The impact of hard winters on waterfowl populations of south Sweden

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Introduction

The southern part of the Baltic and neighbouring waters around the Danish Isles and in the Kattegatt form an important winter area for a number of waterfowl species, especially diving ducks (see, e.g., Atkinson-Willes 1976, 1978, Joensen 1974, Nilsson 1975a). Even if the numbers wintering in the Baltic might be as high as 1.5 million or more, the available food resources seem to be sufficient for even larger numbers (Nilsson 1980a). In the Baltic, however, large parts will freeze in cold winters, covering most shallow areas with ice, dramatically altering the food situation for the wintering waterfowl. That heavy mortality sometimes occurs during cold winters is well-known (cf. Andersen-Harild 1981, Boyd 1964) but the impact on the population status has not been studied to any extent. The present paper tries to evaluate the impact of hard winters on the waterfowl populations of south Sweden for species wintering at least partly in the southern Baltic.

Material and methods

The analysis is based on the International Midwinter Wildfowl Counts started in Sweden in January 1967 and on national September counts started in 1973. Monthly counts undertaken in Sweden from 1959–60 (Nilsson 1976) cover too few localities to yield reliable information relating to the hard winter of 1962–63, but provide some additional data. Regional midwinter counts in the southernmost province, Skane, started in 1964 (Nilsson 1983b).

The methods and organisation of the Swedish waterfowl counts as well as the index calculations have been treated in earlier reports (Nilsson 1975a, 1976). In this paper the annual indices have been recalculated so that the mean indices for September 1973–1982 and January 1969–1978 are both 100. For the January counts the period chosen is that with the most extensive coverage. Indices were calculated for the national samples and for the different regions separately. The midwinter counts cover the coast from the middle part of the west coast to Uppland and Gästrikland in the Baltic, and inland sites in the same part of the country (map in Nilsson 1975a). In January full coverage was obtained of all important inshore waters in most years. The September counts cover a sample of waterfowl localities (map in Nilsson 1980b). Details of individual years are found in annual reports in *Vår Fågelvärld.*

Weather data were gathered from the monthly reports from the Swedish Meteorological Institute. Monthly mean temperatures for ten stations spread over south Sweden were used as a measure of the strength of the different winters (Fig. 1).

Results

The September and January indices of the different species (Fig. 2 and Table 1) show relatively marked fluctuations. The variation was markedly higher in the regional indices which are strongly affected by changes in the distribution of waterfowl in response to local winter conditions. In the national indices these will tend to cancel out. The variability was also higher in the winter indices than in the September indices.

The Goldeneye *Bucephala clangula* showed a smaller variability in the September indices than Tufted Duck *Aythya fuligula,* whereas the situation was reversed in the winter indices. The variation of the national midwinter indices for these two species and Long-tailed Duck *Clangula hyemalis* were similar, whereas the variation in the regional indices of the more efficient diver, Long-tailed Duck (Nilsson 1972), was markedly lower than in the other two species. Coot *Fulica atra,* far less efficient divers, showed a much higher variability in the indices.

Eider *Somateria mollissima.* which

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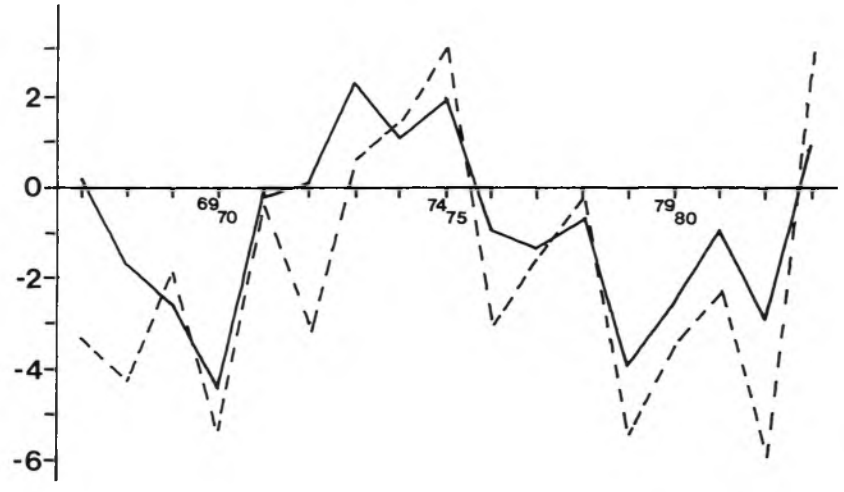


