September and January counts as a measure of changes in south Swedish Mallard populations

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Introduction

One of the main aims of the midwinter counts of waterfowl species that started in Sweden and other European countries in 1967 was to follow trends in the populations on an international scale in addition to studying distribution patterns (Atkinson-Willes 1976, 1978; Nilsson 1975). Regular counts of breeding waterfowl would be impractical in Sweden, where a large proportion of the different species occur well dispersed both in the archipelagoes and in the vast inland areas, especially to the north. Regular September counts were therefore introduced in Sweden in 1973 to study population changes and trends in the early autumn populations. In Sweden monthly waterfowl counts started in 1959/60 (Nilsson 1976a). In the Mallard *Anas platyrhynchos* enough data were obtained to calculate indices for the different months from 1961/62 onwards.

This paper analyses the annual fluctuations of south Swedish Mallard in early autumn and in midwinter in relation to environmental factors. The Mallard is a partial migrant in Sweden, an appreciable proportion of the population remaining in the country during the winter (Nilsson 1976b; Olsson 1960). In September the vast majority of the Mallard counted are of Swedish origin. According to Olsson (1960) only about 10% of the Swedish Mallard have left the country by this time and only insignificant numbers have come from the north. September counts will accordingly measure changes in Swedish Mallard populations. Wintering numbers and distribution patterns of Mallard in Sweden have been presented previously.

Materials and methods

The methods used in the Swedish waterfowl counts have been described in detail in earlier reports. The northern part of the west coast was covered by Pehrsson (1976). Counts were undertaken along the coasts of south Sweden and in inland Sweden north to and including the provinces of Värmland and Dalarna. Details of the coverage in individual years are found in the regular reports from the project (Nilsson 1981), where weather data are also found. Maps showing the coverage during the main part of the study are found in Nilsson (1975, 1980).

As the counts did not cover all localities in each year, indices were calculated. The totals for each species on all localities counted in the master year and a following (or preceding) year were expressed as a percentage of the total for the master year. The comparisons were then extended to the following (preceding) pair of years, the percentages so obtained being recalculated in relation to the master year = 100. Indices were calculated separately for the different regions and for the national sample. Finally all indices were recalculated with the mean indices for September 1973-1980 and January 1969-1978, respectively, being set to 100, these years being the years with maximum coverage.

Weather data used in the analysis are average values of the monthly means from ten meteorological stations evenly distributed over the south of Sweden.

Results

September and January indices for Swedish Mallard (Fig. 1) show relatively marked annual fluctuations. For September the coefficient of variation (standard deviation as a percentage of the mean) was 22 compared with 16 for January. The regional indices showed higher variability, the means being 38 and 48 respectively. Thus much of the variability cancels out in the national indices.

No significant trends were found in the two national indices over the whole period. In the September indices, the

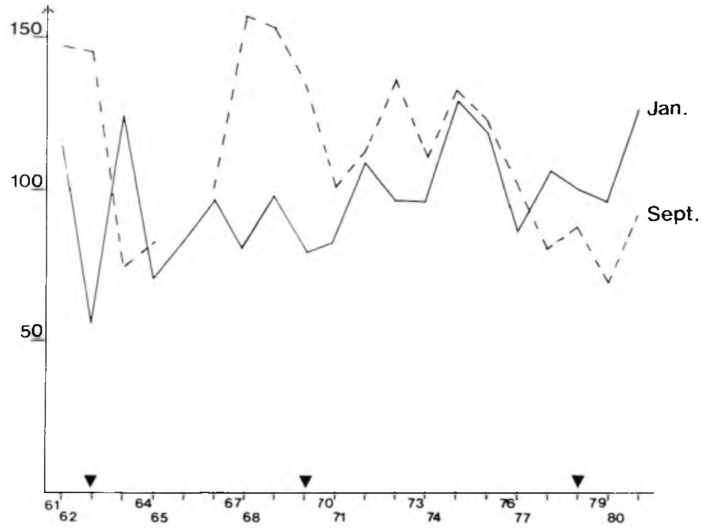

Figure 1. September and January indices for Mallard in south Sweden during 1961/62-1980/81. No September counts were undertaken in 1965. The three hardest winters are indicated by triangles.

period of the more extensive counts during 1973-1980 showed a significantly decreasing trend ($r = -0.77$). The situation could more properly be described as a fluctuating level between 1961 and 1974 followed by a decrease. September indices after the hard winters 1963, 1970, 1979 were markedly lower. September indices did not show any clear relations to the general weather situation during the count period.

