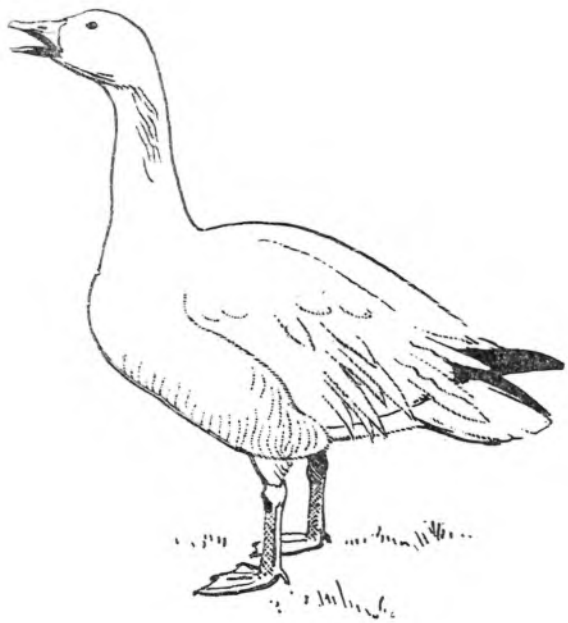

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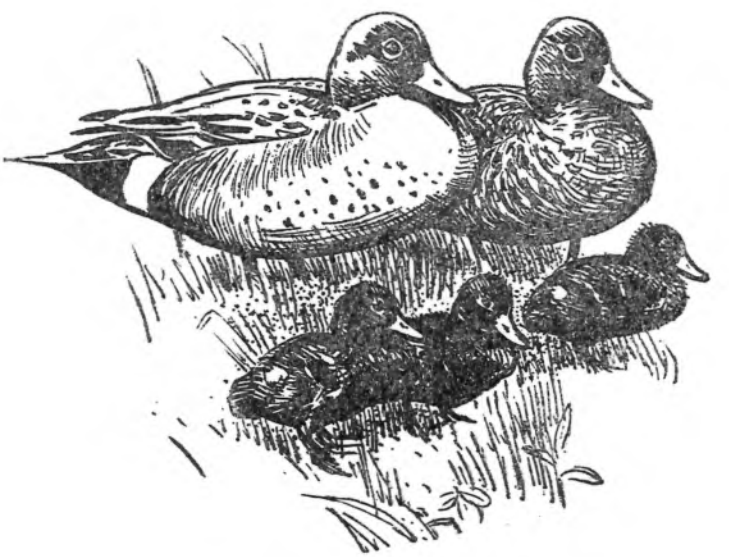

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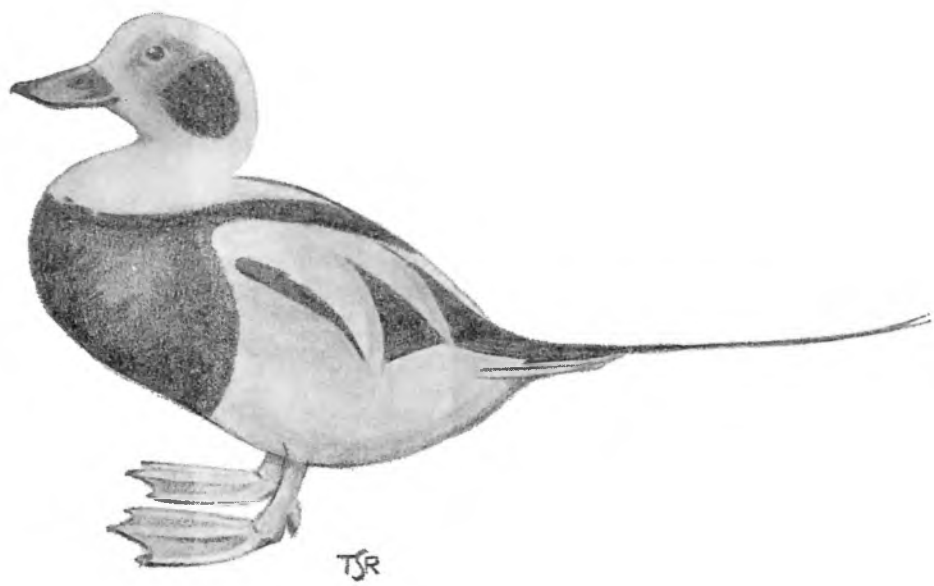

THE WILDFOWL TRUST
SLIMBRIDGE, GLOUCESTER

The aims of the Wildfowl Trust are:

1. To maintain and breed wildfowl in captivity, especially those species which are in danger of extinction.
2. To carry out scientific study of wildfowl in the wild state and in captivity.
3. To apply that scientific knowledge and experience to the conservation of wildfowl at home and overseas.
4. To educate the public by all available means to a greater appreciation of wildfowl in particular and nature in general.

Pink-footed Geese of Iceland and Greenland: a population review based on an aerial survey of þjórsárver in June, 1970

R. H. KERBES, M. A. OGILVIE and H. BOYD

Introduction

The Pink-footed Geese *Anser brachyrhynchus* breeding in Greenland and Iceland winter solely within Britain; they numbered about 70,000 in November in 1968-1970 (Ogilvie 1969, 1970a). Those breeding in Svalbard winter in the Low Countries and Denmark and numbered 12-15,000 in the corresponding years (Morzer Bruyns *et al.* 1969).

The principal breeding ground of the British-wintering population is þjórsárver (64° 35′ N., 18° 40′ W.), an oasis of vegetation in the volcanic desert south of the Hofsjökull icecap in the central highlands of Iceland (Scott *et al.* 1953).

Detailed engineering proposals to make a reservoir on the upper þjórsá River as part of a hydro-electric power scheme have recently been made known. The reservoir would flood almost the entire oasis. The threat this poses to the Pink-footed Goose makes it imperative to obtain precise information on the importance of þjórsárver to the geese and to discover whether suitable alternative breeding sites are available or could be provided. The first step was to obtain an accurate and up-to-date estimate of the numbers of geese breeding in þjórsárver. This was done by means of a survey of nests in June 1970. Preliminary reports have already appeared (Ogilvie 1970b, 1971a). The first section of this paper provides a fuller account, with a description of the technique and a discussion of the statistical reliability. The second section compares the results with earlier estimates of the goose populations of the oasis. A brief review of numbers in other parts of Iceland and in Greenland follows. The present rôle of þjórsárver and of what might happen to the displaced geese if the oasis was to be destroyed are then discussed, with emphasis on the additional knowledge urgently required.

PART I. SURVEY OF þJORSARVER BY HELICOPTER, JUNE 1970.

The primary aim of the survey was to determine the number of Pink-footed Geese breeding in þjórsárver and to describe the distribution of the nests. Most of the survey was done during a period of clear, warm, calm weather from 10th to 12th June 1970. It was completed on 16th June under overcast skies with cool moderate winds.

Methods

The survey was conducted from a Bell Ranger helicopter with a crew consisting of a pilot (Björn Jónsen on 10th-12th and Pall Halldórsson on 16th June), a navigator (Kerbes) and a nest observer (Ogilvie).

The survey began with a qualitative reconnaissance to determine the extent of the nesting area. The area with nests was delimited and then sampled quantitatively by counting the nests within transects of fixed width. The transects were taken with the helicopter flying a straight line course 60 m. above ground at approximately 100 km.p.h. ground speed. Transect positions were selected to cover the nesting area uniformly.

The navigator chose and plotted the transect course and marked position fixes on a map of scale 1:40,000 (Sheet 231, þjórsárver, Vegetation Map of Iceland, Icelandic Survey Department). The observer, by limiting his scan to a sector marked with tape on the plexiglass 'bubble', recorded the number of nests passing beneath him on the transect within a fixed angle of view. The width of the transect on the ground was 50 yd. (45.72 m.). This was carefully checked against a line of markers spaced at 10 yd. intervals on the ground. The observer recorded his nest counts by length of transect to coincide with the position fixes taken by the navigator.

The accuracy of the transect counts was then tested by comparing the densities of nests found in ground searches with the density estimates obtained by aerial transects, on three separate areas. Each area for intensive search was chosen subjectively to provide a reasonable density of nests within limits readily defined both from the ground and from the air. Maps of scale 1:20,000 were used in conducting ground searches and in measuring the areas.

The sizes of the comparison areas were determined by transferring their outlines from maps on to millimetre-squared graph paper. As a check, a photocopy of the map was cut up and the pieces weighed to the nearest 0.001 gm. There

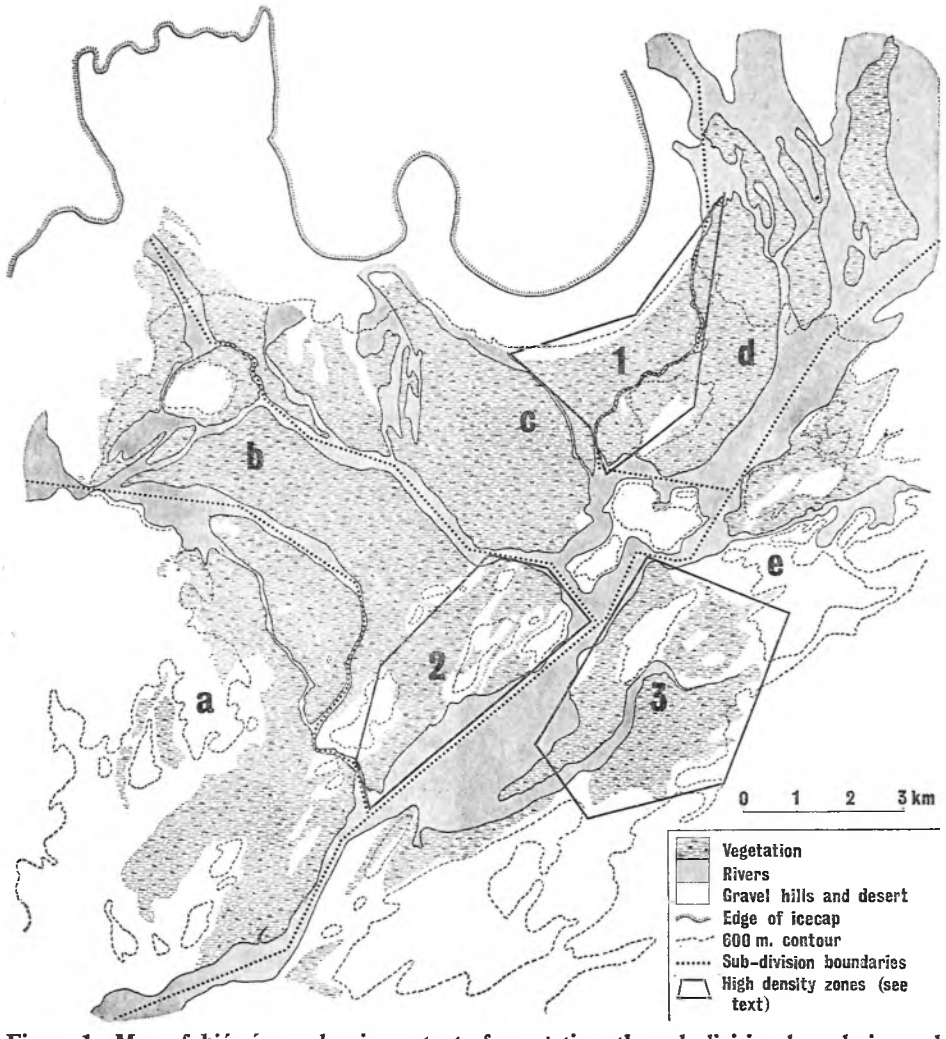

Figure 1. Map of Þjórsárver showing extent of vegetation, the sub-division boundaries and the three high-density zones (see text).

was extremely close agreement between the two methods. The total number of nests was estimated by multiplying the mean nest density of the transect counts by the total area of nesting habitat.

Results

There were approximately 81.6 sq. km. of nesting habitat within Þjórsárver (Figure 1) containing a total of about 10,700 nests (Table I).

The area occupied by nests coincided almost exactly with the vegetated area as depicted on the 1 : 40,000 map. Since nests were not found on gravel hills, sand banks and river channels within Þjórsárver, such areas were excluded from the calculations. The nests were typically situated on dry well-drained sites such as the banks of pools and streams, and on low heathy mounds and ridges. Most of the oasis, however, is flat, boggy ground interspersed with innumerable small pools and streams. Large expanses were under shallow water, following the spring thaw. Through the summer these dry out to become marshy, with lush vegetation on which the geese and their goslings feed (see Plates I and II).

The nests were found over the entire area of vegetated ground within Þjórsárver. Areas of high nest density merged gradually, sometimes suddenly, into areas of low density. Densities encountered during the survey ranged between 36 and 544 nests per sq. km. There were five major subdivisions of the oasis, arbitrarily delimited by watercourses, as shown in

Table I. Summary of results from the survey of Pink-footed Geese nesting in þjórsárver, Iceland, June 1970.

Total length of transects over nesting area	191.69 km.
Transect width (50 yards)	45.72 m.
Total nesting area covered by transects	8.76 sq. km.
Total nests recorded within transects	1,149
Mean nest density within transects	131.11 nests/sq. km.
Total area of nesting habitat within þjórsárver	81.59 sq. km.
Estimated total nests in þjórsárver	10,697
95% Confidence Interval of estimated total nests	9,059 to 12,335

Figure 1. The mean nest densities in each subdivision were rather similar: a — 95, b — 124, c — 146, d — 111, and e — 143 nests per sq. km.

All 88 transect counts were scaled by density, and then ranged into four equal groups. Each of the transects on the map was then categorized by density group. Three zones of high nest density were thereby defined (Figure 1, Table II). Chi-square tests ($P < 0.01$) showed that each of those zones had significantly more nests than would be expected from random or uniform distribution.

Table II. Zones of high nest density compared to nesting area outside those zones, þjórsárver, Iceland, June 1970.

	Nest Density (nests/sq. km.)	*Per cent of total size*	*Per cent of total nests*
Zone 1	251	7	13
Zone 2	170	6	8
Zone 3	186	9	13
non-Zone	102	78	66
Total	131	100	100

The proposed dam below þjórsárver would probably flood the oasis to the 600 metre contour at top water level (Jakob Björnsson, National Energy Authority, pers com.). As Figure 1 shows, the limit of vegetation follows this contour round much of the oasis. Only about 15 sq. km. of the vegetated area was above 600 metres, as calculated from the 1:40,000 vegetation map. The density of nests within the area to be flooded was about 137 nests per sq. km. Therefore, approximately 9,100 nests, or 85% of their total, would have been at risk in 1970.

Non-breeding geese (i.e. those in flocks) were remarkable by their absence. One flock of about 200 was seen during the survey, together with other smaller groups totalling a further 200 birds. Clearly the not inconsiderable non-breeding segment of the population, comprising the immature geese (survivors of the previous two seasons' production) together with any failed or non-breeding adults, had already left on their moult migration to East Greenland (see below, Part III). However, it is not known how many immature non-breeders actually visit þjórsárver at the end of their spring migration though it can be assumed that some one-year-olds do as they apparently leave Britain still in family parties, still being led by their parents.

Discussion of nest survey

The helicopter transect method used for surveying þjórsárver was devised and used by Kerbes to count the nests of Lesser Snow Geese *Anser c. caerulescens* on Baffin Island, Canada. A description, with a discussion of the geometrical principles and problems involved, has been given by Kerbes (1969).

The method used at þjórsárver was subject to four basic sources of error:

1. observer error,
2. calculation error of transect length,
3. variation in transect width,
4. unrepresentative sampling.

Failure of the observer to see and record all nests within the transect is believed to have been insignificant. There was no chance of misidentifying Pink-footed Goose nests because no other bird with a goose-sized nest breeds there. Pairs usually remained at their nests, easily seen from the helicopter as it flew over

them, and if they took flight, the light coloured eggs and down were still conspicuous.

Error due to inaccurate measurement of the transect lengths was also considered to be insignificant. The transects were flown in continuous reference to ground features shown on the map. The beginning and end of each transect was plotted with variation of less than 1% of its total length.

Potentially the most serious technical error was variation in transect width. Kerbes (1969) showed that such error was due to inadvertent movement of the observer's head in relation to the fixed observation sector of the helicopter 'bubble', and to variation in the altitude, pitch, roll and yaw of the machine. Theoretical calculations indicated that head movement and helicopter pitch can have the most effect in changing the width of transect, and that the total possible variation ranged from widening the transect by 42% to narrowing it by 30%. Therefore the sources of error might not cancel each other out, even if a large number of transect counts were taken in varied conditions. Rather, there would be a tendency to widen the transect by up to 12% with consequent over-estimation of nests.

The similar estimates of nest density made from the ground searches and from the aerial transects supported the accuracy of the transect counts. In conducting those comparisons it was reasonable to assume that the systematic ground search resulted in a total count of all nests present. However, some terrain was less easy to search. Area B was rather sodden, with sinuous hummocks in pools of stagnant water. Area C was relatively dry on a high peninsula surrounded by channels of the river. The transect coverage gave nest density estimates higher than the ground coverage in Area A, but lower in Areas B (of intermediate dryness) and C. The overall difference was only a 1.0% over-estimation by the transect count (Table III). Since the three comparison areas covered the whole range of nest densities and habitats, and were about 18% of the total area covered by transects, they provided valid evidence of the accuracy of the transect counts. We may conclude that the survey, conducted in a carefully controlled method under almost ideal weather conditions, had negligible observational or technical errors.

The theory of ratio estimates (Cochran 1953) was used to obtain estimates and confidence limits for the density and total number of nests. It was necessary to assume that the transects, both in length and position, were effectively random over the area. In fact, the transects were selected both randomly and systematically. This was a consequence of the technical limitations imposed by having to fly straight line transects over large areas of homogeneous terrain. In general, transect courses were selected from one recognizable landmark to another, count breaks occurring when intermediate landmarks, such as streams, crossed the transect. The terminal landmarks and direction of flight, however, were selected largely at random. A systematic effort was made to cover the entire nesting area with an approximately uniform density of transects. This was done by a subjective appraisal of the emerging pattern of coverage as the survey progressed. Eventually the transect sample covered more than 10% of the nesting area, a substantial fraction.

The statistical procedure indicated with 95% confidence that the mean nest density lay between approximately 110 and 150 nests per sq. km. With the same degree of confidence the estimates of total nests in Þjórsárver therefore lay between approximately 9,100 and 12,300 nests (Table I). It is stressed that this provides only a rough guide to the statistical accuracy of the method. Nesting density varied so greatly over such short distances that any estimate of mean density would

Table III. Air-ground comparison of Pink-footed Goose nest counts in Þjórsárver, Iceland, June 1970.

	Ground area searched (sq. km.)	*Air transect coverage (sq. km.)*	*Density/Ground (nests/sq. km.)*	*Density/Air (nests/sq. km.)*	*% difference Air vs. Ground*
A	0.545	0.537	115.6	141.9	+ 22.8
B	0.656	0.759	237.7	228.3	— 4.0
C	0.403	0.515	151.3	134.4	— 11.2
Total	1.604	1.811	174.5	176.2	+ 1.0

have had a high variance, regardless of the sampling scheme used.

Prior to the survey some apprehension had been expressed that the helicopter would cause undue disturbance to the geese. Pink-footed Geese in winter in Britain are extremely shy of aircraft, particularly helicopters. In fact, the machine caused only minimal disturbance on the nesting grounds. Most pairs remained at their nests as the helicopter flew over them, and many even made defensive threat postures at the machine. During the ground searches the geese were also very defensive of their territories, usually remaining at their nests until the investigators were to within 20 metres. Kerbes noted that the Pinkfeet were remarkably reluctant to leave their nests in comparison to nesting Lesser Snow Geese, which tend to flee at the distant approach of a helicopter or a man on the ground. Furthermore, there appeared to be very few predators in þjórsárver. Only four Great Black-backed Gulls *Larus marinus* and five Arctic Skuas *Skua parasiticus* were seen during the ground searches. There was, therefore, little chance for predation to occur during any short period in which the survey activities caused geese to be away from their nests.

Expeditions visiting the oasis in July and August in earlier years (summarised by Hardy 1967) saw more predators. In 1966 there were about 20 each of Great Black-backed Gull and Arctic Skua, together with at least one pair of Iceland Falcons *Falco rusticolus*. The gulls have not been recorded as breeding in the area, and so their effect is greatly reduced. Previous expeditions have only found one active earth of the Arctic Fox *Alopex lagopus*. The remoteness of þjórsárver, and lack of a year-round food source, may combine to make it less attractive to predators than might be expected, although the numbers of predatory birds recorded have increased since 1951.

Clutch size and hatching date

In the course of the ground searches, and during other temporary landings in the oasis, 312 nests were closely examined and the clutch sizes recorded. The mean clutch size was 3.9 (range 1-7).

On 16th June the first goslings were seen, a single brood no more than one day out of the nest, and a hatching clutch of eggs was found. Of some two hundred eggs candled, most would be hatching in the period 20th to 27th June. In 1951 the peak hatching date was estimated to have been 22nd June (Scott *et al.* 1953). This date was worked out by extrapolating back from the age of goslings seen soon after the hatch. A similar computation in August 1966 suggested a later peak hatching date that year, in the first week of July (Hardy 1967).

PART II. EARLIER ESTIMATES OF NUMBERS OF NESTS AND GEESE IN þJORSARVER.

þjórsárver had previously been visited by ornithologists interested in geese in 1951, 1953, 1956, 1964, 1966 and 1969. These inspections included a brief visit in May 1956 by Dr. Finnur Guðmundsson in an American Army helicopter. A stay from 17th to 25th August 1966 by a British party (Hardy 1967), though obtaining valuable evidence on several aspects of breeding biology, was not concerned with population measurement.

Numbers of nests in 1951

The only previous attempt to estimate the number of goose nests in the oasis was by Scott *et al.* (1953). They walked transects 102 km. in length and of a mean strip width of about 20 m., a searched area of 2.04 sq. km. They found 67 nests with a density of 32.9 nests per sq. km. They then estimated the total area used by the geese to be 114 sq. km., of which they explored 82 sq. km. Multiplying the number of nests found by (total area)/(area searched), i.e. $67 \times (114/2.04)$ they arrived at an estimate of 3,700 nests for the oasis in 1951. This was "almost certainly too high since much of the area was bog and tundra pools which could not be transected (or colonized)." They noted that the nests were grouped, rather than distributed uniformly or randomly and suggested that the mean density of nests might be as low as 15 nests per sq. km. which would have reduced the estimated number of nests in the colony to 1,700. A factor working in the opposite direction is the difficulty of finding every empty nest in such terrain.

There is no reason to think that the vegetated area used by the geese has altered greatly in its dimensions since 1951. The mapping of the region has been improved and for comparative purposes it seems proper to consider the area of nesting habitat in 1951 equal to that arrived at for 1970. i.e. 81.6 sq. km. rather than 114 sq. km. That would reduce the alternative estimates of the total number of nests in 1951 to 2,700 and 1,200.

Number of geese in May 1964

In May 1964 an aerial survey of Greylag Geese *Anser anser* was carried out in

Iceland and the opportunity was taken to visit Þjórsárver to look at the Pinkfeet (Boyd 1970). A fixed-wing light aircraft was used for the survey with a pilot (Sveinn Bjornsson) and two observers (Boyd and L. R. Schiess). On 8th May no search of the oasis was possible because of a snowstorm, but many groups of geese could be seen, despite the landscape being almost entirely covered in snow and ice.

On 21st May the oasis was surveyed rather more thoroughly. Much of the vegetation was still obscured by snow or ice, making habitat zones hard to identify and map-reading awkward, but a series of transects was flown at about 150 m. above ground. A total of 1,195 geese were seen, many of them in ones or twos, others in small groups. The effective strip width along the transects was believed to be no more than about 0.1 km. on each side of the aircraft. Unfamiliarity of the pilot with the technique of transect-flying and some difficulty in communication with the observers led to the pattern of search being less precise, and much less complete, than would have been desirable. Because of the high speed (160 km./hr.) it was not possible to make detailed records for the short sectors of the flight line where the geese were at all plentiful. The sampling was not proportional to the size of the sectors nor to the relative abundance of geese in each. The proportion of groups differed greatly from place to place.

Assuming the effective searching width to have been 0.2 km., a very rough estimate of 6,600 for the total population can be obtained from the number of birds seen (1,195) divided by 0.2 × distance flown (73.6 km.) and multiplied by the approximate vegetated area of the oasis (81.6 sq. km.). The mean number of geese recorded was 81.1 per sq. km. The density in different sectors varied from 18.2 to 122.0 birds per sq. km. If the geese in flocks are excluded the observed densities fall to 9-21 pairs per sq. km. No confidence limits can be put on these 1964 estimates. Because of the clumping of the geese and the crude sampling technique the limits would undoubtedly be wide. The most serious weakness lies in the unchecked assumption of effective transect width.

In both 1951 and 1969 the estimated peak date for completion of clutches in Þjórsárver was 25th May (Scott *et al.* 1953; Bulstrode and Hardy 1970). Assuming therefore that nesting was well advanced on 21st May in 1964, the geese still in flocks of over 20 birds (695 or 58%) may have been non-breeders. From winter population data (Boyd and Ogilvie 1969), a rough calculation suggests that in May 1964 the proportion of non-breeders was probably of the order of 53% in the Iceland/Greenland population as a whole. Thus the estimated total of 6,600 geese in Þjórsárver on 21st May 1964 did not correspond to 3,300 breeding pairs but to a substantially lower number, perhaps as few as 1,600, much the same as estimated for 1951. Yet the total wintering population had nearly doubled.