Figure 1. Mean temperatures for January (broken lines) and December–March (solid lines) for ten meteorological stations in south Sweden. Mean values for the seventeen winters shown in the diagram are −1.9 and −0.9°C, respectively.

Table 1. The variability of the September and January indices for the different species measured as the standard deviation as per cent of the mean. For each species the variability of the national indices and the mean variability of the regional indices are shown.

Species	September		January	
	National	Regional	National	Regional
Mallard	19	34	19	48
Tufted Duck	37	52	27	56
Pochard	36	–	–	–
Goldeneye	13	50	38	56
Long-tailed Duck	–	–	25	34
Eider	12	33	59	72
Red-breasted Merganser	34	53	44	55
Goosander	28	–	40	73
Mute Swan	16	30	30	60
Whooper Swan	–	–	26	52
Coot	65	69	82	88

showed a high variability in the winter indices although a fairly efficient diver, is not a typical winter species in Swedish waters, numbers varying much in relation to the strength of the winter.

The two species of mergansers showed similar variabilities in the national indices. In the regional midwinter indices the mean variability was markedly higher in the inshore Goosander *Mergus merganser* than in the Red-breasted Merganser *Mergus serrator*.

The indices for some species showed significant correlations with the winter temperature (Table 2). In September the correlation coefficients were significant for Red-breasted Merganser and Coot, and those for Goldeneye and Mute Swan *Cygnus olor* nearly attained significance. In the other species lower correlations were found, but all were positive. Similarly most correlations between changes in September indices and the mean temperatures of the intervening winters were positive although they did not attain significance.

The January indices were compared both with the mean temperature during the count and with the mean temperature for the preceding winter. As for the September indices, most correlations were positive although only two were significant. Correlations between the changes in two midwinter indices and mean temperatures of the latter of the two winters were significant

Table 2. Correlations between January and September indices and changes in these indices between two years, and mean winter temperatures for ten stations in south Sweden. A) January indices and mean temperature for Dec.–March preceding winter, B) January indices and mean temperature for January the same year, C) Changes in January indices and mean temperature for Dec.–March in the first of the two winters, D) Changes in January indices and mean temperature for January in the second of the two winters, E) September indices and mean temperature for a preceding Dec.–March, and F) Changes in September indices and mean temperature for intervening Dec.–March.

Species	A	B	C	D	E	F
Mallard	0.25	0.44	–0.18	0.64*	0.82**	0.31
Tufted Duck	0.43	0.32	0.08	0.25	0.12	0.48
Pochard	–	–	–	–	0.45	0.41
Goldeneye	–0.27	0.13	–0.24	0.32	0.58	0.37
Long-tailed Duck	0.40	0.08	0.16	0.63*	–	–
Eider	0.59*	0.32	0.32	0.30	0.06	0.04
Red-breasted Merganser	–0.20	0.42	–0.24	0.65*	0.76*	0.60
Goosander	0.39	0.12	0.43	0.05	0.20	–0.22
Mute Swan	0.36	0.69*	–0.09	0.48	0.63	0.51
Whooper Swan	–0.34	0.35	–0.05	0.44	–	–
Coot	0.49	0.36	0.22	0.62*	0.84**	0.42

for Long-tailed Duck, Red-breasted Merganser, and the Coot.

