Breeding performance of the Goosander *Mergus merganser* in the archipelago of the Gulf of Finland

Kalervo Eriksson & Juhana Niittylä

Eriksson, K. & Niittylä, J. 1985: *Breeding performance of the Goosander* Mergus merganser *in the archipelago of the Gulf of Finland.* — Ornis Fennica 62:153–157.

The clutch size of the Goosander *Mergus merganser* was studied in the archipelago of the Gulf of Finland, during the years 1973–81. The average clutch size was 9.93 ± 1.69 (SD; N=231). The annual averages did not differ significantly, but the females which started to nest earliest in the spring laid larger clutches than the late starters. Goosanders started to nest on the average on 27 April, but in an early spring the first eggs were found at the end of March. Altogether 75 females were recaptured at least once. The relative age of the female showed a positive correlation with clutch size, and a negative one with the laying date, which indicates that old females lay large clutches early in the season. The average weight of the incubating female was 1196 ± 73 grams (N=156), and there was a positive correlation between the average egg size and the weight of the female. The average hatching success was 91 % (N=199), clutches laid in the beginning of May being the most successful. The most experienced females produced the highest number of young per clutch.

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Introduction

Although clutch size is an important factor in the population dynamics of waterfowl, and clutch size data are fairly easy to gather, relatively little has been published concerning the clutch of the Goosander *Mergus merganser* in Finland. Grenquist (1953) and Hildén (1964) have presented studies on the breeding biology of the Goosander, but their material was restricted. v. Haartman et al. (1964) mention that the clutch of the Goosander in Finland usually varies between 7 and 12 eggs. Most other reference books state that the range is 7–13 or 8–12 eggs. The upper limits reported for the clutch of this species (produced by one female) range from 12 to 19 eggs.

The purpose of this paper is to present the main results of our nine-year study on the breeding biology of the Goosander in the western parts of the archipelago of the Gulf of Finland. Our main interest was the annual and seasonal variations of clutch size, but the relations of clutch size with egg size, the weight of the incubating female and the hatching success were also studied. The effects of the age of the female on the various breeding parameters are also discussed.

Study area and methods

The study area, Strömsö, is a section of the archipelago in the Gulf of Finland (59°55'N, 23°46'E) about 60 km west of Helsinki (Fig. 1). The total area is 17.8 km^2 and the land area is 3.4 km^2, consisting of 51 wooded islands and some rocky woodless islets. Strömsö is owned by the Finnish State Alcohol Company (Alko Ltd) and is used as a recreation area, but no notable disturbance is caused to nesting Goosanders.

The northern part of the study area can be described as inner archipelago, with more or less eutrophic bays rimmed with *Phragmites*, and water somewhat clouded with clay. The southern part of the study area is characterized by rocky-shored, pine-covered islands, with the outermost part of the area facing the open sea and containing rocky, woodless islets and clear water (for the zonation of the archipelago in the Gulf of Finland see Häyrén 1900).

The study was carried out in the years 1973–81. An average of 50 days per breeding season was spent in the study area. In order to establish the start of laying and the final number of eggs in the clutches, the nests were checked at least once during the laying period (except in 1973 and partly in 1974 because of our late arrival at Strömsö) and once during incubation — often when the incubating female was ringed or recaptured. Most of the nest-boxes available for the Goosanders were set up in winter 1972–73 by the company gamekeeper (Table 1). For the dimensions of an average Goosander nest-box, see. e.g. Grenquist (1953). The nest-boxes were erected on the shore, 5–15 m from the shoreline at a height of 1.5–4.0 m, with the flight hole facing the water. The locations of the nest-boxes are shown in Fig. 1.

The length and breadth of the eggs were measured with an accuracy of 0.1 mm with a sliding caliper. Incubating females were weighed with a 2.5 kg spring balance in connection with ringing or recapture, about one week before the eggs hatched. During this study we found that the incubating females should be caught in the latter half of the incubating period, preferably just before hatching, because the slightest disturbance during the laying period or the beginning of incubation causes the Goosanders to desert their nests. Catching the females on the nest can be done by hand or with a hoop net. To avoid desertion, the female should be carried away from the nest (e.g. in a canvas bag), so that she does not see the nest-box during handling. We also noticed that it is better to release her at the ringing site rather than take her back to the nest.