The national midwinter indices show a slight but insignificant increasing trend (Fig. 1). The overall indices for the coasts show a highly significant increasing trend, whereas a corresponding decrease was found for the inland localities (Fig. 2). North of Scania lakes are always frozen in January. An increasing trend was noted in these areas for natural waters with a corresponding decrease for urban waters. Inland in Scania no significant trend was found. This change might be an effect of the mild winters during the early seventies, the changed habits being preserved in the more normal winters later.

The highest January indices were noted in 1975, the mildest winter of the series, especially on inland waters. Over the whole period no significant correlations between Mallard indices and winter temperatures could be found except for the coastal waters of Scania ($r = 0.52$). The index for the hard winter of 1963 was the lowest in the period. Indices showed some decrease in the other cold winters, 1970 and 1979, but this was not very marked.

The September indices for the Mallard were significantly correlated with weather factors in the preceding winter and spring (Table 1). Thus the indices were positively correlated with the mean April temperatures for south Sweden (Fig. 3). On the other hand a negative correlation ($r = -0.55$) with mean May temperatures was found in the longer series (Fig. 4) but this correlation was not significant in the shorter series of the actual September counts (Table 1).

For the years with monthly waterfowl counts the combined indices for September-October and August-September-October showed the same relations with weather factors as the September indices. On the other hand indices for October separately did not show any significant correlation with weather factors. October is within the migration period for the Mallard in south Sweden, so the population is mixed with Mallards from other regions.

A mild, early spring was thus followed by high Mallard counts in September. We can compare September indices with the proportion of Mallard remaining on

Table 1. Correlations between national September indices for Swedish Mallard and meteorological factors. Three series of indices are analysed; see text.

Years included	Per cent of yearly maximum on staging areas in April	Mean temperature in preceding Dec-March	April	May	Mean precipitation April	May
61-80 (excl. 65)	–	0.52^{X}	0.56^{X}	-0.55^{X}	–0.09	0.57^{X}
62-74, 67-75	-0.63^{X}	0.38	0.42	-0.73^{XX}	0.15	0.78^{XX}
73-80	–	0.85^{XX}	0.81^{X}	0.56	–0.48	–0.25

x = $P < 0.05$, xx = $P < 0.01$, n.s. = not significant.

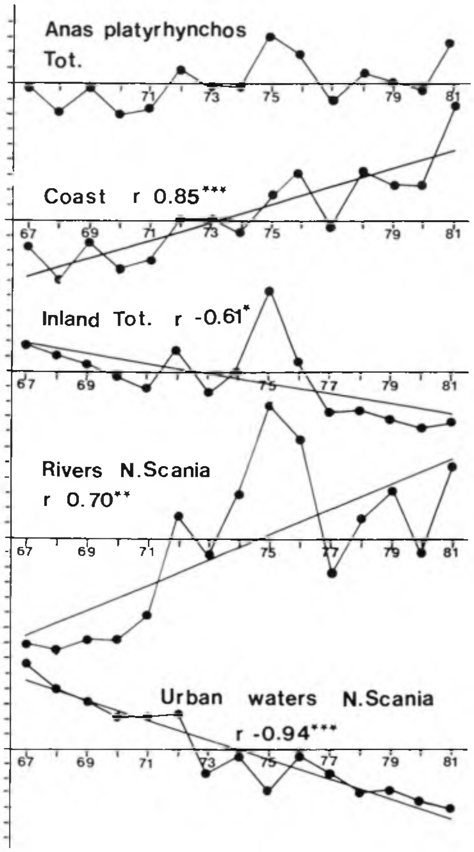

Figure 2. National and regional January indices for Mallard in south Sweden 1967-1981. Mean index for 1969-1978 is 100, the horizontal axis being 10 index units. x = $P<0.05$, xx = $P<0.01$, xxx = $P<0.001$.