Some species showed significant trends (Fig. 2). For the September counts significant decreasing trends were obtained for Goldeneye, Red-breasted Merganser, Mute Swan, and Coot; that for Goosander not being significant. Similar trends were noted in several regional index series. Ten years are, however, a rather short period to establish trends in waterfowl populations and they can probably more properly be interpreted as decreases in the populations following the hard winters of 1979 and 1982 at the end of the period.

The midwinter indices, covering a longer period, are more suitable for the establishment of trends. Significant increasing trends were obtained for Goldeneye, Long-tailed Duck, Red-breasted Merganser, and Mute Swan. Tufted Duck, Goosander, and Coot increased significantly up to the cold winter of 1979, then decreased markedly. The other species showed fluctuations.

It is apparent (Fig. 2) that hard winters affect the waterfowl populations to a varying degree. The September indices more directly show variations in the population level (and productivity), and the mean changes in the indices over the two hard winters were clearly negative for six out of nine species examined (Table 3), whereas only small changes were noted for the eight years with more normal winters. In two species no marked changes were noted over the hard winters, whereas the September indices for the fairly small numbers of Goosander showed an increase.

Direct comparisons between the indices for the hard winters and normal winters will not give much information about population changes because those of the hard winters are much affected by the local distribution changes in response to the ice situation. Therefore the mean indices of the two winters preceding have been compared with the means of the two winters following a hard winter (Table 4). The same comparisons were also made for the September indices before and after the 1979 winter. Marked decreases in the indices after the hard winters were found in Tufted Duck and, especially, Coot, whereas the situation was more varied in the other species. In species showing trends this method will not always reveal decreases after the hard winters but these will show breaks in the trends (Fig. 2).

For Mallard *Anas platyrhynchos,* September indices are available for a longer series (Nilsson 1983a). In the September after the hard winters of 1963, 1970, 1979, and 1982 lower indices were found than in the preceding September. In the January indices small decreases were found when comparing the year before with the year after the hard winters.

In Tufted Duck marked reductions in the populations after the hard winters were indicated. Unfortunately no large-scale counts were available relating to 1963. Regional indices for SW Skane do, how-

