Breeding biology of the Starling *Sturnus vulgaris* in western Finland

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The breeding biology of the Starling was studied in Kauhava, western Finland (63°05'N, 23°06'E). Some data were also collected elsewhere in Kauhava and in the main village of Lapua. This paper is based upon 239 nesting records made over the years 1966—77.

The Starling population studied was much smaller in the 1970s than in the 1960s. This may be due to changes in agriculture and persecution in wintering areas. The median date of the first egg varied from 30 April to 8 May (the median for 12 years was 5 May). The number of eggs ranged from 2 to 8, averaging 5.12. The clutch size decreased linearly throughout the breeding season. Incubation usually took 12 days and the nestling period was 20 days. Losses during incubation were greater than during the nestling stage. The mean production was 3.6 juveniles from each nest started. Being a southern species, the Starling was found to be greatly affected by temperature, which, directly or indirectly, regulates the timing of breeding, the clutch size and breeding success.

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Introduction

The Starling *Sturnus vulgaris* is a southern species which did not spread to Scandinavia until the early 1800s (v. Haartman et al. 1963—72). It is a true cultural species, though the nesting sites may be situated several kilometres away from the inhabited areas where it feeds (e.g. Palmgren 1930, Tenovuo & Lemmetyinen 1970).

The breeding biology of the Starling has been much studied in Central Europe, the British Isles and North America (e.g. Kluijver 1933, Schneider 1952, 1957, 1960, 1972, Lack 1948, Dunnet 1955, Anderson 1961, Havlin & Folk 1961, Pikula & Folk 1970, Kessel 1953, 1957, Collins & De Vos 1966, Royall 1966, Crossner 1977, Luniak 1977). In Finland, information on the breeding of this species is scanty (e.g. v. Haartman 1969, Korpimäki 1969, 1975, Tenovuo & Lemmetyinen 1970, Alatalo 1975, Ojanen et al. 1978a).

The aim of the present study is to supplement our knowledge of the breeding biology of the Starling in Finland and to make some comparisons with the results obtained in Central Europe.

Material and methods

The data were collected in the province of Southern Ostrobothnia, western Finland. The main study area was in the village of Ruotsala in Kauhava commune (63°05′N, 23°06′E), where most nest-boxes were situated. In addition, breeding was investigated in the nearby village of Varpula and in some remote fields in Kauhava. In Lapua town Starlings were studied in the main village. All the nests in inhabited areas were in yards surrounded by fields.

During the first years of the study, the nest-boxes were inspected nearly every day. In later years the nests were observed at suitable intervals to determine the onset and end of egg-laying, size of the completed clutch, and number of young hatched and fledged.

The data were collected over the years 1966—77 and comprise observations on 239 nests. Of these, 129 are from the main area, 81 from other yards and 29 from remote fields. The number of nests was highest in 1968 and 1977 (42 and 43, respectively) and lowest in 1970 (7). The methods used to estimate breeding parameters were similar to those used by v. HAARTMAN (1969).

Results

The date of arrival and beginning of breeding. The onset of breeding in each year was taken as the date on which the first egg was laid in the main area. This date has been compared with the arrival of the first Starling in the area (Table 1).

The date of arrival ranged from 14 March in 1967 to 10 April in 1976, with a mean date of 25 March. The onset of egg-laying varied correspondingly from 26 April in 1968 to 5 May in 1970, the mean being 30 April. On average there was more than one month between the arrival of the first Starling and the first egg laid.

The date of arrival and the onset of egg-laying are marginally positively correlated ($r = 0.32$), though this correlation is not significant. Hence, it is not possible to forecast accurately the timing of breeding from the beginning of spring migration. This is because the species arrives in the area a month before the breeding season and during this period the weather can vary widely.

