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## AN ISOLATED POPULATION OF *CYGNUS OLOR* IN SCOTLAND

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### Introduction

This paper presents a preliminary report on certain aspects of a study of *Cygnus olor,* begun in 1978, in the Outer Hebrides, Scotland. The main objective of the research project is to understand the processes underlying the regulation of numbers in a natural wild population.

Jenkins *et al* (1976) suggested that the numbers of adult *C. olor* were fairly constant between seasons, that an August peak might be due to a temporary immigration to the islands of 200 birds to moult, and that the constancy both of numbers of breeding pairs (around 86) and of adult non-breeders between seasons was due to regulation of numbers through social behaviour in relation to food supply. The population, unlike others studied in Britain recently, appeared to be stable, not declining in numbers, despite a low breeding output each year. Further-

more, being in a relatively isolated area, there was the possibility of being able to gather very complete data on population processes and their controls. Another important aspect is that although the population is an introduced one, dating back no further than the latter half of the 19th century (Harvie-Brown and Buckley 1888), it has never existed in close proximity to man as have populations studied elsewhere in Britain. It is essentially therefore a natural population, relying little on man's activities for its survival.

## Study area

The Outer Hebrides are a group of islands, approximately 210 km in length, situated in the North Atlantic, some 50 km west of the Scottish mainland (Fig 1). Resident *C. olor* does not occur on the islands north of the Sound of Harris, nor south of Barra, and the study area is restricted to the island group of Uist and Benbecula. The nearest other breeding populations (Sharrock 1976) occur on the Isle of Tiree (80 km southsoutheast) and on the mainland around Loch Ewe (100 km eastnortheast).

The islands are composed almost entirely of Lewisian gneiss, overlain by peat deposits. Barra and South Uist are partially mountainous but the rest of the area is predominantly low-lying, with acid peat moorland and hundreds of lochs which vary greatly in size. Along the western seaboard, however, wind action has deposited a layer of calcareous marine shell-sand, which overlies the gneiss forming a narrow fertile coastal plain known as 'machair' (Ritchie 1976, 1979) (Fig 2).

The machair is used for cereal cultivation, while the less fertile 'blackland' area, lying between the machair and the peat moorland, is used for cattle and sheep grazing and the growing of potatoes and hay (Caird 1979). Little fertilizer is used, though shell-sand is occasionally spread on the blackland areas to improve grass production. There are no large urban concentrations or sewage outfalls and the *C. olor* population, unlike many others in Britain, lives with minimal assistance or interference from man's activities in an environment comparatively little altered by modern development.

Three categories of freshwater lochs can be identified on the Uist, on the basis of their water chemistry and vegetation (Waterston and Lyster 1979). The vast majority can be classed as oligotrophic, acidic peat lochs, very low in terms of biological productivity. These moorland lochs have pH values generally well below 7, and both conductivity and alkalinity are also very low, the latter below 10 mg/l $CaCO_3$ (Waterston *et al* 1979). The vegetation is characterized by an open *Littorella-Lobelia* association (Spence 1964) and is generally sparse, except in sheltered areas of silt where larger swards of *Myriophyllum alterniflorum, Isoetes lacustris* and *Potamogeton natans* may occur.

The machair lochs are quite different, being shallow areas of water, wholly or

partially lying on shell-sand, and with high pH and alkalinity values. Alkalinity in these eutrophic lochs is generally greater than 25 mg/l $CaCO_3$ and may be as high as 100 mg/l or above, with pH values always greater than 7. The vegetation, especially in sheltered areas, may be extremely luxuriant, with the *Chara aspera-Potamogeton filiformis* association (Spence 1964) dominant. *Potamogeton gramineus* and *P. perfoliatus* may also occur in dense stands, with *Hippuris vulgaris* and *Myriophyllum spicatum* in nutrient-rich areas.

Lying between these two extremes are the lochs of the blackland area, which can be classed as mesotrophic. These lochs occupy an intermediate position, both geographically and in terms of productivity, between the acidic peat lochs and calcareous machair lochs (Spence *et al* 1979), and their conductivity, alkalinity and pH values reflect this. The *Chara aspera-Potamogeton filiformis* association is missing, but extensive beds of *Potamogeton perfoliatus, P. natans* and *P. gramineus* may occur.

A fourth category of loch can be identified on the Uists, as there are certain areas of shallow brackish water which are also regularly used by swans. Lochs in this category include both those under regular tidal influence and those which only occasionally receive a direct intrusion of sea water at extremely high tides. PH, conductivity and alkalinity vary considerably, but are generally much higher than found in the mesotrophic freshwater lochs. In sheltered and shallow silty locations dense stands of *Ruppia spiralis, R. maritima* and *Zostera marina* occur, with *P. pectinatus* and other euryhaline species distributed according to salinity tolerance and exposure.