Numbers of geese in Þjórsárver in July and August

Estimates of the numbers of adults and goslings in the oasis in 1951, 1953 and 1969 have been published. They are summarized in Table IV. The capture-recapture methods so far used cannot provide reliable estimates in Þjórsárver, where the geese move extensively when disturbed by people and probably also range widely, but not randomly, when undisturbed. No idea of the number of moulters and goslings in any part of the oasis could be made until the birds were rounded up. It was virtually impossible to define the catching-effort with respect to area. The sampling was biased, due to difficulties of access and of visibility (of men to geese and vice versa). Thus confidence limits for numbers based on the assumptions of thorough mixing and random sampling are too narrow, if not wholly inappropriate. The published estimates for 1969 (Bulstrode and Hardy 1970) used the further hazardous assumption that the geese were evenly distributed over the vegetated area (which they were clearly not in 1953).

Nevertheless, it is reasonable to claim that the numbers present in late July were higher in 1953 than in 1951 and much higher in 1969 (and, presumably, in 1970). There is no necessary relationship between the distribution of nests in June and the location of families in late July and August. The latter are dependent upon the distribution of food supplies which are most plentiful in the low-lying, wetter areas—which would be flooded whatever the final upper datum line of the proposed reservoir.

PART III. NUMBERS IN OTHER PART OF ICELAND AND IN GREENLAND.

Iceland: north-east and east of Þjórsárver

All the known breeding places of the Pinkfoot in Iceland are shown in Figure

Table IV. Estimates of the numbers of Pink-footed Geese in þjórsárver in July and August in 1951, 1953 and 1969, from published sources.

(*a*) Published results

Year	*No. of adults*	*No. of goslings*	*Method of estimation*	*Source*
1951	6700	7000	mark-recapture	Scott *et al.* 1953
1953	8200	10200	mark-recapture	Scott *et al.* 1955
1969	13600	17100	sample catch and area ratio	Bulstrode and Hardy 1970

(*b*) Derived results

	No. of successful breeding pairs in þjórsárver in July	*Mean brood size* *þjórsárver late July*	*Britain November*	*Total no. of successful breeding pairs in Britain in November*	*þjórsárver, July / Britain, Nov.* %
1951	3300	4.2	2.50	2900	114
1953	4700	4.3	2.75	3700	127
1969	8000	(4.25)	2.2	8200	98

November data for 1951 and 1953 from Boyd and Ogilvie (1969), for 1969 from unpublished data (M. A. Ogilvie).

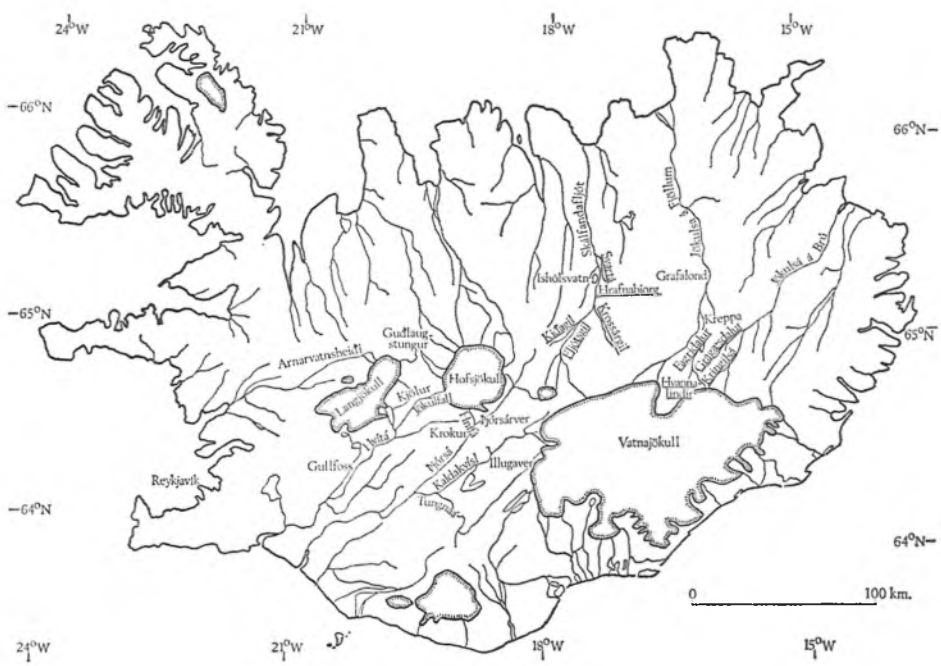

Figure 2. Map of Iceland showing the main localities mentioned in the text. Those underlined are the breeding localities for Pinkfeet recorded prior to 1951.

2. Those localities with the names underlined were known prior to 1951 (Scott *et al.* 1953). They all lie in the north-east quadrant of Iceland and nearly all in the upper reaches and head-waters of three large rivers: Skálfandafljót, Jökulsá á Fjöllum and Jökulsá á Brú.

Pink-footed Geese were first reported to be nesting in Iceland by Congreve and Freme (1930) who found at least seven nests of Pinkfeet at Krossárgil along the gorges of the Skálfandafljót in June 1929. In 1945 Finnur Guðmundsson surveyed the whole river system for geese and estimated that there were up to 200 Pinkfoot nests in all (Scott *et al.* 1953). Guðmundsson found four main breeding groups and nine minor ones (each with less than ten occupied nests) over about 45 km. of gorges.

On 9th May 1964 the Skálfandafljót was flown over from the sea to the vicinity of Isholsvatn (Boyd 1970). Ten pairs of Pinkfeet were found, over the 38 km. between Jarlstadir and Hrafnarbjörg, and one pair on Isholsvatn. The 1964 sighting at Jarlstadir, 25 km. downstream from Aldeyjarfoss, the previous known limit, indicated that some northward extensions of range may have occurred.

Magnus Bjornsson in 1933 found small numbers of Pinkfeet breeding in several scattered localities along both the Jökulsá á Fjöllum and the Jökulsá á Brú. Nowhere were there concentrations sufficient to be termed colonies and breeding in several localities was probably sporadic rather than annual (Scott *et al.* 1953).

On 8th May 1964 three Pinkfeet were seen (Boyd 1970) along the Kreppa, a tributary of Jökulsá á Fjöllum, south-southwest of Fajradalsfjall, near where some had been reported breeding thirty years earlier. The general area requires thorough exploration.

Iceland: west and north-west of Þjórsárver

Blurton Jones and Gillmor (1955), who visited the Arskard area, west of the Hofsjökull glacier, in August 1954, saw several family parties and found one dead gosling, killed before it was able to fly.

On 21st May 1964 low-level flights were made over several of the vegetated areas to the west and south-west (Boyd 1970). In Miklumyrar 23 Pinkfeet, representing 18 pairs, were seen, well scattered. Hrafnstóftaver had a pair and a single bird. There was a group of 13 on Hvítárnes. A further six pairs and a single bird were seen along the course of the river Hvítá itself, over the 40 km. from near Lambafell to just below Gullfoss. On Kjálkaver 22 Pinkfeet, representing 12 pairs, were found near the Þjórsá itself and there were 81 along the gorge near Gljufurleitarfoss (12 in flocks, and ones or twos representing 40 pairs) with another 38, representing 22 pairs, from near the junction of the Þjórsá and Tungnaá southwest to west to Þjofafoss. Closer to Þjórsárver, Eyvafen had only one pair but Hnífárver held 156 geese, 42 dispersed pairs and 72 birds in flocks. On Harnmyrar, above Þjórsárver, there were a group of ten, six pairs, and a single.

On 8th May 1964 Boyd (1970) left the Þjórsá at Langalda (64° 17′ N., 19° 20′ W.) and flew west-southwest across country to Braedratunga (64° 09′ N., 20° 23′ W.). Two small flocks, of 13 and 11 geese, were seen near Langalda itself; four pairs in Kistuver (64° 15′ N., 19° 32′ W.); and 39 geese, including three detached pairs, in Fossolduver (64° 15′ N., 19° 43′ W.). There are other scattered vegetated sites between Fossolduver and the Hvítá that should be searched for geese.

Pinkfeet have not been proved to breed in the central highlands further to the north-west than Guðlaugstungur but some incidental observations during positioning flights in May 1964 suggest that Tvidaegra and Arnavatnsheiði, north of the Langjökull and Eiriksjökull glaciers, should be examined carefully. Arnavatnsheiði is dotted with large numbers of lakes and tarns. Kinlen (1963) saw no families of Pinkfeet there in August 1962 but that does not exclude the possibility that some geese could be breeding in this extensive tract of vegetated upland. In the west, 15 Pinkfeet (a group of eight, three pairs and a single) were seen on 10th May 1964 by the Brennakvísl (at 65° 03′ N., 20° 55′ W.). On 9th May Pinkfeet were seen at three sites north-west of the Stori-Sandur: five pairs,, one single on Adalbolsheiði (at 65° 03′ N., 20° 23′ W.); a group of 14, 11 pairs, one single near the headwaters of the Vidadelsa (at 65° 06′ N., 20° 22′ W.) and two pairs at Skutatjorn (65° 12′ N., 20° 12′ W.). The strips searched during these flights amounted to about 7 sq. km., leading to an estimated density of 3.4 pairs of Pinkfeet per sq. km. That is low, but the area of similar-seeming country is relatively large.

On 11th May 1964, in an inspection of the river Tungnaá from its southern watershed near Kirkjufell (63° 58′ N., 18° 55′ W.), no geese were seen above Tungnaákrokur but from there to the confluence with the Þjórsá (64° 11′ N., 19° 30′ W.) there were flocks of about 60 and 16 and at least 150 in ones or twos,

representing some 70 pairs. This search included Þoristungur and the lower parts of the Kaldakvísl. Following the Þjórsá downstream from the Tungnaá confluence, three pairs of Pinkfeet were seen on Sultartangi, three pairs and a single at Holuskogur, three pairs south-east of Burfell and two pairs at Bringa (64°07′N., 20° 00′ W.).

In 1966 and 1969 British expeditions spent some time in the area known as the Kjölur between the Hofsjökull and Langjökull glaciers (Hardy 1967; Bulstrode and Hardy 1970). This included those parts visited by Blurton Jones and Gillmor in 1954 and also some of the meadow and marsh areas further to the north. An important new breeding site for Pinkfeet was found in 1966 along the gorge of the Jökulfall river (Figure 2), at least 70 nests being counted, though only about half were used that year. In 1969 nests were found in three more localities in the Kjölur, including two river gorges, and adults and goslings seen in five different meadows. Numbers were small, totalling some 40 breeding pairs.

In June 1970 Kerbes and Ogilvie also surveyed certain areas outside Þjórsárver by helicopter (Table V). The Þjórsá river was followed to its junction with the Tungnaá and parts of the latter and the Kaldakvísl were flown over on 12th June. Most of the small patches of vegetation between Kaldakvísl and Þjórsárver were checked. On 18th June the area between Hofsjökull and Langjökull was surveyed, including almost all the vegetated areas within that region. The weather that day was overcast, cool and moderately windy. Table V gives the approximate areas, or, for the rivers, the lengths searched. Even on the small meadows most nearly adjacent to Þjórsárver the nest density was less than one tenth that on the main breeding ground. It should be emphasised, however, that not all the areas of meadow surveyed were necessarily suitable Pinkfoot habitat. For example the large Guðlaugstungur appeared to have rather little lush marsh, most of the vegetation being of a dry heathy nature. The 100 pairs recorded for this area in 1970 contrast with the complete absence of geese in 1969 reported by Bulstrode and Hardy (1970), and the single old nest site found in 1966 (Hardy 1967).

Greenland

Though the range of the Pink-footed Goose in East Greenland in late summer has long been fairly well known (Salomonsen 1967) there is still no good estimate of the number breeding there. By 1950 the species had been found breeding from Mikkisfjord, south of Scoresby Sound, to Dove Bay, over 500 miles to the north. Only some parts of this long stretch of coast, much elongated by the dissecting fjords and islands, provide suitable breeding habitat for Pinkfeet and only in a few places had more than a handful of nests been found. The evidence of nesting summarized by Scott and Fisher (1953) did not account for more than about 500 breeding pairs.

Table V. Number of nesting Pink-footed Geese recorded outside Þjórsárver, Iceland, June 1970.

Locality	*Approx. area or length*	*Approx. no. of pairs or nests*	*Density nests/sq. km.*
Small meadows to south and south-east of Þjórsárver	18.0 sq. km.	190	10.6
Illugaver	2.5 sq. km.	25	10.0
Hnífárver	3.0 sq. km.	25	8.3
Krókur	5.5 sq. km.	25	4.5
Guðlaugstungur	100.0 sq. km.	100	1.0
All other meadows between Langjökull and Hofsjökull	115.0 sq. km.	0	0
Þjórsá—islands and gorge	60 km.	150	
Tungnaá and Kaldakvísl	55 km.	20	
Hvítá gorge	20 km.	50	
Total meadows	244.0 sq. km.	365	1.5 nests/sq. km.
Total river gorges	135 km.	220	1.6 nests/km.

Several ornithological expeditions have visited East Greenland subsequently (Goodhart and Wright 1958; Hall 1963; Marris and Ogilvie 1962), but they did not add much to our knowledge of the number of Pinkfeet breeding in the country. The particular reason for this is the large scale moult migration of non-breeding Pinkfeet from Iceland to east Greenland. This was first suggested by Taylor (1953) who observed skeins of geese apparently migrating north-west from central Iceland in late June. Christensen (1967) reviewed all available information, including his own observations of Pinkfeet moving north in East Greenland in late June and early July 1964, and concluded that as many as 15,000 Pinkfeet might be moult-migrating from Iceland to Greenland. Thus where the expeditions mentioned above reported only a handful of family parties of Pinkfeet among many hundreds of non-breeders, this did not (necessarily) mean that it was a poor breeding season but rather that most of the non-breeders were unrelated to the local breeding stock.

Christensen (1967) suggested that the total number of pairs breeding in Greenland was not more than 1,000, a figure also used by Salomonsen. It is not clear why the earlier estimate was doubled. There is no evidence that the numbers attempting to breed in Greenland have changed in the last forty years. As Christensen pointed out 'Investigations on these subjects should preferably be carried out in May and June, before the immigrants arrive from Iceland and complicate the situation'. This has yet to be done.

The total Iceland/Greenland breeding population in 1970

The survey of 1970 located approximately 11,300 nests of Pinkfeet. A best estimate for the number of pairs in the areas of Iceland not searched is a maximum of 1,500. The maximum figure for East Greenland has been suggested as 1,000 pairs. Thus the total number of breeding pairs in June 1970 probably lay around 14,000. Of this total, therefore, about 75% were in þjórsárver.

Age ratio and brood size counts in Britain each November have shown that the number of successful pairs with young at that date has varied over the years from a low of 2,800 to a maximum of 8,200 (Boyd and Ogilvie 1969; Ogilvie 1970, 1971). This variation reflects the rise in total numbers but also relates to the differing breeding success of each summer. 1970 was the first year in which a comparison could be made between a fairly reliable estimate of the number of pairs nesting in Iceland and Greenland in June (14,000) and the number of pairs with young in Britain in November (7,500). This suggests that almost half the nesting pairs had lost all their eggs or young in the five-month interval. The principal causes will have been weather and predation losses of eggs and young on the breeding grounds; losses on migration to Britain; and shooting on the wintering grounds prior to the census.

It is not possible to say for certain whether such a proportionate loss is normal, as there are no comparable sets of records. In November 1970 there were 23.1% young birds present in the wintering flocks, near the average for 1950 to 1969 of 26.2% (range 10.8 to 48.8).

Another question of considerable importance is whether the geese breeding in þjórsárver are more successful in rearing young than those breeding elsewhere. Such evidence as there is suggests that they should be, having the great advantage of safety in isolation and apparently excellent habitat. The breeding geese in East Greenland will almost certainly have a lower success, being subject to greater vagaries of weather and a shorter summer.

PART IV. THE PRESENT ROLE OF ÞJORSARVER AND OTHER BREEDING AREAS.

There are large numbers of mature Icelandic Pinkfeet (three or more years old) that fail to breed successfully in any given summer (Boyd and Ogilvie 1969). Whether these failures include sub-populations that consistently fail to attempt breeding or to breed successfully, or whether there is great variation in the success of particular pairs from place to place and from year to year, is not known. The sketchy evidence presented in Part III of fluctuations in the use of small nesting areas west of þjórsárver, together with hints of similar changes in the north-eastern colonies in the 1930's (see Scott and Fisher 1953) suggests that it may be inappropriate to regard any breeding area, even þjórsárver, as a stable environment for the annual production of geese. The 'carrying capacity' of other smaller areas may be even harder to assess.

How Pinkfeet choose their breeding places to provide both suitable nesting sites and adequate food supplies for later in the summer is not known. The preference shown for inaccessible nest-sites in river gorges suggests that safety from ground predators is a primary require-

ment. In oasis colonies their choice of nest site seems to be much less important, despite the recorded cases of 'traditional' sites, used year after year. (The same dichotomy between rigorous site-selection in gorges and the unimportance of site in large colonies is also very striking among Snow Geese in Arctic Canada.)

In considering what Pinkfeet displaced from Þjórsárver might do, or what might be done for them, it may be more important to pay attention to food supplies in late summer than to nest-sites. One facet of the problem is that in Þjórsárver few other grazing animals are now competing with the geese.

Some of the other areas inhabited by Pinkfeet are much more likely than Þjórsárver to be subjected to persistent grazing by sheep. A very recent assessment of the range resources of Iceland by Thorsteinsson *et al.* (1971) makes several points of great relevance to an understanding of the present and potential use of the central highlands by geese. Iceland has been subject to intensive soil erosion in the course of nearly 1,100 years of human settlement. Some 30-40% of the originally vegetated area of the country has become wind-eroded following the destruction of tree cover and over-grazing. Over-grazing has also resulted in the palatable herbs and grasses, formerly abundant, becoming relatively scarce. The floristic changes have been greatest in the lowlands. There is in any case a rapid decrease in numbers of plant species with increasing altitude. In the highlands much of the vegetation is moss heath *Rhacomitrium.* Its productivity is very low, the average annual yield being only 260 kg. per ha., dry matter as compared with 1,110 for the grassland and 1,120 for the bogs.

All the western parts of the Icelandic range of the Pinkfoot are classified by Thorsteinsson *et al.* as over-grazed. Only the little-known colonies north and east of the Vatnajökull are in an under-grazed region. The Pinkfeet are concentrated on poorly-drained land where productivity is relatively high but the vegetation is of little value to sheep because of unpalatability and the wet substrate.

It is at least possible that the changes in grazing practices in Iceland in recent years have improved conditions for breeding Greylags and for those Pinkfeet that may visit the lowlands in autumn and spring (Kear 1967; C. J. Sellick, pers. com.). The use of vegetation by geese, even in the seemingly remote interior of the country, should not be considered in isolation from stock distribution and management.

Þjórsárver is at present of paramount importance to the Pinkfeet of Iceland and Greenland, supporting at least 75% of the effective breeding population, with a mean density of nests, of about 130 per sq. km. over the whole oasis, much greater than elsewhere. The 15 sq. km. which may remain unflooded is unlikely to accommodate many of the 6,560 displaced pairs. It does not appear to be suited to intensive use, having a nest density (107 per sq. km.) below the average for the oasis. It is quite certain that it could not provide food for over 18,000 adults and 30,000 goslings in July and August.

What is the likelihood that the displaced geese can breed successfully in other places? In view of the low nest densities found in other areas and the large number of 'non-breeders' already in the population, it seems most improbable that they can be successful elsewhere without deliberate attempts to improve large areas for them. What improvements would be necessary and would be recognised as such by the geese can only be discovered by further research.

PART V. ECONOMICS AND RESEARCH.

In recent years the Icelandic Government has been trying to diversify the economy and to reduce its reliance on the fishing industry, a widely fluctuating source of income. The country has large untapped resources of relatively cheap hydro-electric power, which is being offered to foreign industrial firms to persuade them to operate in Iceland. One new power station on the middle reaches of the Þjórsá already supplies an aluminium smelter. According to the National Energy Authority this station and other power developments on the river would benefit from the proposed reservoir that would inundate Þjórsárver.

The Icelandic authorities have initiated an intensive research programme in the Þjórsárver oasis. This has been started by a team organised by the National History Museum of Iceland, under the direction of Dr. Agnar Ingolfsson of the Division of Biology of the University of Iceland. The programme is being funded by the Icelandic Government, through the National Energy Authority. Its purpose is to examine the ecological significance of the area. In 1971 the Icelandic investigators are making a detailed vegetation map of the area and

studying the feeding habits of the geese more fully. These studies will need to be supplemented by other research, both in Þjórsárver and outside it, which will require additional manpower and funds.

In Þjórsárver itself more needs to be learned about the dispersion of the geese after hatching; about possible differences in nesting and rearing success in different areas; and about the primary productivity of the oasis and the effects of goose grazing and droppings on the ecosystem.

Similar studies need to be conducted in other parts of the breeding range, in Greenland as well as Iceland. A nest survey should cover all potential breeding areas, by means of direct observations from a helicopter or, more practically, by aerial photograph from a fixed wing aircraft. Suitable photographic techniques are now being perfected in work on goose colonies in the Canadian High Arctic. Photography in early August may also be the best means of assessing both goose breeding success and productivity of the vegetation on a broad scale.

The financial backing for the research programme by the Icelandic Government is substantial. If external support of an equivalent amount could be obtained most of the necessary research could be completed within a few years.

If Þjórsárver is eventually flooded and there are no alternative breeding areas capable of sustaining a population of over 60,000 Pinkfeet, including 10-14,000 breeding pairs, what would happen? Presumably nothing immediately dramatic, unless large numbers of the displaced geese chose a moulting site with inadequate food supplies. Because of the cushioning presence of the non-breeders already in the population, it would probably be several years before any substantial decline in the wintering population became unmistakably apparent. The eventual loss would certainly be felt more in Britain than in Iceland and it therefore does not seem unreasonable to suggest that British finance should be forthcoming to help underpin the research.

Acknowledgements

The survey of Þjórsárver in 1970 was made possible through the enthusiastic co-operation of the following Icelandic authorities: Dr. Finnur Guðmundsson, Director of the Natural History Museum, who gave advice and assistance in setting up the operation; Captain Petur Sigurdsson, Director of the Coast Guard, who supplied the helicopter at less than operating costs; and the National Energy Authority, which provided valuable information and field accommodation free of charge. Mr. Brian Holt, Her Majesty's Consul in Reykjavík, gave his usual good humoured assistance. Dr. D. Brown and Mr. P. Rothery of the Nature Conservancy advised on the statistical treatment of the survey data. The survey was conducted while Kerbes was employed by the Canadian Wildlife Service and Ogilvie held a post at the Wildfowl Trust financed by the Natural Environment Research Council. The Canadian Wildlife Service provided the funds for chartering the helicopter.

Summary

The proposal to flood the main breeding ground of the Pink-footed Goose *Anser brachyrhynchus* at Þjórsárver in Iceland required an up-to-date assessment of its importance. A helicopter survey in June 1970 resulted in an estimate of 10,700 nests widely dispersed throughout the 81.6 sq. km. of vegetated ground. The technique is described and its reliability tested. Comparison is made with earlier estimates of the numbers of geese breeding in Þjórsárver, indicating a considerable increase since 1951. Scattered information on Pinkfeet breeding sites elsewhere in Iceland and in east Greenland is assembled. It would appear that Þjórsárver holds approximately 75% of the breeding pairs in the Greenland/Iceland population which winters in Britain. If Þjórsárver is flooded to the designed level, 85% of the nest sites used in 1970 would be lost and the vegetated area remaining could not provide sufficient food to raise more than a small proportion of the goslings now produced annually in the oasis.

References

BLURTON JONES, N. G. and R. GILLMOR. 1955. Observations on gathering and departure of Pink-footed Geese at Åsgarð in central Iceland. *Wildfowl Trust Ann. Rep.* 7 : 153-69.

BOYD, H. 1970. Pink-footed Geese seen during aerial searches in Iceland in May 1964. Unpublished report. Wildfowl Trust archives.

BOYD, H. and M. A. OGILVIE. 1969. Changes in the British-wintering population of the Pink-footed Goose from 1950 to 1975. *Wildfowl* 20 : 33-46.

BULSTRODE, C. J. K. and D. E. HARDY. 1970. Distribution and numbers of the Pink-footed Goose in central Iceland, 1966-69. *Wildfowl* 21 : 18-21.

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Plate I. Aerial survey of the breeding grounds of the Pink-footed Goose *Anser brachyrhynchus* at Þjórsárver, central Iceland, in June 1970 (see pp. 5-17). (a) The north-east corner of the oasis with the Arnarfell mountains beyond the terminal moraine of the Hofsjökull icecap. (b) A view from the helicopter about 60 metres up over a favoured nest area. The drier ridges, on which the geese nest, are only a few metres apart.

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R. H. Kerbes

Plate II. (a) Female Pinkfoot on its nest beside some dwarf willow. The raised rim of the nest indicates that the site has been used again and again over the years. (b) Helicopter view of a low-lying marsh in Þjórsárver which will dry out by August to become an important feeding area for the geese and their goslings. In the foreground is one of the areas searched on the ground to check the counts of nests made from the air. The field of view is about 500 metres in mid-picture.