Size of the breeding population. In the main area the number of nest-boxes, the number of nests and the percentage of nest-boxes occupied were:

Year	Boxes	Nests	% occupied
1966	11	9	81
1967	17	11	65
1968	17	13	76
1969	19	16	84
1970	19	12	63
1971	19	14	74
1972	20	15	75
1973	20	13	65
1974	19	9	47
1975	24	13	54
1976	24	10	42
1977	24	12	50

The number of nest-boxes ranged from 11 to 24, while the Starling population varied from 9 to 16 pairs. The ratio of nests to nest-boxes was highest in 1969 (84 %), gradually decreasing after that. During the last years about half the nest-boxes were occupied.

Nest building and egg-laying. The male starts building the nest before the

TABLE 1. Dates of arrival of the first Starling (A) and beginning of breeding (B) in the main study area.

Year	A	B
1966	22 March	2 May
1967	14 March	1 May
1968	23 March	26 April
1969	5 April	30 April
1970	7 April	5 May
1971	28 March	30 April
1972	28 March	3 May
1973	23 March	29 April
1974	30 March	28 April
1975	26 March	30 April
1976	10 April	2 May
1977	24 March	2 May
Mean	25 March	30 April

female arrives, and after that both build together and the female finishes the work (WITHERBY et al. 1949). In the study area the building time was 3—10 days ($\bar{x}$ = 6.5, N = 27). In one case reported in Finland, the nest building took 5 days (v. HAARTMAN 1969).

Unpaired males frequently carry fresh green leaves into the nest-box (SCHNEIDER 1960). This phenomenon occurred every year in my study area. During the last years leaf carrying became more frequent, in parallel with the decrease of the breeding population.

Most Starlings laid the first egg in early May (Table 2). The date varied from 24 April to 5 May, averaging 1 May. The annual variation in the onset of breeding was small, however; in the 12 study years, the median date of the first egg varied by only 9 days (30 April through 8 May). In the total material, the median date of first egg was 5 May.

In 1967, 1968 and 1977, egg-laying was well synchronized in the population; in 1968 the Starlings laid their first eggs almost simultaneously (Fig. 1). This arises from the sociality of Starlings (SCHNEIDER 1960). Each year the start of egg-laying was preceded by a sharp increase in the daily mean temperature, occurring about 6 to 7 days earlier. In the yards (N = 54), the median date of the first egg was 3 days earlier than that in the remote fields (N = 17).

Late breeding is exceptional for the Starling (v. HAARTMAN 1969). In my data only 3 nests were started in June (N = 165). In the village of Varpula in Kauhava a brood of Starling was ringed as late as 17 July 1977, which indicates that breeding had started in mid-June.

Probable repeat nesting was observed in four cases. Eggs were laid in the same nest-box where a nest had been destroyed 7 to 11 days earlier. Nesting is usually not repeated if the nest is destroyed during the nestling period (v. HAARTMAN 1969).

The Starling lays an egg a day almost regularly (SCHNEIDER 1960). Dur-

TABLE 2. The start of laying for the first (A) and last female (B) in the Starling population studied and the median date of the first egg laid (M), i.e. the date when half the females had started egg-laying.

Year	A	M	B	N
1966	2 May	6 May	9 June	14
1967	1 May	5 May	19 May	21
1968	24 April	30 April	13 May	28
1969	30 April	3 May	4 June	14
1970	5 May	7 May	16 May	6
1971	30 April	7 May	14 May	10
1972	3 May	5 May	10 May	12
1973	29 April	2 May	(4 May)	4
1974	28 April	6 May	12 May	8
1975	30 April	4 May	23 May	17
1976	2 May	8 May	13 May	13
1977	2 May	4 May	14 May	18
Mean	1 May	5 May	18 May	14

