On the breeding ecology of the Starling *Sturnus vulgaris* in the archipelago of south-western Finland

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In an archipelago many ecological factors affecting the incidence of land birds change in a short distance because of the growing influence of the sea. Thus an archipelago may be considered as a natural experimental field, where the demands of a special bird species on its environment can be analysed better than in the more homogeneous surroundings of the mainland.

From among the land birds found in the archipelago of south-western Finland we have chosen the Starling *Sturnus vulgaris* as our research object, because we know this species has a strong tendency to spread out to the islands and also to occupy areas which are uncultivated by man and remain in their natural state (TENOVUO 1966). Further the Starling, as a hole-nesting bird, is a favourable species for study.

The study was commenced in spring, 1968, and comparative studies were made one year later in Naantali, a typical agricultural area. Although this study of the ecology of the Starling in the islands is meant to be of long duration, many valuable results have already been obtained in the two years of study up to now and therefore we consider the publishing of preliminary results to be justified.

Research area and methods

The islands of Kustavi were chosen for the main study area, because at Kustavi the islands dominated by pine soon change to alder islands and further to almost treeless outer islands (Fig. 1). In this district we located nest boxes as follows:

	Zone A	Zone B	Zone C
1968	26	16	—
1969	30	25	10

Nest boxes were placed on different types of islands and in widely varying places, both in trees and on the ground, so that they could be checked every 2—4 days during the breeding season. The nest boxes in zone C could be checked much less frequently, however.

Size of the population and selection of the habitat

We noticed even the first year that the majority of the nest boxes were inhabited regardless of their location. According to our observations the population of the study area before this was at most 5 pairs.

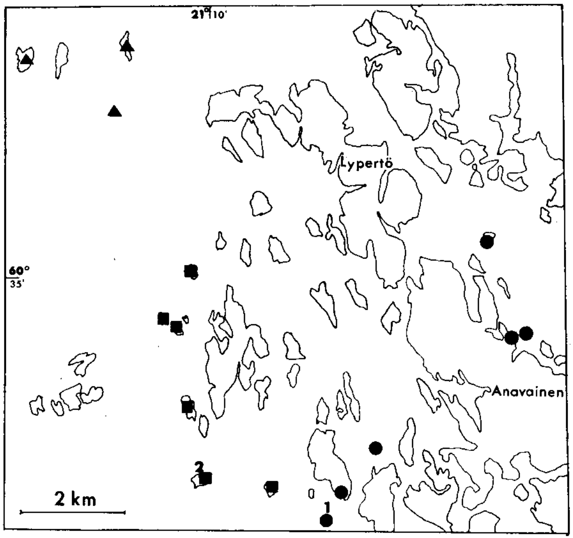

FIGURE 1. Study area in Kustavi parish, south-western archipelago of Finland. Circles = nest boxes of Starling on pine islands (zone A), squares = nest boxes on alder islands (zone B) and triangles = nest boxes on more or less treeless outer islets (zone C). 1 = Kuuskari, 2 = Sandskär. *(Tutkimusalue Kustavin pitäjässä. Ympyrät = mäntysaarilla (vyöhyke A), neliöt = leppäsaarilla (vyöhyke B) ja kolmiot = lähes puuttomilla ulkokareilla (vyöhyke C) sijaitsevat pöntöt. 1 = Kuuskari, 2 = Sandskär.)*

The following tabulation shows the percentages of nest boxes which were inhabited:

	Year 1968	1969
Nests with eggs	64.3 (27)	66.2 (43)
Completed nests, no eggs	26.2 (11)	21.5 (14)
Material for nests	9.5 (4)	9.2 (6)
Completely empty	— —	3.1 (2)
Total	100.0 (42)	100.0 (65)

Some slight differences between the zones were observed regarding the situation of boxes which the Starling selected for egg-laying but, contrary to our expectations, there was no distinct decrease towards the outer sea.