staging areas in April (Fig. 5). If an early spring has a positive effect on September numbers a negative correlation is to be expected and was found. A similar correlation was also found for the combined September-October and August-September-October indices, whereas no significant correlation was found with October indices. Numbers remaining on staging areas in spring in relation to annual maximum numbers were significantly correlated with winter temperatures but not with April temperatures (Table 2). High September indices may follow an early spring either because of increased production of young or because breeding is earlier with a resulting earlier gathering of Mallard on the roosting areas in autumn. Comparisons with counts of migrating birds at the Falsterbo bird observatory in southwesternmost Sweden show no relationship between an early spring and an earlier Mallard migration. This question can also be tested by comparing the numbers on the staging areas in August with the numbers on the same places in September. August counts should be higher relative to September counts in a year with a mild spring. However, the opposite correlation was found (Fig. 6). So a higher production of young may be the main effect of early springs.

Another important aspect here is hunting. With an early breeding the immatures are more experienced at the start of hunting in August and will probably survive better during the early autumn.

Mallard indices from the longer series of September counts also showed a significant positive correlation with increasing amounts of precipitation in May (Fig. 7). The high precipitation is probably not important as such but indicates good wetland conditions during the first weeks of life for the young Mallard. Two years deviated from the pattern found: 1974 after an unusually warm April and 1979 after an extremely hard winter. The negative correlation with May temperatures may be because warm and dry weather in May might cause inferior wetland conditions. Nevertheless May tem-

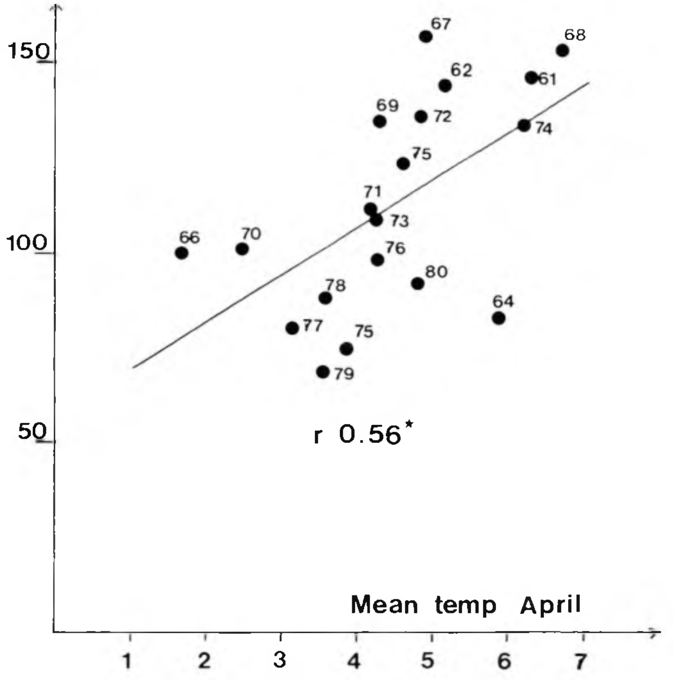

Figure 3. The relation between September indices for the Mallard in south Sweden and mean temperatures for the preceding April. Significance levels as in Figure 2.