R. H. Kerbes

CHRISTENSEN, N. H. 1967. Moult migration of Pink-footed Geese (*Anser fabalis brachyrhynchus* Baillon) from Iceland to Greenland. *Dansk Ornith. Foren. Tidsskr.* 61 : 56-64.
COCHRAN, W. G. 1953. *Sampling Techniques.* New York: John Wiley.
CONGREVE, W. M. and S. W. P. FREME. 1930. Seven weeks in eastern and northern Iceland. *Ibis* 72 : 193-228.
GOODHART, J. and T. WRIGHT. 1958. North-east Greenland Expedition 1956. *Wildfowl Trust Ann. Rep.* 9 : 180-92.
HALL, A. B. 1963. Goose observations from Scoresby Land, 1962. *Wildfowl Trust Ann. Rep.* 14 : 94-97.
HARDY, D. E. 1967. Observations on the Pink-footed Goose in Central Iceland, 1966. *Wildfowl Trust Ann. Rep.* 18 : 134-41.
KEAR, J. 1967. Feeding habits of the Greylag Goose *Anser anser* in Iceland, with reference to its interaction with agriculture. *Proc. VII Cong. Int. Union Game Biol. Beograd-Ljubljana 1965* : 615-22.
KERBES, R. H. 1969. Biology and distribution of nesting blue geese on Koukdjuak Plain, Baffin Island, N.W.T. Unpublished M.Sc. Thesis, Univ. of Western Ontario. 122 pp.
MARRIS, R. and M. A. OGILVIE. 1962. The ringing of Barnacle Geese in Greenland in 1961. *Wildfowl Trust Ann. Rep.* 13 : 53-64.
MORZER BRUYNS, M. F., J. PHILIPPONA and A. TIMMERMAN. 1969. Survey of the winter distribution of Palaearctic geese in Europe, West Asia and North Africa. Document of the Goose Working Group of the International Wildfowl Research Bureau. 111 pages.
OGILVIE, M. A. 1969. Wildfowl censuses and counts. *Wildfowl* 20 : 152-3.
OGILVIE, M. A. 1970a. Wildfowl censuses and counts in Britain, 1969-70. *Wildfowl* 21 : 148-9.
OGILVIE, M. A. 1970b. The Pink-footed Goose in danger. *Scot. Birds* 6 : 183-5.
OGILVIE, M. A. 1971a. A threat to the Pink-footed Goose in Iceland. *Polar Rec.* 15 : 530-4.
OGILVIE, M. A. 1971b. Wildfowl censuses and counts in Britain, 1970-71. *Wildfowl* 22 : 134.
SALOMONSEN, F. 1967. *Fuglene på Gronland.* Copenhagen: Rhodos.
SCOTT, P., H. BOYD and W. J. L. SLADEN. 1955. The Wildfowl Trust's Second Expedition to Central Iceland, 1953. *Wildfowl Trust Ann. Rep.* 7 : 63-98.
SCOTT, P. and J. FISHER. 1953. *A Thousand Geese.* London: Collins.
SCOTT, P., J. FISHER and F. GUDMUNDSSON. 1953. The Severn Wildfowl Trust Expedition to Central Iceland, 1951. *Wildfowl Trust Ann. Rep.* 5 : 79-115.
TAYLOR, J. 1953. A possible moult-migration of Pink-footed Geese. *Ibis* 95 : 638-42.
THORSTEINSSON, I., G. OLAFSSON and G. M. VAN DYNE. 1971. Range resources of Iceland. *J. Range Manag.* 24 : 86-93.
YEATES, G. K. 1955. A visit to Krossárgil, North-Central Iceland, 1954. *Wildfowl Trust Ann. Rep.* 7 : 146-52.

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Distribution and breeding biology of the Lesser Snow Goose in central Arctic Canada

JOHN P. RYDER

Introduction

This paper reports the known nesting distribution and aspects of the breeding biology of the Lesser Snow Goose *Anser caerulescens caerulescens* in central Arctic Canada (Figure 1). Although previous biological work in the area is sparse, the available literature indicated a substantial increase in numbers of Lesser Snow Geese during the last 30 years.

Gavin (1947) reported that the white-phase was uncommon in the Perry River region (Figure 1) between 1937 and 1941. Some 10 to 12 pairs nested each year at the only known colony located 3.2 km. (2 miles) inland from the mouth of the Perry River (67° 42′ N., 102° 15′ W.). On 21st June 1941 he found three nests with two, three and five eggs. The same author reported four blue-phase pairs nesting at Discovery Lake (67° 33′ N., 101° 49′ W.) (Figure 2) on 2nd June 1940. The blue-phase was not known by the Perry Island Eskimos and Gavin's observations extended the known breeding range of this colour phase about 950 km. (600 miles) west.

Hanson *et al.* (1956) conducted ground and aerial surveys east from the Ellice to the Simpson River between 18th July and 1st August 1949 (Figure 1). They reported 120 white-phase, 13 blue-phase geese and two nests, one along the Perry River and one at Arlone Lake (67° 22′ N., 102° 10′ W.) (Figure 2). They also saw 18 Lesser Snow Goose broods averaging 2.9 goslings per brood and two Blue × Lesser Snow Goose pairs with two downy young each. On 30th July, 36 Lesser Snow Geese and four Blue Geese were seen near Nelson Hill (66° 46′ N., 102° 35′ W.).

Barry (1961) made aerial surveys of the western and eastern Arctic from the Anderson (69° 45′ N., 129° 00′ W.) to Sherman Basin (68° 00′ N., 98° 21′ W.).

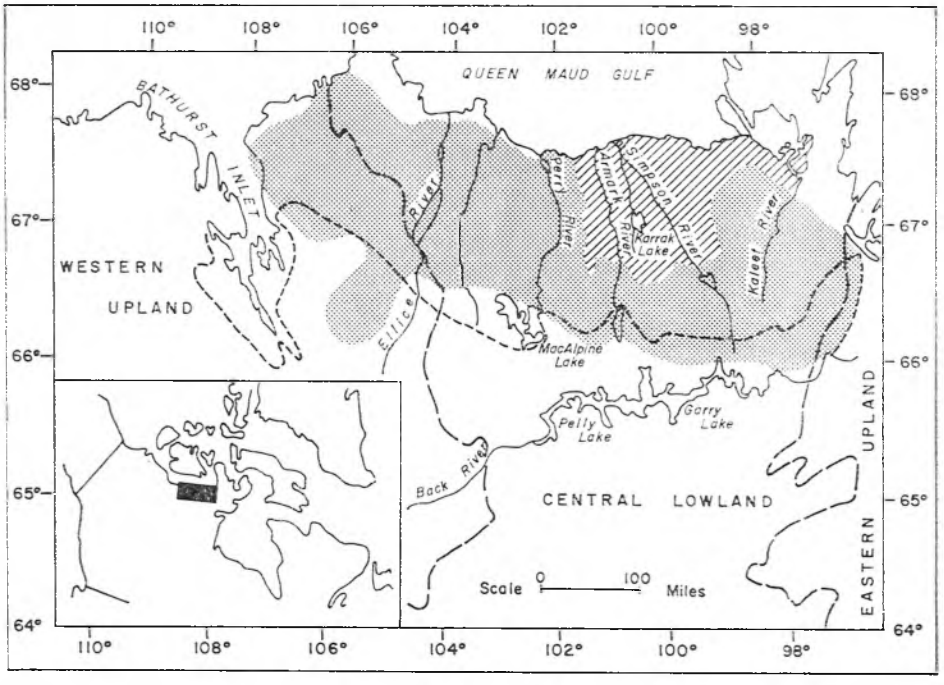

Figure 1. Map of aerial survey area (stippled) in the western upland, central lowland and eastern upland portions of the central Arctic. The Simpson River Rock Plain (diagonal lines) is within the survey area. The heavy broken lines separate the physiographic regions. The thin broken line is southern limit of post-glacial marine transgression. (Map modified from Ryder (1969a).)

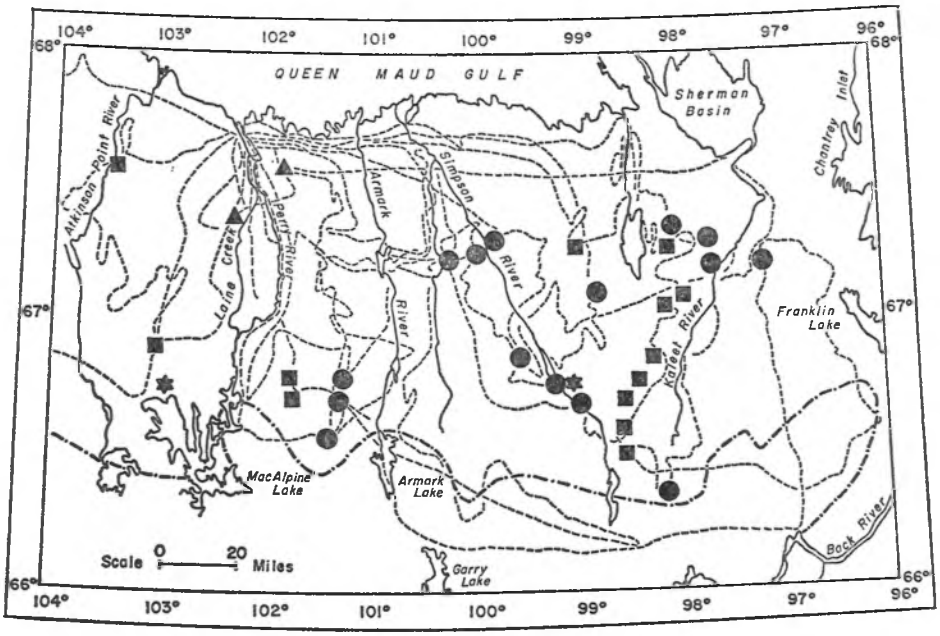

Figure 2. Distribution of Lesser Snow Goose nesting colonies in central Arctic Canada. Circles, squares and stars represent colonies discovered in 1965, 1966 and 1967 respectively. Triangles show location of Arlone Lake near Laine Creek and Discovery Lake east of Perry River. Broken lines are daily flight routes of 1965 and 1966 survey. The 1967 survey route is not shown (see text). The heavy dot-dash line is the southern limit of post-glacial marine transgression. (Map modified from Ryder (1969a).)

Although most of the geese had left their nesting areas by the time of his survey (16th-22nd August), he estimated 20,000 adult and young Lesser Snow and Blue Geese (10% blue-phase) on the mainland south of the Queen Maud Gulf.

Methods

Information in this paper was collected incidentally while conducting research on the Ross's Goose *Anser rossii* (Ryder 1969b). Field work consisted of ecological studies at Karrak Lake (67° 15′ N., 100° 15′ W.) (Figure 1), the location of the largest known colony of Ross's Geese (Hornby 1967), and of aerial surveys. Investigations at Karrak Lake lasted from 27th May to 10th July 1966, 29th May to 18th July 1967 and 1st June to 17th July 1968. We flew surveys on 9th-12th July 1965 and 14th-15th July 1966. On 3rd-4th July 1967 we inspected from the air 15 Lesser Snow Goose colonies discovered in 1965 and 1966 to see if geese were still using them. The aerial survey method (Ryder 1969a) involved marking potentially suitable colony sites on a map of the central Arctic before going into the field. The characteristics of the two known colony sites at Discovery and Arlone Lakes indicated lakes with islands as the most probable nesting sites. For the studies at Karrak Lake, we arrived at the colony site before the geese and noted their arrival dates and numbers. In 1968, histories were compiled from Lesser Snow Goose nests to augment clutch size data collected in 1966 and 1967. On the largest nesting island (18.57 hectares or 45.9 acres) in Karrak Lake, each new nest (i.e. with one clean or unstained egg) was marked with a numbered wooden stake placed about one metre (3 feet) away. The history was recorded until the hatching or disappearance of all the eggs. Marked nests were visited daily during the egg-laying period but only once every two or three days during incubation, to minimize disturbance. Daily visits were resumed during the hatching period, weather permitting. Nest checks were not conducted on unduly cold or rainy days. It was assumed that disturbance under such conditions would be detrimental to the hatching or newly-hatched young. An egg was recorded hatched if the young was almost or fully emerged. Eggs remaining in a nest after the others had hatched were broken open and classified as being addled, infertile (no embryo

development), with a dead embryo or destroyed (cracked shell or hole in egg).

Study area

Aerial surveys

In 1965 the aerial survey boundaries were 66° 10′ to 67° 59′ N. and 96° 55′ to 104° 15′ W. These were expanded to 66° 09′ to 68° 10′ N. and 96° 05′ to 108° 14′ W. in 1966. We flew 2,815 km. (1,750 miles) in 1965 and 3,260 km. (2,026 miles) in 1966.

The survey area is within the 'Barren Lands' of the Canadian Arctic and incorporates parts of the western and eastern uplands and the northern sector of the once-inundated central lowland (Figure 1). The lowland slopes down to the north about 0.5 m./km. (2.5 feet per mile) (Bird 1967). Relief is less than 6 m. (20 ft.) except for an occasional Precambrian rock outcrop. The western upland is a plateau 300-600 m. (1,000-2,000 ft.) above sea level The eastern upland is a lower plateau characterized by hill ridges, protruding rocks and extensive boulder fields. Vegetation in the central lowland consisted of wet meadow and marsh tundra dominated by frost-heaved tussocks of *Eriophorum vaginatum*, *Carex* spp., *Betula glandulosa*, *Ledum decumbens* and *Rubus chamaemorus*. On outcrops and other elevated areas, *Hierochloe alpina*, *Salix* spp., *B. glandulosa*, *Papaver radicatum*, *Cassiope tetragona*, *L. decumbens*, *Vaccinium vitis-idea* and *Dryas integrifolia* were dominants. The boulder fields and well-drained areas of the eastern and western uplands had an impoverished lichen-moss-vascular plant association.

Karrak Lake

This lake is situated in part of the central lowland known as the Simpson River Rock Plain (Figure 1). Drumlins form the dominant topographical feature. These hills rise from 3-15 m. (10 to 50 ft.) above the surrounding terrain and their steep slopes face south, the direction from which glacial ice moved. They are composed of glacial till, a variety of different sized earth materials (silt, sand, gravel, rocks, large boulders) left behind by moving ice. A second important feature of the Simpson River Rock Plain is the badland topography along river banks. Water erosion has exposed marine silts and sands deposited during the post-glacial marine transgression. These small-grained sediments along with glacial till, form the third topographical feature, patterned ground, in the form of mud circles and polygons. These consist of silt and sand deposits, most of which are covered with tussock tundra.

Karrak Lake is approximately 6 km. (4 miles) long and 5 km. (3 miles) wide with an average depth of 1.3 m. (4 ft.). It has 47 islands, 16 of which were used by Ross's and Lesser Snow Geese for nesting. The occupied islands ranged in size from 820 m. (2,700 ft.) long by 365 m. (1,200 ft.) wide, with an altitude of 8 m. (27 ft.) above the July water level, to 60 m. (200 ft.) long by 23 m. (75 ft.) wide and 4.5 m. (15 ft.) above water level. Unoccupied islands were smaller than occupied ones and consisted entirely of rocks. Their low elevation, usually less than 1.5 m. (5 ft.) above the July water level, resulted in their being flooded in early or mid-June when the lake water rose about 1.0 m. (3 ft.) during the peak melting period. Vegetation on nesting islands was kept close to ground level by the geese using it for nest material and food (Ryder 1969b). Very little vegetation reached the flowering or fruiting stage. On the nesting islands, three habitats were visually separable on plant associations. 'Rock habitat' was found on the raised, dry rock and gravel areas which remain exposed throughout the winter and well drained all summer. Except for a variety of crustose lichens, this habitat was virtually devoid of vegetation. 'Moss habitat', a blanket of *Aulacomnium palustre*, *A. turgidum*, *Sphagnum rubellum*, *S. teres*, and *Dicranum angustum*, occurred on the moist lower portions of the islands. 'Mixed habitat' occurred in between. Dominant species were *Empetrum nigrum*, *L. decumbens*, *Potentilla hyparctica*, *C. tetragona*, *Rhododendron lapponicum*, *Pedicularis sudetica*. *B. glandulosa* and *Salix* spp. occurred in small patches and *Hippuris vulgaris* grew in melt pools. *Petasites frigidus* and *Senecio congestus* were common at old nest sites from the accumulation of goose droppings.

The rocky islets were devoid of vegetation. They provided nest sites for Glaucous Gulls *Larus hyperboreus*, Herring Gulls *L. argentatus* and Arctic Terns *Sterna paradisaea*.

Results

Aerial surveys

In 1965 we estimated 8,429 nesting Lesser Snow Geese at 16 colonies in the central Arctic. Their locations and sizes are detailed by Ryder (1969a). In addition 1,473 Lesser Snow Geese not associated

with nesting colonies were observed and classified as non-breeding birds in the post-nuptial moult. All of the colonies but one (Arlone Lake) were previously unrecorded and all had mixed populations of Ross's and Lesser Snow Geese. Five colonies with only Ross's Geese were also found (Ryder 1969a). In 1966 our Ross's Goose studies at Karrak Lake prevented us from doing the survey until after the nesting season. In that year 13 newly recorded colony sites were determined by the presence of freshly used nests on islands and of geese with broods nearby. No population estimates were made in 1966 because the numbers of geese near the islands were not considered to represent the colony population. Near the Kaleet River (Figure 2) for example, it was impossible to establish from where the flocks originated. We found that all of the colonies discovered in 1965 were occupied again in 1966. In 1967 two other colonies were found and 14 of 15 colonies discovered in 1965 and 1966 were again occupied.

Geese used islands which were not flooded in spring (summits higher than 1.5 m. (5 ft.)) but which were not too steep-sided (summits higher than 9 m. (30 ft.)) and rocky to provide adequate nest sites and food. Suitable nesting islands had a varied topography with dry gravel areas 3 to 6 m. (10 to 20 ft.) above the lake surface and a variety of plants and rock cover. All nesting islands were in shallow lakes estimated 0.6 to 1.8 m. (2 to 6 ft.) deep. The ice in shallow lakes melts earlier than in deep ones, preventing Arctic Foxes *Alopex lagopus* from getting to the islands after the geese start to nest (Ryder 1969a).

All colonies were within the limit of post-glacial marine inundation. This is also true for nesting Canada Geese *Branta canadensis* in the Hudson Bay Lowlands (Hanson and Smith 1950; MacInnes 1966) and may indicate the availability and quality of food in such areas. During the post-Wisconsin marine inundation, marine organisms and minerals sedimented on the central lowland (Bird 1967). Beneath these fine-grained deposits, organic soil layers developed which are today reflected, in part, by the dense cover of wet tundra vegetation. The relatively restricted drainage in the central lowlands, as evinced by the many small, shallow lakes, waterlogged substrate and shallow active layer, less than 30 cm. (1 ft.) in the Perry River region (Hanson *et al.* 1956), has also been an important factor in the development of the wet tundra association. Typically, Arctic soils are unfavourable for plant growth because they are shallow, acidic and subject to little biochemical reaction (Bird 1967). It is possible, however, that organic and mineral nutrients were deposited in greater quantities on the old sea bottom of the central lowland than in areas which had no marine history. This abundance of nutrients allows increased plant growth and goose food. The fact that Arctic plants grow vigorously in areas rich in nutrients is strikingly shown near bird cliffs, dens of Arctic Fox and Arctic Ground Squirrel *Citellus parryi*, and goose colonies. After the spring melt the many, often continuous, wet tundra meadows and marshes in the central lowland furnish an abundance of goose food. Food may be an important limiting factor in the western and eastern uplands which have little vegetation.

Breeding biology

Lesser Snow Geese arrived at Karrak Lake in late May or early June, in groups of two to 100 individuals. Within about one week they dispersed over the islands and began nesting (Table I). In all three seasons nesting habitat was available when the geese arrived. Based on aerial surveys on 9th July 1965, 14th July 1966 and 3rd July 1967, the average nesting population at Karrak Lake was estimated at 6,000 Lesser Snow Geese and 12,000 Ross's Geese.

The interval between first arrival and nesting of Lesser Snow Geese was shorter than reported elsewhere in the Arctic. The average interval, calculated from the data of Uspenski (1965) for Lesser Snow Geese at Wrangel Island (74° N., 180° W.) and of Barry (1967) for the Anderson River Delta (69° 40′ N., 129° 00′ W.), was 12 days. Lemieux (1959) reported

Table I. Interval between arrival and start of nesting of Lesser Snow Geese at Karrak Lake, N.W.T., 1966-68. Number of Lesser Snow Geese in brackets.

Year	*Date first Lesser Snow Geese seen*	*Peak arrival date*	*Date of first nest*	*Peak nest initiation date*
1966	28 May (2)	3 June (115)	1 June	6 June (est.)
1967	6 June (20)	13 June (134)	14 June	16 June (est.)
1968	2 June (14)	8 June (129)	8 June	11 June

that Greater Snow Geese *Anser caerulescens atlanticus* on Bylot Island (73° N., 80° W.) started nesting 15 days after the first arrival in 1957. The above authors reported that nesting habitat was usually snow covered when their geese arrived. Barry (1962) observed that Atlantic Brant *Branta bernicla hrota* waited two weeks after their arrival at East Bay, Southampton Island in Hudson Bay, during 1957 when the season was late, with nearly 100% snow cover at arrival. Similar conditions were noted by Cooch (1961) in 1957 and 1959 at Blue Goose nesting areas in the Hudson Bay drainage. Norderhaug *et al.* (1964) specified snow cover as being the most important factor delaying the onset of laying in Pink-footed Geese *Anser brachyrhynchus* in West Spitsbergen. MacInnes (1962) found that flocks of Canada Geese arriving early on the west coast of Hudson Bay in 1959 congregated for 15 days on the few patches of snow-free ground.

The start of the nesting season was taken as the day on which the first egg was found on the study island (Table I). Figure 3 shows the overall distribution of egg-laying in 1968. Figure 4 presents the distribution of clutch initiation and completion. For a single clutch the interval between successive eggs averaged 1.3 ± 0.32 days (Table II). Other workers have reported that geese usually lay eggs at 1- to 1.5-day intervals (Barry 1967; Brakhage 1965; Delacour 1964; Klopman 1958; Kossack 1950; Lemieux 1959; MacInnes 1962). There was no relation between the number of eggs laid per clutch and the mean interval (days) between the laying of successive eggs. On the average, 6-egg clutches took twice as long to complete as 3-egg clutches. As noted by Cooch (1958) this may be important at hatching in view of the restricted amount of time available for nesting.

The most frequent laying patterns in the commoner clutch sizes (3, 4 and 5 eggs per nest) are given in Table III. The two most frequent sequences were to lay two or three eggs then miss a day before completing the clutch. Cooch

Table II. Distribution of clutch completion periods for Lesser Snow Goose clutches at Karrak Lake, 1968.

Days to complete clutches	*Number of nests by clutch size* 2	3	4	5	6	7	8	9	10	*Total*
2	2		1							3
3	1	5								6
4		12	3	1						16
5		2	20	5						27
6		1	9	9	3					22
7		1	1	2	2					6
8			1		2					3
9			2		1					3
10				3	1	1			1	6
11										—
12					1			1		2
Total	3	21	37	20	10	1	—	1	1	94
Mean no. of days between successive eggs	1.2	1.4	1.4	1.3	1.3	1.4	—	1.2	1.0	
Number of days to complete clutch	2.4	4.2	5.6	6.5	7.8	9.8	—	10.8	10.0	

Mean no. of days between successive eggs = 1.3 ± 0.32

Table III. Most commonly occurring egg-laying patterns in Lesser Snow Goose clutches in marked nests at Karrak Lake, 1968.

Egg-laying pattern Days after laying of first egg 0	1	2	3	4	5	*Number of clutches*
1	2	3				6
1	2	—	3			8
1	2	3	4			4
1	2	3	—	4		7
1	2	—	3	4		10
1	—	2	3	—	4	5
1	2	3	4	5		4
1	2	3	—	4	5	6

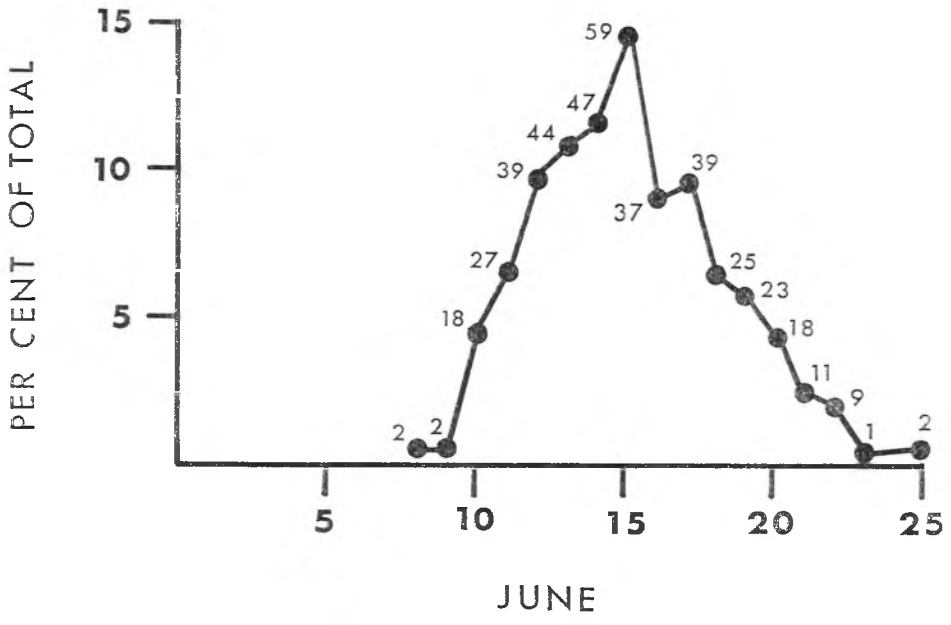

Figure 3. Distribution of egg-laying in 94 marked Lesser Snow Goose nests at Karrak Lake, 1968. Figures on graph equal number of eggs laid each day.

