakes and dormouses. In the case of the Bull-headed Shrike (*Lanius bucephalus*) Takagi & Abe (1996) found that 46% of all nests was depredated by ground mam-

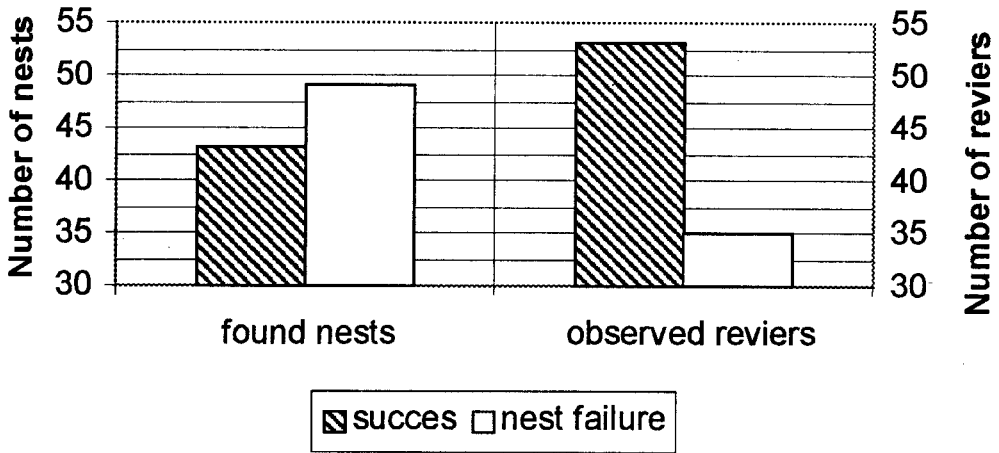


Fig. 7. Observer's inspections decrease success if we do not consider renestings. We did not disturbed nests when only reviers were studied.

mals. It would be important to study nest-predation itself and to identify the actual predators in order to understand the grassland-effect on nesting success found in two independent studies.

On the basis of the studied bush parameters, we can state that only the size of the bush affects nesting success. This effect is probably also due to predation as the interaction between nesting success and bush size was stronger among the predated nests. The bigger the bush is the more dif-

ficult it is to find the nest in it. According to Fuisz (1996) and Fuisz *et al.* (1997) Red-backed Shrikes select large, well developed bushes for nesting. Our result indicates that for the protection of the endangered populations it is very important to preserve the large, continuous bush groups in regions under agricultural cultivation.

The land types did not differ in bush size and the density of breeding pairs was the same in the three habitat types. It sug-

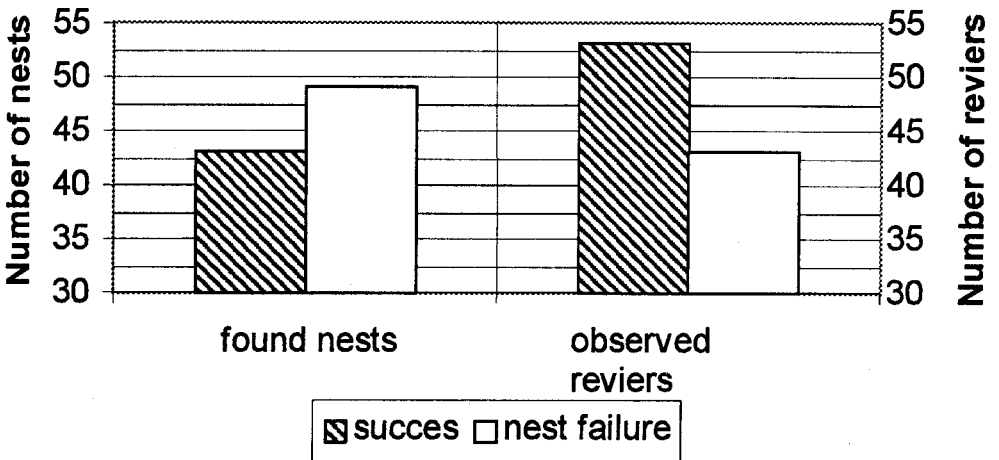


Fig. 8. Observer's inspections do not influence success if we consider renestings.

gests that habitat selection probably depends on the distribution of the bushes suitable for breeding (Diehl 1995).

Though we expected a bush-type effect which was found by Söderström *et al.* (1996), we did not find any difference between the success of nests in thorny and open bushes. Our study considers the whole breeding season, however Takagi & Abe (1996) revealed changing in nesting vegetation at Bull-headed Shrikes during the breeding season, and the nesting success increased as the result of this changing. According to Moskát (pers. comm.) a similar effect may also exist in the Red-backed Shrikes. We did not expect and did not find difference in success depending on the distance from the forests (edge-effect) since the valley is only 150-180 m wide. Others found edge-effects in other situations (Matyjasziak 1995, Söderström *et al.* 1996).

Biologists may also have an effect on the results of field studies. Kuzniak (1991) found that 26% of nest losses was the result of the frequent visits of the observer. According to our results there is no difference between the success of regularly disturbed and rarely disturbed nests. However, the results are not unanimous. It would be worth to do some further research to establish whether human disturbance increases the rate of nest predation or not.

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## Összefoglalás

### A tövisszúró gébics (*Lanius collurio*) költési sikere művelt területen

A tövisszúró gébics európai állománya erős csökkenést mutatott az elmúlt évtizedekben, talán az egyre intenzívebb mezőgazdasági művelés miatt. Mi a faj egy stabil populációját tanulmányoztuk, egy különböző művelési fokozatú parcellákkal borított területen. A művelés lehetséges hatásait vizsgáltuk a költőpárok denzitására és költési sikerességükre. A 107 hektáros mintaterület a Jósua-patak völgyében (Aggteleki Nemzeti Park) fekszik. Háromféle területhasználati típust különítettünk el: intenzíven használt szántók, extenzíven használt kaszálók és legelők, valamint művelésbe nem vont területek. Megfigyeléseket 1991 és 1996 között, évi 50-55 terepnapon végeztünk. A territóriumok elkülönítését és a költési viselkedés megfigyelését egy 5 km-es transzekt mentén végeztük, az első két évben intenzíven kerestük a fészkeket és rendszeresen ellenőriztük a megtaláltakat. A párok territóriumait, a megtalált fészkeket és a területhasználat módját 1:5000 méretarányú térképen jelöltük.