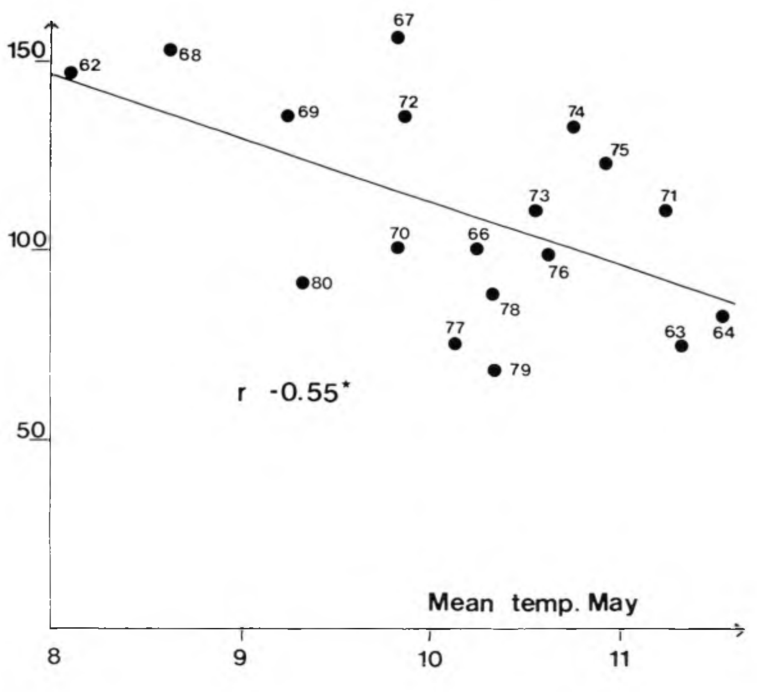

Figure 4. The relation between September indices for Mallard in south Sweden and mean temperatures for the preceding May.

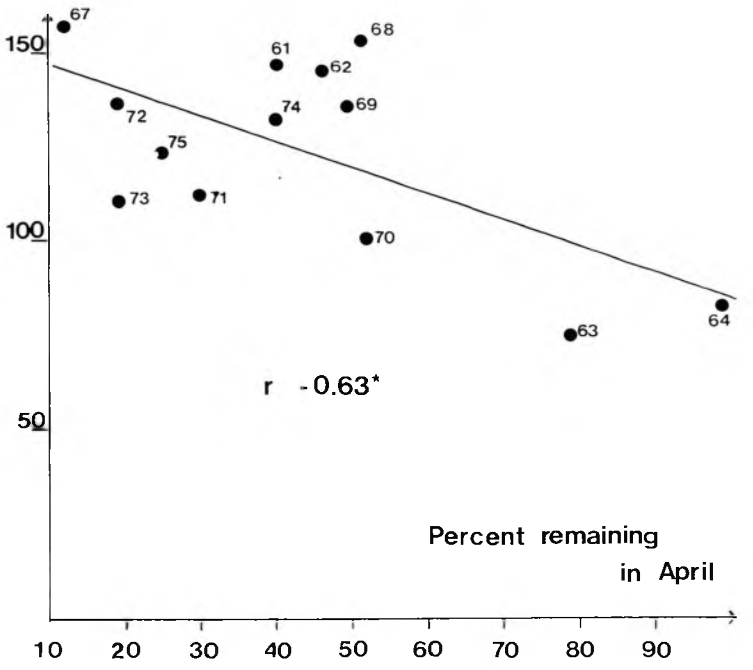

Figure 5. The relation between September indices for Mallard in south Sweden and the percentage (of the yearly maximum) remaining on staging areas in south Sweden in the preceding April.

peratures and May precipitation were significantly correlated with each other (Table 2).

Finally, the indices for the Mallard showed positive correlations with high temperatures during the preceding winter (Fig. 8). Mean temperatures for individual months showed the same correlations with September indices as the overall means for December-March. A similar relationship with winter temperatures was also found when comparing changes in the September indices with the strength of the intervening winter (Fig. 9). Mean temperatures in June, precipitation in April and June did not yield any significant correlations.

Besides the simple correlations discussed above, multiple regression analysis was undertaken for the eighteen-year period 1962-1980 (excluding 1966). Mean temperatures for December-March, April, May and mean precipitation in May were found to account for 40% of the variation in September indices, whereas mean temperatures in April and precipitation in May accounted for 25% (Table 3).

Another multiple regression analysis was undertaken for the twelve seasons with data on the percentage of Mallards remaining on staging areas in April, this factor being added to the factors studied in the previous run. In this case the five factors accounted for 88% of the variation in the September indices. The three factors mean temperature in April, percentage remaining on staging areas in April and mean temperatures in May accounted for 85% of the variation.

When comparing January indices with these same climatic factors, no significant correlations were found. This could be expected as the winter indices are very dependent on the situation during and before the actual count period and as the population is of mixed origin.