In 1969, when there were nest boxes in all three zones, the proportions of nests containing eggs, expressed as percentages of the total number of nest boxes, were as follows:

Zone	% of nests with eggs
A	60.0 (30)
B	76.0 (25)
C	60.0 (10)

The differences between the zones are not statistically significant ($\chi^2 = 1.77$, $f = 2$). Closer analysis shows, however, a certain preference in the selection of the habitat. The island of Sandskär in zone B was the most favoured island of whole area. In 1968 there were six nest boxes; of them five contained nests with eggs and one a completed nest. In 1969 all eight boxes on the island were inhabited. Sandskär, whose area is about 6.5 hectares, differs quite clearly in its physical features from the other islands of the area: the island is principally heath with groups of trees, mainly alder, but with some rowan and pine as well. It is comparable to a wooded steppe; the similarity to the Starling's original habitat is evident.

For comparison we can state that Kuuskari, situated a little nearer the mainland, was not so favoured; both years only two of its five nest boxes were inhabited. The vegetation of Kuuskari is mainly pine. In this connection we must point out that the feeding flights of the Sandskär birds were, at least in 1968, much longer than those of the Kuuskari birds. However, in 1969 small, completely treeless outer islets seemed to be favoured as well, since four nest boxes of six were inhabited.

As we also discovered 3—4 pairs nesting in natural crevices in 1969, we may consider the entire population of the study area to be about 50 pairs that year.

Periods of arrival and nest building

The first birds arrived in the area in late March. In zone A, where observations of the birds were most continuous, but not daily, the first bird appeared near the nest boxes on April 10th, 1968, and on April 6th, 1969. Having chosen their nesting sites, the birds stay by the nest box for only a short time in the beginning, mostly in the morning but sometimes in the afternoon, too. Most of the time they feed in villages in flocks.

Generally, trees are considered to be optimal sites for Starling nests. The height of the nest from the ground is not significant, however. In open country nest boxes on the ground are as favoured as those in trees. This was observed also in zone A where pine predominates. The numbers of nest boxes on the ground which were inhabited were as follows:

Year	No. nest boxes on the ground	No. inhabited
1968	5	3
1969	20	11

There is no significant difference in the choice of nest boxes located either in trees or on the ground.

The birds gather materials for nest building in the neighbourhood of the nest, sometimes under the very nesting tree; there is no certain proof of flights longer than 100 m for nest materials. It was observed that in wooded areas nests by the shore are mostly of *Phragmites,* but nests only about 50 m from the shore are made of less favoured materials like moss, lichen and the pine bark.

The Starling, however, is not very demanding in its choice of nest materials. The materials mentioned above are typical for the nests of zone A, while further out towards the sea — especially on small rocky islets — the nests are chiefly of feathers. It seems evident that feathers are the most favoured material, and broad-leaved species of grass (*Phragmites, Phalaris* etc.) next in popularity.

Fresh, green leaves form a special category of nest materials. Unmated males carry them to the nest to attract the female (SCHNEIDER 1960). In 1968 this was noticed in one nest and in 1969 in about seven nests. The bright green leaves of *Angelica* were the most favoured decoy materials, but also the leaves of *Hieracium* were used as well as the fresh green tops of moss and juniper. In one nest we found violet blossoms *Viola palustris.* The use of blossoms as a decoy has been observed elsewhere, too (SCHNEIDER 1960).

Egg-laying

Full clutches were laid in the study area as follows:

Year	Eggs 3	4	5	6	7	8	9	Mean±SE
1968	1	6	11	5	1	—	—	4.96±0.19
1969	—	6	10	15	1	1	1	5.53±0.19

The difference between the years is not statistically significant.