Criteria of a full clutch: a female incubating a clutch containing ⩽ 13 eggs, or a deserted nest which had been incubated (determined by floating the eggs). Criteria of a dump nest: (1) eggs appearing in the nest at a rate of more than one per day (28 % of the dump nests; the average time between two eggs was found to be about 36 hours); (2) eggs ap-

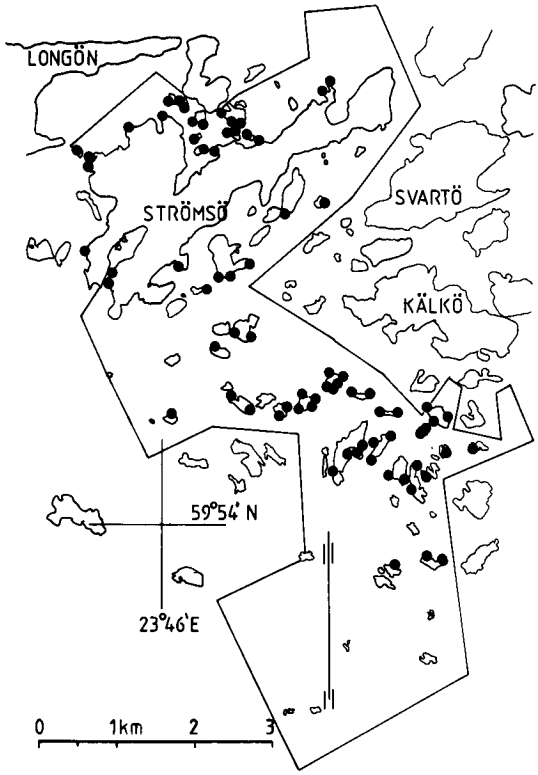

Fig. 1. The study area and the locations of the nest-boxes for Goosanders in the beginning of 1981.

pearing in the nest during incubation (9 %) or (3) the egg number ≥ 14 (54 % of the dump nests). The number of eggs alone is of course an arbitrary criterion for distinguishing between a full clutch laid by one female, and a dump nest laid by two or more females. If the first egg was laid after 20 May, the clutch was classified as a repeat nesting (or late) and omitted from the calculations unless otherwise indicated.

Expressions like 6.0 ± 4.1 depict the arithmetic mean ± the standard deviation.

Results

Our estimates of the population size of Goosanders in Strömsö in different years varied from 30 pairs in 1973 to 61 in 1980. Sixty Goosander clutches were deserted before incubation. These contained 6.0 ± 4.1 eggs. About 360 eggs, or 9.7 per cent of all eggs laid (3709), were lost because of desertion before incubation. In addition, 35 Goosander eggs were found in nests incubated by Goldeneye *Bucephala clangula* or in deserted nests which contained more Goldeneye eggs than Goosander eggs. There were 12 nests in which the final egg number was not determined, of which 10 were successfully incubated, one was destroyed by a carnivorous mammal and one had an unknown fate.

Breeding parameters. The incubated (i.e. full) clutches not classified as dump or repeat nestings totalled 231 and had an average clutch size of 9.93 ± 1.69 (Table 2). The mean for all incubated clutches, including dump and late nestings, is 10.57 ± 2.52 (N=310). Altogether 57 dump nests were found (i.e. 20 per cent of all clutches), and their average clutch size was 13.38 ± 2.30. The most common egg number in the dump nests was 15 (N=17), and the largest clutch was 18 eggs (N=2). As the distinction between a normal clutch (laid by one female) and a dump nest (laid by two or more females) was quite arbitrary, we present a modified clutch size distribution (Fig. 2). In this figure 50 per cent of the dump nests classified only by the number of eggs (≥ 14) are reclassified as normal clutches, while one, 3 and 6 nests with clutches of 11, 12 and 13 eggs, respectively, are reclassified as dump nests. This was done to obtain a more realistic picture of the distribution of clutches between normal and dump nestings. This gives a mean clutch size of 10.05 ± 2.24 (N=257), which does not differ significantly from the value in Table 2. The clutches classified as late or repeat nestings numbered 19 and contained an average of 7.55 ± 0.76 eggs. The annual mean clutch sizes did not differ significantly ($F=0.77$; df_1: 8, df_2: 222).

Although the clutch size did not vary significantly between years, the differences in the earliness or lateness of the season were relatively large. We chose the temperatures of April, because the supply of food for Goosanders — reflected by the weather — might have some influence on the timing of laying and/or the clutch size of the species. The correlation between the average temperature in April and the average laying date of the first egg in different years is significant ($r= -0.676$; $P < 0.05$).

Table 1. The number of nest-boxes available for Goosanders in Strömsö in 1973–81 and the number of inhabited nest-boxes and visits paid to them.
*) includes all nest–boxes which contained ≥ 1 Goosander eggs.