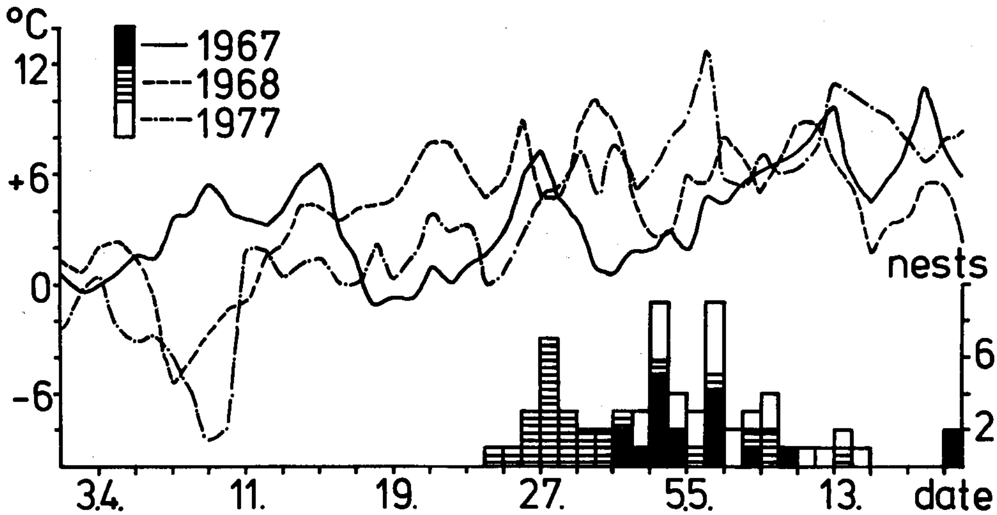

FIG. 1. The beginning of breeding in the Starling during the years 1967, 1968 and 1977 compared with the mean temperatures (°C) in April-May. The columns indicate the number of clutches started and the line indicates the mean temperature at the meteorological station in Ylistaro (ILMATIETEEN LAITOS 1967, 1968, 1977).

ing egg-laying, I inspected 73 nest-boxes daily, sometimes even twice a day. The laying periods are presented in Table 3.

The greater the clutch size, the more intensive is egg-laying. In addition, the intensity of laying is affected by the weather, since cold and rainy weather can interrupt the laying for 1 or even 2 days.

Clutch size. The size of completed clutches ranged from 2 to 8, averaging 5.12 (Table 4). The most common size classes were 5 and 6 eggs (40.4 and 33.3 %, respectively). Nests with 2 and 8 eggs occurred only once.

Clutch size varied considerably between years being highest in 1970 and lowest in 1967 (5.86 and 4.62 eggs, respectively). Some annual differences were statistically significant (t-test).

The clutch size was significantly correlated with the laying time (r = —0.86, $df = 29$, $P < 0.001$***). The regression equation for the clutch size y is

$$y = -0.06x + 7.61,$$

where x is the number of the day (1 = 1 April, ... 31 = 1 May, etc.). The clutch size decreased linearly, the decrease averaging 0.06 eggs per day towards the end of the breeding season (Table 5). The modal clutch size was

TABLE 3. Laying periods for Starling clutches of different sizes.

Number of eggs	Laying period (days) Mean	SD	N
3	3.4	1.1	5
4	4.2	0.8	12
5	5.2	0.5	23
6	6.0	0.2	26
7	6.7	0.8	6
8	(8.0)	(0.0)	1

TABLE 4. Annual variation in the clutch size of the Starling in Southern Ostrobothnia.

Year	Clutch size 2	3	4	5	6	7	8	$\bar{x} \pm SD$	N
1966	—	—	3	3	6	1	—	5.15±1.34	13
1967	—	4	4	9	4	—	—	4.62±1.02	21
1968	—	2	5	10	10	2	—	5.17±1.04	29
1969	—	2	3	3	4	1	—	4.92±1.26	13
1970	—	—	—	3	2	2	—	5.86±0.90	7
1971	—	—	1	4	6	—	—	5.45±0.69	11
1972	—	1	2	6	3	1	—	5.08±1.04	13
1973	—	1	2	3	4	—	—	5.00±1.05	10
1974	—	1	3	4	2	—	1	5.00±1.34	11
1975	—	—	1	9	7	1	—	5.44±0.70	18
1976	—	—	2	9	5	1	—	5.29±0.77	17
1977	1	5	1	18	13	—	—	4.97±1.08	38
Total	1	16	27	81	66	9	1	5.12±1.02	201

6 eggs for nests started in April, 5 eggs in the first half of May, 4 eggs in late May and 3 eggs in June. The mean clutch size was 5.6 eggs in April and 3.5 in June.

