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Ringing of Red-throated Diver *Gavia stellata* Black-throated Diver *Gavia arctica* in Sweden

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Substantial parts of the European populations of the Red-throated Diver *Gavia stellata* and Black-throated Diver *Gavia arctica* are found in the Nordic countries. For the Black-throated Diver, the current estimate is 5,500-7,000 pairs in Sweden (Eriksson & Lindberg 1998), and with populations of the same magnitude in Finland and Norway (Asbirk et al. 1997), comprising a total of 17,000-20,000 pairs, the Nordic countries hold 99 % of the population outside Russia. For the Red-throated Diver, the European population is estimated to 6,000-11,700 pairs (excl. Russia and Greenland), as deduced from Tucker & Heath (1994) and with the main parts in Sweden, Finland, Norway, Iceland and Scotland. The Swedish population is estimated to 1,200-1,400 pairs (Eriksson & Lindberg 1998).

Although better knowledge of the migration and dispersal is essential for the appropriate protection and management of the two diver species in Sweden, also in an international context, ringing of them has never been a large issue outside a limited number of people. This is reflected in the comparatively small number of ringed birds, and hence a small number of recoveries. Not until the 1990s, ringing of Red-throated Divers became more large-scale, but still a very limited number of Black-throated Divers are ringed, due to the practical constraints linked to the capture of these birds. Here, we give some aspects of migration, survival and dispersal patterns, as preliminary concluded from the recoveries and with a reservation for the limited possibilities for any thorough analyses due to the small sample sizes.

Red-throated Diver

Ringing of Red-throated Divers is primarily done at the breeding tarns, where chicks are caught in nets when 4-5 weeks old, i.e. shortly before fledging. Thus, almost all ringing concerns non-fledged young at the breeding sites, although adults birds may be accidentally caught (and ringed or controlled) during the field work. 837 birds have been ringed in Sweden until the end of year 2001. Around 90 % of them were ringed after 1985, i.e. when a work-effective method to catch and ring non-fledged chicks had been developed. In all, not more than 5-10 persons have been actively involved in the field work.

By end of 2001, there was in total 67 recoveries, i.e. a 8 % recovery rate. All except four birds were found dead during the period 1950-2001 and 65 of were ringed as chicks (of which 62 found dead). 86 % of all recoveries are from the mid-1980's and onwards (Figure 1), i.e. a clear effect of the increased ringing effort.

Migration pattern

The long-distance recoveries, i.e. more than 100 km from the ringing site, demonstrates convincingly that Red-throated Divers breeding in Sweden migrate towards south-west to wintering sites in marine habitats in the Skagerack, North Sea and Bay of Biscay (Fransson & Pettersson 2001). There are indications that divers breeding in the province of Jämtland (and northwards?) migrate westwards from their breeding sites directly to the Norwegian coast, after which they turn southwards. The recoveries outside Sweden are from Norway (6 recoveries), Denmark (17), Germany (5) England (3), The Netherlands (5) and France (10). The wintering area is shared with birds from Finland, the northern parts of UK and as distantly as from Greenland (see also Okill 1994).

Young, non-breeding birds spend their first and (mostly also) second year of life in marine habitats, and more occasionally also older birds may stay in their winter quarters during summer. There are no inland recoveries at freshwater habitats of one or two years old birds ringed in Sweden or Finland.

There are no recoveries from the Baltic Sea, neither from Sweden or Finland. The Red-throated Divers wintering here, including the large and recently detected concentrations of around 26,000 divers (around 75 % estimated to be Red-throated Divers) outside the coast of Poland and Germany (Durinck et al. 1993), are presumably from breeding sites in Russia.

Survival rate

For estimates of survival rates, we used all recoveries of birds ringed as non-fledged chicks, without any selection with reference to ringing date or reported cause of mortality. There is thus a risk that the survival rate of young age classes may be slightly underestimated. With a reservation for this source of error, the survival during the first and second years of life was on the same level, 60 % and 62 % respectively (as calculated from data in Table 1). For the mature age classes, the average survival was 84 %, assuming that most Red-throated Divers start breeding when three years old (as concluded from a long-term ringing scheme in Shetland; Okill 1994). Thus, the survival pattern is very similar to other long-lived bird species. The oldest bird in our data set also holds the international longevity record for Red-throated Divers: it refers to a bird ringed in 1928 and found dead (oil damaged) in the Netherlands in 1952, at an age of 23 years and 8 months (Staav 1989).