	1973	1974	1975	1976	1977	1978	1979	1980	1981	$\bar{x}$
No. of nest-boxes	54	67	68	69	77	77	77	81	81	72
Inhabited boxes*	35	39	43	38	40	47	47	50	54	44
Total visits	137	452	924	617	278	478	268	245	328	414

Table 2. The size distribution of Goosander clutches in Strömsö in 1973–81. Only full clutches (see text for the definition) included. (One clutch from 1979 with 4 eggs omitted.)

Clutch size	6	7	8	9	10	11	12	13	N	x̄	SD
1973	–	2	1	5	5	5	2	–	20	9.80	1.44
1974	–	1	5	7	–	3	4	–	20	9.55	1.64
1975	1	2	4	7	4	3	4	1	26	9.58	1.79
1976	–	2	4	4	7	1	3	2	23	9.78	1.76
1977	–	1	4	5	3	5	3	3	24	10.17	1.79
1978	–	1	2	8	5	1	4	2	23	10.00	1.65
1979	1	–	4	9	3	7	–	3	27	9.81	1.69
1980	1	–	2	4	8	6	4	4	29	10.48	1.68
1981	–	3	4	9	11	4	3	5	39	9.97	1.72
1973–81	3	12	30	58	46	35	27	20	231	9.93	1.69

The clutch size of the Goosander tends to decline towards the end of the season in Strömsö (Fig. 3). The median date of the first egg of each year was given the value 0, in order to remove the effects of annual variation in the initiation times. The equation for the linear regression of clutch size on the date of the first egg was then: $y = 10.21 - 0.097x$ ($r = 0.479$; $df = 193$, $P < 0.001$). There was no correlation between the laying date and the size of the Goosander eggs (volume indices used: length × breadth^2). A random sample of 195 eggs from different years divided into five groups according to the date of the first egg showed no significant variation between groups ($F = 0.19$; $df_1 = 3$, $df_2 = 192$, and for linear regression $F = 0.26$). The egg size was also compared between early and late clutches produced by the same female in successive years (a matched pair t-test). In almost half the cases the eggs of the earlier clutch were significantly larger than the eggs of the later clutch. The differences in the initiation times in these comparisons were always ≥ 7 days.

Hatching success data were taken only from full clutches producing at least one duckling that left the nest. If eggs were lost during the incubation, they were treated as unhatched eggs. Altogether about 3700 eggs were laid in 1973–81 in 392 nesting attempts — excluding 10 nests for which clutch size and/or hatching data are lacking. Of these about 2500 eggs hatched i.e. 68 %, and the rest were lost in deserted nests or failed to hatch in incubated nests. The average number of hatchlings per nest in 1973–81 was 9.14 ± 1.95 (N=199) and the average hatching success was 91.0 % (N=199). Neither the absolute nor the percentage hatching success varied in respect to the year, season, or age of the female.

Information given by recaptured females. As a large number of the ringed females (127) were recaptured (156), it is possible to examine the ageing of Goosander females in relation to the clutch size, date of the first egg and weight of the incubating female. Although we do not know the exact ages of the recaptured females, we can divide them into "age groups" by placing the females caught the first time in age-group I and those that came to nest in Strömsö the next year in age-group II, etc. In this way we could distinguish five age groups (group V comprises all females nesting in the study area ≥ 4 years after the first nesting). The average clutch size was found to increase with the age (Fig. 4): $r = 0.891$; $df = 3$; $P < 0.05$. According to our data, age also seems to have some effect on the laying date of Goosanders ($F = 2.943$; df_1: 4; df_2: 186; $P < 0.025$), e.g. the average laying date of age-group III was 6 days earlier than the average date for age-group I (Fig. 4).

We also computed the volume indices of some of the recaptured females' eggs ($\bar{x}$ = 150.2 ± 10.9; N=514 eggs from 58 clutches) in order to see

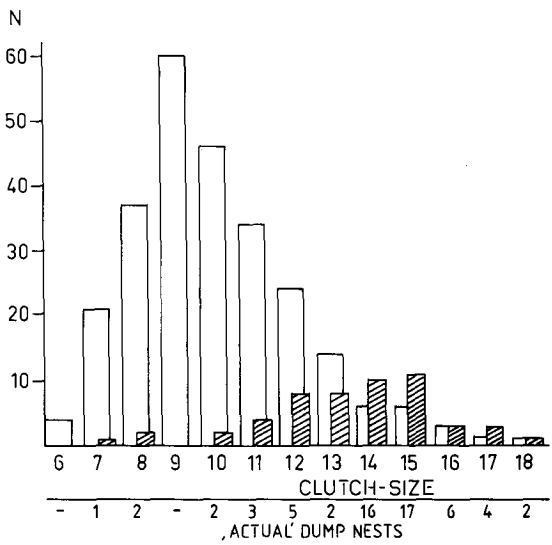

Fig. 2. The modified clutch size distribution; all incubated clutches included. Hatched bars = dump nests, open bars = normal full clutches. Of the dump nests classified by egg number alone (≥ 14), 50 per cent were reclassified as normal full clutches. One, 3 and 6 nests with clutches of 11, 12 and 13 eggs, respectively, were reclassified as dump nests.