In 1971—77, the mean clutch size was 5.2 eggs ($N = 57$) in the yards and inhabited areas, and 4.6 ($N = 21$) in the remote fields. This difference is significant (t-test; $t = 2.77$, $df = 76$, $P < 0.01$**).

Incubation and hatching. Intensive incubation begins as soon as the clutch is completed (v. HAARTMAN 1969). Data pooled over the years give the following frequency distribution for the incubation period (days):

Incubation period	11	12	13	14	$\bar{x} \pm SD$	N
Nests	11	48	5	3	12.0±0.6	67

The incubation period thus lasted 11 to 14 days, the mode being 12 days.

The incubation period of the Great Tit *Parus major* shortens towards the end of the breeding season (v. HAARTMAN 1969). This phenomenon does not occur in the Starling (Table 6). The variation in the length of the incubation period is negligible and not significant.

The synchronization of hatching was observed in 60 nests. In one quarter of the cases, all the nestlings in a clutch hatched within 24 hours, and in half the interval between the hatching of the first and last chick was 24—48 hours. In 13 cases, the difference between the first and last hatching was 2 days and in one case 3 days.

If we exclude eggs that disappeared or were destroyed or deserted (these eggs are considered later), the mean hatching sucess for the Starling clutches was 87.0 %. The smallest proportion of unhatched eggs was found in clutches of 6 and 5 eggs (Table 7). Hatching is therefore most successful in clutches of the common size.

TABLE 5. Seasonal variation in the clutch size of the Starling in Southern Ostrobothnia.

Date of the first egg	Clutch size 2	3	4	5	6	7	8	$\bar{x} \pm$ SD	N
24—30 April	—	1	1	6	13	2	—	5.6±0.9	23
1—5 May	—	1	4	20	19	5	1	5.5±0.9	50
6—10 May	—	2	8	26	19	3	—	5.2±0.9	58
11—20 May	1	4	2	9	1	—	—	4.3±1.1	17
21—30 May	—	1	3	2	—	—	—	4.2±0.8	6
31 May — 9 June	—	2	2	—	—	—	—	3.5±0.6	4

Nestling period. The records on the nestling period (days) during the years 1966—77 were as follows:

Nestling period	17	18	19	20	21	22	23	$\bar{x}$	*N*
Nests	1	1	5	17	6	1	3	20.2	34

The nestling period thus varied from 17 to 23 days with a mean of 20.2 days.

The age distribution of nestlings (in days) that died in the nest was (M = median life of dead nestlings):

Age (days)	Young dying in the nest
1	18
2	9
3	6
4	6
5	4
6	4
7	3
8	2
9	3
10	5
11	4
12	1
14	1
15	1
16	1
17	3
20	1
M	4
N	72

Fifty-four per cent of nestling mortality occurred during the first 4 days after hatching. During the following 16 days mortality was low and decreased with increasing age of the nestlings.

Nesting success. Table 8 gives complete records for 145 nests during the years 1966—72 and 1974—77. The proportion of eggs lost averaged 17.5 %, and that of nestlings 16.0 %. The total losses were 30.7 %; hence 69.3 % of the eggs produced fledged young.

TABLE 6. Seasonal variation in the incubation period of the Starling.

Date of the first egg	Time of incubation (days) 11	12	13	14	$\bar{x}\pm$SD	*N*
24—30 April	2	6	3	1	12.3±0.9	12
1—5 May	4	21	—	1	11.9±0.6	26
6—10 May	2	16	1	1	12.1±0.6	20
11—31 May	2	2	1	—	11.8±0.9	5

Unhatched eggs were the most common reason for egg losses. Part of them were unfertilized, but more often the embryo died during incubation. Young dying in the nest caused the main part of losses during the nestling period. Mortality due to predation was not observed.