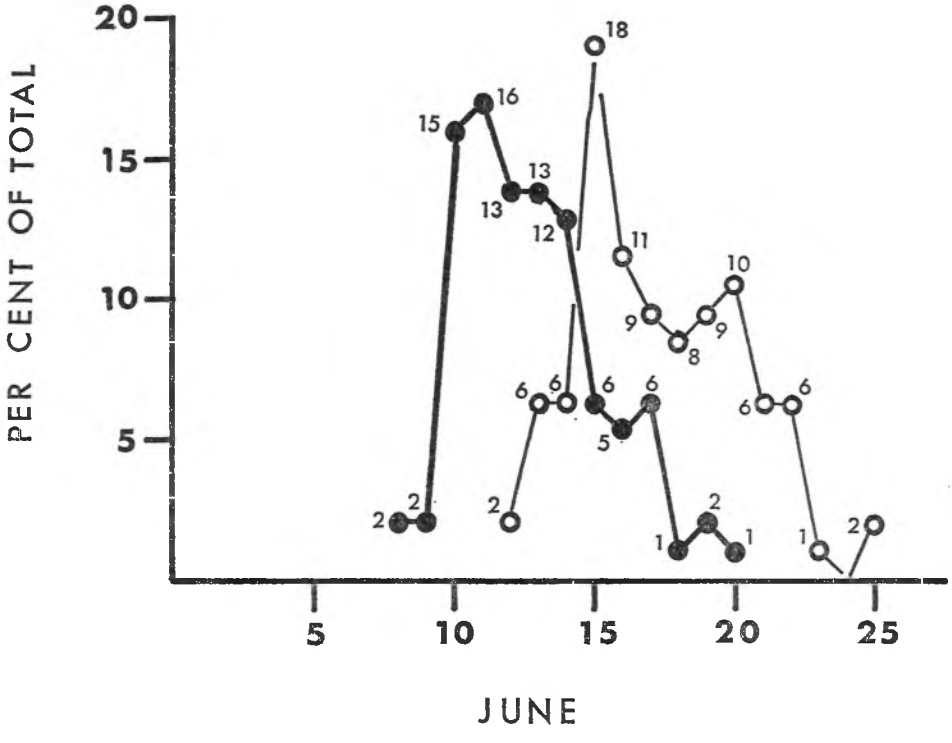

Figure 4. Distribution of clutch initiation and completion in 94 marked Lesser Snow Goose nests at Karrak Lake, 1968.

(1958) reported that Blue Geese generally lay 3-egg clutches on consecutive days but the most common pattern in larger clutches (four-seven eggs) was to lay four eggs, skip a day and then complete. Barry (1967) reported similar egg-laying patterns in Pacific Brant *Branta bernicla orientalis*, White-fronted Geese *Anser albifrons* and Lesser Snow Geese nesting at the Anderson River Delta. It is not clear why the species at Karrak Lake lay two or three eggs, rather than four, before missing a day. The difference may be related to regional, annual or seasonal phenology.

Clutch size

Hilden (1964) noted that clutch size data are one of the easiest types of information to collect. However, they are subject to errors depending on when and how they are collected. In 1968 all the clutch size information was based on the number of eggs found in each study nest at each daily nest check. The data cannot include eggs laid which disappeared between two consecutive daily nest checks. Incomplete clutches have, of necessity, been included in the material because it was not possible visually to separate incomplete from complete clutches. This problem is not, however, unique to this study (see also Sowls 1949).

The distribution of Lesser Snow Goose clutch sizes are given in Table IV. In each of the three seasons, the modal clutch size was 4 eggs and the combined average for the total nest sample (437 nests) was 4.16 ± 1.5 eggs. There were no significant differences in mean annual clutch sizes ($P>0.05$) and no correlation existed between clutch size and the starting date of the nesting season (Table I). However, the smallest average clutch size recorded in 1967 agrees with the findings of Barry (1962, 1967), Cooch (1958), Dementiev *et al.* (1952) and Uspenski (1965) that smaller clutches may result from resorption of some preovulatory follicles possibly stimulated by the lack of nesting habitat. Barry (1962) contended that atresia of ovarian follicles, resulting in smaller than average clutches or, in extended late seasons, failure to nest, may be an adaptation to the short Arctic nesting season, eliminating nesting and incubation that are a physical drain on the female. Thus atresia would enhance the chances of survival of both the females and of the young produced from her smaller clutch size (see Ryder 1970).

Incubation period

Incubation was taken to be complete in nests in which chipping was complete around the blunt end of the last laid egg or in which the newly hatched gosling was still wet. This was done because it was not possible to determine the hatching date of dry goslings. The distribution of incubation periods so calculated for 1968 is given in Table V. The modal period for 1968 was 23 days (54% of 48 clutches) and the average was 22.4 ± 0.89 days.

Table IV. Clutch sizes from Lesser Snow Goose nests at Karrak Lake.

	Number of nests by clutch sizes													*Mean ± 1 standard deviation*
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	
1966	—	—	34	53	72	41	25	8	2	2	1	2	1	4.17 ± 1.4 (n = 24
1967	—	—	8	32	33	14	12	—	2	1	—	—	—	4.03 ± 0.90 (n = 10
1968*	—	—	3	21	37	20	10	1	—	1	1	—	—	4.29 ± 1.3 (n = 94
	**(13)	(3)	(9)	(29)	(32)	(5)	(3)	—	—	—	—	—	—	(2.97 ± 1.5) (n = 94
Totals	—	—	45	105	142	75	47	9	4	4	2	2	1	4.16 ± 1.5 (n = 43

* Data from marked nests of known history. ** Clutch size at hatching.

Table V. Incubation period in relation to clutch size in marked Lesser Snow Goose nests at Karrak Lake, 1968.

	Incubation period (days)						
Clutch size	*19*	*20*	*21*	*22*	*23*	*24*	*Mean ± 1 S.D.*
2					1		23.0
3				5	6	1	22.7 ± 0.48
4	1		1	9	8	1	22.3 ± 1.0
5		1	1		9		22.5 ± 1.1
6		1		1	2		22.0
Total	1	2	2	15	26	2	22.4 ± 0.89

The data presented in Table V indicate that there was a trend towards shorter incubation periods with increased clutch size, agreeing with the results reported by Cooch (1958) for Blue Geese. He postulated that the trend resulted from behavioural differences among the females. Apparently females laying large clutches incubated before the clutch was complete, thus subjecting the last egg to fewer cool spells than in the case of small clutches which the females did not incubate until after the last egg was laid. Cooch (1958) also noted that the nest site of large clutches had had longer to dry out before the last egg was laid. The eggs were then more likely to be kept warmer when incubation began. The attentiveness of birds with replacement clutches (eggs laid after previously laid eggs have been destroyed) may also be a factor. Nelson (1966) showed from his study of known-age Gannets *Sula bassana* that birds which laid and incubated replacement clutches had a diminished urge to incubate. Geese with (smaller) replacement clutches may likewise be less attentive than geese with first clutches.

Hatching

The hatching distribution is given in Figure 5. The daily distribution of hatching initiation and completion in 1968 clutches is shown in Figure 6. The shapes of the two curves are virtually identical indicating a high degree of hatching synchrony. The average number of days required for a single clutch to hatch was 1.4 ± 0.58 days (Table VI) and there was no consistent relation between the number of eggs in a nest at hatching and the amount of time required for a clutch to hatch. Over 60% of the clutches hatched completely in one day (i.e. during the interval between two consecutive nest checks).

Nest and hatching success

The proportion of marked nests producing at least one hatched egg (nest success) was 86.2 ± 3.5% and the number of eggs hatched from the total number marked (hatching success) was 69.2 ± 2.2% (Table VII). Standard deviations were calculated using the normal approximation method and checked with values

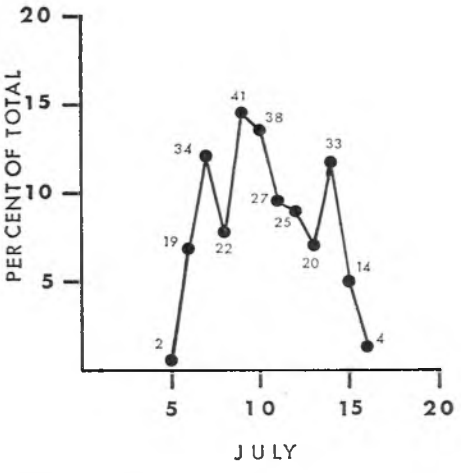

Figure 5. Distribution of egg hatching in 81 marked Lesser Snow Goose nests at Karrak Lake, 1968.

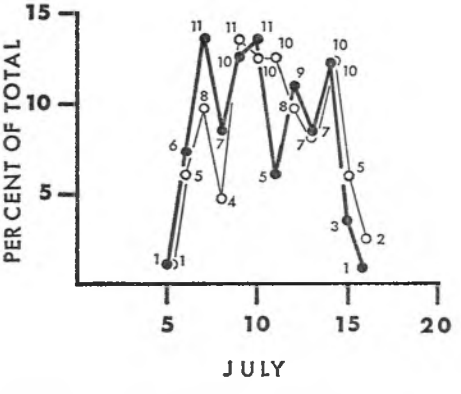

Figure 6. Distribution of hatching initiation and completion in 81 marked Lesser Snow Goose nests at Karrak Lake, 1968.

Table VI. Frequency of hatching times for Lesser Snow Goose clutches at Karrak Lake, 1968.

Days to hatch clutch	*Clutch size (eggs)* 1	2	3	4	5	6	*Total*
1	3	8	20	16	4	1	52
2		1	8	14	1	1	25
3			1	2		1	4
Total	3	9	29	32	5	3	81
Average no. of days per clutch size	1.0	1.1	1.3	1.6	1.2	2.0	1.4 ± 0.58

given in the Clopper and Pearson Charts for the 95% confidence interval (Steel and Torrie 1960).

Variation in nest and hatching success with clutch size is also given in Table VII. Nests containing 2 eggs were the least successful. Clutches of 3, 4, 5 and 6 eggs showed about equal success, because of the relatively large standard deviations. The complete success of the larger clutches (7, 9, 10 eggs) has little meaning because of the small sample size. Similar results were calculated for hatching success in relation to clutch size. The smallest clutches of 2 eggs had the lowest egg success and the most common clutches (3, 4 and 5 eggs) had about equal success. The hatching success in 6+ egg clutches is again difficult to interpret because of sample size. Table VIII compares the average number of eggs hatched per nest in relation to clutch size. More eggs tended to be hatched per nest as the clutch size increased. However, when the frequency of each clutch size is considered, the modal number of eggs per nest (4) hatched more eggs than any other clutch size. As a result, about 40% of the total number of goslings came from females which laid four eggs. The significance of the preponderance of 4-egg clutches has yet to be demonstrated. In geese fledging periods are not well documented and no long term studies have shown which clutch size produces the greatest number of young surviving to breeding age.

Egg loss

The fate of all unhatched eggs in marked nests is recorded in Table IX. In most cases it was not possible to differentiate between eggs which had disappeared and ones which had been destroyed by a specific avian predator. Gulls (Glaucous and Herring) typically carry an egg from a nest and eat it away from the colony. When a gull destroys an egg at the nest site, a large hole is usually left and the contents are gone. Jaegers (Skuas) *Stercorarius* spp. leave a much smaller hole

Table IX. Fate of 124 unhatched Lesser Snow Goose eggs in marked nests at Karrak Lake, 1968.

Fate	*Number*	*% of total*
Disappeared	91	73.4
Destroyed	16	12.9
Broken in nest	8	6.5
No embryo	4	3.2
Out of nest	4	3.2
Hole in egg	1	0.80

Table VII. Nest and hatching success of Lesser Snow Goose in relation to clutch size, 1968.

Clutch size	*Nest success* %	*Hatching success* %
2	33.3 (3)	33.3 ± 27.2 (6)
3	85.7 ± 7.6 (21)	77.8 ± 5.2 (63)
4	86.5 ± 5.6 (37)	74.3 ± 3.5 (148)
5	95.0 ± 4.9 (20)	71.0 ± 4.5 (100)
6	80.0 ± 12.6 (10)	50.0 ± 6.4 (60)
7	100.0 (1)	85.7 ± 13.2 (7)
8	—	—
9	100.0 (1)	55.5 ± 16.6 (9)
10	100.0 (1)	60.0 ± 15.5 (10)
	86.2 ± 3.5 (94)	69.2 ± 2.2 (403)

Table VIII. Average and total number of eggs hatched in relation to clutch size in Lesser Snow Goose nests, Karrak Lake, 1968.

Clutch size	*Average no. eggs hatched per nest*	*Total no. of eggs hatched*	*% of total eggs hatched*
2	0.67 (3)*	2	0.70
3	2.3 (21)	49	17.6
4	3.0 (37)	110	39.4
5	3.6 (20)	71	25.4
6	3.0 (10)	30	10.7
7	6.0 (1)	6	2.2
8	—	—	—
9	5.0 (1)	5	1.8
10	6.0 (1)	6	2.2

* Total sample size

and do not normally carry eggs from the nest site. As shown in Table IX, most unhatched eggs either disappeared or were destroyed by gulls. In only one case was predation by Jaegers definitely identified. The brooding females were generally the cause of eggs being broken in the nest or found outside. I have seen incubating geese break eggs when startled from the nest, treading on them or pushing them out in their efforts to take flight as fast as possible. Egg fertility was high, as only four of 124 eggs showed no embryo development. Cooch (1958) found that infertile, crumpled and rolled out eggs seldom exceeded 1% of the total loss of Blue Goose eggs.

Colour ratios

The little information I have on colour-phase ratios was collected during post-nesting ringing operations. In 1966, 1967 and 1968 a total of 380 Lesser Snow and 20 Blue Geese were banded on the Perry and Simpson Rivers (Figure 1). Although the sample size is small, the observed proportion, 5% blue-phase geese, is much less than the 22% blue-phase predicted by Cooch (1963) for the Perry River (east) region in 1970. Kerbes (1969) found a similar difference from Cooch's prediction of 88% blue-phase geese for Baffin Island in 1970. From a ringed sample of 7,361 Lesser Snow and Blue Geese, Kerbes reported 76% blue-phase geese. He postulated that the departure of present blue-phase frequencies on his study area from the predictions of Cooch may have resulted from a reversal of the warming trend in the Arctic climate. Cooch (1961, 1963) reported that the blue-phase was more successful than the white-phase except in extremely retarded seasons. If the present cooling trend in the Arctic is sufficient to affect the breeding biology of the two colour phases of *A. c. caerulescens*, it is conceivable that white-phase geese are more successful than blue-phase birds at present, thus decreasing the proportion of the latter in the total population.

Discussion

Relative to the findings of Gavin (1947) and Hanson *et al.* (1956), our aerial surveys in central Arctic Canada revealed a definite increase in the numbers of Lesser Snow Geese in the last 20 years. Based on the characteristics of occupied colony sites, there were many unused islands potentially suitable for nesting geese. Unless mortality on other parts of the species' range is limiting their numbers, I expect a continued increase in the population. In view of this, it is of considerable importance that studies of the Lesser Snow and Blue Goose be undertaken in the central Arctic, particularly in regards to their nesting relationships with Ross's Geese. Although the larger Lesser Snow and Blue Geese were not displacing Ross's Geese at Arlone Lake (Ryder 1967), studies are required to confirm this from other locations. Nests of Ross's and Lesser Snow Geese were interspersed at 18 of 23 (78%) of the nesting colonies in the aerial surveys of 1965 and 1967 (Ryder 1969a). The significance of this relationship, especially in view of the limited numbers and restricted nesting distribution of Ross's Geese would be a most fruitful line of research. Wynne-Edwards (1962) summarizes the need for investigating this type of sympatric relationship, 'There is nothing novel to the ecologist in the finding that related species compete with one another for resources and affect each other's success: what needs to be carefully noted is that in habitats where one does not completely dominate and eliminate the other but where both can live side by side more or less precariously balanced, selection appears to favour their incorporation into a single social dispersionary unit, in which they compete together for the same conventional possessions.'

Acknowledgements

I would like to thank the Canadian Wildlife Service for financial support of this and related research.

Summary

Distribution and aspects of the nesting biology of the Lesser Snow Goose *Anser caerulescens caerulescens* in central Arctic Canada are reported. Aerial surveys in 1965, 1966 and 1967 revealed 30 previously unrecorded nesting colonies. The total estimated nesting population in 1965 and 1967 was 8,299 Lesser Snow Geese. All the colonies were located on islands in shallow tundra lakes in the once inundated central lowland portion of the Arctic. It is suggested that food availability may be an important factor limiting goose distribution.

Nesting studies at Karrak Lake (67° 15′ N., 100° 15′ W.) in 1966, 1967 and 1968 showed that the geese arrived in late May or early June and that nesting started about a week later. Clutch sizes in the three years were 4.2, 4.0 and 4.3 eggs. Data from 94 marked nests in 1968 showed that, on the average, successive eggs are laid every 1.3 days. Generally two or three eggs were laid then a day missed before completion. Incubation periods averaged 22.4

days, with a mode at 23 days. Incubation periods tended to decrease with increased clutch size. Over 60% of the marked clutches took less than a day to hatch. There was no relation between clutch size at hatching and the time taken to hatch. Nest and egg success was 86% and 69% respectively. About 40% of the goslings hatched from four-egg clutches. Most egg loss resulted from gull predation. Colour ratios suggest that the blue-phase frequency (5% of 400 ringed geese) is lower than predicted (22%) from earlier studies in the central Arctic. Similar results in Baffin Island may reflect a general cooling trend in the Arctic.

In view of an expected continued increase in nesting Lesser Snow Geese in the central Arctic and the importance of the area as the major nesting grounds of the relatively scarce Ross's Goose *Anser rossii*, studies are needed to determine the relationship between the two species during the nesting season.

References

BARRY, T. W. 1961. Waterfowl reconnaissance in the western Arctic. *Arctic Circ.* 13 : 51-58.
BARRY, T. W. 1962. Effect of late seasons on Atlantic Brant reproduction. *J. Wildl. Mgmt.* 26 : 19-26.
BARRY, T. W. 1967. The geese of the Anderson River Delta, N.W.T. Unpub. Ph.D. Thesis, Univ. of Alberta, Edmonton.
BIRD, J. B. 1967. *The physiography of Arctic Canada.* Baltimore: John Hopkins Press.
BRAKHAGE, G. K. 1965. Biology and behaviour of tub-nesting Canada Geese. *J. Wildl. Mgmt.* 29 : 751-71.
COOCH, F. G. 1958. The breeding biology and management of the Blue Goose (*Chen caerulescens*). Unpub. Ph.D. Thesis, Cornell Univ., Ithaca, New York.
COOCH, F. G. 1961. Ecological aspects of the Blue-Snow Goose complex. *Auk* 78 : 72-89.
COOCH, F. G. 1963. Recent changes in distribution of color phases of *Chen c. caerulescens*. *Proc. Int. Orn. Congr.* 13 : 1182-94.
DELACOUR, J. 1964. *The Waterfowl of the World*, Vol. 4. London: Country Life.
DEMENTIEV, G. P., N. A. GLADKOV *et al.* 1952. *Birds of the Soviet Union*, Vol. IV. Transl. by Israel Program for Scientific Translations, 1967.
GAVIN, A. 1947. Birds of the Perry River district, Northwest Territories. *Wilson Bull.* 59 : 195-203.
HANSON, H. C. and R. H. SMITH. 1950. Canada Geese of the Mississippi Flyway with special references to an Illinois flock. *Bull. Illinois Nat. Hist. Surv.* 25 : 67-210.
HANSON, H. C., P. QUENEAU and P. SCOTT. 1956. The geography, birds and mammals of the Perry River region. *Arctic Inst. N. Amer.*, Spec. Publ. No. 3: 96 pp.
HILDEN, O. 1964. Ecology of duck populations in the island group of Valassaaret, Gulf of Bothnia. *Ann. Zool. Fenn.* 1 : 153-279.
HORNBY, G. 1967. A biological bonanza—Karrak Lake. *North* 14 : 2-6.
KERBES, R. H. 1969. Biology and distribution of nesting Blue Geese on Koukdjuak Plain, N.W.T. Unpub. M.Sc. Thesis, Univ. of Western Ontario, London, Ont.
KLOPMAN, R. B. 1958. The nesting of Canada Geese at Dog Lake, Manitoba. *Wilson Bull.* 70 : 168-83.
KOSSACK, C. W. 1950. Breeding habits of Canada Geese under refuge conditions. *Amer. Mid. Nat.* 43 : 627-49.
LEMIEUX, L. 1959. The breeding biology of the Greater Snow Goose on Bylot Island, Northwest Territories. *Canadian Field-Naturalist* 73 : 117-28.
MACINNES, C. D. 1962. Nesting of small Canada Geese near Eskimo Point, Northwest Territories. *J. Wildl. Mgmt.* 26 : 247-56.
MACINNES, C. D. 1966. Population behaviour of eastern Arctic Canada Geese. *J. Wildl. Mgmt.* 30 : 536-53.
NELSON, J. B. 1966. The breeding biology of the Gannet *Sula bassana* on the Bass Rock, Scotland. *Ibis* 108 : 584-626.
NORDERHAUG, M., M. A. OGILVIE and R. J. F. TAYLOR. 1964. Breeding success of geese in West Spitsbergen. *Wildfowl Trust Ann. Rep.* 16 : 106-110.
RYDER, J. P. 1967. The breeding biology of Ross's Goose in the Perry River region, Northwest Territories. *Canadian Wildl. Serv. Rep.* No. 3 : 56 pp.
RYDER, J. P. 1969a. Nesting colonies of Ross's Goose. *Auk* 86 : 282-92.
RYDER, J. P. 1969b. Timing and spacing of nests and breeding biology of Ross's Goose. Unpub. Ph.D. Thesis, Univ. Saskatchewan, Saskatoon.
RYDER, J. P. 1970. A possible factor in the evolution of clutch size in Ross's Goose. *Wilson Bull.* 82 : 5-13.
SOWLS, L. K. 1949. A preliminary report on re-nesting in waterfowl. *Trans. N. Amer. Wildl. Conf.* 14 : 260-75.
STEEL, R. G. D. and J. H. TORRIE. 1960. *Principles and procedures of statistics.* London: McGraw Hill.
USPENSKI, S. M. 1965. The geese of Wrangel Island. *Wildfowl Trust Ann. Rep.* 16 : 126-9.
WYNNE-EDWARDS, V. C. 1962. *Animal dispersion in relation to social behaviour.* Edinburgh: Oliver and Boyd.

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Biological notes on the Emperor Goose in north-east Siberia

A. A. KISTCHINSKI

Introduction

The Emperor Goose *Anser canigicus* is one of the rarest and least known waterfowl species in the U.S.S.R. Its breeding range is very restricted, and total numbers are low. Further, the ecological peculiarities of the Emperor—one of the most maritime of geese—are interesting and too little known. Some biological observations on the Emperor Goose in the Asiatic part of its area were made by Palmén (1887), Portenko (1939), etc. All data known up to recent times on its distribution and breeding on the Chukotsky Peninsula, are summarized by L. A. Portenko in the monograph *The Birds of the Chukotsky Peninsula and Wrangel Island*, now in press. Considerably more biological information was obtained in Alaska and on St. Lawrence Island (Bailey 1925, 1943, 1948; Conover 1926; Brandt 1943; Murie 1959; Gabrielson and Lincoln 1959; Fay and Cade 1959; Fay 1961), and in recent years there have been many new observations in Alaska, unfortunately still unpublished (P. Lent, C. J. Lensink, pers. com.).

In summer 1970, we had an opportunity to see Emperor Geese and to collect new biological data near the northern limit of the species' range—on the northern coast of the Chukotsk Peninsula between the mouth of the Amguema river and Wankarem. These data are presented in this paper.

Distribution (see map, Figure 1)

The Emperor Goose breeds in the U.S.S.R. along the shores of the Anadyr Gulf and Chukotsk Peninsula westwards up to Amguema lagoon, but we do not know of any areas where its numbers are high. On the Yukon-Kuskokwim Delta (west coast of Alaska), where Emperors are most numerous, breeds the majority of not only the North American (C. J. Lensink, pers. com.) but probably of the world population of the species.