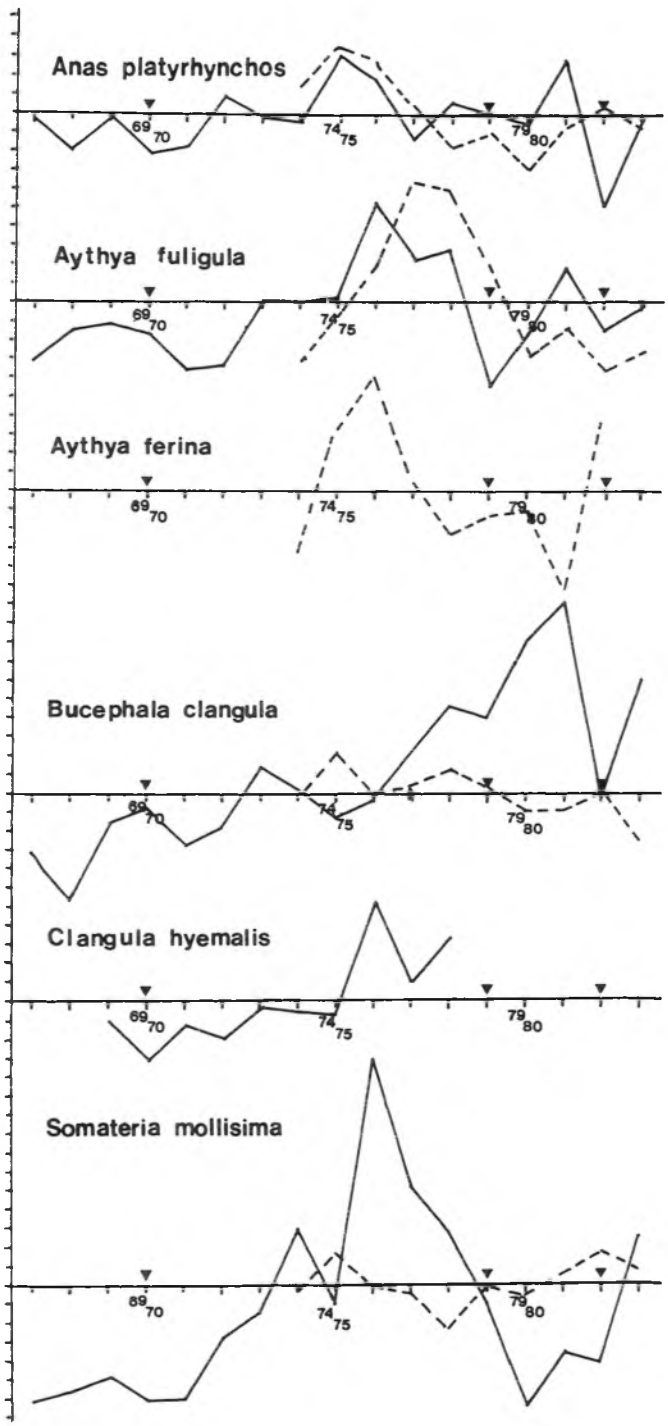
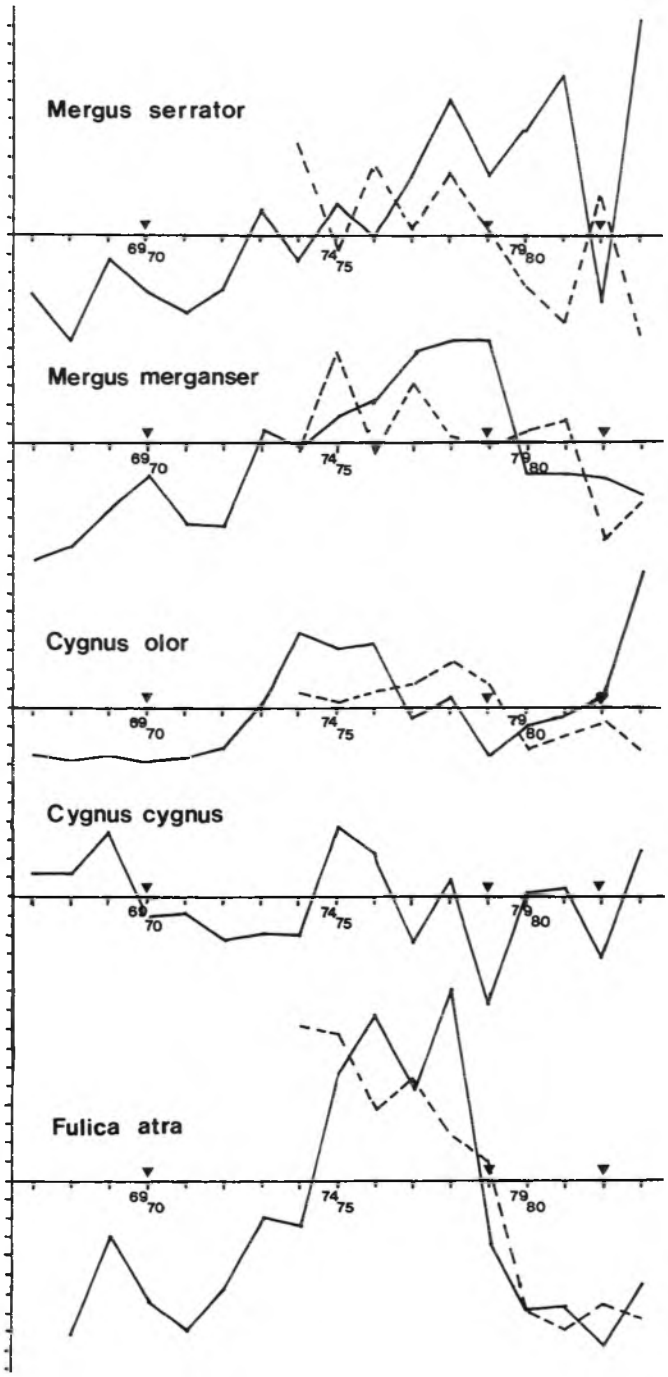