We did not get a chance to check whether the largest clutches (8 and 9 eggs) were nests of two females together. These nests were on bare islets: the clutch of 8 eggs on the navigation mark of an almost treeless, small islet in zone B and the clutch of 9 eggs on a pile of stones on a completely treeless rocky islet in zone C. In addition two other clutches of more than 6 eggs were in zones B and C. The average size of clutches in zone A on the one hand and in zones B and C on the other was:

Zone A	4.89±0.15	(27)
Zone B and C	5.65±0.21	(31)

The difference is significant ($F = 7.94$, $f_1 = 1$, $f_2 = 56$, $p < 0.05$). All these point to the fact that the clutch size in these years increased as the open sea was approached. This tendency was also revealed between the outer zones and mainland areas, for the calculations made in the vicinity of Naantali showed that the average clutch size in 1969 was 4.88 ($n = 16$); clutches of 6 eggs were very rare. In the same year the mean clutch size in the outer zones of Kustavi was 5.94 ($n = 18$). For the whole of Finland the clutch size of the Starling according to recorded nest cards is 5.00 ± 0.07 ($n = 192$) (v. HAARTMAN 1969), which is significantly less than in the outer zones of Kustavi in 1968—69 ($F = 11.95$, $p < 0.01$).

As v. HAARTMAN has implied, the clutch size decreases towards the end of the breeding season. In southern Finland (60°—62° N) the average size was only 4.42 ± 0.21 in clutches laid between May 11th and June 4th. A corresponding result is recorded at Kustavi, where the number of eggs was 4.47 ± 0.18 in those full clutches laid after the middle of May. If an exceptional clutch of 9 eggs is included, the average is 4.79 ± 0.37.

Here are some statistics about the date the clutch reached its full size. The dates of the start of egg-laying are estimated by considering that the bird daily lays one egg (SCHNEIDER 1960). The following shows the differences between the study years and zones A and B:

1968	zone	A	average	May 10th	(n = 8)
	„	B	„	May 12th	(n = 9)
1969	„	A	„	May 16th	(n = 13)
	„	B	„	May 14th	(n = 13)

In Naantali the corresponding date in 1969 was May 9th ($n = 14$). So at Kustavi there is no observable delay in beginning of nesting between the inner and outer zones. However, nesting is evidently a little later there than on the mainland; the difference, however, is not as great as with Hooded Crow *Corvus corone*. That the Hooded Crow nests on outer islands a couple of weeks later than on the mainland is obviously because of the availability of food (TENOVUO 1963). In 1969 the earliest Starling nest of the whole study area was in zone C. The young left it as early as June 7th just when a control of the nest was being made. According to v. HAARTMAN (1969) the Starling starts to lay eggs between May 1st and 10th in southern Finland (60°—62° N), which is also evidence of somewhat earlier nesting on the mainland than at Kustavi.

Egg-laying is very synchronous at Kustavi. On average more than half of the whole population had a full clutch within a margin of a couple of days. This was very obvious in zone B in 1969, when nearly 70 % of the population had a full clutch by May 13th—14th.

Late broods of Starlings are exceptional (v. HAARTMAN 1969). In 1968 there were no observations of egg-laying in June, but in 1969 egg-laying started after June 2nd in one nest. It might have been a repeat clutch as a deserted nest with one egg had been found earlier on the island. This was furthermore the only suggestion of a possible repeat clutch in the study area. In the next latest nest the last egg was laid on May 30th, 1969.

Incubation

Efficient incubation by the Starling begins when the clutch is full (v. HAARTMAN 1969). At Kustavi we noticed that females often stayed in their nests even earlier, 2—3 days before the last egg was laid. This, however, hardly indicates active incubation, for the young hatch at quite the same time, according to our observations generally within 24 hours.

In 29 nests incubation time was estimated to within a day's accuracy:

Estimated time of incubation	11	12	13	14 days
No. of nests	9	15	5	(2)

The length of incubation seems to be same as that obtained from recorded nest cards of the Starling (v. HAARTMAN 1969). In two cases incubation lasted at least 14 days, but breeding was late in both cases.

Breeding results

Hatching rate

Table 1 shows the number of lost eggs. In 1968 we noticed that in eight nests the number of young hatched was 1—2 less than the full clutches of the nests. These — altogether 10 eggs or newly hatched young — remained a puzzle, but it is probable that they were newly hatched young and had died immediately after hatching and were removed from the nest. In 1969 the corresponding difference between eggs and young was 23, which in our opinion can be explained mainly as the juvenile mortality rate.