We have discovered breeding places of the Emperor Goose and considerable

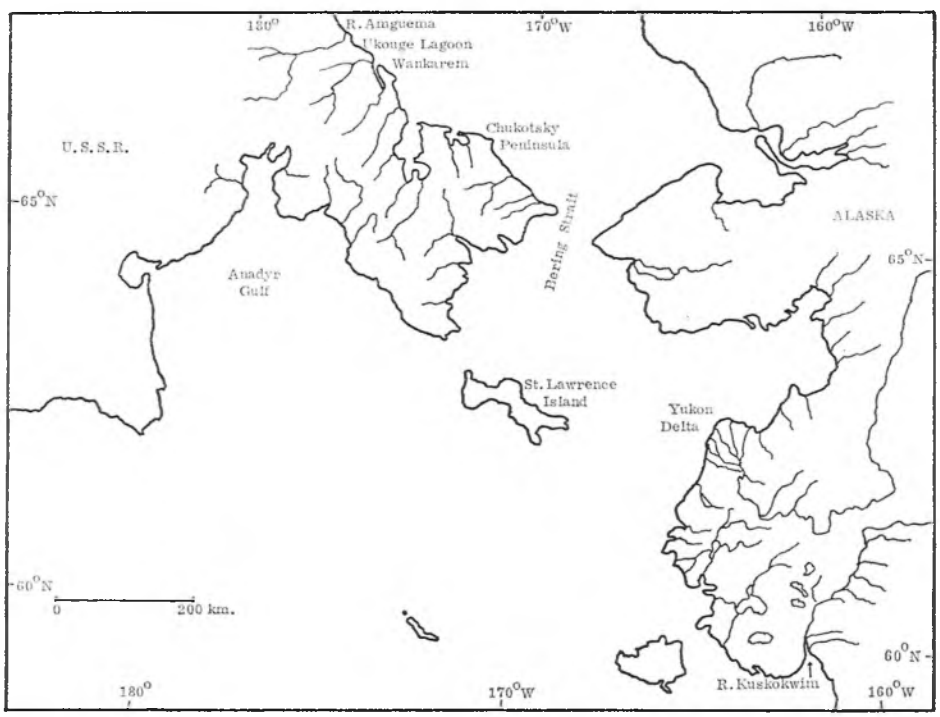

Figure 1. Map of Emperor Goose breeding areas in U.S.S.R. and Alaska.

concentrations of pre-moult non-breeders on the shores of Ukouge lagoon (25 km. eastwards from the Amguema mouth). Flocks of non-breeders were met with along the entire coast surveyed. Further to the west, Emperors probably do not occur. However, Spangenberg (1960) mentioned several pairs observed in the mouth of the Kolyma river. Whether the species breeds there, and if so how regularly, is not known.

Habitats

In the flat tundra of northern Chukotsk, one may distinguish two main types of habitats important for the Emperor Goose.

Low shores of coastal lagoons are bordered with a strip of grassy tundra (salt meadow) from several metres to one or two km. wide. This is distributed as far as tidal waters can flood into the ponds connected with the lagoon. Due to the constant influence of tidal water, soils are more or less salty here. This terrain is covered by wet, short-grass tundra dominated by *Dupontia psilosantha*, in some places also by *Carex subspathacea*; besides, there grow in lesser quantities *Cochlearia arctica* and *Stellaria humifusa*. There are many small and large brackish ponds. This meadow 'lagoon' tundra is practically the only habitat of Emperors (as well as Black Brants *Branta bernicla orientalis*) out of the breeding period.

Further from the sea, beyond the tidal influence, this tundra is replaced by rolling inland moss-sedge tundra with freshwater ponds and lakes. Plants typical of the former habitat are absent here, and sedge *Carex stans* predominates—the most important food of the geese. In this inland tundra Emperors nest, and these breeders feed on the spot.

As far as we know, these two types of habitat are used by Emperors throughout their summer range. In its southern parts (Yukon-Kuskokwim Delta) geese nest in the lagoon tundra as well but inland tundra between the tidal meadows and the upland is preferred (Conover 1926; Lensink, pers. com.). In the extreme north of the area, nesting in lagoon tundra is practically impossible because during the egg-laying period it is too wet, and large portions of it are still under ice and snow.

Ecological notes

Arrival

On the shores of the Anadyr Gulf, Emperors arrive in the middle of May (Portenko 1939), and in the Bering Strait area and in Chukotsk at the end of May and early in June (Belopolski 1934; Bailey 1943; Portenko in press). In 1879 members of the *Vega* Expedition first noted Emperors near Kolyuchinskaya Bay on 13th-17th June (Palmén 1887). We saw our first geese on 7th June and on 8th-12th June couples and small groups were met with regularly. No marked migration occurred here, near the northern range limit.

According to Bailey (1943) and May and Cade (1959), for a few days on arrival (before lakes become free of ice) the Emperors stay along the shore-ice where they forage among the kelp thrown up by the waves. There was no such thing on the heavily iced Chukotsk Sea.

For the first five days, Emperors occurred in the wet lagoon tundra in small flocks (four to five birds) in which one could easily distinguish pair bonds already formed. The flocks fed together and rested, swimming on lakes or roosting on large tidal mudflats.

Breeding

We did not see any forms of courtship behaviour; they probably took place during migration. Having arrived, Emperors began to breed. Already on 8th June we took a female which had laid two eggs and had two other large follicles in the ovary. Two incomplete clutches were found on 17th June; next day both of them were finished containing two and nine eggs. Hence, egg-laying in the comparatively early spring of 1970, began on 6th-16th June, that is on the whole several days after that of White-fronted Geese *Anser a. albifrons*. The *Vega* expedition found clutches (three to six eggs) eastwards of the Kolyuchinskaya Bay on 30th June - 9th July (Palmén 1887), and Kuzyakin (1965) near Uelen on 29th June. Further south, in the Yukon-Kuskokwim Delta, nesting begins earlier, at the end of May and in the first days of June (Conover 1926; Brandt 1943; Headley 1967, etc.).

Breeding pairs were observed not further than five to six km. from sea or lagoons, that is only in the zone where short-grass lagoon tundra occurred. However, nests were not made there but in the wet inland moss-sedge tundra rich in ponds. On the typical area of 40 sq. km. studied in detail (near Ukouge lagoon) there were three pairs. In this inland tundra White-fronted Geese bred as well (with density five to six times as high) but there were no Brants.

In the eastern part of the Chukotsk Peninsula, Emperors with downy young were seen by Portenko (in press) on the Uttaweyem river among the foothills but not too far (20-30 km.) off the sea.

Two nests we studied were made two and a half kilometres from the lagoon and 600 m. apart. The first nest (nine eggs) was located 20 m. from a lake, on a tussock among wet moss-sedge tundra; the other one was on a rather dry edge just beside a pond. Within 100 m. of the first nest, in the same wet tundra near the lake, there was an Emperor's nest of the previous year containing old feathers and egg-membranes. Within 125 m. of the second nest there was a nest of a White-fronted Goose.

The nests were lined with dry sedges, cotton-grass, feathers and down; although they were made in a very wet tundra, the bottoms of the nests were dry. Nest sites and pattern of building were the same as usually described (Conover 1926; Brandt 1943; Bailey 1943; Gabrielson and Lincoln 1959; etc.). Nests were located in wetter places than those of White-fronted Geese. Feathers and down at the end of egg-laying were scarce but during the time of incubation geese continued to pick them and to improve the nest bed. Similar data were obtained in Alaska (Brandt 1943). Nevertheless, even by the end of incubation, the downy 'pillow' under the eggs was not so thick and soft as that of Whitefront or Brant nests.

Both the adults spent most time at and near the nest. The female incubated eggs and the male as a rule stood or fed in the grass within 10-100 m. of the nest. However, sometimes the male was absent from sight but if the incubating bird was disturbed he appeared shortly after this. During all the incubation time a pair bond keeps its entity, although a male can fly rather far to the feeding grounds, join flocks of non-breeding birds for some time or, according to Bailey (1943), congregate with other breeding geese.

The female on leaving the nest without alarm pulls the mantle of down and grass over the eggs. The reaction of geese to an observer's approach is interesting. The brooding bird presses close to the nest with neck outstretched forward or sideways like a stick; her head is perfectly concealed among sedges. One can approach to within 10-20 m. more often 50-300 m. (the limit is influenced by weather, time, stage of incubation, observer's caution, etc.). After this the female leaves the nest and silently, bending to the ground with head stretched, goes across the sedges to the water. Not being disturbed further, the bird and the gander if he is not too far, swim or go away 100-150 m. from the nest and begin to walk to and fro nibbling sedges. When quietening, the geese little by little approach the nest, but often stop and start to feed again. Finally, after half an hour to an hour, they come to the nest. The female turns the eggs, sits down and stretches her head, while the male stays nearby.

If the geese are heavily disturbed, they move a few metres after leaving the nest, then flush and go away out of sight, flying low over the ground. After 20-40 minutes, they return just as low as before, land several hundred metres from the nest, start to feed and, if the cause of alarm is no longer present, perform the same pattern of approach to the nest. If geese are disturbed during the 'walk-feed' stage or while returning to the nest, they retreat or fly away again.

Once we observed, after geese were frightened from the nest, a neighbouring pair of Emperors were also uneasy around their nest. Brandt (1943) reports similar facts. Nests are sometimes separated by only hundreds of metres or even only tens of metres (see also Conover 1926; Headley 1967). It seems that although the Emperor cannot be considered as a 'colonial' bird, a degree of gregariousness is not alien to it.

In our nests young began to hatch on 11th-12th July, and on 13th July hatching was finished. Thus, incubation time was 25 days.

On the days of hatching, the weather was usual for the time, cold (2° to 5°C.) and stormy. During the last two days, the Emperors incubated especially strongly and after leaving the nest, returned in a few minutes. Hatching eggs usually had the holes facing the downy 'pillow'. Nevertheless, nesting success was very low. Embryos did not develop in three eggs out of eleven, and five goslings died of cold in the first hours of life or even during hatching. At the same time, however, young of Whitefronts successfully hatched. We did not find their downy young dead, and the mean sizes of clutches and broods observed were equal. It seems that poor resistance of the young to cold and the restricted heat-insulating properties of the nest limit further penetration of Emperor Geese to the north.

The time of hatching in the studied area was probably the latest. In the eastern part of the Chukotsky Peninsula

and on the shores of Kotzebue Sound, downy goslings were observed 7th-11th July (Bailey 1948; Portenko, in press), and on the Yukon-Kuskokwim Delta the young were produced at the end of June and early in July (Conover 1926; Brandt 1943; Gabrielson and Lincoln 1959; Headley 1967).

Just after hatching, both the adults led downy young to the water, a fact noted by all researchers. Emperors from one pair during one day after hatching kept their gosling within 100-300 m. of the nest, walking across the tundra or swimming on lakes. Sometimes, one or both adults left their young and fed 100-150 m. away. The goslings lay hidden in the grass or swam on a pond together with two Long-tailed Duck *Clangula hyemalis*. Later, the family gathered again. When an observer approached, one goose flew around while the other led the goslings away. According to Portenko (in press) who met goose families on the river, neither parent tried to fly but ran or swam away, together with their downies.

Breeding birds fed in the nesting habitat—as a rule, in the vicinity of the nest. The only plant that proved to be a mass Emperor food was *Carex stans*. Emperors bit the top parts of its fresh green leaves off (the same way as Whitefronts). Sometimes, Emperor and White-fronted Geese foraged together. The sedges within several dozens of metres of the nests were noticeably damaged. Preliminary calculations showed that supplies of this food are not a limiting factor. The Emperors drank water from fresh ponds.

Eleven Emperor Geese taken by Portenko (in press) in the eastern part of the Chukotsky Peninsula at the breeding time, did not have subcutaneous fat while nearly all the geese shot just on arrival were very fat (as they were in the present study).

Ecology of non-breeding stock

In the second half of June, non-breeding Emperor Geese started their moulting movements. We have discovered considerable numbers of them in the lagoon tundras around the Ukouge lagoon. From 20th June we saw flocks (6-30 birds) flying every day towards the lagoon from the south-east. On 22nd June there were hundreds of birds near the lagoon, and the peak number counted, on 25th-27th June, reached 2,000. Such concentrations were only observed for about ten days, and in the first ten days of July most geese left this area. Out of four males taken on 25th-28th June, two were adult non-breeders and two immatures (probably second or third year) in the transitional plumage containing old and recently changed feathers. All the four birds had begun to moult (replacement of feathers on the breast, sides, and back). Up to 19th July all the observed Emperors were able to fly. We do not know yet where they moult their wing feathers.

Non-breeders moulting near Ukouge lagoon occurred in flocks of from 10-20 to 200-300 individuals; the largest flock had more than 650 birds. Only a few groups (5-11 birds) were met with on 28th June along the Ekugwaam river, 5-10 km. from its mouth. Emperors sat on the dry shore edges, sometimes together with Whitefronts, and fed on the tops of leaves of *Poa arctica* and *Carex stans*. Emperors kept almost exclusively to the wet brackish lagoon tundra. They fed on the most common grass *Dupontia psilosantha* and, to a lesser extent, on *C. subspathacea*. Geese ate fresh shoots of these plants or bit the top 10-15 mm. of the leaves off when the whole plant did not exceed 4-6 cm. high. As the vegetation in different places in the lagoon tundra commences growing at different times, geese can always find a suitable feeding place. Emperors do not eat the old and, especially not, the flowering specimens. Black Brant use the same food items and the same parts of plants as Emperors; Whitefronts sometimes also eat *Dupontia*, but at older stages (just before flowering) when the leaves are 10-12 cm. high and coarser. We did not find any other plants in the digestive tracts nor among grazing debris on the feeding grounds. Animal food remains were likewise absent. In the gizzards of Emperors shot in June-July more to the east (Palmén 1887; Portenko in press) there were also only remnants of grass, among them (in one downy young) a shoot of *Equisetum*. It is known that at other times Emperors eat shoots and roots of *Elymus mollis*, rootstocks of *Equisetum*, crowberries, algae, and marine invertebrates (Murie 1959; Gabrielson and Lincoln 1959; Headley 1967).

The males killed were well fed and had a layer of fat 1-2 mm. thick, essentially thinner than on arrival. They weighed 2,500-2,700 gm. (adults) and 2,000-2,500 gm. (immatures).

Emperors in flocks feed intensively; after this, they stand and carefully look around, or lie down and rest, curving the neck and keeping the head under the

E. E. Jackson

Plate III. (a) Male Cape Shelduck *Tadorna cana* in the upright posture of mild alarm. (b) A pair of New Zealand Shelduck *Tadorna variegata*. The white-headed female is making the sideways 'inciting' movement of the head. The male has adopted the aggressive head forward low position.

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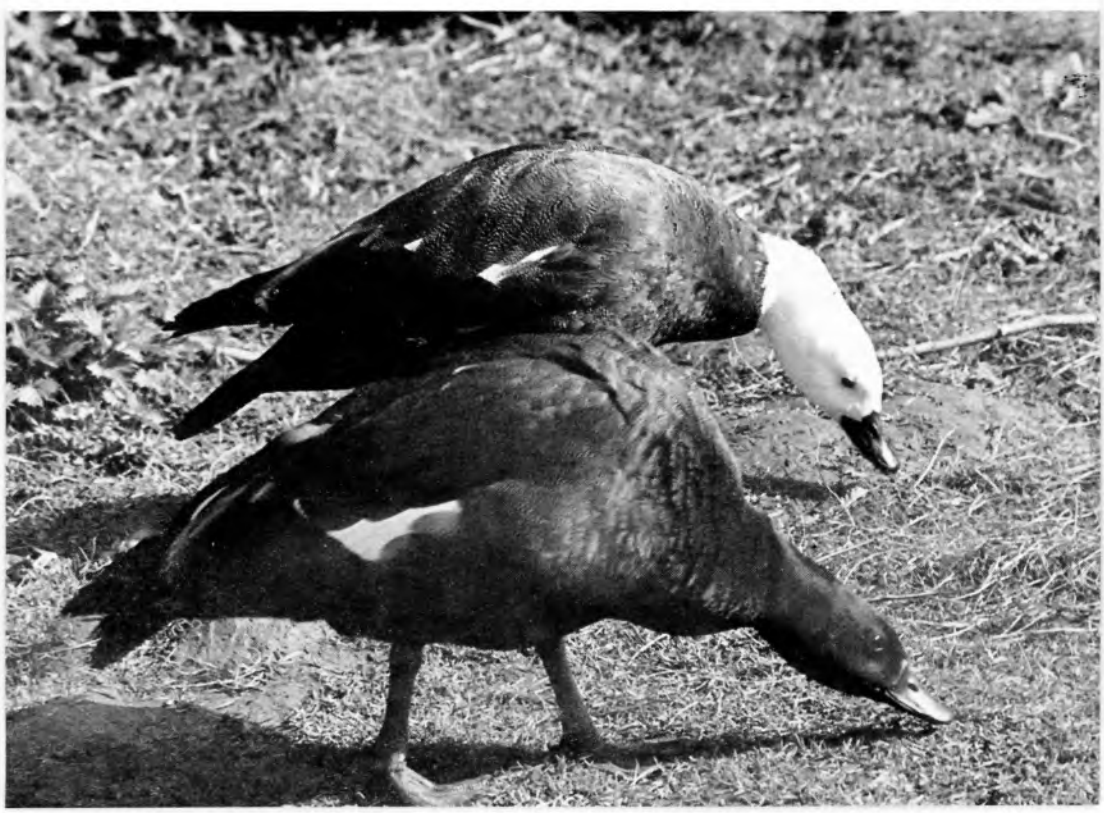

Philippa Sc

Plate IV. (a) The rocky coast of the Auckland Islands, fringed with kelp beds. (b) A male Auckland Islands Flightless Teal *Anas a. aucklandica* blends into its background of floating kelp. The shortness of his wings is obvious (see pp. 44-45).

Philippa Sc

wing. In a large flock some birds are always on the alert. If not disturbed geese feed on the same place for several hours. Emperors moulting near the Ukouge lagoon made some local movements but, in general, did not leave its shores. On the same plots there were also flocks of Black Brants up to several dozens which often fed together with Emperors.

On the feeding grounds, moulting flocks leave many droppings—in the middle of July, up to 3-5 per sq. m. Geese must add dozens of kg. of faeces per hectare of lagoon tundra. Using the calculations and chemical analyses given by Kear (1963) for other geese, we conclude that Emperors may return into the soil about 0.5-0.9 kg. N_2, 0.25-0.4 kg. P_2O_5, and 0.5-0.8 kg. K_2O per hectare. Thus, they promote acceleration of organic rotation in the ecosystem.

We have cut off the tops of *D. psilosantha* and *C. subspathacea* 10-15 mm. long (the same size as we found in oesophagus) on sample plots in a typical habitat and calculated that there are nearly 1,500 kg. of accessible food per hectare. Besides Emperors, these plants are eaten only by scattered Black Brants and probably to a small extent by Pintail *Anas acuta* moulting there. Using the standards accepted in poultry farming, we estimate that the lagoon tundras bordering Ukouge lagoon can support several thousand geese for a month or even longer. Thus, food supply is quite sufficient. Judging by the abundance of droppings, geese concentrate here every year.

Brackish lagoon tundra with *Dupontia* and *Carex*—practically the sole habitat of non-breeders—occurs only as narrow strips fringing shores and islands of coastal lagoons. Its total area is not large.

Flocks of up to several dozen non-breeders have been observed in summer by various investigators in different parts of the species' range from the Anadyr Gulf to Wankarem. We saw such flocks on 5th-20th July on the shores of lagoons between Wankarem and Amguema estuary—in all not more than 200 birds. We do not know as yet of any other large concentrations (such as those near Ukouge lagoon) in the Asiatic part of the range. The lack of such data, the generally low numbers of the breeding population, and the pattern of summer movements allow us to suppose that non-breeding Emperors from a considerable part of Chukotsk coasts gather for moulting around this lagoon.

Still greater numbers of non-breeding Emperors—10-20,000—moult in similar coastal tundras on St. Lawrence Island (Fay 1961). On the whole, non-breeders make up a sizeable portion of the total population.

Peculiarities of the digestive system

In all gizzards we found much fine sand but no large gastrolithes. The caecum is well developed. In two males, the total intestine length was 364 and 420 cm., and length of caeci (both) 84 and 95 cm., i.e. 23% of the intestine length. The relative lengths of caeci in Whitefront and Black Brant were 11-15% (n = 3).

Parasites

In the intestines of two Emperors studied for this purpose, we have found many cestodes of two species: *Aploparaksis larina* (Fuhrman 1921) and *Drepanidotaenia* sp.

Voice

The cry uttered in flight is a low metallic '*yang . . . yang . . .*'. The same call was made when escorting downies. On the ground, in feeding flocks, Emperors call to one another by a low '*kya kya kya kya*' or '*kyi kyi kyi kyi*'; this call is lower and less abrupt than, for instance, the cackling of Bean Geese *Anser fabalis*.

At the nest or walking near it Emperors keep silent. Only in the last day of incubation, being greatly excited, a female which had left the nest uttered an anxious call—a low recurring '*kyur . . . kyur . . . kyur . . .*'

Acknowledgements

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for sending us results of unpublished studies on the Emperor Goose in Alaska and for kind permission to cite some of these results. Prof. Portenko, Dr. Lent, and Dr. Lensink have read the manuscript and made valuable comments.

Summary

Observations were made in 1970 on Emperor Geese *Anser canagicus* on the northern coast of the Chukotsky Peninsula. The first geese were seen on 7th June. Nesting began immediately on arrival on the narrow coastal strip, in the wet moss-sedge tundra rich in freshwater ponds. The breeding density was three pairs on 40 sq. km. Two nests (two and nine eggs) are described. Nest bedding of grass, goose's feathers and down was added during egg-laying and incubation, but was never so thick and soft as that of White-fronted *Anser a. albifrons* or Brant Geese *Branta bernicla orientalis*. Eggs were laid from 6th to 18th June, incubation time being 25 days. During incubation the pair bond is maintained, although the male may fly quite far for feeding and join other birds for a while. Hatching took place on 11th-13th July; the weather was very severe at the time, and mortality was high (eight eggs and young of eleven). It is thought that poor resistance of goslings to cold and low heat-insulation properties of nests limit further extension of the species to the north. Breeding geese feed in the nesting habitat on the sedge *Carex stans*.

In the second half of June non-breeding Emperors began their moult movements. Large concentrations of non-breeders (up to 2,000) were found near Ukouge lagoon but remained there only up to the first ten days of July. We believe that a sizeable part of the Asiatic population gathered there. Flocks of non-breeders kept to the wet brackish grassy tundra around the lagoon consisting of *Dupontia psilosantha, Carex subspathacea, Cochlearia arctica* and *Stellaria humifusa*. Geese ate shoots and terminal parts of the young leaves of *D. psilosantha* and *C. subspathacea*. This food is unlimited. Moulting flocks leave dozens of kilograms of droppings per hectare; thus, they return to the soil considerable quantities of nitrogen, P_2O_5 and K_2O. A massive development of the caecum is noted. The behaviour when breeding and in moulting flocks, and the calls, are described.

References

BAILEY, A. M. 1925. A report on the birds of northwestern Alaska and regions adjacent to Bering Strait. *Condor* 27 : 197-207.

BAILEY, A. M. 1943. The birds of Cape Prince of Wales, Alaska. *Proc. Colorado Mus. Nat. Hist.* 18, No. 1 : 1-113.

BAILEY, A. M. 1948. *Birds of Arctic Alaska.* Colorado Mus. Nat. Hist. Popular Ser. No. 8.

BELOPOLSKI, L. O. 1934. On the avifauna of the Anadyr territory. *Proc. Arct. Inst. II, Leningrad* : 23-24. (In Russian)

BRANDT, H. 1943. *Alaska Bird Trails.* Cleveland, Ohio: Bird Research Foundation.

CONOVER, H. B. 1926. Game birds of the Hooper Bay region, Alaska. *Auk* 43 : 162-80.

FAY, F. H. 1961. The distribution of waterfowl to St. Lawrence Island, Alaska. *Wildfowl Trust Ann. Rep.* 12 : 70-80.

FAY, F. H. and T. J. CADE. 1959. An ecological analysis of the avifauna of St. Lawrence Island, Alaska. *Univ. Calif. Publ. Zoology* 63 : 73-150.

GABRIELSON, I. N. and F. G. LINCOLN. 1959. *The Birds of Alaska.* Washington: Wildlife Management Institute.

HEADLEY, P. C. 1967. Ecology of the Emperor Goose. Unpublished report on file at Alaska Cooperative Wildlife Research Unit, College, Alaska.

KEAR, J. 1963. The agricultural importance of wild goose droppings. *Wildfowl Trust Ann. Rep.* 14 : 72-77 .

KUZYAKIN, A. P. 1965. On the waterfowl in North-East Siberia. In *Geography of the waterfowl resources in the U.S.S.R.*, pt. 2 : 114-116. Moscow: Publ. Mosc. Soc. Natur. (In Russian)

MURIE, O. J. 1959. *Fauna of the Aleutian Islands and Alaska Peninsula.* North Amer. Fauna, No. 61, U.S. Dept. of Interior, Fish and Wildlife Service.

PALMEN, J. A. 1887. Bidrag til Kännedomen om Siberiska ishafsjustens Fogelfauna. In *Vega-Expeditionens Iakttagelser,* Vol. 5 : 245-511. Stockholm.

PORTENKO, L. A. 1939. The fauna of the Anadyr Region. Parts I-II: The Birds. *Trans. Inst. Polar Agric., Animal Husbandry and Fish and Hunting Industry,* Ser. "Hunting and Fishing Industry", 5 : 1-211; 6 : 1-198. (In Russian)

PORTENKO, L. A. (in press). *The Birds of the Chukotsky Peninsula and Wrangel Island.* Moscow-Leningrad: Nauka Press. (In Russian)

SPANGENBERG, E. P. 1960. New data on the distribution and biology of the birds in the lower reaches of the Kolyma river. *Bull. Mosc. Soc. Natur., biol. dept.* 65 : 31-35. (In Russian)

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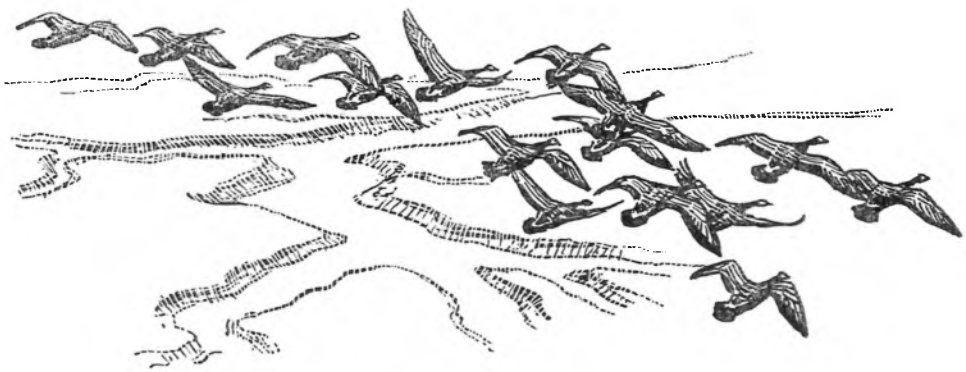

Passage of the Barnacle Goose through the Baltic area

ERIK KUMARI

At present the total world population of the Barnacle Goose *Branta leucopsis* is estimated at about 50,000 individuals and an increase in the numbers of the species has been noted during the last decade (Mörzer Bruyns, Philippona and Timmerman 1969). The populations of three different areas are isolated, to a great extent or even completely, at all seasons of the year (Boyd 1961, 1963, 1968):—

1. Greenland population—nests on the east coast of Greenland, winters in Ireland and western Scotland; at least 20,000 individuals.