## Development of methods and techniques

### *Population censuses*

Previous censuses (Jenkins *et al* 1976) have involved counting swans only on lochs accessible from the roads, concentrating on the machair and certain saline lochs, and were carried out within a two to three day period at the beginning of each month. The present study, however, has involved a series of complete surveys of the islands, though less often, visiting all lochs, except some of the remote oligotrophic ones, either by car or on foot. Such is the nature and extent of the study area, however, that it proved impossible, in the absence of aerial censuses, to check all water bodies on the island in less than ten days and frequently bad weather extended this time.

Accuracy of this counting method has been checked in a number of ways to ensure birds were not missed or counted twice. Financial and logistical constraints precluded the use of complete aerial censuses, but whenever possible ground counts were checked using aerial photography and the remote and inaccessible areas rapidly censused from the air as well. Such flights were used in particular to census

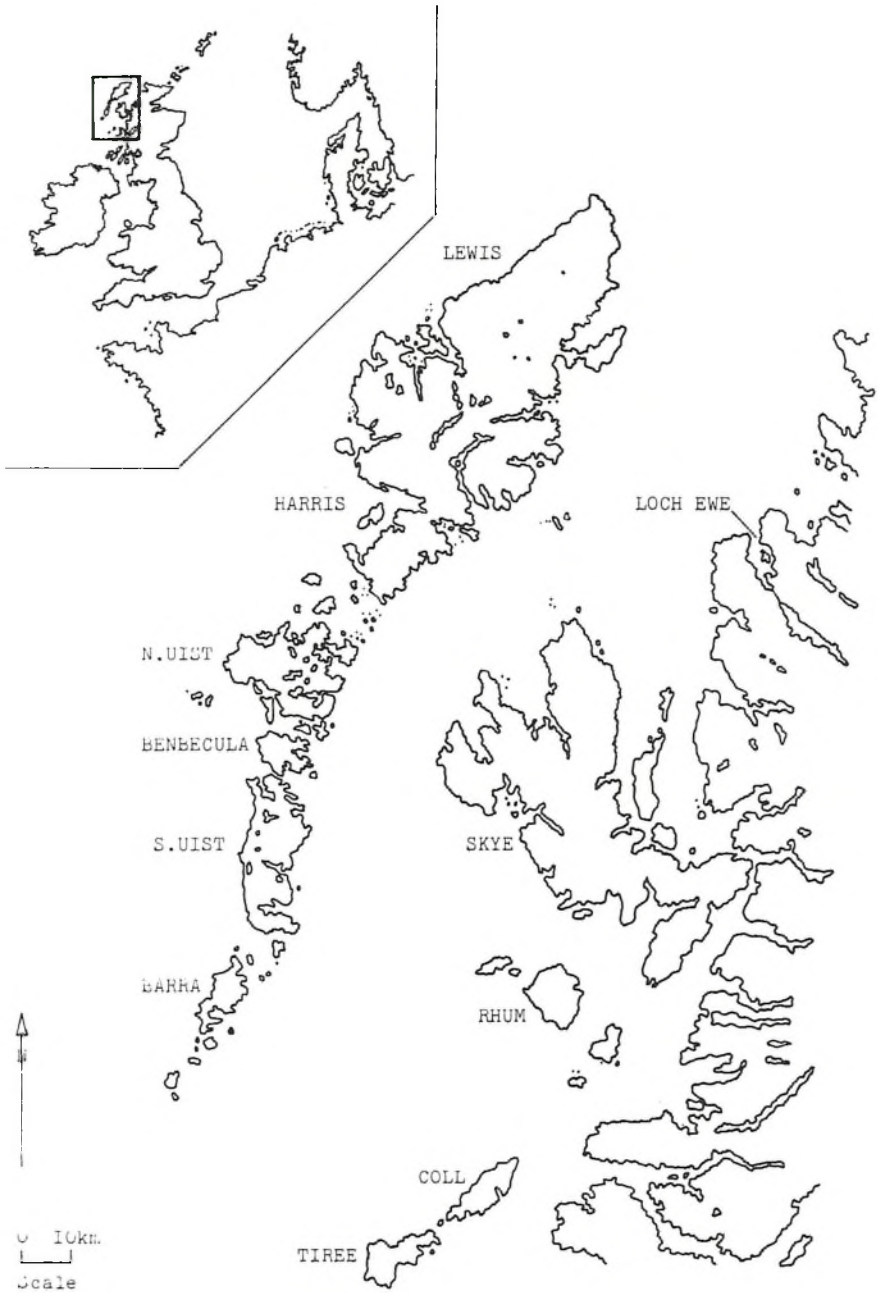


Fig 1. The Outer Hebrides.


Fig 2. The study area within the Outer Hebrides.

the main non-breeding flocks on Loch Bee (South Uist) and Loch an Duin (North Uist) and to compare the numbers counted with figures obtained from ground counts (Table 1). Possible misidentification of *Cygnus cygnus cygnus* was a problem in the aerial counts.