Discussion

The number of waterfowl counted on staging and wintering areas will be affected by the strength of the breeding population, the annual production of young, changes in the pattern of migration in relation to climatic factors and mortality prior to the count. Thus marked annual and seasonal variations are to be expected in such counts and the indices based on them. The effect will, however, not be so marked in national indices as in regional indices.

Because of the influence of the weather on the distribution of waterfowl populations and thus on the indices, it is clear that the detection of genuine trends in the populations will require fairly long periods of counts.

In the Mallard the Swedish midwinter indices were found to be markedly affected by weather conditions. Hardweather movements occur and movements to and from urban areas have been documented in several studies (e.g. Hansson 1966).

The midwinter indices will thus not be a true indicator of annual changes in the Swedish Mallard population. The September indices, on the other hand, are less affected by weather and are thus more suitable. Both indices might, however, reveal long-term trends.

The September indices were found to be correlated with several weather factors in the period prior to the counts. Thus a significant correlation with high temperatures in south Sweden in April was found. Moreover, high September indices were noted after an early departure of Mallard from the staging areas in south Sweden.

That a mild spring will cause earlier nest initiation has been reported for the Mallard (Fiala 1972; Newton & Campbell

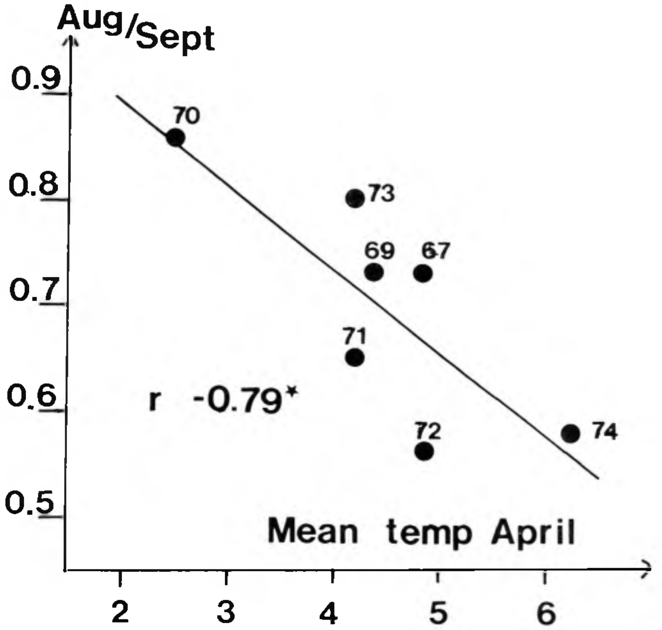

Figure 6. The ratio between August and September counts of Mallard in south Sweden in relation to the mean temperatures in the preceding April.

Table 2. Correlations between the different weather factors and the percentage of Mallard remaining on staging areas in April.

		Factor				
		1	2	3	4	5
1.	Mean temperature April	1.00				
2.	Per cent remaining on staging areas in April	0.13	1.00			
3.	Mean temperature May	−0.17	0.23	1.00		
4.	Mean temperature Dec-March	0.37	−0.66^{XX}	0.16	1.00	
5.	Precipitation May	0.19	−0.33	−0.78^{XXX}	0.13	1.00