The mean number of young fledged in a clutch was 3.6. The productivity was highest in 1971 (5.2) and lowest in 1967 (2.6). Thus, the breeding success shows great annual variation.

LACK (1948) reported that 5-egg Starling clutches produced as many fledged young as larger clutches. Accordingly, LACK (1966) suggested that in birds in general the most common clutch size has the most viable offspring. In my data, the most productive clutches were those with 7, 6 and 5 eggs.

Discussion

Population changes. In my main study area, the breeding Starling population decreased since 1974. In two other yards in Kauhava, the trend was similar and even more marked. In north-

TABLE 7. Unhatched eggs in relation to clutch size in the Starling.

Clutch size	Unhatched eggs 0	1	2	3	4	5	6	Clutches	Eggs	Unhatched	%
2	1	—	—	—	—	—	—	1	2	0	0.0
3	2	3	1	—	—	—	—	6	18	5	27.8
4	10	10	1	—	1	—	—	22	88	16	18.2
5	30	21	6	—	1	—	—	58	290	37	12.8
6	33	13	1	2	1	—	1	51	306	31	10.6
7	3	5	—	2	—	—	—	10	70	11	15.7
8	—	—	1	—	—	—	—	1	8	2	25.0
Total	79	52	10	4	3	0	1	149	782	102	13.0

ern Finland (64°—65°N), observations made on seven different populations from the early 1960s onwards show that a strong decrease has taken place in recent years (ALATALO 1975, HIRVELÄ 1977, OJANEN et al. 1978b). At Lemsjöholm (60°30′N, 21°27′E), SW Finland, the number of Starling nests in 29—47 nest-boxes has decreased catastrophically, from 15—35 during the years 1962—75 to 2—6 in 1976—78 (v. HAARTMAN 1978a, b). In Salo (60°21′N, 23°06′E), the trend has been similar (v. KNORRING 1978). According to these records, the breeding populations of Starlings started to decrease in Finland in the 1970s. Possible reasons for this must be looked for either

TABLE 8. Losses of eggs and nestlings, and nesting success in Kauhava.

	1966	1967	1968	1969	1970	1971	1972	1974	1975	1976	1977	Total
No. of nests examined	10	16	22	11	6	10	12	10	14	12	22	145
Total of eggs laid	53	74	117	55	36	55	62	47	74	64	113	750
Unhatched	6	12	15	5	6	2	4	4	5	8	7	74
Disappeared	1	6	5	0	0	0	0	0	12	5	6	35
Broken in nest	0	0	0	0	5	0	0	1	0	0	0	6
Deserted	0	3	5	8	0	0	0	0	0	0	0	16
Total of eggs lost	7	21	25	13	11	2	4	5	17	13	13	131
Percentage of eggs lost	13.2	28.4	21.4	23.6	30.6	3.6	6.5	10.6	23.0	20.3	11.5	17.5
Total of young hatched	46	53	92	42	25	53	58	42	57	51	100	619
Died in nest	7	11	22	8	1	1	5	8	4	6	26	99
Total of fledglings	39	42	70	34	24	52	53	34	53	45	74	520
Loss of whole brood	0	3	5	3	1	0	0	2	2	1	4	21
Total of nestlings lost	7	11	22	8	1	1	5	8	4	6	26	99
Nestlings lost (%)	13.2	14.8	18.8	14.6	2.7	1.9	8.6	19.0	7.0	11.8	26.0	16.0
Total loss percentage	26.4	43.2	40.2	38.2	33.3	5.5	14.5	27.7	28.4	29.6	34.5	30.7
Eggs per nest	5.3	4.6	5.3	5.0	6.0	5.5	5.2	4.7	5.3	5.3	5.1	5.2
Hatched young per nest	4.6	3.3	4.2	3.8	4.2	5.3	4.8	4.2	4.1	4.3	4.6	4.3
Fledglings per nest	3.3	2.6	3.2	3.1	4.0	5.2	4.8	3.4	3.8	3.8	3.4	3.6

in the breeding area or in the wintering area in Western Europe.