Vizsgálataink szerint nincs szignifikáns különbség a fészkelőpárok denzitásában az egyes habitat-típusok között. A fészkealjok pusztulását döntő többségben a ragadozók okozzák. A fészkelési sikeresség lényegesen nagyobb az intenzíven művelt és a nem művelt területeken, mint az extenzíven művelteken, talán azért, mert itt az alacsonyabb vegetációban a fészkekrablók könnyebben megtalálják a fészkelőhelyet. Úgy találtuk, hogy a nagyobb bokorcsoportokban jóval kevesebb fészkealj semmisül meg, mint a magányos bokrokban. Ezért a veszélyeztetett gébics-populációk védelmének érdekében a nagy kiterjedésű bokrosokat meg kell óvni. A bokortípus és az erdőszéltől való távolság nem befolyásolta a fészkepusztulásokat. Az emberi zavaró hatásnak rendszeresen kitett fészkek és csak ritkábban zavartak sikeressége között nem találtunk különbséget.

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# Distinction of solitary and colonial breeding in waders

Z. Hegyi and L. Sasvári

Hegyi, Z. and Sasvári, L. 1997. Distinction of solitary and colonial breeding in waders. – Ornis Hung. 7: 39-42.

Distances between neighbouring nests, antipredator attacks and foraging distances from the nests were recorded in Lapwing (*Vanellus vanellus*), Redshank (*Tringa totanus*) and Black-tailed Godwit (*Limosa limosa*) breeding on 380 ha of meadows in Kiskunság National Park, 50 km south of Budapest. We found a notable low level of simultaneous activities in antipredator behavior when distances between neighbouring nests were longer than 200 m, both in conspecific and heterospecific neighbourhoods and a lower proportion of simultaneous antipredator attacks in non-conspecific neighbourhoods than in conspecific ones. Parents foraged over distances greater than 200 m in most often when they nested closer than 200 m from each other and conversely, parents foraged closer than 200 m when they nested further than 200 m from each other. When the nearest neighbours were closer than 200 m there was a higher proportion of longer foraging distances in conspecific than in non-conspecific neighbourhoods. We suggest that an aggregation of Lapwing, Redshank and Black-tailed Godwit nests separated by less than 200 m may be considered as a single or mixed species colony of waders.



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## 1. Introduction

It has been showed that aggregation of waders in the breeding season is a strategy that reduces the risk of predation on eggs and chicks. Göransson *et al.* (1975) found that predation rate on artificial nests, exposed in habitats of ground-nesting birds, was lower within aggregations of breeding Lapwings than outside them. Field work focused on the costs and benefits of breeding aggregations in waders has been restricted to single species colonies (Elliot 1985a, 1985b, Berg *et al.* 1992). Only Byrkjedal & Kalas (1983) have reported studies of the adaptive value of mixed species colonies in breeding shore birds.

In this study our question was how the colonial and solitary breeding could be distinguished in waders. Berg *et al.* (1992) con-

sidered coloniality exists in Lapwings when neighbouring nests were closer than 200 m. We predicted that coloniality should be reflected in cooperative activities and longer foraging distances from the nests than the distances separating neighbouring nests. Hence we compared the proportion of simultaneous antipredator attacks of neighbouring parents which nested at various distances from each other and the proportion of foraging at distances longer than 200 m for parents whose nearest neighbours nested either closer or further than 200 m.

## 2. Study area and methods

The study area was chosen on a site where artificial fish ponds had been created in 1953 over 380 ha in Kiskunság National

Tab. 1. Proportions (%) of simultaneous antipredator attacks by neighbouring pairs of three wader species. Antipredator attacks were recorded when both parents of neighbouring pairs were closer than 50 m to their own nest. When one or both of the parents attacked, together with one or both of parents of neighbouring pairs, simultaneous attack was recorded.

Distance from neighbouring nest (m)	Neighbouring species	Lapwing			Redshank			Godwit		
		n	$\bar{x}$	SD	n	$\bar{x}$	SD	n	$\bar{x}$	SD
<100	Conspecific*	12	96.3	10.7	12	78.7	9.3	7	97.8	8.4
	Non-conspecific**	17	86.4	7.6	13	71.1	6.3	15	78.7	10.2
100-200	Conspecific	10	84.0	7.9	11	66.7	5.2	8	83.7	9.4
	Non-conspecific	14	78.9	8.5	15	61.4	7.3	14	74.4	10.1
>200	Conspecific	7	12.0	2.1	14	7.6	2.7	7	10.5	3.1
	Non-conspecific	9	8.4	3.0	21	7.0	2.9	10	7.4	2.8

\*There was not heterospecific nest closer than the nearest conspecific nest.

\*\*There was not conspecific nest closer than the nearest heterospecific nest.

Park, 50km south of Budapest (19°07'E, 47°08'N), and where fish breeding was abandoned in 1966. The fish ponds had dried up and were first flooded artificially in 1987. Each August the ponds dried up and were re-flooded every autumn during the study period from 1988-1995.

Lapwing (*Vanellus vanellus* L.), Redshank (*Tringa totanus* L.) and Black-tailed Godwit (*Limosa limosa* L.) nests were detected by observing the incubating parents either from a car parked on the banks or from hides where suitable nesting sites were a long way from the banks. About 70-80 ha could be viewed from the hides and 130-160 ha from the banks. Nests were marked with sticks placed a few meters from them, and their arrangement in the study area was

mapped. Nest identification started at the beginning of March.

