Differences between old and newly established Goldeneye *Bucephala clangula* populations

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Goldeneye populations suffering from a scarcity of nest-sites (tree-holes) often increase considerably after the erection of nest-boxes. An old and a newly established population in SW Sweden differed significantly only with respect to clutch size, which on average was smaller in the newly established population. The hatching success and laying dates did not differ significantly. The proportion of first-time breeders is assumed to be comparatively large in the newly established population, and this may contribute to the smaller average clutch size. Scandinavian Goldeneye populations in freshwater habitats seem to level out at a rather constant population density, 0.3—0.5 pairs per km shoreline. Insufficient food supplies or cover for the ducklings are suggested as possible factors preventing further populations increase when there is an abundance of nest-sites.

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Introduction

The provision of nest-boxes in habitats suitable for holenesting anatids has often resulted in considerable increases of the population (e.g. Sirén 1952, Fredga 1962, Jones & Leopold 1967, Leidgren 1967, Rajala & Ormio 1971). Among Goldeneye populations, the initial increase has often been found to level out before all the nest-boxes are occupied (e.g. Rajala & Ormio 1971, Leidgren 1978). Apparently factors other than nest-site availability also limit the population size.

In the present study I compare some parameters of breeding performance in a newly established Goldeneye population in SW Sweden with those of an older population in the same geographical region. The upper limit of Scandinavian Goldeneye populations breeding in areas with oligotrophic lakes, which is the main breeding habitat, is briefly discussed.

Study areas

Various measures of breeding performance are compared between two study areas in SW Sweden.

1. *Svartedalen,* 58°01'N, 12°01'E, total area 55 km², lake area 7.1 km², total shore length 126.4 km. This coniferous forest area is described in further detail by Eriksson (1979). A nest-box breeding population was established during the 1950s, after which the population size increased continually until about 1970 (Fig. 1, Table 1). Since then the population has fluctuated around 30 pairs. The numbers of available nest-boxes and their occupation by Goldeneyes are given in Table 1. Although the number of nest-boxes increased continually, the proportion of occupied boxes never exceeded one third, except in 1967 and 1968. Thus, nest-box availability did not limit the