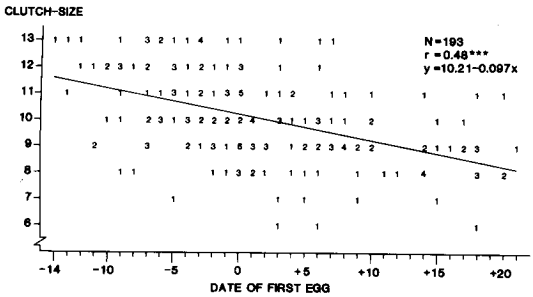

Fig. 3. Seasonal variation of clutch size. Linear regression for 1974–81. The annual median date of the first egg was given the value 0. N=194. Two nests from 1978 started 23 and 25 days after the median dates (7 and 8 eggs) were excluded. Fifteen clutches were omitted because the date of the first egg was unknown.

whether the size of the egg correlates with clutch size, laying date or weight of the female. In every age group the inter-individual variation was significant, i.e. some clutches had consistently larger eggs than others, but the differences in the volume indices between age groups were only nearly significant (P=0.052). The largest eggs were laid in age-group II ($\bar{x}$ = 152.7 ± 10.5; N=102 from 11 females), and the smallest in age-group IV ($\bar{x}$ = 149.1 ± 9.4; N=92 from 10 females). Intra-female variation in the volume indices was computed with data from 8 females whose eggs were measured in 2, 3 or 4 years (not always consecutive ones). In three cases the variation between years was significant (P <0.05) and in two of those one of the clutches was a dump nest.

The average volume index did not correlate with either the clutch size or laying date, but there was a positive correlation with the weight of the incubating female (the female was usually weighed about a week before the eggs hatched; r=0.40; N=60; P <0.01). In the years 1975–79 we weighed a total of 156 females and they averaged 1200 ± 75 grams. The weigths of the incubating females did not vary with age or with the clutch size. Through the study years the annual variation in the weights remained nonsignificant.

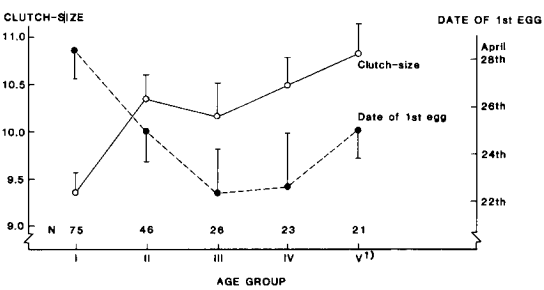

Fig. 4. Clutch size and laying date in different age groups (see text for the definition of age group) in 1973–81. Mean ± standard error of the mean. 1) age-group V includes 12 females renesting ≥ 4 years after the first time.

Discussion

In this study we classified all nests which contained 14 or more eggs as dump nests or compound nests (Fig. 2). This was based on the clutch size distribution and on common sense. Although we tried to remove as many dump nests as possible from the clutches of > 13, a few evidently remained, which will bias the mean upwards. Naturally the clutches with more than 13 eggs laid by one female, which were left out of the clutch size distribution in Table 1, bias the mean downwards. In a species such as the Goosander, whose intra-individual variation of clutch size (i.e. differences in clutch size between successive years) is almost as great as the inter-individual variation, it is very difficult to determine the upper limit of the clutch size, and the question arises whether this is in fact necessary.

One reason for dump nesting is probably a lack of suitable nesting sites (Jones & Leopold 1967), but this habit prevailed even in Strömsö, where there was a surplus of nest-boxes during this study. Morse & Wight (1969) observed similar behaviour in the Wood Duck *Aix sponsa* when there was no competition for nest sites. In Strömsö about 60 % of the nest-boxes were occupied by Goosanders each year (Table 1).