Figure 2. September (broken lines) indices for 1973–1982 and January (solid lines) indices for 1967–1983. Mean indices for September 1973–1982 and January 1969–1978 are set to 100, respectively, and are represented by the horizontal lines in the diagrams. On the vertical axis each mark denotes 10 index units. The three hard winters during the study period are marked with triangles. The following



species showed significant trends over the period studied (correlation coefficients given): September indices: Goldeneye −0.67*, Red-breasted Merganser −0.65*, Mute Swan −0.66*, Coot −0.94***, January indices: Goldeneye 0.81***, Long-tailed Duck (1969–1978) 0.77**, Red-breasted Merganser 0.75***, Mute Swan 0.56*.

Table 3. Mean changes in per cent in September indices over the two hard winters of 1979 and 1982 and over eight mild or normal winters in south Sweden.

Species	Hard winters	Normal winters
Mallard	−14	+1
Tufted Duck	−26	+6
Pochard	+3	+10
Goldeneye	−20	+2
Eider	−6	+3
Red-breasted Merganser	−44	+4
Goosander	+20	−5
Mute Swan	−24	+3
Coot	−46	−3

Table 4. Per cent changes in the mean indices for the two seasons preceding and the two after the hard winters of 1970 and 1979.

Species	1970 January	1979 January	1979 September
Mallard	+9	+15	+8
Tufted Duck	−26	−20	−43
Pochard	–	–	−17
Goldeneye	+18	+34	−17
Eider	+15	−65	+15
Red-breasted Merganser	−3	+12	−46
Goosander	0	−44	+8
Mute Swan	+5	−7	−31
Whooper Swan	−31	+10	–
Coot	−32	−82	−78

ever, indicate a marked decrease in wintering numbers after this very hard winter (Nilsson 1975b).

The September and January indices for Goldeneye showed opposite trends, both significant. The slow decrease in the September indices was probably an effect of the hard winters during the latter part of the period, and was found only for the inland localities; the coastal September indices merely fluctuated around a steady level. Slight decreases were found after the two hard winters. The January indices for 1983 were lower than the indices for 1981. A slight decrease was noted after the 1970 winter but not after 1979. The decreases were much smaller than in Tufted Duck.

For Long-tailed Duck, national indices were available only for the period 1969–1978. No effect of the one hard winter included could be established. The same applies to regional indices from important areas covering longer periods than the national indices. Eiders are seen only in small numbers on the Baltic coast of Sweden in winter. In the September indices fluctuations around a steady level were indicated, whereas the January indices show fluctuations and some increase during the mild winters.

For Red-breasted Merganser, as in Goldeneye, opposite trends were found in September and January. The September indices decreased markedly after the hard winters. In midwinter lower values were noted after the hard winters of 1970 and 1979 but the differences were not very marked.

The September indices for Goosander are inconclusive, numbers counted being relatively small. Its midwinter indices showed an increasing trend from the start of the counts to the winter of 1979, when there was a marked decrease and indices then remained low. A decrease was also noted after the hard winter of 1970; a clear break in the increasing trend. Indices based on the monthly counts show a marked decrease after the hard winter of 1963 followed by an increase (Nilsson 1976).

For Mute Swan, the September indices showed a marked decrease after the 1979 winter and a smaller decrease after 1982. The January indices show a slight decrease after the 1979 winter, whereas no such decrease was noted after the hard winter of 1970 which caused heavy mortality among swans wintering in Danish waters (Andersen-Harild 1981).