Marking of birds was carried out using the technique suggested by Paton & Pank (1986). Dummy eggs were treated with a mixture of oil jelly and either Rhodamin B, anilin blue or xylinene orange. Beads of gel (5-10 x 3-5mm) were placed along the length of the eggs, which were then substituted in the nests while both parents were involved in the incubation. Combinations of the colours marked the birds in unique patterns on their abdomens and breasts so that they could be individually identified. Parents from 7-11 nests were marked in each species in each year.

We carried out 280 hours of observations through 8 years for records of

Tab. 2. Proportion (%) of foraging distances longer than 200m from the nests in three wader species. Number of nests indicate small and large aggregation where the neighbouring nests are closer than 200m. Distances were calculated in the aggregations where three species bred.

Distances from nearest neighbour further than 200 m				Distances from nearest neighbour closer than 200 m							
				number of nests	Only conspecific neighbours			Heterospecific neighbours*			
Lapwing	Redshank	Godwit			Lapwing	Redshank	Godwit	Lapwing	Redshank	Godwit	
n	16	35	17	3-4	n	8	9	8	8	7	6
$\bar{x}$	15.5	8.1	11.2		$\bar{x}$	79.4	68.9	84.4	66.4	62.2	75.7
SD	2.8	1.5	1.9		SD	8.9	8.3	7.3	8.1	9.0	5.2
				7-8	n	14	14	7	23	21	23
					$\bar{x}$	82.3	78.2	85.6	71.4	65.2	81.3
					SD	9.7	9.1	6.6	7.5	6.1	5.9

\*There was not conspecific nest closer than the nearest heterospecific nest.

antipredator attacks and foraging distance from the nests. To avoid differences due to diurnal fluctuations, the daily period was divided into five time units: 5.00-8.00, 8.00-11.00, 11.00-14.00, 14.00-17.00 and 17.00-20.00, and events were observed and recorded for one hour in each unit. The parents of several nests were observed simultaneously and observations on each type of activity were distributed equally between the first and second half of the incubation period. Observations in all five time periods were taken over one or two days. Magpie (*Pica pica* L.) and marsh harrier (*Circus aeruginosus* L.) represented the most frequent avian predators.

One antipredator attack was recorded when either or both sexes attacked the predator. Foraging distance was estimated by the distance travelled by the parents after leaving the clutch and first beginning to search for food. The distance was coded as 1 = less than 50 m, 2 = between 50 and 200, and 3 = greater than 200 m. Distances over the five hours were averaged for each individual.

Statistical analyses were carried out using the SPSS statistical package, percentage data were arcsine square root transformed for parametric testing.

### 3. Results and discussion

We found a notable low level of simultaneous activities in antipredator behaviour when distances between neighbouring nests were longer than 200 m, both in conspecific and heterospecific neighbourhoods (ANOVA conspecific and non-conspecific neighbours, Lapwing:  $F_{2,26} = 10.43$  and  $F_{2,37} = 14.20$ ; Redshank:  $F_{2,34} = 9.16$  and  $F_{2,46} = 11.83$ ; Godwit:  $F_{2,19} = 11.35$  and  $F_{2,36} = 13.09$ ;  $p < 0.001$  in each

occasion; Tab. 1). Pooled data, recorded for various distances showed a lower proportion of simultaneous antipredator attacks in non-conspecific neighbourhoods than in conspecific ones. (In conspecific and non-conspecific neighbourhoods Lapwing:  $n = 29$ ,  $\bar{x} = 71.7$ ,  $SD = 6.2$  and  $n = 40$ ,  $\bar{x} = 66.2$ ,  $SD = 5.8$ ,  $t = 3.74$ ; Redshank:  $n = 37$ ,  $\bar{x} = 48.2$ ,  $SD = 4.7$  and  $n = 49$ ,  $\bar{x} = 40.6$ ,  $SD = 4.9$ ,  $t = 7.31$ ; Godwit:  $n = 22$ ,  $\bar{x} = 65.0$ ,  $SD = 5.0$  and  $n = 39$ ,  $\bar{x} = 58.9$ ,  $SD = 6.1$ ,  $t = 4.21$ ,  $p < 0.001$  in each occasion.)

We found that parents foraged over distances greater than 200 m in most often when they nested closer than 200 m from each other and conversely, parents foraged closer than 200 m when they nested further than 200 m from each other (Tab. 2). This was recorded both when the number of close neighbours was low (3-4 pairs) and high (7-8 pairs). (ANOVA Lapwing:  $F_{2,32} = 9.81$ ,  $p < 0.001$  and  $F_{2,51} = 12.37$ ,  $p < 0.001$ ; Redshank:  $F_{2,31} = 7.33$ ,  $p = 0.001$  and  $F_{2,53} = 11.09$ ,  $p < 0.001$ ; Godwit:  $F_{2,29} = 7.18$ ,  $p = 0.002$  and  $F_{2,45} = 10.46$ ,  $p < 0.001$ . Calculations made for small and large aggregation separately, include the same values of parents whose nearest neighbours were further than 200 m.) When the nearest neighbours were closer than 200 m pooled data showed a higher proportion of longer foraging distances (more than 200 m) in conspecific than in non-conspecific neighbourhoods. (In conspecific and non-conspecific neighbourhoods Lapwing:  $n = 22$ ,  $\bar{x} = 81.2$ ,  $SD = 9.4$  and  $n = 31$ ,  $\bar{x} = 70.1$ ,  $SD = 7.7$ ,  $t = 4.55$ ,  $p < 0.001$ ; Redshank:  $n = 23$ ,  $\bar{x} = 74.6$ ,  $SD = 8.7$  and  $n = 28$ ,  $\bar{x} = 64.4$ ,  $SD = 7.8$ ,  $t = 4.36$ ,  $p < 0.001$ ; Godwit:  $n = 15$ ,  $\bar{x} = 84.9$ ,  $SD = 6.9$  and  $n = 29$ ,  $\bar{x} = 80.1$ ,  $SD = 5.7$ ,  $t = 2.62$ ,  $p < 0.02$ .)