When explaining the lost eggs we must primarily take into account disappearing eggs and deserted nests. It seems quite probable that the disappearance of eggs from the nests must be attributed entirely to the Wryneck *Jynx torquilla*. There are no direct observations of this, but e.g. in one case a Wryneck bred in the same nest box after the disappearance of the eggs of the Starling. In another case the whole nest had been thrown down, which is typical of the Wryneck. It is also possible that some desertions are due to the Wryneck: in a couple of cases eggs disappeared from the nests at the beginning of egg-laying and that probably caused the desertion.

TABLE 1. Egg losses of the Starling in Kustavi archipelago, south-western Finland in 1968 and 1969. *(Kottaraisen munatappiot Kustavin saaristossa vuosina 1968 ja 1969).*

	No. of eggs *Munien lukumäärä* 1968	1969
Unfertile *Hedelmöittymätön*	4	5
Dead embryo *Sikiö tuhoutunut*	1	2
Disappeared *Hävinnyt*	5	6
Broken in the nest *Rikkoutunut*	1	—
Deserted *Hylätty*	8	26
Total of lost eggs *Munatappiot yhteensä*	19	39
Total of eggs laid *Munittuja munia yht.*	122	186
Total percentage of eggs lost *Munatappiot %*	15.6	21.0

It is difficult to estimate if our control visits caused any desertion. Destroyed females might have been one reason for desertion. At least in 1968 a Merlin *Falco columbarius* bred in the middle of the study area. In 1968 there were two deserted nests, or 7.4 % and in 1969 six, or 13.6 %.

Number of young lost

In estimating the number of young lost (table 2) account must be taken of all those nests, in which we know the size of the final clutch and the fledged brood.

The calculation of the time at which the young were lost is approximate for practical reasons. It seems obvious, however, that most young die during the first days of their life. Mortality, however, is not as distinctly concentrated to the early juvenile period as with the Hooded Crow breeding in the archipelago, because most of the Crows' young died in the first four days of life (TENOVUO 1963).

TABLE 2. Losses of Starling nestlings in Kustavi archipelago, south-western Finland in 1968 and 1969. *(Kottaraisen poikastappiot Kustavin saaristossa vuosina 1968 ja 1969.)*

	1968	1969
No. of nests examined *Tutkittuja pesiä*	22	29
Total of hatched young *Kuoriutuneita poikasia*	103	153
Hatched young per nest *Kuoriutuneita poikasia pesyettä kohti*	4.68	5.28
Died in the nest *Pesään tuhoutuneita*	49	108
Total of fledglings *Lentopoikasia*	54	45
Fledglings per nest *Lentopoikasia pesyettä kohti*	2.45	1.55
Lost young per nest *Tuhoutuneita poikasia pesyettä kohti*	2.23	3.73
Totally destroyed broods (excluding predation) *Kokonaan tuhoutuneita pesyeitä*	4	9

According to estimates a remarkable proportion of Starling juveniles did not die until they were eight days old or more. In 1968 they formed about 22 % and in 1969 29 % of all dead young. The differences in juvenile mortality between the Crow and the Starling (a dead Crow brood is a rare exception) may depend on the fact that the Starling, as a more southern species, is less well adapted to the cool conditions of early summer in the archipelago.

In trying to explain the reasons for the high juvenile mortality rate attention must be paid to weather conditions: in both years the nights were very cold or the days rainy during the peak period of juvenile mortality. However, in 1969 mortality was distinctly higher than the first year ($\chi^2 = 12.80$, $f = 1$). Temperature and rain as such could not have caused the difference and therefore feeding conditions were probably not so favourable in 1969. The fatal influence of cold is probably as follows: cold forces one parent bird to concentrate on warming the young continuously. The other parent, which is engaged in seeking food, has not then enough time to get sufficient food for the whole brood. When ringing the young we have noticed that in most cases it is the smallest and the lightest that dies first.