2. Svalbard population—nests mainly on Spitsbergen, winters in Scotland (Solway area); up to 4,000 individuals.

3. Barents Sea population—nests on the southern island of Novaya Zemlya and on Vaigach Island, winters on northwest coasts of the European continent (particularly in the Netherlands); up to 25,000 individuals.

We shall confine ourselves to the third population only, that of Novaya Zemlya and Vaigach Island which migrates through the Baltic area. The species nests on almost inaccessible rocks of northern regions with severe climate, where until recently no field observations had been made. Only during the last 20 years have ornithologists succeeded in obtaining some scant data in its nesting places.

According to Gorbunov (1929) the Barnacle Goose nested on the southern island of Novaya Zemlya in small colonies (of up to 75 pairs), arrived around 20th May, nested from June until the end of July and then moulted. However, the author did not visit the nesting places himself but collected these data from nomadic hunters. It was not until 1948 to 1950 that the nesting of the Barnacle Goose was observed on the southern island of Novaya Zemlya and not until 1957 on Vaigach Island (Uspenski 1951, 1958, 1964). On both of these islands nests are situated in small colonies on steep rocks. In the 1950's the population totalled only approximately 1,000 pairs. The birds arrived in the nesting places in the middle of May and laid eggs around 10th June. The goslings hatched in the second half of July. The adults moulted between the end of July and 20th August, and the departure from the nesting places took place at the end of August or at the beginning of September. At the time, a part of the moulting (i.e. flightless) birds were destroyed by people visiting the islands and this contributed to the decrease of the species.

Spangenberg and Leonovich (1960) refer to a brisk passage of the species in an easterly direction on the Kanin Peninsula (20th-25th May), but these data were obtained from the residents working here. The authors observed for themselves only four geese on 9th June 1957. According to the residents, the species was decreasing in that locality as well.

In the summer of 1960 Karpovich and Kokhanov (1967) recorded only about 50 pairs nesting on Vaigach Island as well as 50-70 non-breeding birds. In the summer of 1957, when Uspenski was there, the total number of the species had been two to two-and-a-half times higher. Local inhabitants destroyed nestlings, as well as adults in August when they are flightless. Young birds were able to fly at the beginning of September.

This is a short survey of our knowledge of the Barnacle Goose nesting in the Soviet Union.

General data on the passage of Barnacle Geese through the eastern and northern Baltic Sea

For 150 years it had been known that large flocks of Barnacle Geese halted during migration on the west coast and islands of Estonia, while in other parts of the Baltic area the species appeared to be rare or only occasional, particularly inland.

The Barnacle Goose had been met with only seldom on the southern coast of the Baltic Sea in Mecklenburg, German Democratic Republic (H. Schröder, in litt.). Greater numbers were recorded in some areas (particularly in the vicinity of the Wismar Bay), but a few individuals have been noted inland as well (Kuhk 1939). The species was equally rare in the neighbourhood of Hiddensee Island (H. Schildmacher, in litt.). In former East Prussia the Barnacle Goose was met with extremely rarely, only three times on the Courland Spit (Tischler 1941). The species was also a rare transit migrant in Lithuania (Ivanauskas 1939) and Latvia (E. Taurinsch, pers. com.). Only solitary individuals had been met with in the Baltic interior—in the area of Lake Peipsi (own data), in the Pskov (Zarudny 1910) and Leningrad regions (including Lake Ladoga, South Karelia and the environs of Vyborg) (A. S. Malchevski, in litt.; Putkonen 1942). The species was also regarded as a rare transit migrant near Joensuu, close to the south-east border of Finland, 130 km. to the north of Lake Ladoga (Pynnonen 1934).

The passage of the Barnacle Goose through the Gulf of Finland is more intensive than that through the Gulf of Bothnia (Merikallio 1958). Only occasional observations have been made inland. According to the short notes in the journal *Ornis Fennica* the Barnacle Goose has been recorded most frequently on the islands and coastal areas of south-west Finland, while the numbers decrease towards the east along the Gulf of Finland and there is an especially marked drop towards the north along the Gulf of Bothnia.

The data for Sweden (*List of the Birds of Sweden* 1970) indicate that the species is numerous as a transit migrant in the neighbourhood of Gotland Island, occasionally also at Blekinge and Öland, elsewhere being scattered. It is rare in Scania, where in the nineteenth century it occurred considerably more frequently. The species is rare in the northern part of the Gulf of Bothnia (Wahlstedt 1967).

Spring passage in the Baltic area

Equally with the neighbourhood of Gotland Island, the west coast of Estonia and the West-Estonian archipelago serve as an important transit area for the Novaya Zemlya-Vaigach population, but this fact has not been mentioned even in the latest studies on the European bird fauna (for example, Bauer and Glutz 1968). Every spring, thousands of individuals concentrate for several weeks round about the middle of May in the same localities on the coast and on maritime islands. These mass halting places have been known to local residents for many decades. In the old days the birds were hunted here, the shooters using decoys specially made for that purpose of wood and cloth and painted in oils. At present in Estonia the hunting of all *Branta* species has been banned and their mass halting places have been put under state protection.

We can divide observations of the passage of the Barnacle Goose through Estonia into two periods: up to 1957, and from 1958 to the present time. During the latter period the study of the geese migration has intensified owing to the activities of the Baltic Commission for the Study of Bird Migration.

Period before 1957

According to the information of elderly local residents the Barnacle Goose has been a numerous transit migrant on the western shores of Matsalu Bay, on Saaremaa and Hiiumaa Islands from time immemorial. In the second half of the nineteenth century and at the beginning of the present century the Barnacle Goose has been claimed to have been present in far greater numbers than in the 1930s and 1940s. Most of the people making these claims have died and therefore there cannot be direct comparison with the records of the last twenty years when a steady increase has been observed.

The Barnacle Goose is characteristic of Estonia in the spring, whereas its halts in the autumn are of shorter duration, territorially more restricted and do not attract so much attention. There is no doubt, however, that the numbers of the species in the autumn are at least equal to those in the spring.

Loudon and Buturlin (1908) were the first to refer to the plentiful passage of the Barnacle Goose through the coastal areas of Matsalu Bay. Halting places on the west coast of Saaremaa Island were discovered by F. E. Stoll, who repeatedly visited the area between 1906 and 1910. During the period 1910 to 1950 the halting of the species in flocks of various sizes was observed in a number of places on the south and west coasts of Saaremaa Island, on Muhu Island, Hiiumaa Island, Vormsi Island and in the vicinity of Haapsalu Bay. On the north coast of Estonia the species was represented in considerably smaller numbers during the autumn transit flight and not a single mass halting place has been discovered in this area.

Occurrence from 1958 onwards

The spring halting places of the Barnacle Goose on the west coast of Estonia and on its islands are shown on the map (Figure 1). The numerals indicate the main localities where counts have been made over several years during the first half of May. The migrating geese are then settled for a considerable period and the highest numbers are recorded.

Although counts in different years are not equally complete, the results for

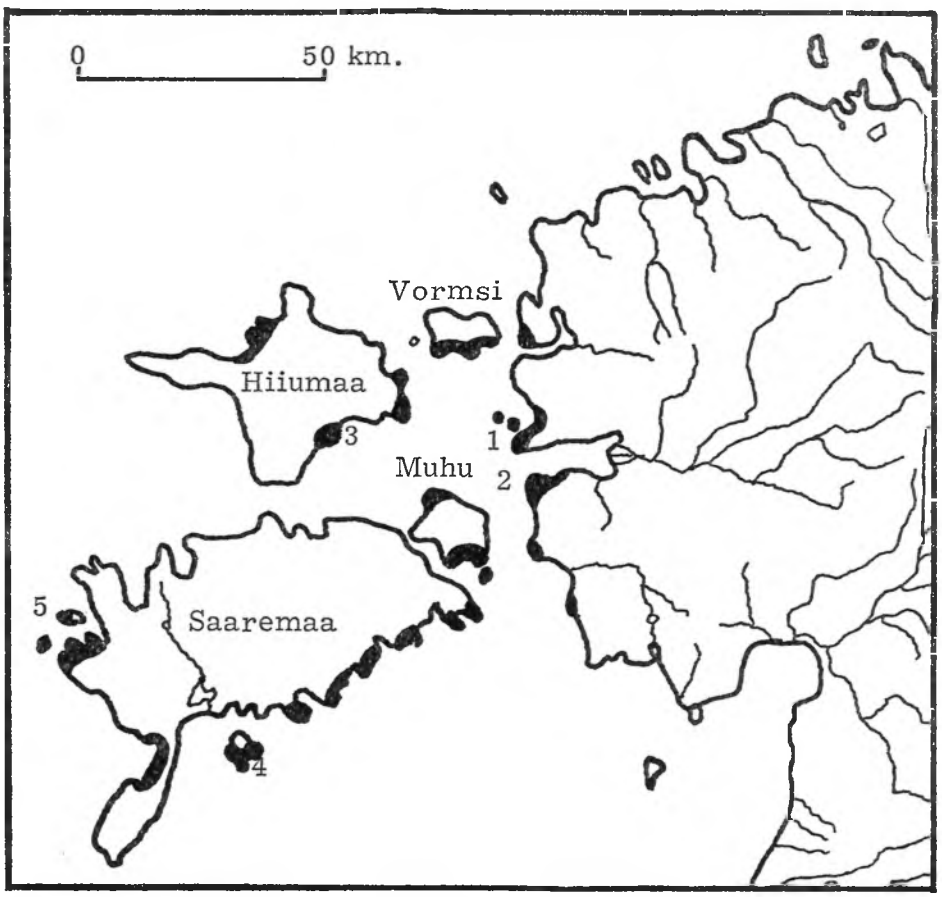

Figure 1. Halting places of the Barnacle Goose during the spring passage in Estonia. The chief ones: 1 (Puise) and 2 (Saastna)—Matsalu nature reserve, 3—area of Kassari Island, 4—Abruka Island, 5—Vaika nature reserve (the neighbourhood of Vilsandi), and the west coast of Saaremaa Island.

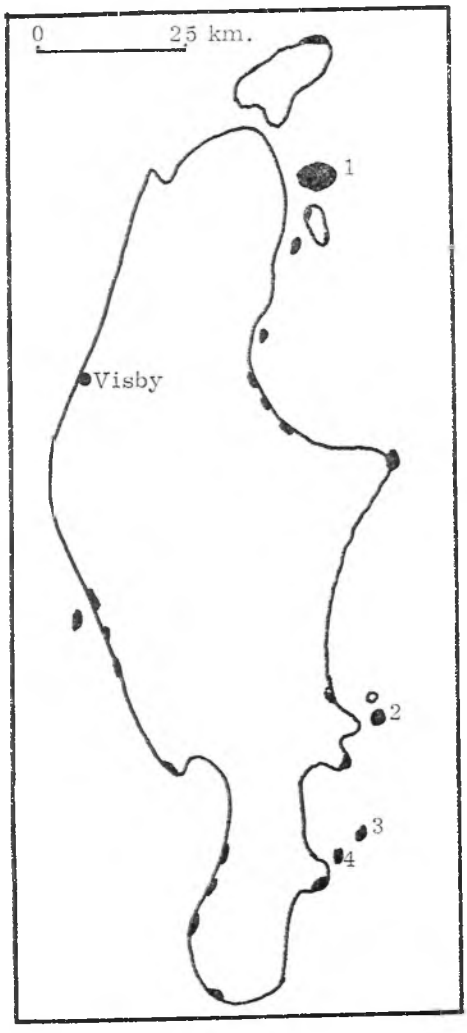

Figure 2. Halting places of the Barnacle Goose during the spring passage in the vicinity of Gotland Island (after G. Hakansson and S. Högström). The chief ones: 1—Skenholmen, 2—Laus holmar, 3—Ytterholmen, 4—Grötlingsboudd.

1964-70 are presented in Table I. Prior to that period we only have quantitative data for the Matsalu nature reserve (1 and 2 on the map); for 1958 to 1963 which are respectively:— 2,000, 2,500, 2,000, 2,500, 3,000 and 3,000.

On the strength of the three springs (1964, 1968, 1970) with sufficient counting data we may conclude that annually in the first half of May not less than 8-10,000 migrating Barnacle Geese halt in Estonia. The results of occasional observations made outside the above areas indicate that the actual numbers are considerably higher. For example, at the beginning of May over 5,000 individuals were on the east coast of Saaremaa Island, and on maritime islands (Jõgi 1965). Flocks of several thousand individuals have also been observed in some places on the south coast of Saaremaa Island, on the west coast of the Sörve Peninsula and on Hiiumaa Island during the first half of May.

Over 10,000 Barnacle Geese now halt on the small coastal islands of Gotland Island each year in about 25 regular places (Figure 2). The data for some earlier years (aerial counts) were: 1961—3,775; 1962—3,875; 1963—5,995 (S. Högström, in litt.). If compared with the numbers at Matsalu in the same springs, we can say that there is the same tendency to increase at the end of April and beginning of May 1968. At the request of the Baltic Commission for the Study of Bird Migration, the counts by G. Håkansson and S. Högström on Gotland Island were synchronised with those in Estonia. Large numbers, 4,800-9,000, were recorded by the two Swedish colleagues. The largest concentrations were 580 to 2,225 birds (where in 1963 there had been 800 to 2,000). During the last decade it has been noticed that in the first three weeks of May the birds tend to concentrate at certain set places into ever bigger flocks of up to 2-3,000, whereas the peak was only 500 in the 1950s. On the eve of departure to the north-east these dissolve into smaller migrating

Table I. The numbers of Barnacle Geese in Estonia in the first half of May.

Year	*Matsalu*	*Neighbourhood of Kassari*	*Abruka*	*Vaika*	*West coast of Saaremaa*	*Elsewhere*	*Estimated total*
1964	4000	2000	1500	1500	1000	800	10800
1965	5000	?	?	?	?	?	?
1966	6000	?	1000	?	?	?	?
1967	6000	4000	?	4000	?	?	?
1968	4000	1700	2500	4000	800	1000	14000
1969	3000	2500	?	2500	700	?	?
1970	3000	2500	?	1500	500	500	8000

All the figures have been given in round numbers.

parties of a few dozen to a few hundred birds.

Since these large concentrations of the Barnacle Goose can be observed simultaneously in Estonia and on Gotland Island in the first half of May, there is no reason to doubt that they are different birds. These areas serve as the two chief places of concentration for the species on its migration route (Figure 3) from the wintering area to the nesting places, the total numbers of over 20,000 here being similar to those of the wintering population in the Netherlands (Timmerman 1962; Bofenschen and Kramer 1969). It is interesting to note that not a single halting place of the Barnacle Goose on spring migration has been recorded to the north-east of Estonia, though the distance between the Baltic countries and the nesting places is over 2,000 km. and the birds are unlikely to cover such a long distance without stopping. Probably there are a few undetected halting places somewhere in the area of the White Sea or on the south coast of the Barents Sea.

The birds wintering in the Netherlands usually begin their spring migration in March (Philippona 1962; Stichmann and Timmerman 1965). They halt in the North Friesland archipelago up to the end of April. Counts there by Timmerman on 8th-13th April 1965 yielded a total of 10-15,000 individuals (Wolf 1970). Hamburger Hallig Island serves as an important intermediate halting area, for on 14th March 1968 Danish ornithologists registered 3-4,000 Barnacle Geese there, while not a single regular spring halting place has been recorded in Denmark (Mette Fog, in litt.). Passing across the basal part of the Jutland Peninsula (Schleswig-Holstein), the mass migration of the Barnacle Geese is an annual phenomenon between the middle of March and the end of April in the south-east Danish archipelago, in Moen, Lolland, and Falster, but they occur only irregularly in the areas lying to the north (Salomonsen 1963).

Afterwards the route probably lies over the waters of the Baltic Sea, since the species has been met with in the coastal areas of south Sweden to a lesser extent in the spring than it could have been expected (S. Ulfstrand, in litt.; and short notes in the journal *Vår Fågelwärld*). The geese arrive in the halting places in the neighbourhood of Gotland either at the end of March or at the beginning of

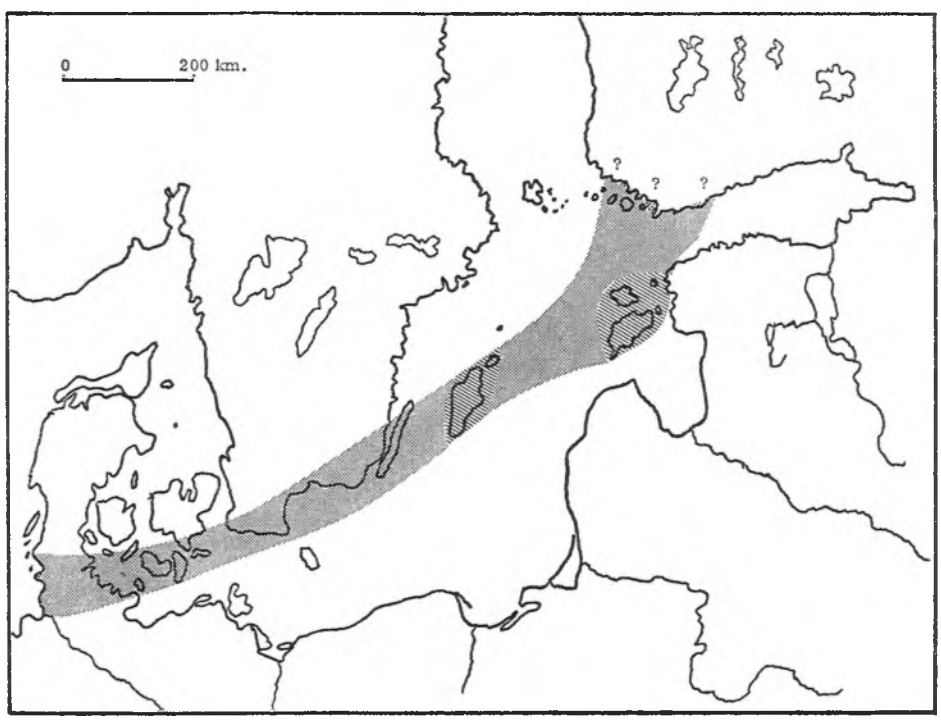

Figure 3. Spring migration route of the Barnacle Goose in the Baltic Sea. Hatching indicates halting areas, stippling — passage.

April, that is simultaneously with the arrival on the west coast of Saaremaa Island (the distance between the two islands is 200 km.). In the period 1953-1970 the species arrived in Estonia in March on only three occasions: 27th March 1961—Matsalu; 25th March 1961—Vaika; 27th March 1968—Vaika. The arrival in the Matsalu nature reserve is most frequently in the middle of April. The birds, having reached maximum numbers by the middle of May depart quite suddenly (20th-26th May) in a north-easterly direction. In some years solitary flocks remain until the beginning of June (Jögi 1965; Renno 1968).

Migrating from Estonia in a north-easterly direction the species is lost sight of in the area of the Gulf of Finland. On the Porkkala Peninsula, west of Helsinki, no noticeable passage has been observed (G. Bergman, in litt.) It appears as an occasional visitor to the north coast of Estonia but not, as a rule, in the areas east of Tallinn. The birds arrive in Novaya Zemlya and Vaigach Island in the second half of May.

Recoveries of the Barnacle Geese ringed in the Netherlands shed some light on the present problem. Goose netting there was initiated in the winter of 1956-57 as the joint effort of professional goose trappers and ornithologists, and during the first three winters 114 individuals were captured (Eygenraam 1960). By the end of 1966 1,236 individuals had been ringed, predominantly in Friesland, Gelderland and Utrecht, and 97 recoveries obtained. These prove that the whole population wintering in the Netherlands comes from the north-east (Boyd 1968) and that it has no connection with the population nesting in Greenland as was suggested by Jennov (1963). Of these recoveries 20 were obtained in the Soviet Union (Shewarjowa 1961; Bauer and Glutz 1968; the Netherland ringing centre, in litt.). With the exception of two autumn recoveries in north Estonia, the recoveries were obtained in the spring:— six in west Estonia at the end of April and in the first half of May, one on the Kola Peninsula in May, six on the Kanin Peninsula in May, two on Kolguev Island in May and June, and three in the nesting places on Vaigach Island in June and July. Despite the small number of recoveries, they serve to illustrate the spring migration route of the Barnacle Goose. It is imperative to carry out further special field researches in Karelia, the area of the White Sea and in the southern part of the Barents Sea.

Autumn passage in the Baltic area

The departure of the Barnacle Goose from its nesting places takes place at the end of August or the beginning of September. The autumn migration differs considerably from that in the spring. The birds do not halt for long while traversing the Baltic area. Small flocks (making a total of up to a few hundred birds in the course of one season) have been observed in September near Virma on the south coast of the White Sea (Kumari 1963). The transit through Finland is greatly dispersed and takes place in September and October.

In Estonia the autumn migration lasts from the middle of September until the middle of November. Halts of shorter duration take place in places not coinciding, on the whole, with those of the spring. The liveliest migration has been recorded in October. The species also arrives regularly on the north coast of Estonia where it occurs very rarely in the spring. Between the middle of September and the middle of October in 1958, 1960 and 1962 the species occurred on the north coast of Estonia (Viinistu, Lohusalu, Pöösaspea) with total numbers of 1,600-2,200 birds in each place. On the protruding capes of Hiiumaa Island (Tahkuna, Ristna), on the outermost tip of the Sörve Peninsula, and on the westernmost tip of Saaremaa Island only 250-800 individuals were recorded at each locality. In these autumns the total estimated numbers of the Barnacle Geese traversing Estonia were not less than 10,000.

Counts for the subsequent years have yielded still larger numbers of the species on passage, particularly in the West Estonian archipelago. A lively migration took place in the autumn of 1967 (Vorsmi Island, Muhu Island, west coast of Saaremaa Island) when on 28th-30th October on Vilsandi Island alone (Vaika nature reserve) at least 6,000 birds passed, not including the 1,500 remaining there until 18th November (L. Aumees, in litt.). An even more intensive passage occurred in the autumn of 1969 when at least 7,000 birds traversed the area of Kassari Island mostly during four and a half hours on 18th October (J. Kallas, in litt.) and not less than a couple of thousand traversed the west coast of Saaremaa Island on 17th-18th October. On the night of 21st/22nd October a mass migration could be heard passing through the Ristna foreland and Hiiumaa Island. In the same autumn on three occasions between 29th October and 13th

November small flocks were met with at Matsalu where the species is usually absent in autumn (V. Paakspuu, in litt.).

That the 1969 autumn mass migration extended further to the west is confirmed by observations from Denmark (Mette Fog, in litt.): on 20th October, 200 birds were at Saltbaekvig (Zealand); on 20th-25th October, 3,000 birds near Blavands Huk (West-Jutland) (at the same time there were numerous records in Schleswig-Holstein); 21st-24th October, 400 birds were heading westward in south-east Jutland; 24th-28th October, 2,000 were to the west of Skaekbaek (south-west Jutland); on 27th October, 800 were halting on Saltholm Island (Öresund). Occurrences on these dates and in these localities as well as in such numbers are unusual for Denmark.

During the autumn passage (October, November) a few hundred Barnacle Geese regularly visit the coastal areas of south-eastern and southern Sweden (Falsterbo and Ottenby ornithological stations, Kalmarsund, etc.—surveys of their activities published in the journal *Vår Fågelwärld* and numerous short notes).

Before arriving in the winter quarters in the Netherlands the Barnacle Geese make intermediate halts in the Danish archipelago and in the northern part of the German Federal Republic. An intensive passage took place in the autumn of 1967 in the East Baltic area. In November a total of 613 birds halted in six localities of the Danish archipelago, the bulk, 250 birds, being recorded at Saltbaekvig Bay, in the northern part of Zealand Island (Mette Fog, in litt.). In December 200-280 birds were in the Cuxhaven sector in East Friesland (Ed. v. Toll, in litt.). The west coast of Schleswig-Holstein serves as a regular halting area. Counts on 26th November 1961 yielded a total of 25,000 birds, including approximately 2,000 on Hamburger Hallig Island (Jennov 1963). According to observations from 1935 to 1965 (Wolf 1970) the first Barnacle Geese arrive in the North Friesland archipelago during the first ten days of October, while regular numbers of 3-4,000 are reported in the second half of November. The total numbers involved may be as many as 10,000. In January, when the cold sets in, the birds leave for their wintering quarters in the Netherlands. It is not known whether the Barnacle Goose annually winters in the North and East Friesland archipelago (Stichmann and Timmerman 1965; Bofenschen and Kramer 1969).