Table 1. Comparison of aerial and ground censuses.

Number of adult swans counted in two flocks.

| | Ground census | Aerial census | Dates |
|---|---|---|---|
| Loch Bee | 224 | 248 | 15/13 December 1978 |
| Loch Bee | 204 | 211 | 14/16 February 1979 |
| Loch an Duin | 91 | 93 | 19/16 February 1979 |
| Loch an Duin | 90 | 85 | 19/13 March 1980 |

The counting method was also checked against another ground census technique by comparing the results of the usual autumn and winter censuses in 1979 with the results obtained by ten teams of observers covering the whole study area on one day (Table 2). A number of birds, mainly cygnets, were certainly missed by the teams of counters on 18 November, and some confusion with *C. c. cygnus* was also possible. Despite very bad weather conditions on 18 November, though, the numbers recorded by the two methods are remarkably close.

Table 2. Comparison of ground census techniques

| | | | |
|---|---|---|---|
| 13–26 September 1979 | 754 adults | 179 cygnets | – autumn census |
| 18 November 1979 | 743 | 112 | – ten teams of observers |
| 30 November–11 December 1979 | 738 | 152 | – winter census |

Where possible, the identity of all marked birds was recorded. The repeat sighting of a marked bird in the same census occurred so rarely that counting the same individuals twice in different locations is not considered to have affected the accuracy of the census technique. The possibility that certain birds were missed at each census remains. However, aerial surveys did not locate swans in areas where they were not expected, and the general consistency between the total numbers recorded in sequential censuses, rather than large random fluctuations, does not suggest this to be the case either.

## Catching and marking

It has not been possible to catch breeding swans at the nest site, as the Hebridean

birds, unlike most others in Britain, are extremely wary and do not stay to defend their nest, swimming away quickly when approached. Instead, adult birds have been captured during the moult period in July/August, when they are flightless, and cygnets caught in early October just prior to fledging. The autumn catching effort has been primarily directed at non-breeders and failed breeders gathered in moulting flocks, though a certain number of successful breeding adults, which moulted on territory, have also been caught. During 1978, 283 cygnets and 91 cygnets were ringed, with a further 47 adults and 130 cygnets in 1979.

Birds in the moulting flocks were caught by using teams of people on the bank, in canoes and in inflatable dinghies to herd the swans into temporary pens erected at the water's edge. This technique works best on small or confined water bodies and was only partially successful on the main loch used by moulting swans, Loch Bee, as it is so large. Cygnets were caught from a small inflatable dinghy fitted with an outboard engine, the catcher standing in the bows with a swan-hook while his assistant manoeuvred the boat.

All birds handled were weighed, aged, sexed and ringed, in addition to having measurements made of wing-, skull- and tarsus-length. Traditional plastic colour leg-rings were considered to be of little use as a marking technique, as they could not be identified at the distances to which the wary Hebridean swans could be approached. Instead, 330 adults and 162 cygnets have been marked with specially made and engraved plastic neck-collars, a technique not in use elsewhere in Britain, though widely used in America and some other countries.

The neck-collars were made at Aberdeen University, having been tested initially on tame birds kept at the Zoology Department's field station. In specification they follow broadly the outlines set in the IWRB Swan Research Group's Technical Note No 5 (Sept 1972). The collars are made of triple laminate 1.5 mm thick yellow 'Darvic' and weigh c 34 gm each (0.3% of the body weight of an adult *C. olor).* They are 8 cm high x 23 cm in length, with the ends overlapped to give an internal diameter of 6 cm and the overlap glued using the plastic manufacturer's recommended PVC solvent cement. A three-digit combination of two letters and one number is engraved in black three times vertically around the collar, the individual digits being 23 mm high. Under favourable conditions they can be read at distances up to 600 m.

## Results

### *Total population*

The number of *C. olor* recorded in the study area for the two years 1978 to 1980 is shown in Table 3. Until December most young birds remained with their parents and so cygnets could be easily censused. Soon afterwards, however, they left their natal territories and dispersed widely, eventually joining the non-breeding flocks.

Table 3. Total population counts.

| | 1978 Full-grown | Cygnets | 1979 Full-grown | Cygnets |
|---|---|---|---|---|
| April | 892 | | 838 | |
| May | 943 | | 770 | |
| June | 948 | +267 | | |
| July | | | 753 | +216 |
| August | 889 | +218 | | (+194) |
| September | | | 754 | +179 |
| October | | (+182) | | (+174) |
| November | | | | (+158) |
| December | 845 | +156 | 738 | +152 |
| | 1979 | | 1980 | |
| January | | | | |
| February | 820 | | | |
| March | | | 820 | |

During this period they gradually lost their brown juvenile colouring, so they were not separated from adults from January onwards.