A breeding colony is generally defined as a place where birds nest in a relatively

small areas and where foraging occurs outside that area. Field applications of the concept of a colony is often difficult, because there is a continuum from solitary breeding to semicolonial and colonial nesting. If, however, co-operative or mutual interactions operate among the individuals they may be regarded as an integrated group (Coulson & Dixon 1979). Nevertheless Alexander (1974) and Koenig (1982) argue that while co-operation and mutual interaction may or may not occur among the colony members, competitive interactions are always evident.

We found a higher level of simultaneous activities in antipredator behaviour for birds which nested within 200 m of each other than for birds nesting further apart. In addition we recorded longer foraging distances for the parents which nested within 200 m of each other than for parents which nested further apart. We believe that our findings support our decision to consider a single or a mixed species colony as an aggregation of Lapwing, Redshank and Black-tailed Godwit nests separated by less than 200 m.

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## Összefoglalás

### Magányos és telepes fészkelés parti madaraknál

A bicic (*Vanellus vanellus*), a piros lábú cankó (*Tringa totanus*) és a nagy goda (*Limosa limosa*) szomszédos fészkeinek a távolságát, ragadozó ellenes viselkedését, és a táplálkozás során a fé-

szektől való eltávolodás nagyságát vizsgáltuk a Kiskunsági Nemzeti Park egy 380 ha-os vizes réti élőhelyén. Amikor a szomszédos fészkek távolsága 200 m-nél nagyobb volt, a szimultán ragadozó ellenes viselkedés ritka volt. Azonos fajhoz tartozó szomszédos fészkek esetében a szimultán ragadozóellenes viselkedés gyakoribb volt, mint a más fajhoz tartozóknál. A szülők gyakrabban táplálkoztak 200 m-nél távolabb, ha 200 m-nél közelebb fészkeltek egymáshoz, és általában 200 m-nél közelebb táplálkoztak, ha fészkeik 200 m-nél távolabb voltak. Ha a 200 m-n belüli legközelebbi szomszédok azonos fajhoz tartoztak, nagyobb volt a távolabb táplálkozás aránya, mint amikor más fajhoz tartozók fészkeltek egymás közelében. Szerintünk a bicic, a piros lábú cankó és a nagy goda fészkeinek csoportosulása 200 m-n belül egy-, illetve többfajú kolóniának tekinthető.

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# Spatial distribution of migrating Sedge Warblers (*Acrocephalus schoenobaenus*) in a Hungarian reed bed

J. Gyurácz and L. Bank

Gyurácz, J. and Bank, L. 1997. Spatial distribution of migrating Sedge Warblers (*Acrocephalus schoenobaenus*) in a Hungarian reed bed. – *Ornis Hung.* 7:43-47.

Data from a ringing program in a south Hungarian reed swamp were used to analyse the horizontal and vertical distribution of juvenile and adult Sedge Warblers during autumn migration. The horizontal spatial pattern of the juvenile birds showed clumped distribution in the reed bed. 492 (35%) juvenile and 59 (20%) adult Sedge Warblers were trapped in three nets. The horizontal distribution of adults was spaced evenly. The vertical spatial distribution of the age classes were significantly clumped. Investigate of food dispersion in a reed bed, vegetation structure and interspecific competition among reed warblers are required for complete comprehension of spatial pattern of migrating Sedge Warblers.



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## 1. Introduction

The Sedge Warbler is a very common breeding bird in marshlands and swamps of Europe (Cramp 1992). This species prefers reed beds as a stopover habitat during autumn migration (Gyurácz & Csörgő 1994) and spends the winter in Africa, south of the Sahara (Moreau 1972, Dowsett *et al.* 1988).

Habitat selection is one of the most important mechanism in the ecological segregation of bird populations. The spatial distribution of passerine species during the breeding and the wintering seasons has been studied in more detailed than during migration (Baccetti 1985, Pambour 1990).

Food availability and vegetation structure are known to influence the spatial distribution of most breeding and migrating birds (Pearson *et al.* 1979, Haland & Burkjeland 1982, Shennan 1985, Ormerod *et al.* 1991, Morel & Morel 1992, Pearson & Lack 1992, Moskát *et al.* 1993). Competition has always been regarded as an important factor in habitat selection of sympatric warblers (Rolando & Polestrini 1989, Hoi *et al.* 1991, Leisler 1992, Catchpole 1973).

In this study, data from a longterm ringing program in a south Hungarian reed swamp were used to analyse the horizontal and vertical distribution of juvenile and adult Sedge Warblers during postbreeding migration.

## 2. Study area and methods

The study was carried at Sumony Bird Observatory (Lake Sumony: 45°58' N, 17°56' E). The area is a fish pond surrounding with a large reed bed (Fig. 1). *Scirpeto-Phragmitetum* with *Typha* is the dominant plant association. The data were collected during autumn migration, from 1989 to 1993 (30 July - 10 September, 1989; 28 July - 09 September, 1990; 27 July - 08 September, 1991; 26 July - 13 September, 1992; 17 July - 19 September, 1993). The birds were caught in reed bed, using 18 mist-nets 12 m in length, with four 50 cm high shelves. There was 20-25 cm between the ground and the first shelf. Four line of mist-nets (6 + 4 + 4 + 4 mist-nets) were on a raised path 20-30 cm above the water level in homogenous area of

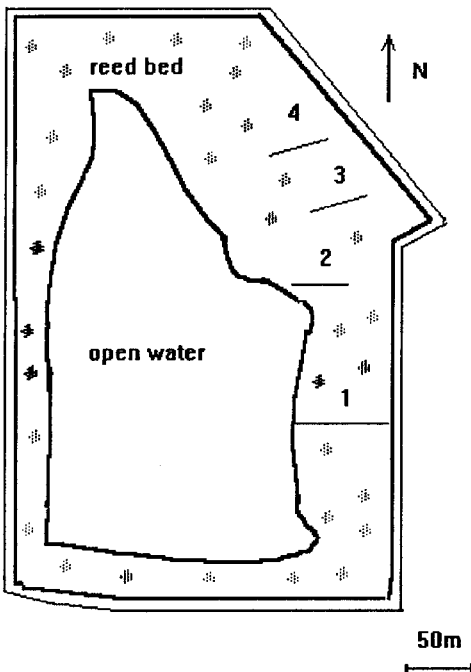


Fig. 1. Location of the mist-nets (line 1: 6 nets, lines 2-4: 4-4 nets) at Lake Sumony.