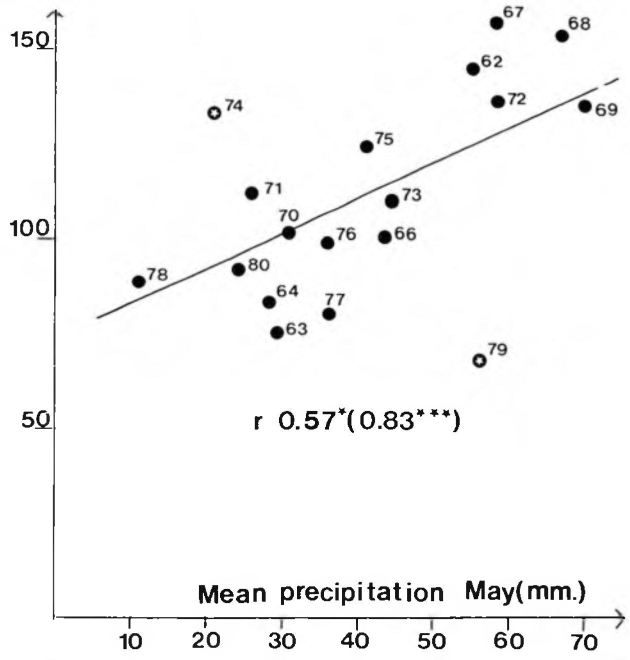

Figure 7. The relation between September indices for Mallard in south Sweden and mean precipitation for the preceding May. A markedly higher correlation coefficient is obtained when 1974 (warm April) and 1979 (cold winter) are excluded.

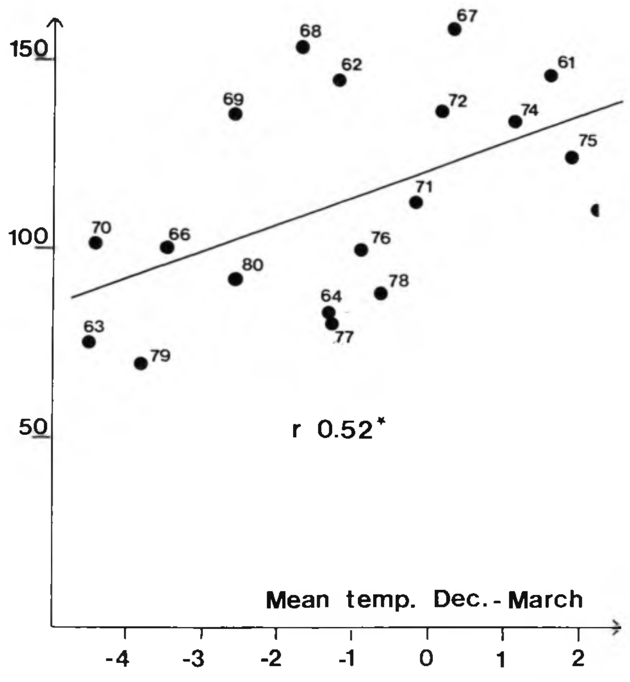

Figure 8. The relation between September indices for Mallard in south Sweden and mean temperatures for the preceding winter (December-March).

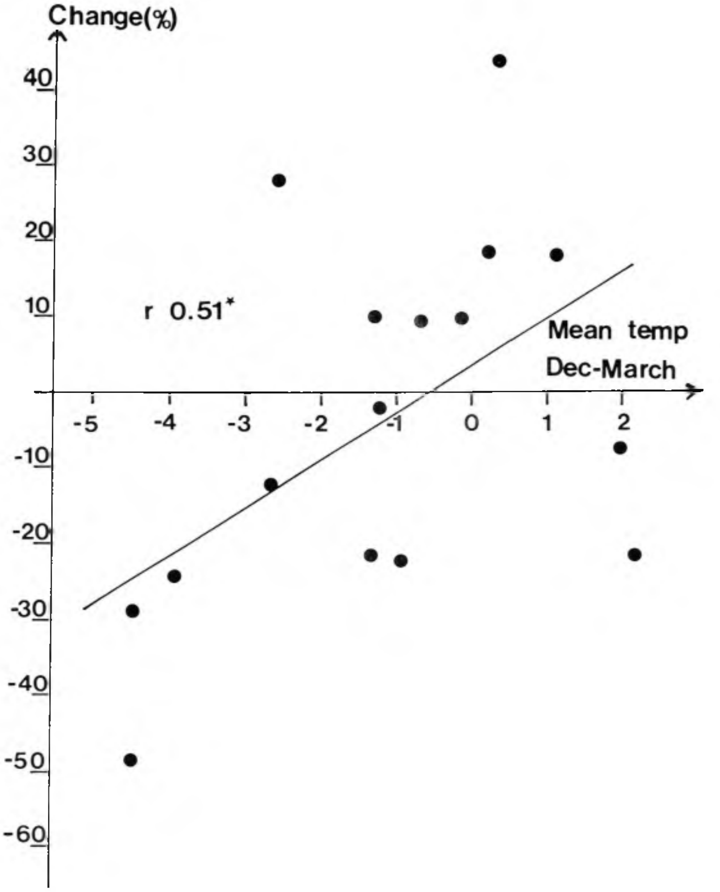

Figure 9. The relation between the change in September indices for Mallard in south Sweden between two years and mean temperatures for the intervening winter (December-March).