Using the survival rate estimates deduced from Table 1, we assessed the minimum annual production of fledged in order to compensate for the mortality to 0.86 fledged chicks per pair, using the method developed by Henny et al. (1970). The average breeding success reported for Sweden during the period 1994-2000 was above this level in the northern parts of the country, but slightly below in the central and southern parts (Eriksson et al. 2001).

Causes of mortality

Any analyses of causes of mortality must be done with caution, considering that there is no information of the cause of death for more than one third of all recoveries (Table 1). Furthermore, the probability of recovery differs for various causes of death, which may contribute to biased proportions.

Accidental capture in fishing gear is the most frequently reported cause of death (43 %, Table 1). Birds caught in fishing gear have been found in lakes close to the breeding grounds, as well as in lakes and marine areas along the migration routes and at the wintering sites. But the real importance of this factor is hard to evaluate, as birds caught in fishing gear are much more easily found than those that died due to other causes. Thus, the reported proportion is presumably overestimated.

The second largest cause of death (10 %) refer to birds damaged by oil. General overviews (e.g. Williams 1995) indicate that divers (together with auks) are among the most susceptible groups of birds that spend the winter in marine habitats in the North Sea.

Two birds (3 %) are reported as killed by shooting; both are from the 1950s, when there was still an open shooting season for the Red-throated Diver.

Natal dispersal

Recoveries during the breeding season (April-August) at potential breeding areas indicate that the adults to a large extent return to the same region where they were born. Among nine recoveries of birds 3-12 years old, six were found between 3 and 20 km from the birthplace, and the remaining three ones, 50, 58 and 90 km from the birthplace. This result is in accordance to with findings from Shetland, where a range of 0.5-68 km were reported among eleven recoveries (Okill 1992).

Black-throated Diver

The Black-throated Diver has not attracted ringers to the same extent as the Red-throated Diver, and only around 250 birds have been ringed until year 2001. Surely, this reflects the technical difficulties involved in

catching these birds. There was a peak in the ringing activities during the 1950s and 1960s, but after that very few birds have been ringed (Fransson & Pettersson 2001).

By end of 2001, there was in total 26 recoveries; all of them birds found dead from 1935 and onwards. 20 of them refer to birds ringed as chicks, and there are only two recoveries after the 1960s (Figure 2). Thus, the data for any kind of conclusions is scanty.

Migration pattern

Our knowledge of the migration pattern of the Black-throated Diver still relies on the ringing done by the German ornithologist Ernst Schüz at Rositten in Ostprussen (nowadays the Russian enclave Kaliningrad) during the 1920s and 1930s. Recoveries from this ringing scheme indicate that Black-throated Divers breeding in Scandinavia, Finland and Russia to a large extent spend the winter in the Black Sea and eastern part of the Mediterranean (Schüz 1974).

Although there are only few long-distance recoveries of birds ringed in Sweden, they nevertheless confirm the results obtained by Schüz (1974). Seven recoveries outside Sweden, from Ukraine (4 recoveries), Greece (1), Yugoslavia (1) and Italy (1), indicate the existence of a south-eastern migration route. But presumably, an almost equal proportion migrate towards south-west to wintering sites in marine habitats in the Skagerack, North Sea and Bay of Biscay, as indicated of five recoveries from Norway (2 recoveries), Denmark (2) and France (1). But there are no long-distance recoveries after the 1960s, so we do not know to what extent our conclusions reflect the situation of to-day.

Survival rate

The recoveries of birds ringed as chicks at the birth sites indicate a 40 % survival during the first year of life, and after that an average survival of 80 %, i.e. in accordance to the pattern found for other long-lived bird species.

Information about age of first breeding is even more scanty for the Black-throated Diver than for the Red-throated but is mostly supposed to occur at the age of five years, as concluded from the thorough study by Leo Lehtonen in Finland during the 1960s (Lehtonen 1970). With reference to this figure and the survival pattern indicated by the recoveries, only 15 % of the chicks reach maturity. If these estimates reflects any kind of reality, the average breeding success recorded for various parts of Sweden during 1994-2000, i.e. 0.39-0.57 "large" chicks per pair and year (Eriksson et al. 2001), is much too low to compensate for the mortality.