In some cases the mortality of the young has varied greatly in nests situated near each other although the young have been of the same size. The reasons for this are unsolved, but the successful broods seem to have been those, where the parents have found a good feeding site or source of nourishment. Future studies may shed light on this.

The following shows the mortality of young in zones A and B:

Zone	Young lost	Young fledged	Total
A	58	50	108
B	91	46	137

The differences between the zones are not statistically significant ($\chi^2 = 3.58$, $f = 1$). The mortality of young in zone B is, however, on average, greater.

Furthermore, e.g. in 1968 the maximum was four surviving fledglings in four nests, two of which were in zone A and two in zone B. In the bad year of 1969 the maximum of four young was reached in only two nests, of which one was in zone A and the other in zone C! Around Naantali the survival of five fledglings was not unusual. Nor have losses of complete broods been observed in the vicinity of Naantali.

Our observations further indicate that there are individual differences in ways of warming the young as well as in the sharing of nesting duties between the parent birds. It is normal that the female stays in the nest at night when the young are small (SCHNEIDER 1960); according to our observations until the young are about two weeks old. In some exceptions we have also noticed warming of the young by day, e.g. on May 2nd, 1969, at 2 pm a female was warming its one-week-old nestlings, although the temperature was about + 12° C.

Earlier we have suggested that the parent birds in most cases remove the dead young from the nest more or less immediately, but not if all the young have been destroyed. Fairly often, however, a few dead young remain in the nest, but usually only one. These have nearly always been under the other young, sometimes being buried deep in the nest material. Parent birds seldom remove large nestlings that have died when more than 10 days of age. It is possible that young nestlings rotting in the nest have been fatal to the other young.

Fledging period

In some cases it has been possible to estimate the time the young remain in the nest to within a day's accuracy. In the following zones A and B have been treated separately:

	Days							
Zone	18	19	20	21	22	23	$\bar{x}$	n
A	—	—	3	4	4	4	21.6	15
B	1	—	3	2	1	2	20.9	9

There is no significant difference between the zones. In Naantali, however, there are no observations of fledging periods of more than 20 days.

Feeding ecology

The studies so far have emphasized breeding ecology. For practical reasons this has formed the basis of the study. In feeding ecology attention has been paid only to feeding sites and feeding flights. The conditions of the archipelago offer a good field for experiment in which to study these features. In the following we restrict ourselves to presenting only the most important observations.

The first year even, we found that reed belts occurring sporadically in this archipelago played a very important part in feeding areas. The majority of flights were directed to herbage from most of those nests where the parents' food flights could be recorded. The lengths of these flights varied from about 100 m to 1 km, in extreme cases up to 2 km. Flights of about 0.5 km were usual. Our observations so far have not shown a distinct correlation between the successful rearing of young and the length of the flight.

The favouring of reed growths does not mean a distinct dependence on them, for also low patches of juniper, waterside meadows, rocky shores, etc. served as feeding sites. In some cases we noticed that birds which quite regularly searched for food in certain reed growths sometimes flew to nearer waterside meadows and rocky shores as if to "test" the food supply. If it proved to be bad, the birds after a while continued their flight to herbage. We can consider the amount of food gathered in a certain time unit to be decisive for food seeking. Our few observations of the food of the Starling in the archipelago suggest that larger kinds of prey, such as dragonfly caterpillars, compensate for long flights, while on near-by shores the birds look for small Diptera, Coleoptera, etc. — We must, however, point out that future studies on feeding may partly change this picture, which is based on field observations. Further, there are signs that the importance of herbage varies in different years, possibly depending on humidity.

It is important to notice that during the breeding season the whole population seems to be entirely independent of cultivation. Although some of the nests are located no more than 0.5 km from the nearest cultivated land, there are no observations of flights directed to them.

After nesting the broods in many cases disappear from the neigbourhood of the nest and they seem to seek, at least partly, cultivated land.