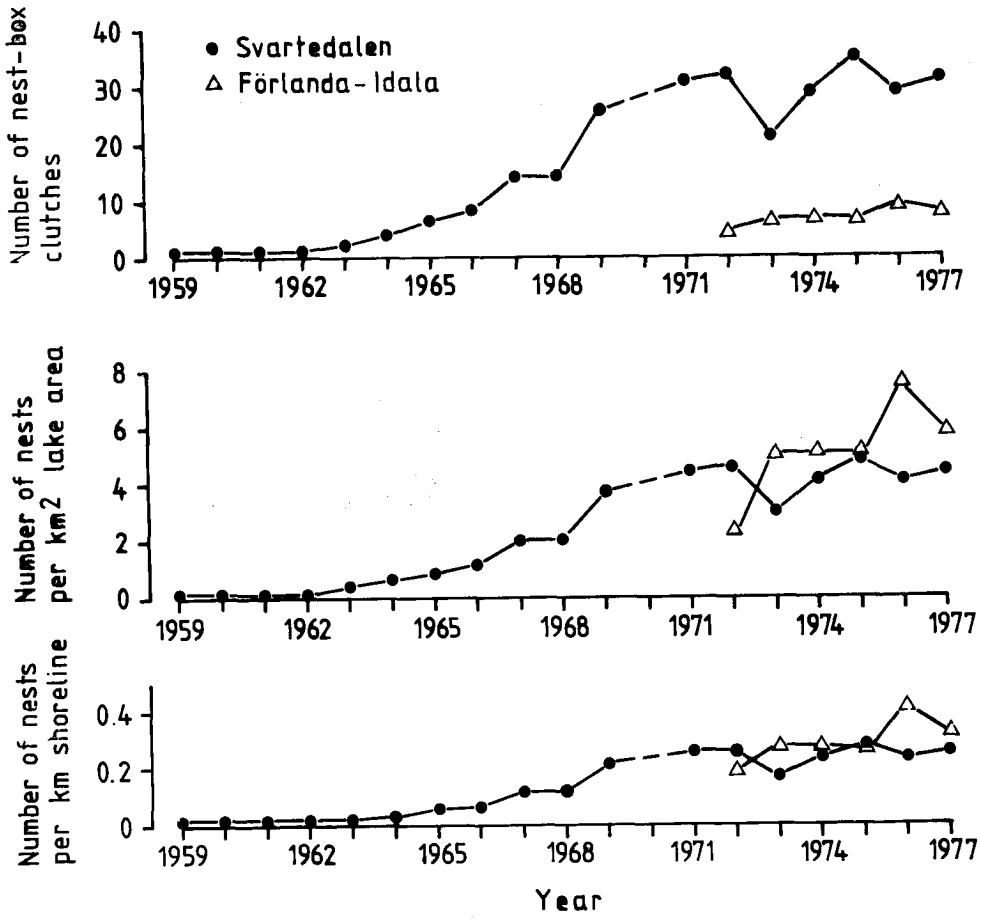

FIG. 1. Estimated size of the Goldeneye populations in Svartedalen and Förlanda-Idala. The population estimates are based on nest counts, see Methods. No counts were carried out in Svartedalen in 1970 or in Förlanda-Idala before 1972.

population size during most of the period 1959—77.

The data from 1972—77 are used as reference values for an established population which has ceased to increase. This seems appropriate since during this period there was no correlation between time and population changes (Spearman $r_s = 0.087$, $N = 6$, $P > 0.05$).

2. *Förlanda-Idala,* 57°23'N, 12°22'E, total area 25 km², lake area 1.2 km², total shore length 21.6 km. This area is mainly covered with coniferous forests but is also interspersed with smaller areas of deciduous forest. The distance between this area and Svartedalen is approximately 75 km. After erection of nest-boxes in 1971—73 (Table 1), the Goldeneye population increased from an assumed number of 1—2 pairs around 1970 to 9 pairs in 1976 (Fig. 1). The proportion of occupied nest-boxes never exceeded 30 % (Table 1), so nest-box availability never limited the population size during the investigation period 1972—77. During this period the increase was significant (Spearman $r_s = 0.88$, $N = 6$, $0.01 < P < 0.05$). Thus the data from this population

TABLE 1. Nest-box occupation by Goldeneyes in Svartedalen and Förlanda-Idala, SW Sweden, 1959—77.

	Svartedalen			Förlanda-Idala		
	Nest-boxes available	Nest-boxes occupied	%	Nest-boxes available	Nest-boxes occupied	%
1959	6	1	17	—	—	—
1960	6	1	17	—	—	—
1961	6	1	17	—	—	—
1962	6	1	17	—	—	—
1963	6	2	33	—	—	—
1964	6	4	67	—	—	—
1965	7	6	86	—	—	—
1966	48	8	17	—	—	—
1967	49	14	27	—	—	—
1968	62	14	23	—	—	—
1969	94	26	31	—	—	—
1970	Not investigated			—	—	—
1971	117	31	26	—	—	—
1972	114	32	28	19	4	21
1973	116	21	18	29	6	21
1974	127	29	23	31	6	19
1975	129	35	27	32	6	19
1976	131	29	22	33	9	28
1977	132	31	23	32	7	22

may be considered to represent a newly established Goldeneye population undergoing increase.

For descriptions of the areas listed in Table 5 for comparison, see the cited references.

Methods

Measurements of population size and breeding performance. Every record of at least one egg in a nest-box was regarded as a clutch, and the total number of clutches was used as an estimate of the size of the breeding population. For clutch size calculations, only nests where incubation was confirmed were included. For clutches found during the laying period, the onset of laying was calculated according to Eriksson (1979). Hatching success was related to the daily survival rate of nests by the Mayfield-40 % method (Johnson 1979). Predation losses were related to the total number of nest days, after exclusion of nests where the reason for failure was unknown. The census methods used in the studies cited for comparison are listed in Table 5.

Measurement of food supplies. The main food items of Goldeneyes in freshwater habitats are imagines and larvae of aquatic insects (see e.g. references in Cramp & Simmons 1977). The abundance of potential prey during the laying period in the two areas was estimated in late April 1977, by making hauls with a long-handled sweep net from places along the shore. Ten horizontal hauls of three metres were made in each lake. For further details, see Eriksson (1979).

Results and discussion

Comparison between the old and newly established population. The Svartedalen and Förlanda-Idala populations differed significantly only in the clutch size, which was smaller in the newly established Förlanda-Idala population (Table 2). Hatching success was similar in the two populations. Losses through predation, which was the most important reason for failures in Svartedalen (Eriksson 1979), also occurred frequently in Förlanda-Idala (Table 2). The dates of the start of egg-laying did not differ significantly (Table 3).