The total population of full-grown swans in the Uists peaked at 948 in June 1978 and fell to 838 in April 1979 following severe winter mortality. The actual total fell from 1001 swans (of all ages) in December 1978 to 820 in February 1979. The total then stabilized at around 750 birds for the rest of the year, rising again to 820 by March 1980 with the inclusion of young birds in the total once more.

Immatures and non-territorial adults were found in two main flocks. That on the complex of saline lochs centred on Loch an Duin and Loch an Strumore (North Uist) regularly held over 100 birds, except during the winter 1978/79, when all but a small part of the loch was frozen (Fig 3). In addition mid Loch Ollay (South Uist) regularly held high numbers during the moult period, including many birds that had come from the non-breeding flock on Loch Bee, although birds also remained to moult on Loch Bee itself. Other moulting flocks occurred on Loch Grogary (North Uist) with a maximum of 43 birds in July 1978, and Loch Bhruist on the Island of Berneray, maximum 47 birds in August 1978. At other times of the year, like Loch Ollay, these two lochs had few, if any, swans.

Both Loch Bee and Loch an Duin are brackish water lochs and this is reflected by the fact that at all times of the year the majority of swans were found on lochs which have a saline influence (Table 4). Eutrophic machair lochs were important during winter, though numbers did not vary greatly, whereas mesotrophic lochs were important only during late summer. Oligotrophic lochs, despite their great

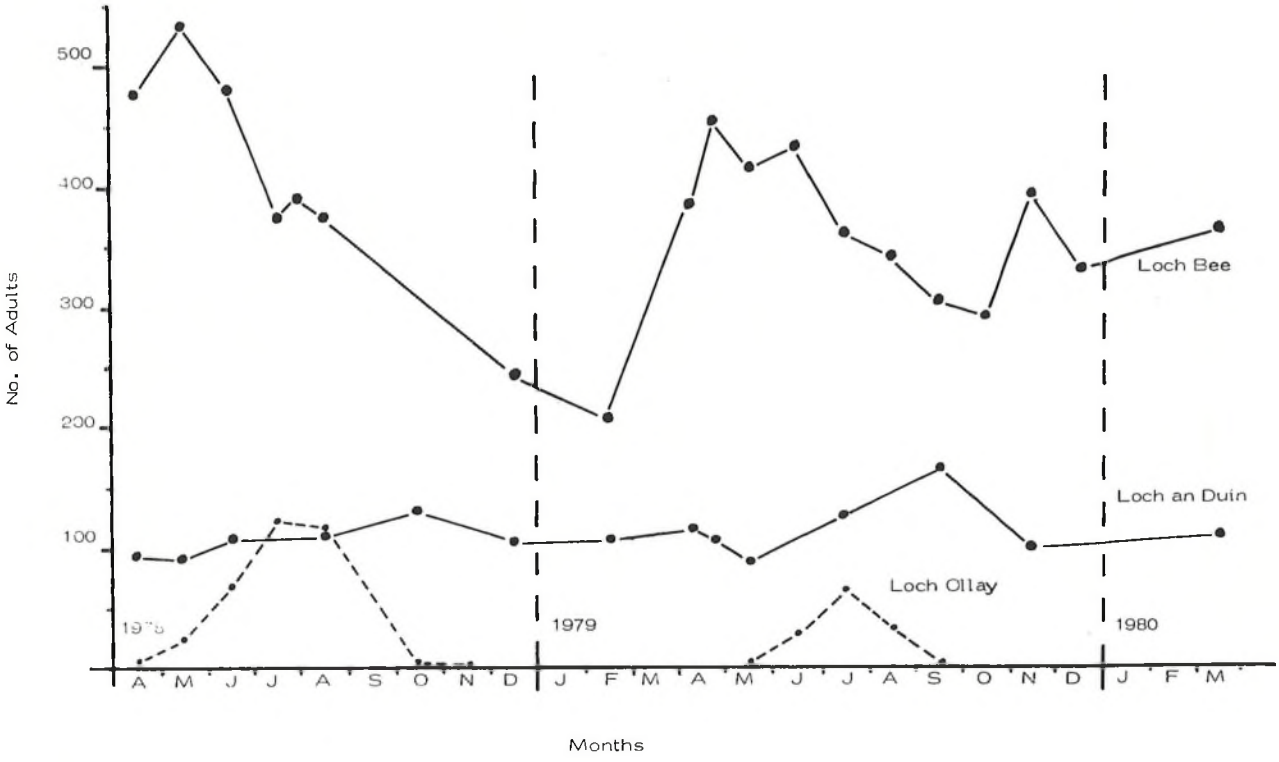


Fig 3. Numbers of adult *Cygnus olor* on three selected lochs.