*Phragmitetum*. The net and shelf number were recorded for each bird trapped. Birds were ringed, weighed and measured.

The index of clumping ( $I$ ) was used to analyse the spatial distribution of birds (Southwood 1978):  $I = s^2/D$ , where  $s^2$  = variance and  $D$  = mean number of trapped birds by net. The distribution can be random ( $I = 1$ ), spaced ( $I < 1$ ) or clumped ( $I > 1$ ). We used the  $\chi^2$  test to estimate the relationship between number of birds caught and location of capture (net number). The statistical analyses were performed with the Statgraf and Windows Excel 5.0 softwares.

## 3. Results

We trapped 1398 juvenile and 290 adult Sedge Warblers during the five years of the study. Four hundred and ninety-two (35%) juvenile Sedge Warblers were caught in the three external nets of the first line of mist-nets (Fig. 1), which represents only 16% of the nets. These 3 nets are standing in the 30-40 m wide littoral edge of the reed bed. The number of juveniles caught decreased significantly from open water to shore in the 1st line of mist-nets ( $r = 0.95$ ,  $t = 6.2$ , d.f. = 5,  $p < 0.05$ ) (Fig. 2). The horizontal pattern of juveniles was spatially clumped in the reed bed ( $I = 24$ ,  $\chi^2 = 413.39$ , d.f. = 17,  $p < 0.01$ ). Fifty nine (20%) adult Sedge Warblers were trapped in the same three nets standing in the edge of reed bed near open water. There was no significant trend in the number of adult birds along the shore - open water gradient ( $r = 0.34$ ,  $t = 0.73$ , d.f. = 5,  $p > 0.05$ ) (Fig. 2). Adult birds' distribution was random in the reed bed ( $I = 0.89$ ,  $\chi^2 = 15.39$ , d.f. = 17,  $p > 0.05$ ).

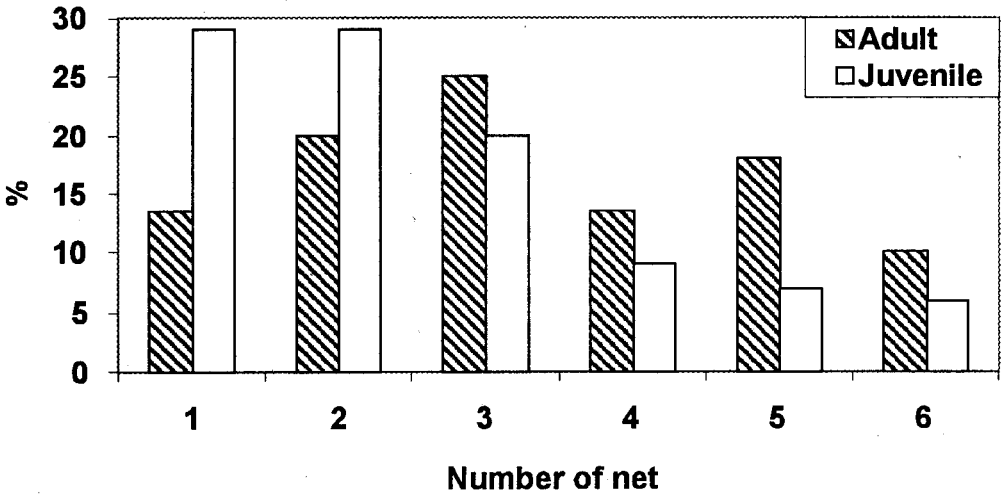


Fig. 2. Capture rate of Sedge Warblers from open water (net 1) to shore (net 6) at the first line of mist-nets.

Fivehundred and fifteen (36%) juvenile and 113 (38%) adult Sedge Warblers were caught in the third net shelf, about 2,5 m above the ground. The vertical distribution of the birds was significantly clumped for both age classes (juvenile:  $I = 25$ ,  $\chi^2 = 75.12$ , d.f. = 3,  $p < 0.01$ ; adult:  $I = 10.06$ ,  $\chi^2 = 30.41$ , d.f. = 3,  $p < 0.01$ ) (Fig. 3).

#### 4. Discussion

Our results showed that juvenile Sedge Warblers preferred the edge of the reed bed near open water during autumn migration. According to Pambour (1990) most individuals of Sedge Warblers and other passerine species occurred near the lake