TABLE 2. Breeding parameters of the Goldeneye populations in Svartedalen and Förlanda-Idala. Data from 1972—77.

Area	Clutch size Mean±*SE*	*N*	Young hatched/ successful nest Mean±*SE*	*N*	No. of nest days[1]	Daily nest survival rate	Predation rate per nest day
Svartedalen	8.8±0.3	84	8.7±0.4	46	2416.5	0.955	0.026
Förlanda-Idala	7.4±0.3	20	7.5±0.3	10	507.0	0.957	0.033
Statistical test:							
χ^2	—		—			0.0001[3]	0.45[3]
P, two-tailed	= 0.001[2]		= 0.09[2]			≈1.0	≈0.5

[1] Mayfield-40 % method (Johnson 1979).
[2] Mann-Whitney *U* test.
[3] χ^2 calculated according to Mayfield (1975)

A plausible explanation can be found for the difference in clutch sizes. It is known that Goldeneye females generally show strong nest-site tenacity (e.g. Sirén 1957, Nilsson 1971, Rajala & Ormio 1971). Thus females with previous breeding experience would not be expected to search for new nest-sites unless the old nest-site has fallen into disfavour, e.g. after a failure (see Eriksson 1979). Females breeding for the first time, however, may be expected to migrate to new areas, especially if there is a scarcity of nest-sites in the natal localities. Thus, first-time breeders will be over-represented in areas in which suitable nest-boxes have recently been provided. In various anatid species, females breeding for the first time have been reported to lay a smaller average clutch than older ones (e.g. Dane 1965, Heusmann 1975, Krapu & Doty 1979, see also references in Hildén 1964), and a similar trend is found in the Goldeneye (Eriksson 1980). Thus, a large proportion of first-time breeders may explain the smaller mean clutch size of the newly established population.

TABLE 3. Laying dates of the Goldeneye populations in Svartedalen and Förlanda-Idala. Data from 1972—77.

Area	Onset of laying Mean	Range	*N*
Svartedalen	25 April	3 April — 24 May	47
Förlanda-Idala	20 April	1 April — 5 May	14
Mann-Whitney *U* test, *P*, two-tailed	≈0.15		

Unfortunately, the Förlanda-Idala population was not investigated accurately enough to detect intraspecific nest parasitism, so the two populations cannot be compared in this respect. If nest parasitism was more frequent in Svartedalen than in Förlanda-Idala, this may have contributed to the clutch size difference. Eriksson & Andersson (1982) found that the clutch size was significantly increased in Goldeneye nests parasitized during the laying period. Differences in the food supply can probably be ruled out as an explanation of the different clutch sizes. The sampling in the laying period in 1977 revealed no tendency to-

wards higher abundances of potential food organisms in Svartedalen than in Förlanda-Idala (Table 4).

The upper limit of Goldeneye populations. Fig. 1 gives various measures of the relative sizes of the Svartedalen and Förlanda-Idala populations. The size estimates related to lake area and shore length suggest that the Förlanda-Idala population rapidly reached the same level as in Svartedalen. Comparison with other studies (Table 5) indicates that in oligotrophic Scandinavian lakes the maximum numbers of Goldeneye pairs per unit shore length may be relatively constant. Among the six populations compared in Table 5, all except one levelled out at a density of approximately 0.3—0.4 pairs per km shoreline (in the Bjurbäcken area with a maximal density of 0.51 pairs per km shoreline, a large part of the lake area is small water bodies in bogs). These calculations include all the lakes in the study areas; if only lakes where Goldeneyes breed were considered, higher densities would often be recorded. However, all the lakes in a study area should be included in calculations of

TABLE 4. Mean number of potential prey organisms of Goldeneye per sample of 10 sweep net hauls in each lake investigated during the egg-laying period in 1977. *N* = number of lakes.

Area	Mean ± *SE*	*N*	Sampling data
Svartedalen[1]	17.0 ± 6.0	9	25 April
Förlanda-Idala	21.9 ± 14.4	7	27—28 April

[1] From Eriksson (1979)

TABLE 5. Densities of some Goldeneye populations in Sweden and Finland.