Changes in Finnish agriculture have obviously affected the environment of the Starling. DUNNET (1955) reported that Starlings do not forage in high grass. Accordingly, the recent abandonment of fields in Finland has reduced their feeding areas. The decrease of cattle grazing and the increase of land under crops has had the same effect; in addition, the latter development has increased the use of herbicides. Unsuitable weather cannot be the reason for the decline, because the nesting success did not decrease in the 1970s.

In the wintering area in Western Europe, the Starling has been persecuted because it causes damage in gardens and fruit plantations (SCHNEIDER 1960). This may be an additional reason for the decline in its breeding populations.

Timing of breeding. According to the Finnish nest-card material, most Starlings start breeding on 1—5 May in southern Finland (60°—62°N) and on 6—10 May in central Finland (62° —64°N) (v. HAARTMAN 1969). In southern Finland the proportion of clutches initiated in April was 16.5 %, while from central Finland no records of egg-laying in April are known. In my area, no less than 18.5 % of the clutches were laid in April, and breeding most often started in early May. Suitable weather conditions may be the reason for this early breeding, because in Southern Ostrobothnia the temperature is higher and there is generally less snow than elsewhere in central Finland. The Starling also arrives early in the area (LEHTORANTA 1952). In northern Finland (north of 64°N), breeding usually starts on 11—15 May and there are only four known cases of egg-laying in late April — early May (v. HAARTMAN 1969, ALATALO 1975.

I investigated the influence of temperature on the onset of breeding in the Starling by calculating the correlation between the median date for the start of egg-laying and the mean temperature of 5-day periods (ILMATIETEEN LAITOS 1966—77) during the years 1966—77. The mean temperature for the period from 21 April to 5 May had the greatest influence on the timing of breeding (r = —0.74, df = 10, $P<0.01$**). If the period for which the mean temperature is calculated is shifted towards early April or late May, the correlation decreases.

A rapid increase in temperature in late April thus stimulates the egg-laying of the Starling, whereas a warm period in mid-April has no effect (see Fig. 1). In the male Starling, the final development of the gonads is regulated by daylength (BURGER 1949, 1953). Another factor influencing the growth of the gonads is the weather (BURGER 1948, BULLOUGH 1942), and this is probably the main reason for the observed annual variations of up to 1 week in the timing of breeding in my study area (see KESSEL 1957). The period of about 1 week elapsing between the temperature rise and the start of egg-laying is the time needed for the development of an egg (SEEL 1968).

Clutch size. The clutch size of the Starling varies with the season, year and region. According to my data and the observations of v. HAARTMAN (1969) and ALATALO (1975), the Starling is one of the species whose clutch size decreases linearly through the breeding season (see KLOMP 1970). The clutch size is greater near houses than in remote fields because breeding starts about 3 days later in the fields. Nest-boxes near houses are occupied before those in fields (v. HAARTMAN et al. 1963—1972).

The annual variation in clutch size is not due to differences in the timing of breeding, as clutch size does not correlate with the onset of egg-laying. On the other hand, clutch size is affected by the temperature during egg-laying (Table 9). The higher the temperature during this period, the greater the clutch size ($r = 0.78$, $df = 10$, $P<0.01$**). If the weather is bad, the female presumably has difficulties in finding food and the energy available for the developing eggs decreases. Egg-laying can be interrupted for one or even two days during cold weather. The temperature during egg-laying also affects clutch size in the Reed Bunting *Emberiza schoeniclus* (HAUKIOJA 1970).

In most birds clutch size increases towards the north (e.g. CODY 1966, LACK 1966, 1968). If the results from the SW archipelago are excluded, the clutch size of the Starling in Finland increases markedly with increasing latitude (Table 10). In the archipelago, exceptional ecological factors may be responsible for a higher clutch size than on the mainland, since TENOVUO & LEMMETYINEN (1970) found a larger clutch size on islands near the open sea than in the vicinity of the coastline.