1975; Langford & Driver 1979), the Goldeneye *Bucephala clangula* (Eriksson 1979) and the Long-tailed Duck *Clangula hyemalis* (Pehrsson 1976). However, the start of egglaying is probably not related to the clutch size in most waterfowl species (Hildén 1964; Bengtsson 1971; Eriksson 1979). Nor did the laying data influence the proportion of breeding adults or hatching success in the Goldeneye (Eriksson 1979).

An earlier start of breeding may affect the future survival of the young, as early-hatched young gain more experience before the start of the hunting season. Fiala (1972) noted higher breeding populations of Mallard after a year with a mild spring in Czechoslovakia. Bengtsson (1972) on the other hand concluded that population changes at Lake Myvatn, Iceland, were not correlated with variations in reproductive success.

In the Mallard, September indices were also correlated with the amount of precipitation in May. The condition of the wetlands in spring will be important for the production of young in various waterfowl species (Schroeder et al 1976; Calverley & Boag 1977) and a high water level will offer better feeding conditions for the females and especially for the newly hatched young. Nichols et al (1982) reported some evidence for an effect of habitat quality on future survival in the Mallard.

The nature of the winter will influence future September indices directly via winter mortality or indirectly via the influence on production of young. A link between winter weight and the future breeding performance in waterfowl was established by Milne (1976),

Table 3. Multiple regression analysis of Mallard September indices on mean temperatures in December-March, April, May, mean precipitation in May and the percentage remaining on staging areas in April.

Years	Independent factors included Mean temperatures Dec-March	April	May	Mean precipitation May	Per cent remaining staging areas April	Multiple Correlation Coefficient
62-64	n.s.	xxx	n.s.	xxx	–	0.65xx
	n.s.	xxx	–	xxx	–	0.61xx
	–	xxx	–	xx	–	0.51xx
62-64, 67-75	n.s.	xx	xx	n.s.	xxx	0.94xx
	n.s.	xx	xxx	–	xxx	0.94xxx
	–	xx	xxx		xxx	0.92xxx
	–	–	xxx	–	xx	0.77xx

see also Owen & Cook (1977). Moreover, Nilsson (1979) found a significant correlation between winter temperatures and the future production of young in the Whooper Swan.

Severe winter weather will cause heavy mortality among wintering waterfowl (Boyd 1964). Andersen-Harild (1981) calculated a mortality rate of 30-35% for Danish Mute Swans during the hard winter of 1969/70 compared with 7-15% in more normal winters. Similarly, marked decreases in the indices were found for several species after the hard winters. In the Mallard, Ogilvie (1982) reported an increased hunting mortality in the hard winter of 1978/79. In Sweden no hunting of Mallard is allowed at this time of the year but an appreciable proportion of Swedish Mallard migrate to areas where winter hunting is allowed.

Acknowledgements

The study was undertaken at the Department of Animal Ecology, University of Lund, Sweden. Financial support was obtained from the National Swedish Environmental Protection Board. My sincere thanks are also due to the large number of duck counters making the study possible.

Summary

The paper analyses annual indices for Mallard *Anas platyrhynchos* in south Sweden based on the International Waterfowl Counts in Sweden in January 1967-1981 and a similar series of September counts in 1973-1980. Smaller samples for the same months were available from the monthly waterfowl counts in Sweden since 1961/62. Indices were compared with meteorological factors that might be of importance for measuring the breeding conditions for the species.

No trends were noted for the Mallard populations in south Sweden although there was a redistribution in wintering Mallard from urban to natural waters. January indices showed marked fluctuations in relation to weather conditions in the actual winter. September indices (measuring Swedish populations) were correlated to factors in the preceding winter and spring. Thus a mild winter followed by an early spring and an early departure from staging areas and a high precipitation in May (indicative of good wetland conditions) often led to high September counts for the Mallard in south Sweden.

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