Numerical fluctuations and conservation

Timmerman's (1962) thorough survey shows that it was during the last twenty years that large numbers of Barnacle Geese invaded two wintering areas in the Netherlands (West Friesland in the north and the Delta area in the south-west) in addition to a few less important sites. During the period 1917-1938 only a few hundred individuals wintered in the Netherlands; in the years 1939-1952 the number was between a few hundred and several thousand; only since 1953 have the numbers of the species been almost constantly growing. In 1960 the wintering population of the Netherlands was estimated at 19-20,000, while at present a total of 25,000 is indicated (Mörzer Bruyns, Philippona and Timmerman 1969).

Several authors (Harrison 1952; Ringleben 1957) are of the opinion that such an increase in the numbers of wintering geese in the coastal areas of the North Sea was due to vast areas of seabed being reclaimed, and providing suitable feeding places. This might be so to some extent, but it is necessary to find reasons to explain the nesting success in the north and the successful course of the migration in intermediate areas.

In connection with the above there arises a problem which is rather difficult to solve now. Granted that the spring passage of the Barnacle Goose on the coast of west Estonia in the second half of the nineteenth century was considerably more substantial, where could the winter quarters of the species have been situated in those times? Before 1920 the species was represented in the winter quarters in the Netherlands in only small numbers. Yet around 1910 hundreds were shot every spring in their halting places in West Estonia. Therefore they must have had good wintering areas in some localities of west Europe.

In the course of a severe winter in 1962-63 only 3-4,000 stayed in the Netherlands (Stichmann and Timmerman 1965). At the same time up to a couple of thousand birds concentrated in the reserves of Belgium (Robyns de Schneidauer 1967; E. Kuyken, in litt.), where in ordinary winters there are, at maximum, a few scores. In that year the species occurred even on the north coast of France (F. Roux, in litt.).

The Barnacle Goose has such a small population that its nesting, mass halting, and wintering areas should be put under protection. The hunting of the species has been banned only in the Netherlands,

Baltic countries and in the greater part of Sweden (with the exception of Gotland Island). Even more dangerous for the species than hunting appear to be the changes in its habitats. Lebret's (1965) prophecy concerning the Netherlands causes anxiety, for during the coming years a number of regular wintering places will disappear owing to large-scale amelioration work.

At the all-Union conference on the study and preservation of geese held in the Matsalu state nature reserve (Estonia) in May 1970 special weight was laid on the protection of Barnacle Geese during migration. The hunting of the species should be banned in every country all the year round and seasonal sanctuaries should be set up in its mass halting places. A number of measures have already been taken in Estonia, but it is also necessary to put regular mass halting places on Gotland Island under protection and to ban goose hunting of every kind there.

Furthermore, it is necessary to proceed with the study of the Barnacle Goose in all the areas where the species occurs in great numbers at any season. The Netherlands (and to a smaller extent the areas of the German Federal Republic adjoining the North Sea) seem to be the only wintering areas for the whole of the Barnacle Goose population nesting in the Soviet Union. We shall welcome further joint efforts by specialists in bird preservation and ornithology in the Netherlands, the German Federal Republic, Sweden and the Soviet Union to discuss the world problems connected with the study and protection of this beautiful and rare goose species.

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The author has collected material for the present article over a long period and only part has been used in the present survey. In addition, numerous publications and a large amount of material obtained from colleagues in our country as well as abroad have been used. The author wishes to express his sincerest gratitude to the following colleagues: L. Aumees, Dr. G. Bergman, Cand. mag. Mette Fog, G. Hakansson, S. Högström, J. Kallas, Dr. E. Kuyken, Prof. Dr. S. A. Malchevski, Cand. biol. S. Onno, V. Paakspuu, Cand. biol. O. Renno, Dr. F. Roux, H. Ränk, Dr. H. Schildmacher, H. Schröder, Prof. Dr. R. Tenovuo, Ed. v. Toll, Dr. S. Ulfstrand, Cand. biol. V. B. Zimin. An especially large number of migration observations have been carried out in Estonia by L. Aumees, J. Kallas, V. Paakspuu and H. Ränk to whom the author is particularly grateful.

Summary

The Barnacle Goose *Branta leucopsis* is a numerous transit migrant on the west coast and islands of Estonia (particularly in the spring). Mass halting places in the same localities have been known to local residents for at least 150 years. In earlier times the geese were hunted from hides, but nowadays hunting has been banned and its mass halting places have been put under state protection. The greatest numbers occur during the first twenty days of May when up to 10,000 individuals are present. At the same time every spring, a similar number can be recorded in regular halting places in the vicinity of Gotland Island (Sweden). The whole population nesting in Novaya Zemlya and Vaigach Island, and wintering in the Netherlands, passes through these two areas. The autumn migration is dispersed and the birds do not halt for any considerable time. During the last ten years a constant increase in numbers has been observed, owing primarily to the breeding success. The species has not been sufficiently studied in the nesting areas and very little is known about migration to the north-east of Estonia. It is necessary to continue the study of the biology, migration and distribution of the Barnacle Goose as well as to guarantee the protection of the species all the year round, in nesting and wintering areas.

References

BAUER, K. M. and U. N. GLUTZ VON BLOTZHEIM. 1968. *Handbuch der Vögel Mitteleuropas.* Vol. 2. Frankfurt am Main: Akademische Verlagsgesellschaft.

BOFENSCHEN, G. and H. KRAMER. 1969. Uberwinterungsplätze der Wildschwäne und Wildgänse im Bereich der Nordsee- und der westlichen Ostseeküste. *Decheniana* 122 : 87-116.

BOYD, H. 1961. The number of Barnacle Geese in Europe 1959-1960. *Wildfowl Trust Ann. Rep.* 12 : 116-24.

BOYD, H. 1963. The present status of the different species of wildfowl. Pages 249-306 in: *Wildfowl in Great Britain.* London: H.M.S.O.

BOYD, H. 1968. Barnacle Geese in the west of Scotland, 1957-1967. *Wildfowl* 19 : 96-107

EYGENRAAM, J. A. 1960. Goose-netting in the Netherlands. *Wildfowl Trust Ann. Rep.* 11 : 77-79.

GORBUNOV, G. P. 1929. Materials on the fauna of mammals and birds of Novaya Zemlya *Trudy instituta po izučenju severa* 40 : 169-239. (In Russian)
HARRISON, J. G. 1952. The recent status and distribution of wild geese in north-west Germany. Wildfowl counts 1947-1952. *IWRI publ.* Nr. 3 : 23-31.
JENNOV, J. G. 1963. Some remarks on the number of Barnacle Goose (*Branta leucopsis* Bechst.). *Dansk Ornith. Foren. Tidsskr.* 57 : 221-8. (In Danish, with English summary).
JÖGI, A. 1965. Migration of divers (Gaviae) and anseriform (Anseres) in the environment of Suurväin, Estonia. A dissertation. (In Estonian)
IVANAUSKAS, T. 1959. *Birds of the Lithuanian S.S.R.* Vol. 2. Vilnius. (In Lithuanian)
KARPOVICH, V. N. and V. D. KOKHANOV. 1967. Bird fauna of the Vaigach Island and the north-east coast of the Jugor Peninsula. *Trudy Kandalakshkogo zapovednika* 5 : 268-338. (In Russian)
KUHK, R. 1939. *Die Vögel Mecklenburgs.* Güstrow.
KUMARI, E. 1963. Number dynamics of some migrating seabirds on the White Sea and in the eastern part of the Baltic Sea. *Comm. of the Baltic Comm. for the Study of Bird Migration* 2 : 67-80.
LEBRET, T. 1965. The prospects for wild geese in the Netherlands. *Wildfowl Trust Ann. Rep.* 16 : 85-91.
List of the Birds of Sweden. 1970. 6th Edition. Stockholm: Svensk Natur. (In Swedish)
LOUDON, H. BAR. and S. A. BUTURLIN. 1908. Eine ornithologische Fahrt an die Matzal Wiek. *Journ. f. Orn.* 56 : 61-72.
MERIKALLIO, E. 1958. Finnish birds, their distribution and numbers. *Fauna Fennica* 5.
MÖRZER BRUYNS, M. F., J. PHILIPPONA and A. TIMMERMAN. 1969. *Survey of the winter distribution of palearctic geese in Europe, Western Asia and North Africa.* Zeist, Netherlands: Goose Working Group of the IWRB.
PHILIPPONA, J. 1962. The surroundings of Beetsterzwaag and Gorredijk as a haunt for geese. *Limosa* 35 : 17-28. (In Dutch, with English summary)
PUTKONEN, T. A. 1942. Die Vogelfauna der Gegend von Viipuri. *Ann. zool. Vanamo* 9, No. 2.
PYNNÖNEN, A. 1934. Migration of the Barnacle Goose, *Branta leucopsis* (Bechst.) in Finland. *Ornis Fennica* 11 : 18-21. (In Finnish)
RENNO, O. 1968. Passage of the Barnacle Geese at Matsalu. *Trudy zapovednikov Est.S.S.R.* 1 : 174-6. (In Russian)
RINGLEBEN, H. 1957. *Die Wildgänse Europas.* Wittenberg Lutherstadt: Die neue Brehm-Bücherei.
ROBYNS DE SCHNEIDAUER, T. 1967. 1962-1967 wildgeese counts. *Gerfaut* 57 : 242-53.
SALOMONSEN, F. 1963. *Oversigt over Danmarks fugle.* Kobenhavn.
SHEWARJOVA, T. P. 1961. Ringing results of the geese. *Kolčevanie i mečenie zhivotnykh* 1 : 35-45. (In Russian)
SPANGENBERG, E. P. and V. V. LEONOVICH. 1960. Birds of the NE coast of the White Sea. *Trudy Kandalakshkogo zapovednika* 2 : 213-336. (In Russian)
STICHMANN, W. and A. TIMMERMAN. 1965. Durchzug und Uberwinterung der Gänse in Nord-deutschland, den Niederlanden und Belgien 1960/61, 1961/62 und 1962/63. *Vogelwarte* 23 : 140-8.
TIMMERMAN, A. 1962. On the occurrence of the Barnacle Goose in the Netherlands. *Limosa* 35 : 199-218. (In Dutch, with English summary)
TISCHLER, F. 1941. *Die Vögel Ostpreussens und seiner Nachbargebiete.* Königsberg und Berlin.
USPENSKI, S. M. 1951. Nesting places of the Barnacle Geese in Novaya Zembla. *Okhrana prirody* 13 : 124-7 (In Russian)
USPENSKI, S. M. 1958. Some birds in the North-East of the European part of the U.S.S.R. *Ornitologia* 1 : 35-47. (In Russian)
USPENSKI, S. M. 1964. Die Weisswangengans in der Sowjetunion. *Falke* 11 : 7-10.
WAHLSTEDT, J. 1967. Fågelfaunan på Haparanta Sandskär. *Vår Fågelwärld* 26 : 131-51.
WOLF, W. 1970. Die Weisswangen- oder Nonnengans (*Branta leucopsis*) als Uberwinterer an der schleswig-holsteinischen Westküste. *Jordsand-Mitteilungen* 2 : 2-10.
ZARUDNY, N. 1910. *Birds of the Pskov Government.* St. Petersbourg. (In Russian)

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The Auckland Island Flightless Teal

DAFILA SCOTT

The Auckland Island Flightless Teal *Anas aucklandica aucklandica* was first described by Gray (1844). His specimens were collected on Sir James Clark Ross's expedition which spent from 20th November to 12th December 1840 at the Auckland Islands (50-51°S., 165-166°E., 200 miles south of New Zealand). On 23rd November, the surgeon, Dr. R. McCormick, noted in his diary that '. . . a brown coloured duck frequents the harbour'. Earlier in that year a French expedition had visited the archipelago and discovered the now extinct Auckland Island Merganser, but made no mention of a flightless duck. Between 1806 (when they were discovered) and 1830, sealers and then whalers visited the islands frequently. The only settlers were a small colony of Maoris (1842) and about 300 British people (1849) sent there to re-establish the whaling industry. However, conditions were inhospitable and after 1856, when the last inhabitants left, the islands were seldom heard of, except in connection with numerous shipwrecks. Much of the early information on the Flightless Teal came from the crews of the Government steamer *Hinemoa*, which made several trips after 1879 to look for castaways. The one in 1907 included a scientific team and it was on this expedition that 12 Flightless Teal were caught off Ewing Island and taken to the Kapiti Island bird sanctuary off the coast of New Zealand near Wellington.

A Flightless Teal was also exhibited at London Zoo in 1895. In 1955 three birds came to the Wildfowl Trust as a gift from the New Zealand Government, but unfortunately they did not survive to reproduce. At the moment, no live specimens are known to exist outside the Auckland Islands.

A number of domestic animals were introduced on the Aucklands, mainly for the benefit of visiting ships and castaways. Pigs were released on Enderby in 1807 and, later, on most of the other islands. Sheep, goats and cattle were present from 1850. The latter are now only to be found on Rose and Enderby Islands, those on the main island having been killed by sealers. Rabbits and mice are plentiful on Rose and Enderby Islands. Rats from the numerous shipwrecks never became properly established. Dogs have not been seen recently and cats are limited to the main island. However, it appears that when Reischek (1889) visited the islands in 1888 most of the introductions were abundant. Reischek's description of the place is fairly detailed but he does not mention the flightless duck of which he had certainly been told. So by this time it might be supposed that numbers had been diminished by the introduced predators. Chapman (1891) reports that the expedition of 1890 saw only a few 'rare flightless Auckland Island duck'. In January 1901 only four were recorded by Lord Ranfurly's expedition. However, the habits of the Teal (which may even have been altered as a result of the necessity to avoid the predators) make it probable that it was not scarce but seldom seen, and according to Myers (Phillips 1926) there was no reason to suppose that its numbers had diminished much since its discovery. By 1941 it does seem to have become fairly rare. Teal were only seen occasionally on the outer islands and even less commonly on the main island by the coast watching party stationed there (Dr. C. A. Fleming, unpub.). During 1942, Fleming recorded the largest numbers on Ewing, Ocean, Rose and Enderby Islands, and in a bay west of Grafton Point, Adams Island. He had only two records for the main island, one at Tucker Point, and at Ranui Cove where Teal were seen 'occasionally'. The most ever seen at one time was 30-40 near Grafton Point.

Introductions may well have been the cause of their disappearance from the main island. The vegetation has apparently remained unchanged despite human settlement. The Aucklands are hilly and covered for the most part by low forests of mountain rata *Metrosideros lucida* with dense undergrowth. The open areas are covered with tussock grass or a short rough pasture which on Enderby Island forms an ideal hauling-out place for sea lions. The shores are steep and in some places the basalt cliffs of about 30 metres tower over numerous small inlets and caves. These caves, fringed with kelp appear to have become a refuge for the Flightless Teal.

On 7th February 1971 a party of tourists from the *Lindblad Explorer* saw one bird in the entrance to a cave in Sandy Bay, Enderby Island, standing on a ledge preening. At the approach of our small rubber dinghy it walked back into the cave where it stood for a few moments

before disappearing into the darkness. On the following day two birds were found, in this and the neighbouring cave. There was no obvious difference in plumage, which is probably to be expected in February, since, according to Falla and Stead (1938), males are eclipsed by March. The slight vermiculations on the feathers of the one shown in the photograph (Plate IV facing page 33) suggest that it could have been a male, and the prominent white ring around the eye indicates an adult.

The appearance of the duck is different from its relative, the New Zealand Brown Teal *Anas aucklandica chlorotis*, its shortened wings exposing a relatively large extent of tail behind. The colour is chestnut brown and fairly uniform, as against the speckled dark grey-brown of the Brown Duck, and the edges of the feathers are not as pale. Our two birds were probably not paired, since Fleming observed that pairs usually stay close to each other and maintain contact by calling. The whistled 'twirp' which he describes was not heard. The first bird, when approached on foot, walked through the cave and out at another entrance, swam along the shore amongst the kelp and returned to the cave. The second on seeing the boat returned to its hiding place on the shingle at the back of its cave and ran back to a ledge just inside. Both were fairly tame and swam past the boat at a distance of about three metres. At one point the second bird demonstrated its limited flying ability by flapping its short wings as it jumped from the ledge. Although it did not go very far, it was evident that the wings are not completely ineffectual.

The camouflage is excellent amongst the brown kelp strands heaving with the swell. The movements of the Teal also match this background, as they swim low and hunched, and move rather jerkily. They were not feeding and are probably nocturnal feeders (Buller 1888), as are the Brown Teal. Fleming, however, records both nocturnal and diurnal feeding. On Rose, Adams, Ewing and Ocean Islands, he found birds or their excreta in tussock grass *Stilbocarpa* and under trees near holes, though in all these places they were probably within reach of the sea. Earlier observations have reported them near 'inland watercourses' (Waite 1909) but it is possible that the cave-dwelling members of the population have avoided predators and survived better in the long run.

References

BULLER, W. L. 1888. *A History of the Birds of New Zealand.* London.

CHAPMAN, F. E. 1891. The outlying islands south of New Zealand. *Trans. N.Z. Inst.* 23 : 491-522.

FALLA, R. A. and E. F. STEAD. 1938. The plumages of *Nesonetta aucklandica. Trans. Roy. Soc. N.Z.* 68 : 37-39

FLEMING, C. A. Unpublished. Auckland Island Teal *Nesonetta aucklandica.* Field notes, etc. extracted from the diaries of C. A. Fleming.

GRAY, G. R. 1944-45. In *The Zoology of the Voyage of H.M.S.* Erebus *and* Terror. London: Janson.

PHILLIPS, J. C. 1926. *A Natural History of the Ducks.* Boston: Houghton Mifflin.

REISCHEK, A. 1889. Notes on the islands to the south of New Zealand. *Trans N.Z. Inst.* 21 : 378-89.

WAITE, E. R. 1909. Aves. In *The Subantarctic Islands of New Zealand.* Vol. 2. Wellington: Philosophical Institute of Canterbury.

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Observations on sound production in the Anatidae

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It has been known for a long time that, among non-passerine birds, the Anatidae are remarkable for the diversity of specializations in the trachea and syrinx, associated with sound production. It has also been recognised that these variations have taxonomic significance (Heinroth 1911; Johnsgard 1961), but virtually no attempts have been made to correlate the complex tracheal structures with the sounds produced. Yet the group offers many fascinating problems such as the adaptive significance of the looping of the trachea, either outside the body cavity as in the Magpie Goose *Anseranas semipalmata*, or inside the sternum as in the northern swans *Cygnus cygnus* and *C. columbianus*. Additionally, males of many species of ducks, particularly pochards (Aythyini) and sea ducks (Mergini), exhibit irregular enlargements of the tracheal tube. The majority of anatine species also show marked sexual dimorphism in the structure of the syrinx. Asymetrically enlarged bullae are typical in adult males, while females retain the relatively simple condition similar to that found in geese and swans. This paper is a first and perhaps naive attempt to understand the functional significance of such complex variations in waterfowl vocalizations.

General structural and acoustical aspects of sound production

One of the earliest attempts thoroughly to describe the structure of the avian syrinx and relate it to vocalizations was that of Myers (1917), whose description of the domestic fowl's *Gallus gallus* syrinx remains a classic. Rüppell (1933) agreed with Myers that sound produced in the syrinx by vibrating the tympaniform membranes is strongly influenced by the tracheal tube. Myers found that shortening the effective length of the trachea by severing it in the neck region served to raise the pitch of calls from 375 to about 500 cycles per second. As Sutherland and McChesney (1965) have pointed out, this result suggested that the length of the trachea can influence the rate of vibration of the tympaniform membranes, as in a wind instrument. Thorpe (1959) believed that the principle might be applied to many 'primitive' (non-songbird) avian species. Yet, Greenewalt (1968) has recently come to the surprising conclusion (p. 183) that the 'trachea plays no acoustical rôle in avian vocalization', a view that is hardly understandable considering the aforementioned studies.

Harris *et al.* (1968) analysed sound production by means of sonagrams when air was forced through syrinxes of dead roosters. They varied tension on isolated and intact syrinxes, varied the lengths of attached tracheal tubes, and examined the effects of the beak and glottis. They concluded that the fundamental frequency of sound generated by the tympaniform membranes is determined exclusively by the degree of syrinx tension. However, the associated structures (bronchi, trachea, beak and oral cavity) operate as a resonating tube and an associated expansible chamber, tending to tune the vocalizations to a basic resonant frequency. In chickens and similar birds with a uniformly narrow trachea, this resonant frequency is primarily determined by the length of the tracheal tube. The formula used by Harris *et al.* clearly indicates that they visualised this resonating system as being acoustically equivalent to a closed pipe, a reed-pipe instrument. Thus, they calculated that the amplitudes of the fundamental frequency and successive harmonics could be explained on the basis of the tracheal tube and bronchi acting as a single resonating tube.

In contrast, Sutherland and McChesney (1965) used similar sonagraphic techniques to analyse the calls made by living Snow Geese *Anser caerulescens* and Ross's Geese *Anser rossii*. They also calculated resonant frequencies based on the measured (but not indicated) lengths of the tracheal tubes, and on the assumption that the trachea may act either as an open-pipe (trumpet) or closed-pipe (reed instrument) resonating chamber. A tracheal tube acting like a closed pipe would generate a resonant frequency only half as great as an open pipe of the same length, and thus would have correspondingly lower-frequency harmonics. Comparison of the sonagrams with calculated resonant frequencies caused these authors to conclude that the tracheal tube operates in the manner of an open-pipe instrument. The Snow Goose had a lower

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membrane fundamental frequency although the total tympaniform membrane areas and membrane thicknesses of the two species appeared to be approximately the same. The authors therefore concluded that the width of the tympaniform membrane may be more important than either its length or total area in determining its vibration rate.

Both these studies confirmed the basic idea that two different processes are involved. First, the tympaniform membranes vibrate at a frequency partially regulated by their size or area, but which can be increased by increasing membrane tension. Assuming that the rate of vibration increases in proportion to the square root of tension, a theoretical ninefold increase in tension resulted in a threefold increase in frequency of sounds (Harris *et al.* 1968). Secondly, the tracheal tube and associated respiratory and pharyngeal structures provide a resonating chamber having a basic resonant frequency that is primarily determined by the length of the tracheal tube. The longer the tube, the lower the trachea's resonant frequency, and the greater the number of harmonics that will be generated in the audible range. Since low-frequency sounds have the greatest carrying power, a species that must communicate over great distances clearly needs the longest possible resonating tube. This would provide a possible explanation for the evolution of elongated tracheal tubes in the Magpie Goose and northern swans, as well as in various cranes and cracids.

Greenewalt (1968: 161) doubts this and instead attributes the loud voices of swans and cranes to their ample reserve of available air. As noted above, he questioned the ability of the trachea to modulate their calls, in spite of the marked differences in relative harmonic amplitudes that he reported. Instead he attributed these variations to unexplained mechanical constraints imposed on the tympanic membranes. However, Amadon (1970) noted that species of Cracidae having long tracheae usually have 'booming' voices with great carrying power. He also noted the relatively large size of their syrinxes and associated tympaniform membranes (also found in the northern swans). This would permit a low membrane vibration, and a consequent low fundamental frequency of vocalizations.

Greenewalt suggested (p. 183) that a critical test of tracheal modulation in birds would be to determine whether, in a helium-oxygen atmosphere, the theoretical increase in tracheal resonance frequencies caused an increase in the pitch of the vocalization. Such studies had already been performed by Hersch (1966), who found that at least in the case of the Mallard *Anas platyrhynchos*, the only duck tested, a change in vocal pitch *did* occur. The current evidence thus strongly favours a rôle of tracheal modulation, at least in species possessing fairly long tracheae.

Being controlled by independent factors, there is no *a priori* reason to believe that the fundamental (source-generated) frequency of vibration of the tympaniform membranes should necessarily coincide with the resonant (carrier-generated) frequency of the tracheal tube or any one of its harmonic multiples. Rather, it may be imagined that these two systems come into phase only at certain common harmonic frequencies which would thus be relatively amplified. The harmonics of the fundamental frequency that are not in phase with the resonant frequency harmonics would tend to be dampened out. Such differential amplitude development of 'frequency zones' may clearly be seen in some of the sonagrams accompanying this paper, particularly those of the true ducks. In contrast, some species' calls exhibit relatively uniform development of harmonics from the lowest to the highest frequencies covered by the sonagraph. This is suggestive of a distinct 'tuning' effect, of the trachea on the source-generated fundamental frequency. Not surprisingly, this is especially clear in the northern swans, since the very long trachea produces an extremely low resonant frequency, whose many harmonics are much more likely to be nearly 'matched' with harmonics of the fundamental frequency than are the relatively few and high-pitched resonant frequencies produced by a very short trachea. Thus, the calls of pygmy geese (*Nettapus*) are high-pitched, virtually lacking in harmonics (see Frith 1967: 270), and have a considerable resemblance to the nearly pure-toned calls of whistling ducks (*Dendrocygna*).

Greenewalt (1968: 164) pointed out that for each bird species a frequency threshold for pure whistles apparently exists, above which no audible harmonics are generated and below which one or more harmonics develop. As the fundamental frequencies fall, such harmonic monics becoming progressively dominant over the fundamental ones, higher harmonics becoming progressively dominant as the fundamental frequency falls. This was so up to at least the ninth harmonic

and apparently up to the fifteenth in some Trumpeter Swan *Cygnus c. buccinator* calls (p. 160). However, Greenewalt attributed these differential harmonic amplitudes to a transition from a rippling to a more pulse-like membrane vibration, rather than to modulating effects of the trachea.