In Whooper Swan *Cygnus cygnus,* a decrease was noted after the 1970 winter and the indices stayed low for a number of years. After the winter of 1979 no decrease was noted.

The most dramatic changes were found in Coot, especially after the winter of 1979 when September indices, which had been high in the early seventies, decreased by 78% and January indices by 80%. A less marked decrease was also noted after the 1970 winter. The January indices also show a marked increase in the population level in the early seventies, with very high wintering numbers in 1976–1978.

Several species show similarities in their fluctuation patterns, with many significant correlations (Table 5). Both for the September and January indices most correlation coefficients were positive but relatively few for September attained significance. Table 5 can be used to construct dendrograms to elucidate the similarities in the fluctuation patterns of the different species (Fig. 3). Both for September and January three groups were obtained but they did not include the same species in both cases.

In January, the diving species formed two distinct groups, largely reflecting differences in diving ability. One group included the three superior divers: Long-tailed Duck, Red-breasted Merganser, and Goldeneye, whereas the other group included Tufted Duck, Goosander, Eider, and Coot. The swans and Mallard had different fluctuation patterns.

The fluctuation patterns in the September indices of Goldeneye and Red-breasted Merganser were also similar and came in the same group as Coot and Mute Swan, all showing marked decreases after the hard winters in the latter part of the study period. The January indices for Tufted Duck and Goosander fell in the same group. The Eider deviated from all other species studied.

Discussion

The data presented above clearly demonstrate the importance of the winter conditions for the populations of waterfowl resting and wintering in south Swedish waters. The general tendency over the seventeen-year period of the midwinter counts was a marked increase in the wintering poulations. For Goldeneye, Long-tailed Duck (to 1978), Red-breasted Merganser, and Mute Swan the trends were significant for the whole period, whereas the Tufted Duck, Goosander, and Coot showed significantly increasing trends up to the cold winter of 1979, after which the indices decreased markedly. The major increase in most populations occurred during the years with mild winters in the early seventies.

The September indices cover only ten years. For some species decreasing trends

Table 5. Correlations between September (lower left corner) and January (upper right corner) indices, respectively.

Species	Mallard	Tufted Duck	Pochard	Goldeneye	Long-tailed Duck	Eider	Red-breasted Merganser	Goosander	Mute Swan	Whooper Swan	Coot
Mallard	1	0.39	–	0.33	0.40	0.35	0.46	0.24	0.28	0.45	0.49
Tufted Duck	–0.06	1	–	0.28	0.30	0.76**	0.39	0.48	0.54*	0.39	0.73**
Pochard	0.61	0.03	1	–	–	–	–	–	–	–	—
Goldeneye	0.46	0.49	0.39	1	0.83***	0.16	0.90***	0.42	0.32	–0.10	0.04
Long-tailed Duck	–	–	–	–	1	0.23	0.78**	0.40	0.16	–0.02	0.14
Eider	0.49	–0.65*	0.30	–0.12	–	1	0.32	0.64**	0.64**	0.06	0.77**
Red-breasted Merganser	0.35	0.30	0.34	0.54	–	–0.37	1	0.45	0.53*	0.18	0.27
Goosander	0.25	0.44	–0.16	0.56	–	–0.15	–0.08	1	0.25	–0.28	0.76**
Mute Swan	0.27	0.76**	0.13	0.75**	–	–0.54	0.77*	0.32	1	0.31	0.35
Whooper Swan	–	–	–	–	–	–	–	–	–	1	0.30
Coot	0.62	0.46	0.23	0.71*	–	–0.14	0.66*	0.57	0.77**	–	1