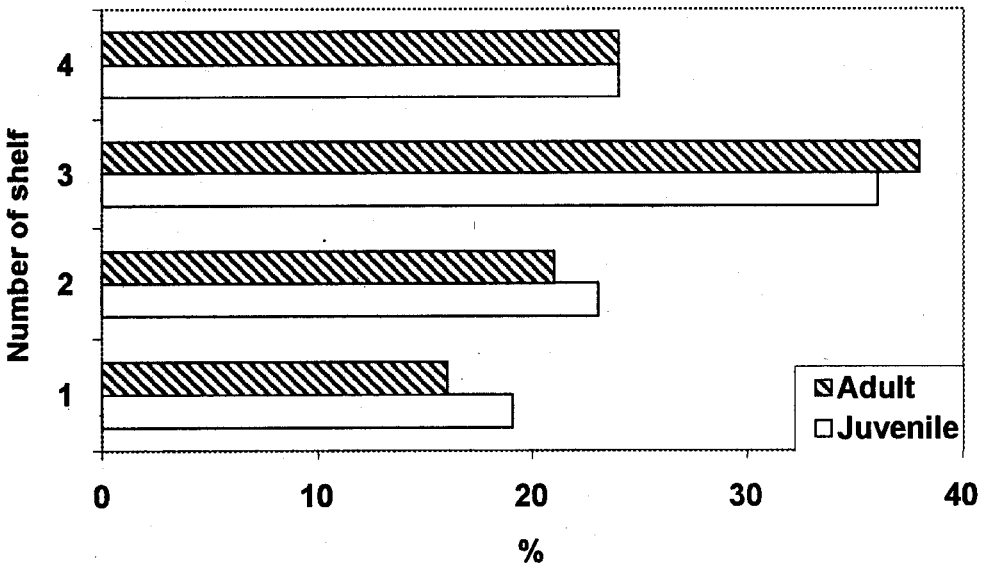


Fig. 3. Capture rate of Sedge Warblers from the lower to the upper net shelf.

shore during the postbreeding migration period in a reed bed of the Camargue, France. Migrating adult birds, however, selected the stopover habitat uniformly. Differences in spatial pattern by age classes may reflect their different feeding sites, techniques and social status. Probably food abundance is higher and prey diversity is greater in the zone near open water than at the littoral edge of the reed bed. The reed aphids, other insects and spiders occur in large number near open water (Vásárhelyi 1995). It could influence the spatial distribution of juveniles in particular, because they are inexperienced and less efficient than adults in gathering food (Alatalo *et al.* 1983, Koskimies & Saurola 1985). Considering that the migration of adult birds started and ended earlier than that of juveniles at Sumony (Gyurácz & Bank 1995), the different horizontal distribution of adults and juveniles could result from temporal variations in spatial distribution of food resources. The inter- and intraspecific territoriality may also play an important role in habitat selection by Sedge Warblers during the breeding, stopovering and wintering seasons (Moreau 1972, Aidley & Wilkinson 1986, Ormerod 1990, Hoi *et al.* 1991). The dominant adult birds divide the reed bed approximately in an equal proportion.

The vertical distribution of juvenile and adult birds did not differ significantly from each other, birds preferred the third shelf. This result from Sumony is similar to other studies (Berthold & Schlenker 1975, Pambour 1990). According to niche breadth and comorphological investigations, the Sedge Warbler is the most specialist among reed warblers, as a consequence of its strong specialization in vertical distribution (Catchpole 1973, Bibby & Green 1983, Rolando & Palestini 1989).

Investigate of food dispersion, vegetation structure and interspecific competition among reed warblers within the reed habitat is required for a better understanding of the spatial distribution of Sedge Warblers during migration.

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## Összefoglalás

### A vonuló foltos nádiposzták (*Acrocephalus schoenobaenus*) térbeli eloszlása egy dél-magyarországi nádszegélyben

Az őszi vonulási időszakban befogott 1398 fiatal és 290 öreg foltos nádiposzták horizontális és vertikális eloszlását vizsgáltuk. Vizsgálatainkat 1989 és 1993 között végeztük a Sumonyi-halastavak nádszegélyében. 492 (35%) fiatal példányt a vízhez közeli, vízben álló három hálósával (hálók 16%-a) fogtuk be. Ugyanezzel a három hálósával csak 59 (20%) öreg madarat fogtunk. A fiatalok horizontális eloszlása aggregált, míg az öregeké nem. A korosztályok vertikális eloszlásában szignifikáns különbséget nem találtunk, az alulról számított harmadik hálózsebben volt a legtöbb egyed megfogva. Eredményeink hasonlóak a vonuló foltos nádiposzták más európai nádasokban tapasztalt térbeli eloszlásához.

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# A population of diurnal raptors on Dravsko polje (NE Slovenia)

Milan Vogrin

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Between 1985 and 1996 quantitative data were collected about raptor populations on Dravsko polje (46°25'N, 15°45'E) in Slovenia. A total of 8 (including 2 possible breeders) species were reported to occur in the area under study. The average bird density was 2.8 pairs/10 km<sup>2</sup>. The greater part of the breeding community is comprised of two species *i.e.* Kestrel *Falco tinnunculus* and Common Buzzard *Buteo buteo*. Breeding density of the Common Buzzard is up to 0.66 pair/10 km<sup>2</sup> and density of the Kestrel up to 1.43 pair/10 km<sup>2</sup>. The breeding population of Kestrel decreased steadily during 12 years of study, from about 30 nests at the start (1985-1986) to about 15 at the end of the study (1995-1996). The changes are significant. Breeding communities were also analysed in relation to the migratory habits of birds of prey. The density of the breeding community on Dravsko polje depended primarily on the density of resident raptors (average value: 2.2 pairs/km<sup>2</sup>). The differences between numbers of pairs according to migratory habits is highly significant.

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## 1. Introduction

In Slovenia few analyses of breeding populations of raptors have been carried out on quantitative data (e.g. Polak 1993, Trontelj 1994). Geister (1995) attempted to estimate numbers of all the species which breed in Slovenia, but his extrapolation to such large area (20,256 km<sup>2</sup>) may lead to substantial errors. This paper attempts the quantitative estimation of the population of eight species of raptors breeding on Dravsko polje.

## 2. Study area and methods

This study was conducted on Dravsko polje alluvial plains (Drava field) (about

210 km<sup>2</sup>) in NE Slovenia between the river Drava and Mt. Pohorje at altitudes from 238 m to 270 m (46°25'N, 15°45'E). Dravsko polje is an intensive agriculture area. On Dravsko polje numerous man-made water bodies (fish ponds, reservoirs, gravel pits) and villages can be found. The area belongs to the sub-Pannonic phytogeographical area (Marinček 1987). The climate is Continental (mean annual rainfall = 1000 mm, mean temperature = 8°C) (see Furlan 1990 for details).