TABLE 9. Mean daily temperatures (°C) in Ylistaro for the period extending from 5 days before to 5 days after the mean laying date, and the mean clutch sizes of the Starling in 1966—77.

Year	Period	°C	Clutch size
1966	1—10 May	4.8	5.2
1967	30 April—9 May	3.0	4.6
1968	25 April—4 May	6.1	5.2
1969	28 April—7 May	4.9	4.9
1970	2—11 May	8.3	5.9
1971	2—11 May	7.9	5.5
1972	30 April—9 May	7.2	5.1
1973	27 April—6 May	4.8	5.0
1974	1—10 May	3.1	5.0
1975	29 April—8 May	8.7	5.4
1976	3—12 May	7.9	5.3
1977	29 April—8 May	7.0	5.0

The regional trend in the clutch size of the Starling is not linear for the whole of Europe (Table 10). However, in North America the clutch size increases with increasing latitude (ROYALL 1966, KESSEL 1957, COLLINS & DE VOS 1966). The general regional trend may be masked by temporal and

TABLE 10. Clutch size of the Starling in different areas of Europe.

Area	$\bar{x}$	N	Source
N Ostrobothnia (65°—66°N)	5.27	78	OJANEN et al. 1978a
Oulu (65°N)	5.44	66	ALATALO 1975
S Ostrobothnia (63°N)	5.12	201	Present study
S Finland (60°—62°N)	4.94	149	v. HAARTMAN 1969
SW Finland (60°35′N)	5.29	58	TENOVUO & LEMMETYINEN 1970
Total Finland	5.15	552	
Holland (52°N)	5.14	1785	KLUIJVER 1933
Germany (51°N)	5.07	310	SCHNEIDER 1960
Czechoslovakia	4.69	132	PIKULA & FOLK 1970
Switzerland	5.15	246	SCHIFFERLI 1957
Scotland	4.92	335	DUNNET 1955, ANDERSON 1961
England	4.88	105	LACK 1948

TABLE 11. The average productivity of the Starling for some areas in Europe measured by the number of young fledged per clutch.

Area	$\bar{x}$	Source
Oulu	3.4	ALATALO 1975
S Ostrobothnia	3.6	present study
SW Finland	1.9	TENOVUO & LEMMETYINEN 1970
Holland	4.1	KLUIJVER 1933
Holland	2.5	WESTERTERP 1973
Germany	4.0	SCHNEIDER 1960
Czechoslovakia	4.0	HAVLIN & FOLK 1961
Switzerland	4.3	SCHIFFERLI 1957
England	3.5	LACK 1948

local variation depending on the food supply, habitat, age of the female and population density (LACK 1966).

There are many theories on the determination of clutch size in birds (e.g. LACK 1966, 1968, CODY 1966, SKUTCH 1967). Together with several other studies, this paper supports the conclusion that the clutch size of the Starling is dependent on the allocation of energy between breeding, avoidance of predators and the struggle with competitors (CODY 1966).

Nesting success. The number of young fledged in my study area averaged 3.6. In Oulu, during nearly the same period, the number was slightly smaller (ALATALO 1975), although the clutch size was clearly greater. In the SW archipelago of Finland productivity was extremely small due to adverse conditions (TENOVUO & LEMMETYINEN 1970). Comparison of these records with other data suggests that the Starling may be slightly less productive in Finland than in Continental Europe and the British Isles (Table 11).

COLLINS & DE VOS (1966) reported that hatching success is dependent on the timing of breeding. In their study area in Canada (44°N, 80°W) the hatching percentage was highest in the years when breeding was late. In my data, the timing of breeding and the temperature during incubation did not affect hatching success.

The young that die in the nest are usually those that hatch last. The same observation has been made earlier (e.g. DUNNET 1955, ANDERSON 1961). More than half of the nestling mortality occurred during the first 4 days. There is evidence that temperature affects mortality closely during the early nestling period (KORPIMÄKI 1977), when the thermoregulation of the nestlings is poorly developed (KENDEIGH & BALDWIN 1928).