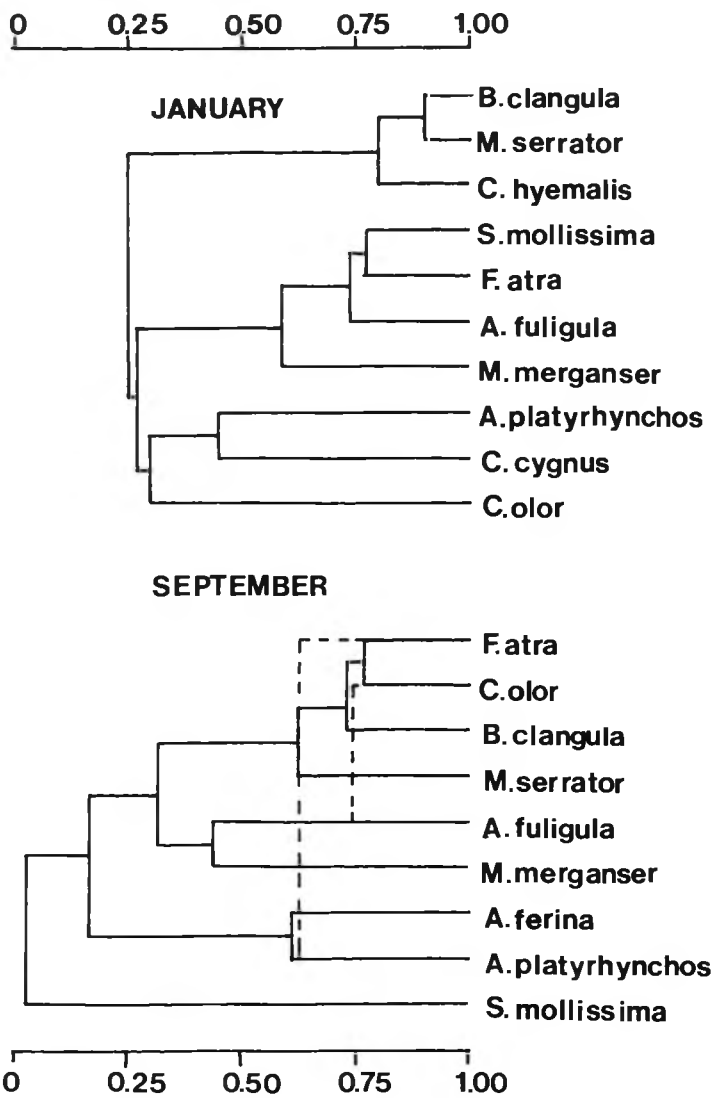


Figure 3. Dendrogram showing similarities in the fluctuation patterns of species for September and January indices based on the correlation matrices in Table 5.

were found, probably only effects of the cold winters during the latter part of the relatively short period. It must, however, be be remembered that the September and January counts in many cases certainly sample different populations.

In Mallard, the indices for the more extensive September counts show a decreasing tendency, but those available for a longer series of counts since 1961 show that the population changes can more properly be described as fluctuations.

In most waterfowl species wintering in Swedish and other north European waters the population levels had probably been markedly reduced during the hard winter of 1962–63. Counts are few from the early sixties, but the restricted monthly samples indicate low population levels for Tufted Duck and Goldeneye followed by an increase during the latter part of the 1960s and especially the earlier part of the 1970s (Nilsson 1976). For Goosander the indices showed a decrease after the 1962–63 winter

followed by a marked increase. Local studies in Skåne show the same pattern (Nilsson 1975b). The populations were probably also held down by the relatively cold winter of 1965–66.

Few annual indices have been published from the international waterfowl counts in other countries. Increasing trends during part of the period considered here were, however, reported for some diving ducks in Central Europe by Bezzel (1972) and Schuster (1975, 1976). Indices for the Mallard showed increasing trends in Czechoslovakia and France (Fiala 1980; Hemery *et al.* 1979), though not in Sweden.