Table 4. Dispersion of full-grown *Cygnus olor* in relation to loch type (as % of total population).

| Date | | Brackish | Eutrophic | Mesotrophic | Oligotrophic | Total numbers |
|---|---|---|---|---|---|---|
| April | 1978 | 78.7 | 10.5 | 9.6 | 1.1 | 892 |
| May | 1978 | 76.6 | 9.8 | 12.9 | 0.7 | 943 |
| June | 1978 | 71.4 | 12.8 | 15.0 | 0.6 | 948 |
| August | 1978 | 62.5 | 15.5 | 22.0 | – | 889 |
| December | 1978 | 76.2 | 15.4 | 8.4 | – | 845 |
| February | 1979 | 75.7 | 18.1 | 6.0 | 0.2 | 820 |
| April | 1979 | 80.8 | 9.9 | 8.0 | 1.3 | 838 |
| May | 1979 | 79.6 | 11.1 | 8.1 | 1.2 | 770 |
| July | 1979 | 74.4 | 9.2 | 15.9 | 0.5 | 753 |
| September | 1979 | 76.7 | 13.1 | 9.8 | 0.4 | 754 |
| December | 1979 | 80.7 | 16.1 | 3.2 | – | 738 |

abundance, were hardly utilized at all.

*Breeding population*

A complete survey of the study area was undertaken from the air and from the ground during April and May each year to locate territorial pairs of swans. Not all pairs nested each year, about 12% apparently failing to build a nest and lay eggs, though it is possible that nests which were destroyed or deserted early in the season might have been missed. Wherever possible, clutch size, hatching and fledging success were also recorded and details are given in Table 5.

Table 5. Breeding of *Cygnus olor* in the Uists.

| Number of territorial pairs | % of total population | Number of nesting pairs | % of total population | Clutch size | % nests hatching | % nests fledging | Young fledged per nesting pair |
|---|---|---|---|---|---|---|---|
| 1978: 163 | 35% | 143 | 31% | 6.17 (n = 52) | 56% | 34% | 1.22 |
| 1979: 116 | 27% | 102 | 24% | 5.66 (n = 68) | 65% | 49% | 1.74 |

The density of breeding pairs is extremely high, with 1 nesting pair/5.4 $km^2$ in 1978 (1 territorial pair/4.7 $km^2$). The actual density of pairs on North Uist, Benbecula and South Uist alone, excluding offshore islands, is 1 nesting pair/4.7 $km^2$, nearly twice as dense as the highest density recorded in any area in Britain during the 1955 *C. olor* census (Campbell 1960) and four times as great as the density recorded in the Midlands during the 1960s (Minton 1968). These figures are even more impressive when one considers that several parts of the study area are mountainous and the majority of the low-lying ground is acid peat moorland. Breeding pairs were not colonial, though in 1978 four pairs attempted to nest on two islands in a small eutrophic loch of only 6 ha, and in both years the minimum distance recorded between any two nests was only 30 m.

The number of breeding birds as a percentage of the total population, however, is low compared with figures from other studies in Britain. Returns from the 1955 census (Rawcliffe 1958; Campbell 1960) give an estimate of 3500 to 4000 breeding pairs in Britain with another 11 000 non-breeders, indicating that about 40% of the total were nesting pairs, compared with only 24% to 31% in this study. Minton (1968) in a more detailed study in the Midlands reported that nesting pairs made up 39% of the population in 1966. At the same time the percentage of territorial pairs was 57% (Minton 1971).

Data from the two years of the present study show differences in almost every aspect of breeding biology examined and it is therefore very difficult to comment. Breeding success, however, was very much better in the second year, when, despite a 29% drop in the number of nesting pairs and a drop in clutch size, hatching and fledging success improved and the total number of cygnets alive at the end of each year was similar (156 vs 152). The mean number of young fledged per nesting pair, even in the better year, is still very low in comparison with other studies in Britain, eg 2.0 per breeding pair, Perrins and Reynolds (1967), Minton (1968); 2.3, Eltringham (1966); 2.4, Cramp (1957); 2.9, Reynolds (1965).

However, comparison of the breeding success of pairs nesting on different types of loch showed that there were marked differences in the production of young (Table 6).

Table 6. Breeding success in relation to loch type (1979 data only)

| | Eutrophic (Machair) | Mesotrophic | Brackish | Totals |
|---|---|---|---|---|
| Number of pairs | 20 | 10 | 68 | (98) |
| Clutch size | *6.31 (n = 16) | *4.75 (n = 8) | 5.49 (n = 43) | 5.66 |
| % nesting pairs that hatch at least 1 cygnet | 90% | 70% | 56% | 65% |
| % nesting pairs that fledge at least 1 cygnet | *80% | 50% | *41% | 49% |
| Number of cygnets fledged per nesting pair | 3.00 | 1.40 | 1.44 | 1.74 |
| Mean weight of cygnets at fledging (October) | 8.00 kg<br>11 broods<br>40 cygnets | 6.3 kg<br>5 broods<br>12 cygnets | 8.1 kg<br>21 broods<br>71 cygnets | |

* Significant at P = 0.05.