The habitats of Dravsko polje were classified into four categories: woodland (forests, scrubs, hedges) - about 18%, open area (fields, meadows) - about 68%, urban land (villages, farmhouses, airport) - about 12%, wetland (ponds, reservoirs, gravel pits) - about 2%.

Research began in 1985 and ended in 1996; it is based on more than 500 days of field work, spread over the entire year, with a peak activity of field work during spring and summer months.

Data were collected on the distribution of pairs, and the feeding habits and reproductive cycle of some species. The information was recorded on 1 : 25 000 scale maps as confirmed or probable breeding records following the classification of the EOAC method.

Possible breeding (presence of adult birds in suitable habitats during breeding periods) is not considered in the present paper, as it is not uncommon for some raptors to occur in the study area without attempting to breed (e.g. White-tailed Eagle *Haliaeetus albicilla*, Peregrine *Falco peregrinus*).

A total of 8 species were reported to occur in the area under study. In the total area of 210 km<sup>2</sup>, up to 66 pairs (possible breeders area excluded) of raptors breed, the average density being 2.8 pairs/10 km<sup>2</sup>. The bulk of the breeding community is comprised of two species, i.e. Kestrel and Common Buzzard.

Some resident species (Common Buzzard, Sparrowhawk *Accipiter nisus*, Goshawk *Accipiter gentilis*) show seasonal fluctuations in their numbers: all mentioned species are much commoner in winter (pers. obs.). Their breeding densities (Buzzard: up to 0.66 pair/10 km<sup>2</sup>; Sparrowhawk: up to 0.14 pair/10 km<sup>2</sup>; Goshawk: up to 0.38 pair/10 km<sup>2</sup>) are below the values given for other European localities for the same species (e.g. Anonimus 1989, Gemauf & Winkler 1991,

Tab. 1. Breeding parameters and migratory habits of population of eight species of raptors on Dravsko polje (NE Slovenia): ? - possible breeders, T - tropical migrant, S - resident species.

Species	No. of breeding pairs	Density (pair/10 km <sup>2</sup> )	Migratory habits
<i>Pernis apivorus</i>	6-8	0.29-0.38	T
<i>Circaetus gallicus</i>	1?	-	T
<i>Circus aeruginosus</i>	1?	-	T
<i>Accipiter gentilis</i>	6-8	0.29-0.38	S
<i>Accipiter nisus</i>	1-3	0.05-0.14	S
<i>Buteo buteo</i>	12-14	0.57-0.66	S
<i>Falco tinnunculus</i>	15-30	0.7-1.43	S
<i>Falco subbuteo</i>	2-3	0.1-0.14	T
Total (excluding possible breeders)	42-66	2.0-3.14	

Chi-square test were used for statistical comparison of data sets (Sokal & Rohlf 1995).

### 3. Results and discussion

The composition of the bird community on Dravsko polje is shown in Tab. 1.

Newton *et al.* 1991, Danko *et al.* 1994, Henrioux & Henrioux 1995, Teyrovsky 1995). Only Glutz Von Blotzheim *et al.* (1989) and Steiner (1992) give similar densities for the Goshawk and the Buzzard as were found for Dravsko polje (Tab. 2). Sparrowhawk can be detected only with difficulty in woodland, so their numbers may have been underestimated.

Tab. 2. A comparison of the results of quantitative studies made on Dravsko polje (NE Slovenia) with other areas > 50 km<sup>2</sup> in Central Europe.