According to Grenquist (1953), the normal range of the clutch of the Goosander in Finland is 6–16 eggs, but Hildén (1964) reported a range of 6–12 eggs from the island group of Valassaaret — excluding dump nests. A seasonal decline in clutch size has been well documented in various species of Anatidae, and other birds as well (reviewed by Klomp 1970 and summarized by Johnsgaard 1973; see also Hildén 1964, Koskimies 1957a, Ryder 1972, Hydec & Kux 1971). Koskimies (1957a) found that genetic polymorphism played a role in the determination of the laying date and Ryder (1972) thinks the decline in the clutch size of Ross' geese *Anser rossii* might be due to incomplete clutches later in the season or a great proportion of young birds in the population breeding later and laying smaller clutches. He also considers (see also Ryder 1970) that the energy budgets of the females may play a part in the seasonal decline of clutch size; early starters may have enough fat energy reserves to lay a large clutch, while the late breeders may have used so much of their reserves that they can produce only a limited number of eggs. v. Haartman (1971) speculates that the low air temperatures may favour production of larger

clutches early in the season in nidifugous species, because ducklings gather together to warm each other and thus benefit from increased brood size.

The tendency of older Goosander females to lay larger clutches than young females fits well with similar trends in other birds (Klomp 1970, Morse et al. 1969, Richdale 1949). In general, birds nesting for the first time start laying slightly later than older birds (Klomp 1979). This is supported by our data, the 'young' breeders seem to start lying later than the older ones. One reason could be the competition for nest-boxes. The females breeding for the first time are unable to start early in the season because the older and more experienced females take the preferred nest-boxes.

The egg size of Goosanders seems to vary rather little between age groups, and the inter-individual variation is statistically significant. Koskimies (1957b) found in the Velvet Scoter that a female lays eggs of the same size over a 4-year period and the inter-individual variation was very marked in every year of his study. In contrast, Richdale (1955) found in the Yellow-eyed Penguin that young (2–3 years) and old females (14–19 years) tend to lay smaller eggs than the "mature" females (4–13 years). He also reports that the width of the egg is the least variable parameter describing the egg size, which was also noted by Koskimies (1957b).

Acknowledgements. We are very grateful to the personnel of Strömsö, who gave us generous help during the field work. We also wish to thank Mr. Seppo Kuusela and Mr. Erkki Virolainen for excellent field work in 1980 and 1981. Thanks are due to Dr. David Sinclair for valuable criticism of the manuscript and for revising the English language.

Selostus: **Isokoskelon pesimäbiologiasta Suomenlahden saaristossa**

Isokoskelon pesimäbiologiaa tutkittiin vuosina 1973–81 Alkon omistamalla Strömsö-nimisellä saaristoalueella Tammisaaren kunnassa (kuva 1). Tutkimuspopulaation suuruus vaihteli 30–60 parin välillä ja täysilukuisia pesyeitä löytyi vuosittain 20–39 (taul. 2). Telkät häiritsivät jossain määrin isokoskelon pesintää munimalla niiden pesiin. Isokoskelon keskimääräinen pesyekoko oli 9.93 ± 1.69 (N=231).

Yhteispesiksi (dump nest) määriteltiin yhteensä 60 pesyettä, joko munamäärän (vähintään 14) tai muninnassa ja haudonnassa todettujen häiriöiden vuoksi. Pesyekoko oli suurin aikaisin keväällä aloitetuissa pesissä ja pieneni tasaisesti pesimäkauden loppua kohti (kuva 3), kuten monilla muillakin lintulajeilla. Isokoskelo aloitti pesintänsä keskimäärin 20.4.–2.5., vaikka aikaisina keväinä (esim. 1973 ja 1975) ensimmäiset munat ilmestyivätkin uuttuihin jo maaliskuun lopulla.

Tutkimuksen aikana rengastettiin yhteensä 127 hautovaa naarasta, joista saatiin kaikkiaan 156 kontrollia. Ensimmäistä kertaa Strömsössä pesivät naaraat munivat keskimäärin pienempiä pesyeitä ja aloittivat pesinnän myöhemmin kuin aikaisempina vuosina pesineet linnut.

Munien koon (pituus × leveys^2) todettin vaihtelevan merkitsevästi ($P < 0.001$) naaraiden välillä ja myös 'ikäryhmien' (kontrollointivuosien määrän perusteella) välillä ($P < 0.05$). Keskimääräinen kuoriutumisprosentti vaihteli vuosittain 87–94 välillä. 'Ikäryhmistä' eniten poikasia tuottivat viidettä kertaa tai myöhemmin tutkimusalueella pesineet naaraat (keskimäärin 10.0 poikasta/pesye, N=20) ja vähiten ensikertalaiset (8.8 poikasta/pesye, N=81).

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Received February 1982, revised June 1985