In both years birds nesting on the eutrophic machair lochs did considerably better than those using other habitats. Differences in clutch size between eutrophic and mesotrophic nests were statistically significant in both years. In 1979 there was also a statistical difference between the percentage of nesting pairs that fledged at least one cygnet on eutrophic and brackish water lochs. Differences in clutch size may possibly be related to weight and condition of the female in early spring, whereas differences in fledging success could be due to laying date, egg quality, feeding conditions for cygnets or parental care.

The majority of nests sites were on islands (75% in 1978, 81% in 1979) with inaccessible sites in reedbeds accounting for a further 6% each year. The remaining sites were along the edges of lochs, many on promontories and all close to the

Table 7. Hatching success in relation to nest site location (1978 data only).

| | Nest site | | | |
|---|---|---|---|---|
| | Islands | Reedbeds | Bankside | Total examined |
| Number of nests | 104 | 9 | 26 | 139 |
| % nests hatching at least 1 cygnet | 55% | 78% | 54% | 56% |

water. Had human interference been an important cause of clutch losses, as reported elsewhere (Minton 1968), one might expect hatching success to be lowest in these easily accessible nests. In fact, there was no statistical difference between hatching success at the three different nest sites in either year (Table 7).

*Movements and mortality*

A total of only eight birds out of 551 ringed on the Uists during 1978 and 1979 has been reported from areas outside the study area. Seven of the eight were identified by their collar codes and are of known age. The collar of the eighth, a bird reported on the Isle of Tiree in April 1980, was not read.

All seven identified birds were immatures, having left the study area in their second calendar year. One bird hatched in 1979 had moved only 15 km north on to South Harris in January 1980; three cygnets hatched in 1979 moved as a group 85 km northnortheast on to Lewis during April 1980; two birds, both in their second winter, were recovered dead on Tiree (80 km southsoutheast), one each in the winters of 1978 and 1979; the longest movement involved a bird hatched on South Uist in 1978, which was reported on the Scottish mainland, 190 km southsoutheast, on the Mull of Kintyre in July 1979. It remained there until at least November 1979 and then in April 1980 it was reported near Port Stewart, County Derry, in Northern Ireland (a further 110 km southsouthwest and 225 km south from its ringing site), the first record of any *C. olor* moving from Britain to Ireland.

Table 8. Recovery distances of swans found dead within the study area.

| | Distance moved from ringing site (km) | | | | | | Mean distance |
|---|---|---|---|---|---|---|---|
| | 0–1 | 2–5 | 6–10 | 11–20 | 21–50 | 50 | |
| Cygnets (n = 30) | 15 | 8 | 2 | 3 | 2 | 0 | 4.7 km |
| Adults (n = 43) | 7 | 20 | 6 | 8 | 2 | 0 | 6.7 km (♂6.5, ♀7.1) |

The recovery distances for swans found dead within the study area are shown in Table 8. 'Cygnets' are birds recovered within one year of fledging, while adults refer to all full-grown birds (minimum age two years) caught in moult flocks during 1978. This latter class includes a number of failed breeders which moult in the flocks, as well as non-breeding swans. Four adults ringed as breeding birds on territories have also been recovered. All were reported during winter icing of their territorial waters and had hit electricity cables nearby (mean distance of movement 2.5 km).

The pattern of recoveries follows closely those observed by Ogilvie (1967) and Minton (1971), with very few movements over 50 km, though to a certain extent the shape and size of the study area precludes much longer movements. No adult birds have been reported outside the study area at all, the only movements over 50 km involving six birds all in their second year, the age at which *C. olor* is most prone to wandering (Minton 1971). Collared swans are conspicuous and it is unlikely that many are leaving the islands undetected, as most of their likely destinations (Tiree, Rhum, Skye, Harris and Lewis) are being regularly checked.

Sightings of collared birds within the study area have shown that internal movements can be accounted for by the dispersal of juvenile birds from their natal territories to join the non-breeding flocks, by the movement of adults to and from the flocks, especially during the moulting period and in severe winter weather, and by the short term movements of paired birds prospecting for territories. Such movements are similar to those observed in the Midlands (Minton 1971) and the population therefore appears to be essentially a closed one, though a certain amount of emigration of immature birds may occur. Because of their size and conspicuousness, dead swans are easily discovered and a large number, including many collared ones, have been reported dead. The monthly distribution of deaths (Fig 4) shows a heavy concentration during winter 1978/79, with most birds having died between late December and April, similar to that reported by Ogilvie (1967). There is no indication of any tendency for more deaths to have occurred in spring and autumn than in summer and mid-winter, as suggested by Perrins and Reynolds (1967), although the number of deaths in summer is very low. However, the winter of 1978/79 was severe, even in the usually relatively mild maritime climate of the Outer Hebrides, with much icing of lochs, and the mortality pattern may be rather different from more normal years (Boyd and Ogilvie 1964).