Analyses of recoveries of birds ringed as adult during migration through the Baltic Sea during, primarily during the 1930s (i.e. the ringing scheme co-ordinated by Ernst Schüz) indicate a higher adult survival, 87-91 %. With these recoveries as a reference, the minimum annual production to compensate for mortality has been assessed to 0.37-0.47 fledged chicks per pair and year (Nilsson 1977), i.e. on the same level as reported for the Swedish population during the 1990s.

The oldest bird in our data set is 16 years and 1 months. But birds from Ernst Schüz's scheme during the 1930s were found until the 1960s, i.e. 26-27 years after they were ringed (Schüz 1974). Considering that these birds were at least 2-3 years when ringed, this indicates that single Black-throated Divers becomes up to 30 years old.

Causes of mortality

As for the Red-throated Diver, the cause of death was not known for more than one third of all recoveries (Table 2). Six birds (30 %) were reported as deliberately killed, all shot during the 1930s-1950s, i.e. when there was still an open shooting season for the species. Accidental capture in fishing gear is the second most frequently reported cause of death (20 %) but the number of birds is too few for any more conclusive analyses.

Natal dispersal

There are only three recoveries during the breeding season (April-August) at potential breeding areas of birds ringed as chicks, all within the range of 21-29 km from birthplace when the birds were 2-16 years old. In addition, there are two recoveries of birds ringed as adults, found 2-3 km from the ringing place 1-6 years later. Although a small number of recoveries, they indicate a tendency of tenacity to the region the birds were born.

The future

The increased ringing effort directed towards the Red-throated Diver since the mid-1980s is now rewarded in terms of an increased number of recoveries, although data still is too scarce to allow for more definitive conclusions about survival rates and dispersal. But considering the level of the ringing effort during the last years, the prognosis for further recoveries is fairly good. This will make more accurate analyses and conclusions possible in a near future.

But for the Black-throated Diver, our knowledge about the migration and survival pattern still relies on information from recoveries some decades ago and with only few recoveries after the 1960s. We do not know to what extent the species has been affected of the large changes in the marine habitats all around Europe during the last decades. The lack of knowledge about central issues for an appropriate conservation work is worrying in the perspective that Sweden, Norway and Finland hold around 99 % of the European population outside Russia. For the future, experiences from the ringing of Common Loon *Gavia immer* in North America needs to be tested and adjusted, in order to make it possible to increase the ringing effort in the core area of the European population of the Black-throated Diver.

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Table 1. Age distribution and reported causes of mortality among Red-throated Divers ringed as non-fledged chicks in Sweden.

	Number of birds							
Age class	**Shot or trapped (deliberate killing)**	**Oil damaged**	**Caught in fishing-gear**	**Caught in other human artefacts**	**Sick or wounded**	**Predation by mammal**	**Cause unknown**	**Total**
0-1	1		12	1		1	10	25 (40 %)
1-2	1	1	4				8	14 (23 %)
2-3		1	2		1		1	5 (8 %)
3-4		1	2	1				4 (6 %)
4-5							2	2 (3 %)
5-6			2					2 (3 %)
6-7		2	4					6 (10 %)
7-8			1					1 (2 %)
8-9							1	1 (2 %)
19-20							1	1 (2 %)
23-24		1						1 (2 %)
Total	2 (3 %)	6 (10 %)	27 (43 %)	2 (3 %)	1 (2%)	1 (2 %)	23 (37 %)	62

Table 2. Age distribution and reported causes of mortality among Black-throated Divers ringed as non-fledged chicks in Sweden.