Some differences among the species can be related to their feeding ecology and distribution pattern. All three small diving ducks showed increasing winter indices during the period 1967(1969)–1978. In Tufted Duck a marked decrease was noted after the hard winter of 1979, whereas no such decreases were found in Goldeneye and Long-tailed Duck. In Goldeneye small decreases were noted in the midwinter indices after the hard winters of 1970 and 1982 but the decreases were much less marked than in Tufted Duck. For the September indices differences were smaller between the two species. The Tufted Duck is the least efficient diver of the three and will be the first to encounter difficulties in obtaining sufficient food (Nilsson 1972). Emaciated individuals of Tufted Duck were commonly found along the coasts of south Sweden after the hard winter of 1970.

Pochard *Aythya ferina* also belongs to the small diving ducks and is a much inferior diver, but the species is sparse in south Sweden in winter and thus no January indices can be calculated. In the September indices a marked decrease was found after the 1979 winter.

The Goosanders are mostly found inland or in inshore waters, whereas Red-breasted Mergansers normally feed far out at sea (Nilsson 1972). In relation to this Goosander showed the most marked reductions in the winter indices after the hard winters. Red-breasted Merganser showed the smallest variability in the regional indices. The smallest variability of the indices was noted for Long-tailed Duck, which is the most efficient diver.

The most marked reductions after hard winters were found in Coot, which apparently have great difficulties in finding enough food during cold weather. Its indices also showed the most marked variability of any species studied. Marked reductions were also found in the breeding populations of south Sweden and Denmark after the hard 1979 winter (Brae & Laursen 1980; Svensson 1981). Similarly Fiala (1978) and Cavé & Wisser (1983) reported heavy mortality in Coot after hard winters.

In Mute Swan, decreases were noted after the winters of 1979 and 1982 but not after 1970, although Andersen-Harild (1981) calculated a mortality of 30–35% for Danish wintering swans during this winter compared with the more normal 7–15%. Swans, however, are often fed in many places, certainly offsetting some of the detrimental effects of hard winters.

The winter situation is certainly of importance for Mallard (Nilsson 1983a) but decreases after the hard winters were relatively small. A large proportion of the Swedish wintering population is, however, found on urban waters where they may be fed (Nilsson 1975a).

Hard winters will affect the populations of wintering waterfowl both via direct mortality (Boyd 1964; Andersen-Harild 1981) or via reduced productivity after cold winters (Nilsson 1979). The winter weight of Mallard and Eider was found to influence the future breeding performance (Milne 1976; Owen & Cook 1977).

The fluctuation patterns observed indicate that the winter conditions and especially the availability of food during the winter can be a regulatory factor for several species of waterfowl wintering in northern areas (cf. Lack 1968). During normal and mild winters the available food resources are probably sufficient for much larger populations than normally using them (Nilsson 1980a) and there are large similarities in the diet of the bottom-feeding diving ducks in the Baltic (Nilsson 1972). Ice in hard winters imposes serious limits to the available food resources for the less efficient divers and for the non-diving species. Such species experienced the most marked reductions in their populations after the hard winters, whereas the more efficient divers experienced only little or no extra mortality.

Summary

This paper tries to evaluate the possible influence of hard winters on the populations of waterfowl wintering (at least partly) in the Baltic

on the basis of the international midwinter counts (1967–1983) and September counts (1973–1982) undertaken in south Sweden. Three especially cold winters occurred (1970, 1979, 1982). During the study period most species showed increasing tendencies in the winter indices although the increases ended with the 1979 winter for some species. The hard winters had a marked effect on the populations of some wintering species, being most marked in Coot *Fulica atra* that decreased by 80% after the 1979 winter. In general the least efficient divers experienced the most marked reductions after hard winters. The variability in the indices showed the same relation to diving ability. Winter conditions and especially the availability of winter food can be a regulatory factor for several species of waterfowl wintering in northern areas. During normal winters the food resources are sufficient for much larger populations, but the ice will impose serious limits to the available food resources.

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