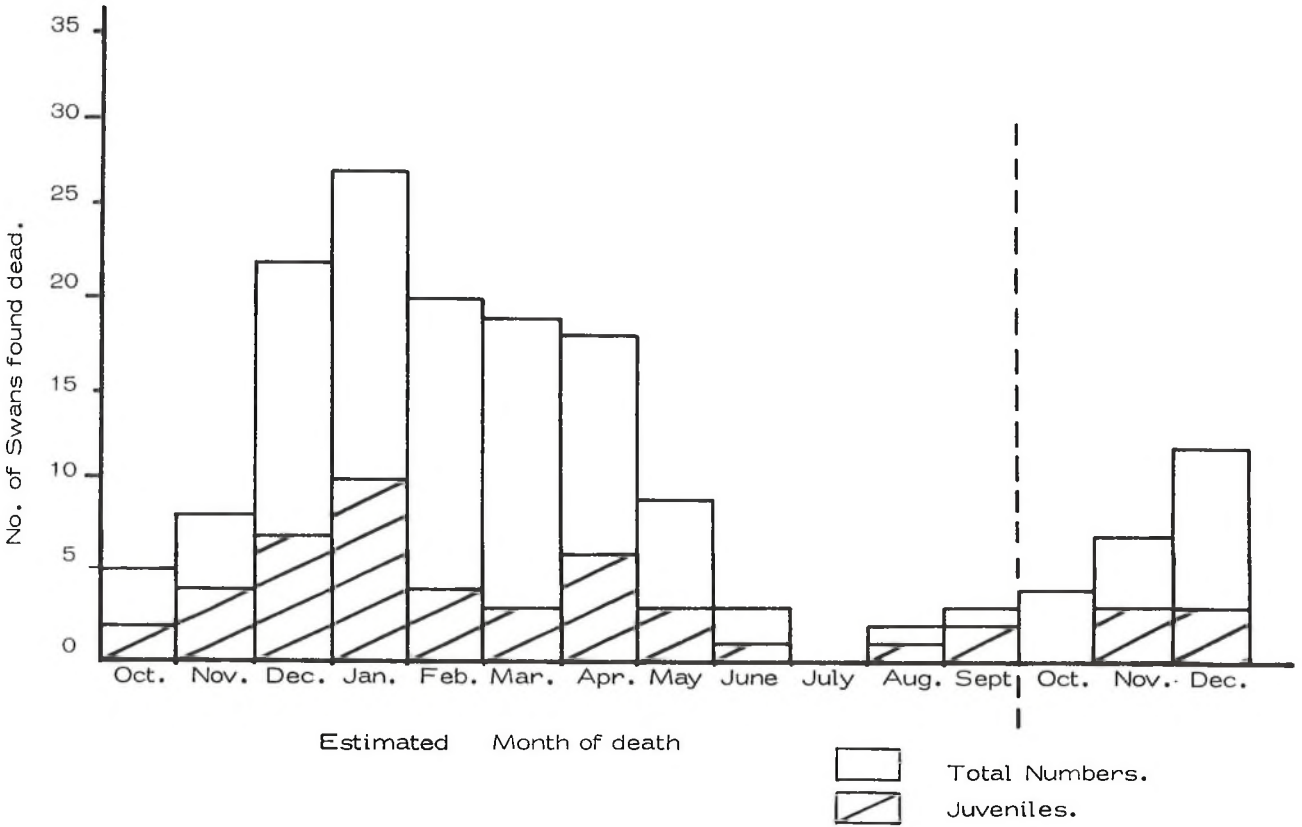


Fig 4. Mortality of *Cygnus olor* in Uists 1978 and 1979.

Table 9. Cause of death of *Cygnus olor* in the Uists 1978/79.

| Cause of death | Numbers | % | % known causes |
|---|---|---|---|
| Unknown | 76 (61) | 52 (53) | |
| Powerline collisions | 60 (44) | 41 (38) | 86 (81) |
| Shot | 4 (4) | 3 (3) | 8 (7) |
| Fighting | 3 (3) | 2 (3) | 4 (6) |
| Disease/starvation | 3 (3) | 2 (3) | 4 (6) |
| TOTALS | 146 (115) | 100% | 100% |

(Figures given in brackets are those found by the author).

The causes of death are given in Table 9, though, as post-mortem examinations were not possible in most cases, the reported causes are probably biassed towards those that produced obvious characteristics of death. Linesmen working for the Hydro Electric Board were one obvious source of bias, as they were especially on the look-out for swans. However, even if birds found only by the author are included, the figures remain much the same, and it is apparent that death due to collision with electricity cables is the major cause of mortality in the Uists.