Species	Density (pair/10 km <sup>2</sup> )	Study area	Source
<i>Pernis apivorus</i>	up to 3.2	Lorraine (France, 147 km <sup>2</sup> )	Cramp & Simmons 1980
	up to 0.64	District Boblingen (Germany, 440 km <sup>2</sup> )	Glutz Von Blotzheim <i>et al.</i> 1989
	0.39	District Stuttgart (Germany, 1825 km <sup>2</sup> )	Glutz Von Blotzheim <i>et al.</i> 1989
	up to 0.55	Slovak karst (Slovakia, 362 km <sup>2</sup> )	Uhrin 1992
	up to 0.32	Krivoklatsko area (Czech Republic, 630 km <sup>2</sup> )	Pojer 1992
	0.36	Between river Krems and Steyr (Austria, 112 km <sup>2</sup> )	Steiner 1992
	1.1	Zahorska nizina (Czech Republic, 126 km <sup>2</sup> )	Danko <i>et al.</i> 1994
	up to 0.6	Ljubljansko barje (Slovenia, 160 km <sup>2</sup> )	Trontelj 1994
	0.49	Swiss midland (Switzerland, 144 km <sup>2</sup> )	Henrioux & Henrioux 1995
	up to 0.3	Doupov Hills (Czech Republic, 600 km <sup>2</sup> )	Tejrovsky 1995
	up to 0.38	Dravsko polje (Slovenia, 210 km <sup>2</sup> )	this study
<i>Accipiter gentilis</i>	up to 0.09	District Peine (Germany, 343 km <sup>2</sup> )	Oelke 1981
	up to 0.12	Hamburg and vicinity (Germany, 2050 km <sup>2</sup> )	Glutz Von Blotzheim <i>et al.</i> 1989
	0.23	District Lobau (Germany, 400 km <sup>2</sup> )	Glutz Von Blotzheim <i>et al.</i> 1989
	0.5	Drava valley (Austria, 60 km <sup>2</sup> )	Gemauf & Winkler 1991
	0.49	Swiss midland (Switzerland, 144 km <sup>2</sup> )	Henrioux & Henrioux 1995
	up to 0.5	Doupov Hills (Czech Republic, 600 km <sup>2</sup> )	Tejrovsky 1995
	up to 0.38	Dravsko polje (Slovenia, 210 km <sup>2</sup> )	this study
<i>Accipiter nisus</i>	0.08-1.1	Flachen (Germany, 137 km <sup>2</sup> )	Glutz Von Blotzheim <i>et al.</i> 1989
	1.16	Between river Krems and Steyr (Austria, 112 km <sup>2</sup> )	Steiner 1992
	2.62	Territory of Prague (Czech Republic, 495 km <sup>2</sup> )	Danko <i>et al.</i> 1994
	0.69	Swiss midland (Switzerland, 144 km <sup>2</sup> )	Henrioux & Henrioux 1995
	up to 0.5	Doupov Hills (Czech Republic, 600 km <sup>2</sup> )	Tejrovsky 1995
	up to 0.14	Dravsko polje (Slovenia, 210 km <sup>2</sup> )	this study
	<i>Buteo buteo</i>	up to 2.46	District Peine (Germany, 354 km <sup>2</sup> )
2.7		Drava valley (Austria, 60 km <sup>2</sup> )	Gemauf & Winkler 1991
0.8		Between river Krems and Steyr (Austria, 112 km <sup>2</sup> )	Steiner 1992
2.5		Swiss midland (Switzerland, 144 km <sup>2</sup> )	Henrioux & Henrioux 1995
up to 0.66		Dravsko polje (Slovenia, 210 km <sup>2</sup> )	this study
<i>Falco tinnunculus</i>	1	Schleswig-Holstein (Germany, 200 km <sup>2</sup> )	Ziesemer 1973
	up to 0.86	District Peine (Germany, 336 km <sup>2</sup> )	Oelke 1981
	up to 1.4	Oberhausen (Germany, 78 km <sup>2</sup> )	Glutz Von Blotzheim <i>et al.</i> 1989
	1	Drava valley (Austria, 60 km <sup>2</sup> )	Gemauf & Winkler 1991
	up to 1.7	Germany, 100 km <sup>2</sup>	Kostrzeva 1991
	0.27	Austria, 112 km <sup>2</sup>	Steiner 1992
	2.7	Swiss midland (Switzerland, 144 km <sup>2</sup> )	Henrioux & Henrioux 1995
	up to 1.43	Dravsko polje (Slovenia, 210 km <sup>2</sup> )	this study
<i>Falco subbuteo</i>	up to 0.06	District Peine (Germany, 354 km <sup>2</sup> )	Oelke 1981
	0.27	Between river Krems and Steyr (Austria, 112 km <sup>2</sup> )	Steiner 1992
	up to 0.17	Doupov Hills (Czech Republic, 600 km <sup>2</sup> )	Tejrovsky 1995
	up to 0.14	Dravsko polje (Slovenia, 210 km <sup>2</sup> )	this study

The Kestrel on Dravsko polje usually nest in old nests of Corvids (i.e. *Pica pica*, *Corvus corone cornix*), in old building and on transmission-line pylons (Janžekovič & Šorgo 1995, pers. obs.). It was found

throughout the study area, showing a preference for open area with small woodlands. Its breeding density was similar to the values given by other authors (e.g. Ziesemer 1973, Glutz Von Blotzheim *et*

al. 1989, Gemauf & Winkler 1991, Kostrzewa 1991) and much higher than those given by Oelke (1981) and Steiner (1992). The breeding population decreased steadily during 12 years of study, from about 30 nests at the start (1985-1986) to about 15 at the end of the study (1995-1996). The changes between years are significant (Chi-square test,  $\chi^2=5.0$ ,  $p < 0.05$ ). This decline is thought to be associated with the use of pesticides, high predation rate by small mammalian predators, competition with Corvids for nest sites and a consequent reduction in the area of suitable nesting and foraging habitat.

Density of the Honey Buzzard *Pernis apivorus* was similar to the values given for Germany, Czech republic, Slovakia and Austria (Tab. 2) and much lower than the density found in Lorraine, France (Cramp & Simmons 1980), in Stuttgart, Germany and other towns (Glutz von Blotzheim *et al.* 1989) and on Ljubljansko barje, Slovenia (Trontelj 1994) (Tab. 2). According to Cramp & Simmons (1980), high breeding density is presumably correlated with high density of Honey Buzzard's main food (wasps).

The density of the Hobby *Falco subbuteo* on Dravsko polje is calculated as 0.14 pairs/10 km<sup>2</sup>. Because of its breeding biology, which makes it hard to find during the breeding cycle, numbers of this species are underestimated. Its breeding density was similar to the values obtained in Norway (Steen 1994) and in the Czech republic (Tejrovsky 1995) and lower than the values obtained by Steiner (1992) and Henrioux & Henrioux (1995) (Tab. 2).

The density of the breeding community on Dravsko polje depended primarily on the density of resident raptors (average

value: 2.2 pairs/10 km<sup>2</sup>). The differences between numbers of pairs according to migratory habits (Tab. 1) is highly significant (Chi-square test,  $\chi^2=29.3$ ,  $p < 0.0001$ ).

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## Összefoglalás

### Nappali ragadozómadarak populációi Dravsko pole-n (ÉK Szlovénia)

Kvantitatív felmérést végeztünk a Dravsko polje (46°25'N, 15°45'E) (ÉK Szlovénia) ragadozómadár állományain 1985-1996 között. A vizsgált területen 8 fajt mutattunk ki, köztük kettő költése bizonytalan. Az átlagos ragadozómadár sűrűség 2,8 pár/10 km<sup>2</sup> volt. A két leggyakoribb faj a vörös vércse (*Falco tinnunculus*) és az egerész ölyv (*Buteo buteo*) volt. Az egerész ölyv sűrűsége 0,66 pár/10 km<sup>2</sup>-t is elérte, a vörös vércsée pedig az 1,43 pár/10 km<sup>2</sup>-t. A vörös vércse állománya jelentősen csökkent a vizsgálati idő alatt, 30 fészekről 15-re. A Dravsko polje-i ragadozómadár állomány sűrűsége elsősorban a nem vonuló fajoktól függött, melyek össz-sűrűségének átlaga 2,2 pár/10 km<sup>2</sup> volt.

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