	Number of birds					
Age class	**Shot or trapped (deliberate killing)**	**Caught in fishing-gear**	**Caught in other human artefacts**	**Sick or wounded**	**Cause unknown**	**Total**
0-1	3	3	2		4	12 (60 %)
1-2	2					2 (10 %)
2-3	1	1			1	3 (15 %)
5-6					1	1 (5 %)
8-9				1		1 (5 %)
16-17					1	1 (5 %)
Total	6 (30 %)	4 (20 %)	2 (10 %)	1 (10%)	7 (35 %)	20

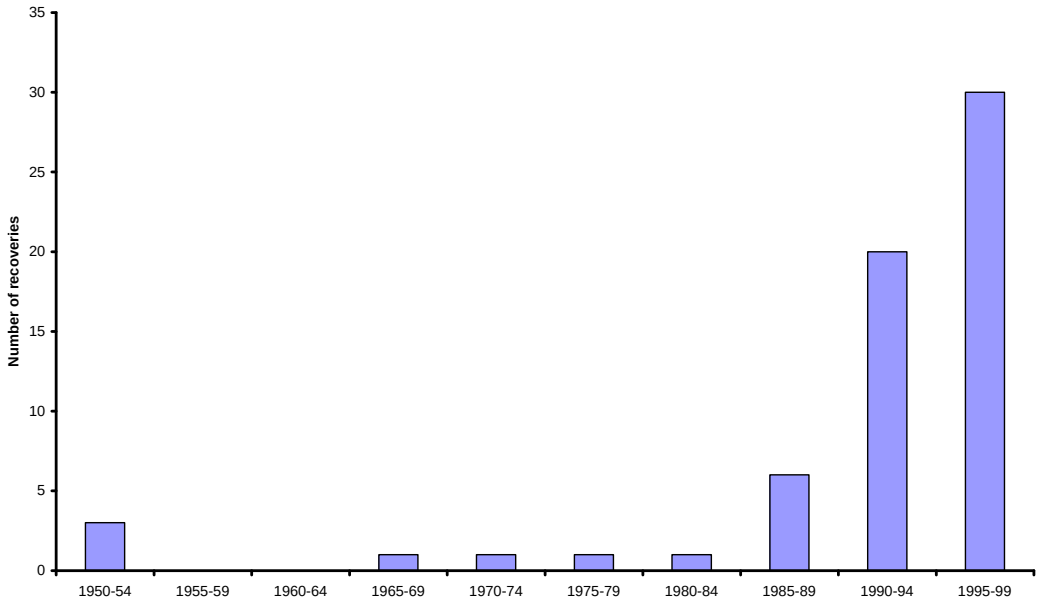

Figure 1. Recoveries of Red-throated Divers, ringed as non-fledged chicks at breeding sites in Sweden. In addition, there is one recovery each from 2000 and 2001.

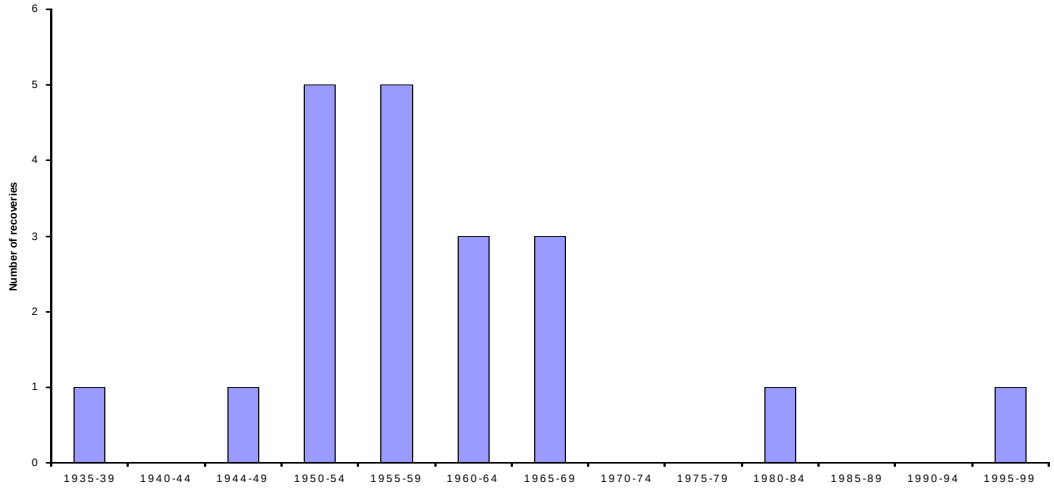

Figure 2. Recoveries of Black-throated Divers, ringed as non-fledged chicks at breeding sites in Sweden. There are no recoveries from 2000 or 2001.