It should be noted that, although collision with overhead wires was indeed the commonest ultimate cause of death, the extremely cold weather may have caused birds to move off their usual haunts to find feeding grounds elsewhere, increasing the risk of collisions, and indeed several of the corpses were very low in weight. However, the percentage of deaths due to collision with wires (86%) is still nearly twice as high on the Uists as recorded for the whole of Britain, 44.1% (Ogilvie 1967) of the swans for which cause of death was specified, though very locally higher mortality rates may occur for a short time (Harrison 1963).

## Discussion and conclusions

Data collected in the first two years of this present study differ markedly in several important aspects from those collected in the earlier study of this population between 1971 and 1974 (Jenkins *et al* 1976). In particular the present data show none of the regular large-scale seasonal fluctuations in the total numbers, while the number of breeding pairs observed is much higher than they reported. These differences could be due to the different census techniques being used, rather than to a real change in the numbers and pattern of movement of swans in the study area in the intervening years.

The two census methods were therefore compared directly, a simultaneous survey being carried out in June 1978, with Colin Brown (who did the actual counting in the censuses of 1971 to 1974) using the original method, while the author used

the current technique. The results showed a disparity of 253 birds, with 695 adults counted by the former method and 948 by the present method, a 36% difference. This difference was due both to inadequate counting of several complex lochs which held large numbers of birds and to the fact that 54 lochs on which swans were seen in 1978 were not included in the former censuses.

A further suggestion that the previous census technique was not covering all birds came from the results of a Royal Society for the Protection of Birds (RSPB) group expedition which did an ornithological survey of the Uists in February 1975. The recorded a total of 1350 *C. olor,* in what they described as an unusually good year (Hammond 1975). This figure is over twice the number recorded during February in the years 1971 to 1974 (mean 526 swans) and compares with just 461 and 386 recorded in November and December 1974 only a few weeks before. It is also higher than any count in 1978 and 1979 but the present technique is considered to be accurate, whereas there are no checks on the accuracy of the RSPB count, done by people who had little previous knowledge of the study area or of censusing swans.

Had there been a moult migration to and from the study area, as was hypothesized, by Jenkins *et al,* it would surely have shown up with the ringing and collar-marking of so many birds during 1978. The wide discrepancy in the number of breeding pairs is also considered due to the counting techniques; indeed, the 54 lochs missed in the June 1978 census held 32 nesting pairs that year. It is possible, therefore, that the apparent stability in the number of territorial pairs reported in the study area in the years 1971 to 1974 was also just a product of the census method used.

It is difficult to draw any firm conclusions when the two breeding seasons of the present study were so very different. A number of points, though, do seem to have emerged that are worth very briefly speculating upon. The number of nesting pairs in the study area has not remained constant, showing a 29% drop between years as well as decreasing from 31% to 24% of the total population, despite the presence of a large number of non-breeding birds in the population. This differs from the situation reported by Minton (1971) in the Midlands where the number of breeding pairs remained relatively stable, with the non-breeding flock, which fluctuated more widely, acting as a reservoir of potential territorial pairs.

It is difficult at present in the Uist study area to distinguish between two possible reasons for this lack of stability in the number of breeding pairs: poor body condition of potential breeding adults or the physical state of the breeding territories. Following the severe winter of 1978/79 either or both of these factors may influence the number of breeding territories utilized.

The overall breeding success of the Uist population is very low (even in the better of the two years) when compared with figures from other population studies, and reworking the data on breeding success from Jenkins *et al* (1976) still gives a

mean of only 1.36 cygnets fledged/nesting pair for the earlier years 1971 to 1974. If, however, breeding success is examined in relation to loch type, it is apparent that birds on the eutrophic machair lochs are the most successful. A small subsection of the breeding population may thus be responsible for a disproportionately large percentage of the total breeding output each year.

Although colonial nesting is not found in the Uists, the density of breeding swans is far higher than recorded anywhere else in Britain. At the same time, though, breeding swans account for a lower percentage of the total population, suggesting that in the Uists some factor, such as a limited number of breeding sites, may be setting an upper limit to the number of breeding pairs, whereas availability of suitable habitat for non-breeding birds has not so far limited their build-up in numbers.

These observations, taken together with the conclusions from ringing results and movements, suggest that the population structure of such an isolated and closed community of *C. olor* may well differ from those studied elsewhere in Britain, which are in effect just small parts of a continuous population.

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## Summary

A study of the population of *Cygnus olor* in the Outer Hebrides, which, though originally introduced, is now isolated and essentially natural, may allow understanding of the processes regulating numbers. Data collected in this study differ markedly from those in an earlier study, perhaps because of differing methods. The present study shows no large-scale seasonal fluctuations in numbers and many more breeding pairs, and the earlier hypothesis of an influx of moulting birds therefore seems unjustified.

The number of breeding pairs has not — unlike conditions elsewhere in Britain — remained

constant. Overall breeding success is comparatively low and pairs breeding on eutrophic lakes produce a disproportionately large percentage of the total output. Density of breeding swans is higher than elsewhere in Britain. The population structure of the island community clearly differs from that in the main British population.

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