Area	Estimated number of pairs: Per km² lake area	Per km shoreline	Year	Method	Reference
Förlanda-Idala, Sweden (57°23′N, 12°22′E)	7.5	0.42	1976[1]	Nest counts	This study
Svartedalen, Sweden (58°01′N, 12°01′E)	4.9	0.28	1975[2]	Nest counts	This study
Bjurbäcken, Sweden (59°26′N, 14°09′E)	—	0.51	1976[3]	Nest counts	S. Fredga & H. Dow, in prep.
Coastal region of Västerbotten, Sweden (63°50—55′N, 20°35—47′E)	8.5	0.35	1977	Pair and brood counts	Danell & Sjöberg 1979
Woodland zone of northernmost Sweden (approximately 66—67°N, 19—24°E)	5.6[4]	0.34[4]	1975—77	Aerial survey, pair and female counts	Haapanen & Nilsson 1979
Meltaus, Finland (66°55′N, 25°20′E)	—	0.42	1966	Nest counts	Rajala & Ormio 1971

[1] Peak year during 1972—77.
[2] Peak year during 1959—77.
[3] Peak year during 1960—80.
[4] In other areas investigated by Haapanen & Nilsson (1979) lower densities were found.

this kind, as lakes not used for breeding are often used for feeding. The frequent movements of non-fledged young between lakes (Sirén 1952, Eriksson 1978) indicate that even lakes not used for breeding should be regarded as important resources.

As Goldeneye populations level out when nest-sites are still available, other factors must also influence the population size. Since most of the populations investigated seemed to achieve approximately the same size in relation to the shore length, it is likely that they are limited by at least one quality of the shore areas of the lakes. The abundance of food is one possible factor, and it can reasonably be expected to be more strongly correlated to shore length than to total lake area because the shallowest parts, and hence the parts closest to the shore, are the preferred habitats of the majority of the potential food organisms. Goldeneye females usually take their young to those lakes which contain most food, even when other lakes are located nearer the hatching place and despite the risks connected with travels between lakes by the ducklings (Eriksson 1978, 1979). Another quality related to shore length is the escape cover available for the ducklings (J. H. Patterson 1976). The proximate cause of dispersal of additional pairs may be social interaction (see I. J. Patterson 1976), e.g. aggressiveness before and during the breeding period.

Management application: how many nest-boxes should be erected in a breeding area? In a management programme aimed at increasing nest-site availability, a number of nest-boxes sufficient for a population of 0.3—0.5 pairs per km shoreline might be a minimum. Although Goldeneye females normally return to the same nest-site year after year, changes of nest-sites regularly occur, e.g. if breeding fails (see references above). A number of nest-boxes in excess of the minimum would allow such females to select among alternative nest-sites even when the population size is near its upper level.

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Selostus: **Vakiintuneen ja uuden telkkäkannan välisistä eroista**

Pesäpaikkapulasta kärsivät telkkäkannat yleensä runsastuvat huomattavasti, kun alueelle asetetaan uuttuja. Tutkimuksessa verrataan kahta Lounais-Ruotsin telkkäpopulaatiota, joista toinen (Svartedalen) on pesinyt alueella jo 1950-luvulta lähtien ja toinen (Förlanda-Idala) on syntynyt vasta 1970-luvulla. Uuttujen määrä ja asutusprosentti kummallakin alueella on esitetty taulukossa 1, kantojen kehitys kuvassa 1.

Uudessa kannassa pesyekoko oli pienempi kuin vakiintuneessa, kun taas pesimäajassa ja kuoriutumistuloksessa ei ollut eroa populaatioiden välillä (taul. 2 ja 3). Pienemmän munamäärän oletetaan johtuvan siitä, että uudessa kannassa ensi kertaa pesivien naaraiden osuus on suurempi.

Fennoskandian sisävesissä telkkäkantojen kasvu tuntuu pysähtyvän melko tarkoin siinä vaiheessa kun populaatiotiheys saavuttaa rajan 0.3—0.5 paria rantaviivakilometriä kohti (taul. 5), vaikka uuttuja olisi tiheämmässä. Täten muidenkin tekijöiden kuin pesäpaikkojen saannin täytyy säädellä telkkäkantojen kokoa. Tällaisiksi tekijä katsoo tarjolla olevan ravintomäärän ja poikueiden vaatiman suojan, jotka yleensä ovat selvemmin riippuvaiset rantaviivan pituudesta kuin vesialueiden pinta-alasta.

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