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Selostus: **Kottaraisen pesimäbiologiasta Etelä-Pohjanmaalla**

Kottaraisen pesimäbiologiaa on tutkittu Kauhavalla Ruotsalan kylässä (63°05′N, 23°06′E) maalaistalon pihassa. Osa aineistosta on peräisin myös muualta Kauhavan alueelta sekä Lapuan kirkonkylästä. Pesimätietoja on vuosilta 1966—77 yhteensä 239 pesästä.

Kottaraiset ovat vähentyneet suuresti edellisen vuosikymmenen määristä Etelä- ja Pohjois-Pohjanmaalla sekä Lounais-Suomessa. Mahdollisiksi syiksi todetaan muutokset maataloudessa (herbisidien käytön lisääntyminen, peltojen paketointi, laiduntamisen väheneminen, viljanviljelyn lisääntyminen) ja/tai vaino talvehtimisalueilla.

Ensimmäiset kottaraiset saapuivat tutkimusalueelle useimmiten maaliskuun lopulla ($\bar{x}$ = 25.3.). Pesän rakentaminen kesti tavallisimmin 6—7 vrk. Puolet populaatiosta alkoi munia vuosina 1966—77 30.4.—8.5. ($\bar{x}$ = 5.5). Kevätmuuton alkamisesta ei voitu luotettavasti ennustaa pesinnän ajoittumista. Sen sijaan lämpötila nousi nopeasti noin viikkoa ennen kuin pääosa naaraista alkoi munia (kuva 1).

Munaluku vaihteli rajoissa 2—8, keskiarvo 5.12. Pesyekoko oli riippuvainen munintaajasta erittäin merkitsevästi väheten suoraviivaisesti pesimäkauden loppua kohti. Asutuksen piirissä munaluku oli selvästi suurempi kuin syrjäisillä pelloilla, joilla pesintä alkoi keskimäärin kolme päivää myöhemmin.

Haudonta kesti useimmiten 12 ja pesäpoikasaika 20 päivää. Munavaiheen tappiot (17.5 %) olivat suuremmat kuin pesäpoikasajan (16.0 %). Keskimääräinen poikastuotto oli 3.6 poikasta/pesä.

Valo säätelee kottaraisen pesinnän ajoittumista, mutta vuosien väliset erot ovat aiheutuneet huhtikuun lopun ja toukokuun alun lämpötilasta. Pesyekoon vuosittainen vaihtelu oli riippuvainen muninta-ajan lämpötiloista. Tämä selitettiin Codyn (1966) yleisellä teorialla munaluvun määräytymisestä.

Pesinnän onnistumisen kannalta kriittinen vaihe oli kuoriutumis- ja varhainen pesäpoikasaika, sillä ensimmäisen neljän elinpäivän aikana poikasten lämmönsäätely on vielä heikosti kehittynyt. Eteläisenä lajina kottaraisen todettiin olevan herkkä lämpötilan muutoksille. Ne vaikuttivat joko suoraan tai epäsuorasti pesinnän ajoittumiseen ja onnistumiseen sekä pesyekokoon.

Taulukoissa on esitetty seuraavat tiedot: 1. kevätmuuton ja pesinnän alkamisen riippuvuus toisistaan, 2. pesinnän ajoittuminen, 3. eri kokoisten pesyeiden munintanopeus, 4. munaluvun vuosittainen vaihtelu, 5. munaluvun vuodenaikainen vaihtelu, 6. haudonta-ajan vuodenaikainen vaihtelu, 7. kuoriutumatta jääneet munat suhteessa pesyekokoon, 8. pesinnän onnistuminen ja tuhoutumisen syyt, 9. muninta-ajan lämpötilan vaikutus munalukuun, 10. munalukuja ja 11. poikastuottoja eri puolilla Eurooppaa.

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