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Selostus: **Kottaraisen pesimisekologiasta Lounais-Suomen saaristossa.**

Kirjoituksessa on käsitelty kottaraisen pesimisekologiaa saaristo-olosuhteissa muninnan alkamisesta poikasten pesästä lähtöön asti.

Tutkimukset on suoritettu Kustavin saaristossa vuosina 1968 ja 1969. Vuonna 1968 sijoitettiin eri tyyppisille saarille ja mahdollisimman vaihteleville paikoille, sekä puihin että maahan, yhteensä 42 pönttöä ja seuraavana vuonna pönttöjen lukumäärää lisättiin 65:een. Pöntöt sijoitettiin kolmeen vyöhykkeeseen saariston sisäosista ulkomerelle päin (kuva 1). Vertailuaineistoa on kerätty vuonna 1969 Naantalin ympäristöstä.

Kottaraiset asuttivat suurimman osan pöntöistä jo ensimmäisenä vuonna riippumatta niiden sijainnista. Tässä suhteessa ei voitu havaita eroja tutkimusalueen eri vyöhykkeiden välillä. Lisäksi maassa olleet pöntöt olivat yhtä suosittuja kuin puihin sijoitetut.

Kottaraiset keräsivät pesänrakennusmateriaalin yleensä pesän läheltä. Mäntyvaltaisessa vyöhykkeessä rannoilla sijaitsevien pesien suosituinta rakennusainesta olivat järviruo'n lehdet, ulkosaariston lintukareilla sen sijaan höyhenet.

Keskimääräinen munamäärä oli v. 1968 4.96±0.19 ja v. 1969 5.53±0.19. Ero ei ole tilastollisesti merkitsevä. Tutkimusvuosina munamäärä oli merkitsevästi pienempi alueen sisäosissa ja kasvoi ulkosaaristoon mentäessä. Kesällä 1969 keskimääräinen munamäärä oli Naantalissa selvästi pienempi kuin vastaavana vuonna Kustavissa.

Muninta alkoi v. 1969 Kustavissa keskimäärin muutamaa vuorokautta myöhemmin kuin Naantalissa. Eroja ei kuitenkaan ollut havaittavissa tutkimusalueen eri osien välillä.

Munatappiot (taulukko 1) olivat vuonna 1968 15.6 % ja 1969 21.0 %. Suurin osa munatappioista johtui hylkäämisestä tai munien pesästä katoamisesta. Ainakin jälkimmäisessä tapauksessa lienee käenpiialla merkittävä osuus tappioiden aiheuttajana.

Poikastappiot olivat hyvin suuret (taulukko 2). Lämpötilalla on huomattava merkitys kyseisiin tappioihin. Molempina vuosina poikaskuolleisuuden huippukausina yöt olivat kylmät. Lämpötilan ohella myös sateella ja ravinto-olosuhteilla lienee merkitystä poikasten tuhoutumiselle. Poikastappiot olivat alueen ulkovyöhykkeessä jossakin määrin suuremmat kuin sisäosissa, mutta ero ei kuitenkaan ole tilastollisesti merkitsevä. Neljä lentokykyiseksi kehittynyttä poikasta samasta pesyeestä on ollut maksimi tutkimusalueella. Vuonna 1968 tällaisia pesyeitä oli neljä kappaletta ja v. 1969 kaksi. Naantalin ympäristössä (v. 1969) viiden poikasen selviytyminen lentokykyisiksi ei ollut harvinaista.

Kustavissa kottaraisen poikaset viipyivät pesässä yhtä poikkeusta lukuunottamatta 20 vrk tai kauemmin. Sen sijaan Naantalissa ei todettu yhtään yli 20 vrk:n pesässäoloaikaa.

Ravintoekologiaa ei ole vielä selvitetty riittävästi. Tähänastisten havaintojen mukaan näyttävät kuitenkin järviruokokasvustot muodostavan tärkeän, joskaan ei ainoan saalistusalueen saariston kottaraisille.

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