More recently Wurdinger (1970) has provided an important analysis of the comparative vocalisations of four goose species and their anatomical correlates. She concluded that the necessary variations in tension of the tympanic membranes are regulated by the interclavicular air sac rather than the tracheal muscles. This air sac pressure is also directly correlated with the call's fundamental frequency and amplitude. Differences between species' fundamental frequencies correlate negatively with the area of the tympanic membranes, and the differences in amplitudes correlate negatively with tracheal diameters. Further, the tracheal width may also influence the relative development of harmonics, wider tracheal tubes being associated with the reduction of higher harmonics.

Since the tracheal and syringeal anatomy of the Anatidae varies between the major taxonomic groupings, a short review of the acoustical characteristics of the calls made by species representing the various tribes is now presented. Unless otherwise indicated, the accompanying sonagrams were made with a Kay Audiospectrograph Model 6061B, with frequency ranges of 80 to 8000 cycles per second, wide-band filter, and HS setting. The sequence of discussion follows my earlier (1961) paper on tracheal anatomy, but the tribes Cairinini and Oxyurini are excluded from consideration owing to lack of adequate comparative material. Estimates of fundamental frequencies were determined by two methods. For those species having fairly high fundamental frequencies and thus few harmonics, the frequencies were measured directly from the sonagram baseline, using a calibrated scale. In cases where the fundamental frequencies were relatively low and exhibited strong harmonic development, the frequencies were estimated by determining the frequency range covered by several harmonics and dividing by the number of harmonics (Fouquette 1960). The dominant frequency represents the fundamental frequency or harmonic having the maximum amplitude, as indicated by the relative darkness of the sonagram or by taking a 'section' of the call in its midpoint. Harmonics were numbered by considering the fundamental frequency as zero and the first overtone above it as harmonic number one (whereas Fouquette (1969) numbers the fundamental as the first harmonic).

In the calls of some species, the fundamental frequencies may be obscured by pulsed or trilled characteristics of the sounds. Where the pulse rate of the call is considerably under 100 per second, the human ear detects the pulse rate rather than the audible sound frequencies (McAlister 1959), and the trill or pulse rate can be counted by the number of vertical energy pulses on the sonagram per unit of time. It is not yet clear whether these vertical pulse rates represent actual fundamental frequencies of less than 100 Hz., or whether the pulse rates are independently generated, as in some anuran species (McAlister 1959). The glottis might provide a possible start-stop control of pulsed sounds that would be independent of tracheal resonating effects (Thorpe 1959).

Few data on the actual length of the trachea and associated structures *in situ* are available. Comparisons between dried and fresh specimens in ducks and quails indicated that dried tracheae shorten by between 20 to 50%, making museum specimens quite useless. Audubon (1840-1844) gave some lengths of fresh tracheae when 'moderately' extended, but these are not really precise enough for our purposes. Detailed dissection of a wide range of species is a future requirement to check the estimates of effective tracheal length derived below from acoustical properties.

SUBFAMILY ANSERANATINAE

Tribe Anseranatini (Magpie Goose)

The vocalizations of the monotypic Australian Magpie Goose are of special interest because of the extraordinary length of the adult male's trachea which may reach 150 cm. (Johnsgard 1961), whereas it is considerably shorter in females. This maximum length would allow a remarkably low minimum resonant frequency (about 115 Hz. in an open-pipe system), and the potential for a very large number of resonating harmonic frequencies. Contrary to my earlier (1961) observations, Frith (1967) reported that male Magpie Geese have higher pitched voices than do females, and the sonagrams that he published would support this view.

To resolve this problem, I recorded the

vocalizations of the breeding Magpie Geese at the Wildfowl Trust in May 1971. The adult male was the bird I studied and reported on in 1961, and by 1971 was at least 20 years old, while the two females were six years old. Magpie Goose calls recorded by D. S. McChesney at the Wildfowl Trust involved the same male but two different females. Several individual calls sonagrammed from these recordings indicate that the male calls exhibit fundamental frequency ranging from about 270 to 300 Hz, and have a large number of harmonics that diminish in a relatively progressive fashion, disappearing at about 6,000 Hz. These typically fall slightly in pitch near the end of the call, but in the case of alarm calls, uttered as the bird tosses his bill upwards, the pitch rises slightly during the call. The females' calls exhibit considerable variation in pitch, and it was not possible to determine whether these reflect individual or possible functional or intensity variations. A low volume grunting note uttered in situations of mild disturbance has a fundamental frequency of about 200 Hz and is strongest in harmonics at about 1,000 Hz. Another female call, uttered during apparent excitement, has a considerably higher pitch, with a fundamental frequency of about 520 Hz, and fairly uniform development of harmonics that gradually diminish at higher frequencies. It would thus appear that male Magpie Goose vocalizations, although not consistently lower than those of females, do seem more uniform in pitch, suggesting a distinct 'tuning effect' of the extremely long tracheal tube. Female calls vary considerably in pitch, and may be higher or lower than those of males. Measurements of the tracheal tube lengths for adult females are not available, but those of males could effectively resonate calls with fundamental frequencies as low as 115 Hz.

SUBFAMILY ANSERINAE

Tribe Dendrocygnini (Whistling Ducks)

The whistling ducks have a somewhat surprising sexual dimorphism of the syrinx, with males possessing an oval-shaped tracheal bulla and the females a relatively simpler structure. So far, sonagrams of adult calls from only one species of *Dendrocygna* have been published, by Frith (1967) for the Eyton's Whistling Duck *D. eytoni*. I have prepared sonagrams from three additional species of *Dendrocygna* and of *Thalassornis*, a probable near relative of the whistling ducks (Johnsgard 1967).

The calls of the Fulvous Whistling Duck *D. bicolor* are the most typically anserine, in that they exhibit the least varied overall frequency range and a relatively large number of harmonic frequencies are amplified (Figure 1a). The typical double-note *'wa-kew'* begins with a short (1/20 sec.) rising and falling note ranging in maximum amplitude from about 2,720 to 4,000 Hz. This is immediately followed by a longer ($\frac{1}{4}$ sec.) note that also rises and falls in pitch and with maximum amplitude between 2,400 and 3,600 Hz. The fundamental frequency of the mid-point of this second note appears to be at about 900 Hz., and the nearly uniform development of harmonics suggests that this is near the resonating frequency of the tracheal tube, which thus might be expected to be about 19 cm. long.

The calls of the White-faced *D. viduata* and Red-billed *D. autumnalis* Whistling Ducks differ considerably from those of *bicolor*, both in their more complex temporal and frequency patterning and in their greatly reduced harmonic content (Figures 1b and 1c). Both species have flight calls that consist of three or more major rising and falling syllables and with only one well developed harmonic above the fundamental frequencies and under 8,000 Hz. In *viduata* the frequencies vary from about 2,000 to 3,850 Hz., with the greatest amplitude around 3,500 Hz. The actual fundamental frequency, however, appears to be under 1,000 Hz., with the greatest amplitude thus being apparently generated in the fifth harmonic, and again between 4,500 and 8,000 Hz., particularly around 7,200 Hz. A tracheal tube 24 cm. long would generate a resonating frequency of 717 Hz. with the fifth and tenth harmonics falling at 3,583 and 7,166 Hz., which would nicely account for the observed amplitude increases in these zones.

The flight calls of *autumnalis* have surprising similarities to those of *viduata*, although even more drawn out, and the preliminary rising note is better developed. Again, only two major harmonics are well developed below 8,000 Hz., both of which appear to be multiples of some lower fundamental frequency that is but weakly developed. Some sonagrams clearly indicate that there are four sound zones below the first major zone of sound energy, and four more between the first and the second. The zones of maximum sound production in these two patterns are between 2,880 and 3,760 Hz., and between 6,800 and 7,200 Hz. Again,

a tracheal tube of 25 cm. would provide fifth and tenth resonating frequencies of 3,440 and 6,880 Hz.

The White-backed Duck *Thalassornis leuconotus* is most unusual (Figure 1d). It not only differs from the stiff-tailed ducks so far studied, but also shows the rapid and sharp frequency fluctuations characteristic of *Dendrocygna*, as well as a markedly differential amplification of certain harmonics. The calls usually begin fairly low in pitch, suddenly 'break' to a high note with a single dominant harmonic of about 4,500 to 6,000 Hz., that abruptly terminates. The pitch then drops back down to the original strong amplication of several lower harmonics. These lower harmonics are fairly uniformly generated at frequency multiples of about 1,250 Hz., suggesting a resonating tracheal tube length of about 14 cm. Well-developed harmonics in the middle, high-pitched phrase segment are virtually lacking. This suggests that the source-

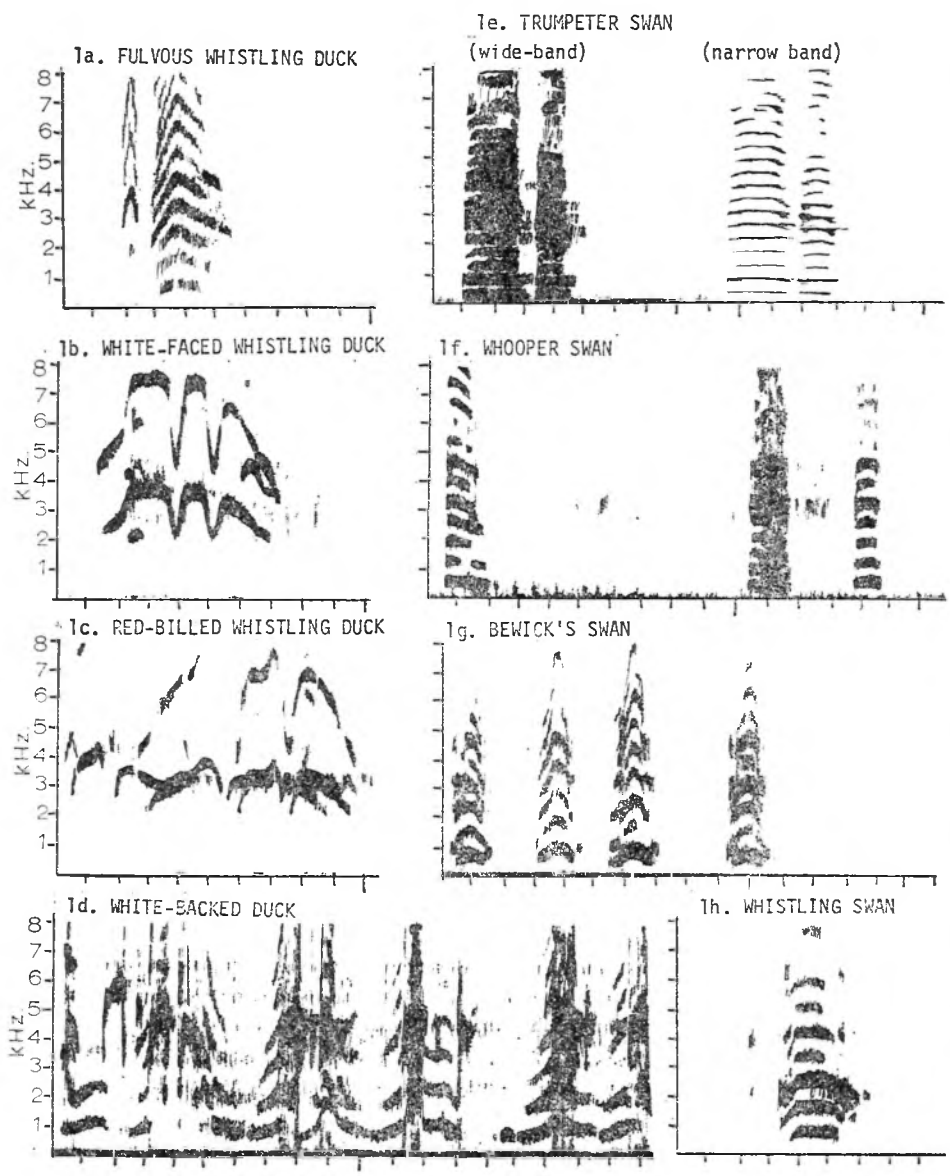


Figure 1. Sonagrams of representative whistling ducks and swans.

generated (tympaniform membrane) fundamental frequency is out of phase with most of the resonating frequencies, while under maximum tension under the syringeal membranes, and finally drops back to the fundamental frequency at which the call started.

Tribe Anserini (Swans and True Geese)

The typical swans *Cygnus* include the arctic-breeders *C. cygnus* and *C. columbianus*, which possess strong voices and tracheal that convolute within the sternum, and three relatively weak-voiced and more temperate-breeding swan species, the Mute *C. olor*, Black *C. atratus* and Black-necked *C. melanocoryphus*. There is also the monotypic Coscoroba Swan *Coscoroba coscoroba*, which has a syringeal structure similar to that of the Mute Swan, but with strong calls of complex harmonic development like those of geese and the northern swans.

Sonagrams (Figures 1e, 1h) are available for all four northern swans, which in sequence from the largest to smallest are the Trumpeter *C. cygnus buccinator*, Whooper *C. cygnus cygnus*, Whistling *C. columbianus columbianus* and Bewick's *C. columbianus bewickii*. When these are compared, it is evident that the larger birds have calls exhibiting less frequency fluctuation than the smaller ones, suggesting that a long tracheal tube may indeed tend to 'tune' the call by placing constraints on the fundamental frequency. Additionally, the fundamental frequencies and thus the number of developed harmonics are correlated with relative body size; in the 80 to 8,000 Hz. range the usual number of harmonics evident were as follows: Trumpeter 17-19 Whooper 12, Whistling and Bewick's 9-10.

Greenwalt (1968) calculated fundamental frequencies for two Trumpeter Swans at 475 and 485 Hz., and two Whistling Swans at 815 and 833 Hz. For the calls shown here, the approximate fundamental frequency in the middle of each call, based on average distances between harmonics, is 461 for the Trumpeter, 666 for the Whooper, 750 for the Whistling, and 800 for the Bewick's Swan. These increasingly higher fundamental frequencies would be expected with the smaller syringeal sizes and shorter tracheal tubes, and could be generated by tracheal tubes of the following lengths and their multiples: 37.3, 26.8, 22.9 and 21.5 cm. Actual measured fresh tracheal lengths of Whistling and Trumpeter Swans have not been published to my knowledge. A fresh adult Whistling Swan trachea examined by Mrs. D. Jean Tate (*in litt.*) measured 117.1 cm. (intrasternal length of 35.1 cm.), with bronchi of 4.1 and 3.0 cm.

The snorting threat uttered by male Mute Swans is curiously pulsed (ca. 55/sec.) (Figure 2b) and, apart from its initial phrasing, develops few harmonics. However, the fundamental frequency of the first phrase appears to be about 720 Hz., which would develop with a tracheal tube length of some multiple of 23 cm., perhaps 69 cm.

By contrast, the Black-necked Swan has a more musical call (Figure 2a) with a fundamental frequency ranging from about 900 to 1,600 Hz. This relatively high figure correlates well with the small size of the adult and its relatively small syrinx. The maximum amplitude of the call occurs at about 960 Hz., which would be in phase with a tracheal tube of 18 cm. or some multiple, perhaps 54 cm.

Sound analyses of the Canada Goose *Branta canadensis* have been made by Greenewalt (1968) and of two species of *Anser* by Sutherland and McChesney (1965). The Canada Goose provides an ideal subject for the influence of tracheal length, since sub-species range in adult size from nearly 9 kg. to under 2 kg. A representative sonagram of a moderately large *B. c. canadensis* race is shown in Figure 2c. This illustrates well that the prolonged, fairly uniform-pitch calls of these birds are quite low: Greenewalt reported fundamental frequencies of 131 and 383 Hz. In Figure 2c, the fundamental frequency is at approximately 510 Hz., and the great amplitudes occur, judging from cross-section study, in the second, fourth, and ninth harmonics, or at intervals of 1,150 Hz. This would correspond to a tracheal length of some multiple of 15 cm. Würdinger (1970) indicated that two Canada Geese that she examined had tracheal lengths of 42.6 and 46.3 cm., as measured in freshly dead specimens.

The relatively small Ne-ne *Branta sandvicensis* has a call with an average fundamental frequency about 670 Hz. (Figure 2d), and consequently a large number of harmonics. These harmonics are amplified especially in the frequencies between 2,000 and 4,000 Hz., primarily at about 2,500 and 3,800 Hz. Again, these frequencies would be resonated well with a tracheal tube length some multiple of 14 cm.

The curious Cereopsis *Cereopsis novaehollandiae*, which might be either anserine or tadornine in its affinities, has a voice (Figure 2e) that is astonishingly similar to that of the Mute Swan's snort.

It has the same rattling trill characteristics of about 40 pulses per second, and a very wide frequency range with few harmonics.

SUBFAMILY ANATINAE

Tribe Tadornini (Shelducks and Sheldgeese)

In this subfamily well-defined sexual dimorphism in tracheal anatomy and adult calls first appears. The calls of the females tend to retain the highly developed harmonic content and the relatively minor frequency variations typical of geese and swans, whereas the males sometimes produce nearly pure whistled sounds having considerable frequency variation. An example of a typical female call is the inciting of the Ruddy Shelduck *Tadorna ferruginea* shown in Figure 2g. Apart from its broken cadence characteristics, it is remarkably like that of the Canada Goose shown in Figure 2c, with a low fundamental frequency that is under 500 Hz., and with differential amplification of the harmonics, particularly in the frequency zones of about 1,000, 2,500 and between 4,000 and 5,000 Hz. This ampli-

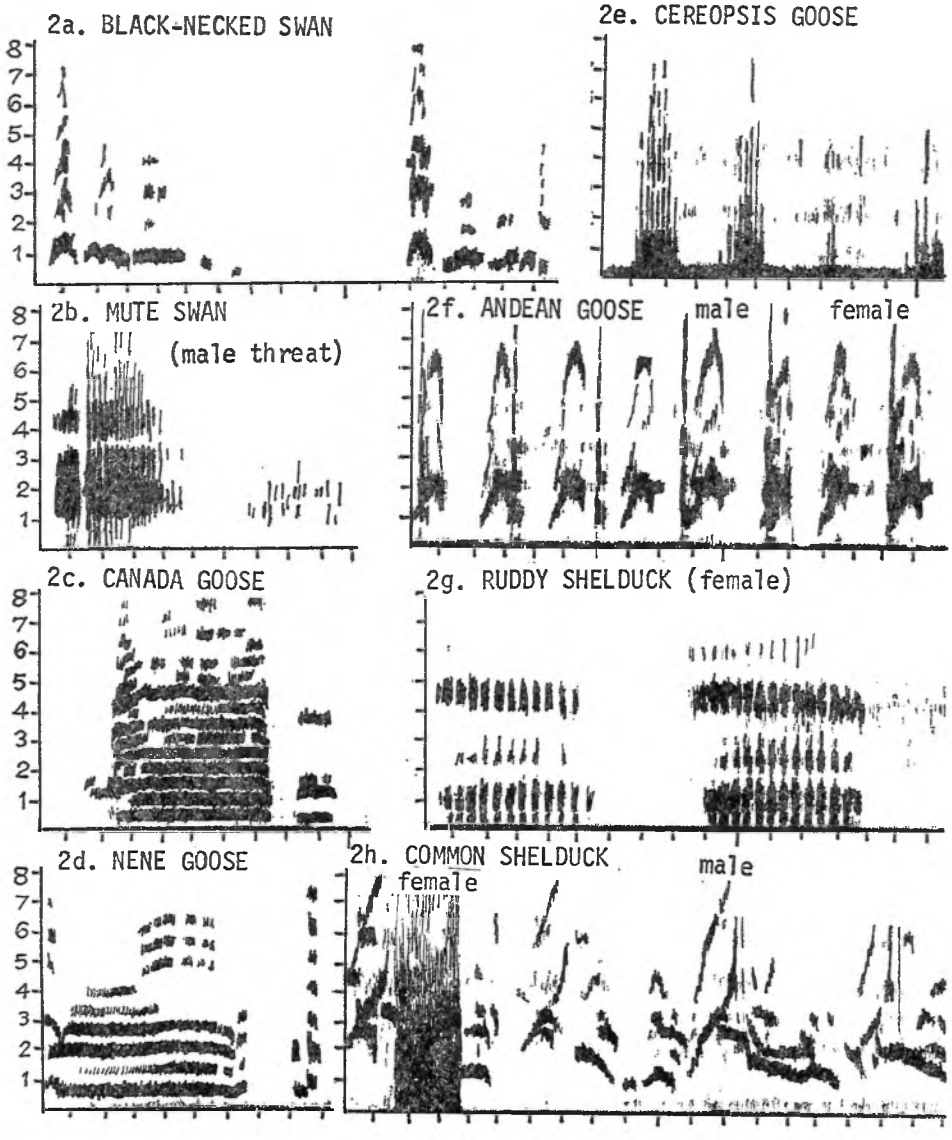


Figure 2. Sonagrams of representative swans, geese and shelducks.

cation could be readily accounted for by a tracheal tube some multiple of 13 cm. in length.

The very low-pitched call of the female Andean Goose *Chloephaga melanoptera* (Figure 2f) has less developed harmonics but several tones of harmonic amplification are evident, as in the male's chuckling notes. In his more sibilant series of *'wi wi'* notes the fundamental frequency fluctuation (from about 1,000 to 2,500 Hz.) becomes more evident and the harmonic bands in the zones around 3,400 and 4,600 Hz. are relatively less amplified, with major amplification instead at 2,170, 3,400 Hz., and again at 4,600 Hz., but not around 4,000 Hz. (Figure 2f). Whether these differences in resonant frequencies are enough to account for the observed damping of sound between 3,400 and 4,600 Hz. is difficult to judge.

Sexual dimorphism in vocalizations is even more pronounced in the Common Shelduck *Tadorna tadorna.* The female calls vary considerably in duration and rate of repetition (up to about seven per second in the case of rapidly repeated cackling notes), and in all cases have a fundamental frequency too low to measure on the sonagrams, but with poor development of resonant harmonics (Figure 2h). In contrast, the whistling notes of the male are fairly pure, mostly in the range of 1,000 to 3,000 Hz., initially rising sharply in pitch, then dropping back more gradually. In the 'casarca' group the males possess a rudimentary tracheal bulla, and the two sexes exhibit only very limited sexual dimorphism, as shown by Frith's (1967) sonagrams for the Australian Shelduck *Tadorna tadornoides.* This would certainly support the view (Johnsgard 1961) that a well developed tracheal bulla is probably responsible for the ability of males of the larger Anatinae to produce pure whistled notes.

Tribe Anatini (Dabbling Ducks)

The number of species of *Anas* and of related genera is far too great to show representative sonagrams from all of them. Frith (1967) has already published sonagrams for the Grey Teal *Anas gibberifrons,* Chestnut Teal *A. castanea,* Australian Black Duck *A. superciliosa* and the aberrant Pink-eared Duck *Malacorhynchus membranaceus.*

Two common calls of adult female Mallard *Anas platyrhynchos* are the inciting call and the decrescendo call (Figure 3a). Besides differing markedly in cadence characteristics, the inciting calls appear to have a lower fundamental frequency that is completely out of phase with the resonating frequencies of the tracheal tube, producing vertical energy bands on the sonagrams, with little if any harmonic structuring. In contrast, the decrescendo call is a series of repetitive notes having nearly the same fundamental frequency but of diminishing amplitude, all with well developed harmonic structure. The fundamental frequency of the call shown is at about 585 Hz., and maximum amplication occurs between 1,500 and 2,500 Hz. Greenewalt (1958) reported a fundamental frequency of 179 Hz. for a female Mallard call, with maximum amplification in the harmonic centering at 1,428 Hz.

The alarm notes of *Anas* females appear to be similar to the decrescendo calls in their acoustic characteristics, but are more uniform in cadence and amplitude (Figures 3b, 3c). The *'raeb'* call of the male is drawn out (0.3 sec.) in a manner similar to the female's alarm notes, and otherwise appears quite similar to them on the sonagrams. As in the female, maximum amplitude occurs around 2,000 Hz.

Whistled notes of the male Mallard are not available for sonagraphic inspection, but the courtship calls of male Gadwall *Anas strepera* interestingly alternate between typical *'raeb'* sounds and whistled notes (Figure 3d). The very low-pitched fundamental frequency of the *'raeb'* notes (estimated at about 105 Hz. from the vertical striations on the sonagrams) is somewhat amplified in the zone around 2,500 Hz., whereas the whistled notes centre on a frequency zone of about 3,300 Hz., with a weak harmonic at 6,600 Hz. It is unlikely that tension changes on the syringeal muscles alone could account for this dramatic shift in frequency, and it instead seems possible that the shift reflects a change from a tympaniform-membrane-generated sound to a bulla-generated sound, on the aeolian whistle principle (Johnsgard 1961). Similarly, the 'cricket' whistle of male European Green-winged Teal *Anas crecca* has its lowest amplified frequency at about 2,400 Hz., with a minor harmonic at 4,800 Hz. and a more intense one at 7,600 Hz. (Figure 3e). By comparison, the female alarm calls of both the Teal and Shoveler *Anas clypeata* have very low fundamental frequencies of under 500 Hz. In the case of the Gadwall these have maximum resonant amplification of harmonics between 2,000 and 3,000 Hz., while in the Teal these are best developed between 2,800 and 3,800 Hz. Greenewalt (1967) reported the

fundamental frequency of a female Teal call as 273 Hz., with maximum amplitude in the 12th harmonic at 4,296 Hz.

Inspection of sonagrams of various species of *Anas*, such as those appearing in Frith's book (1967), indicate that similar acoustical characteristics to those of the Mallard female occur in the decrescendo calls of many *Anas* species. Smaller species generally have more rapidly repeated notes and somewhat higher fundamental frequencies, but with little actual change in frequencies throughout the entire call sequence.

A few species of dabbling ducks have male calls that diverge from the typical *Anas* pattern. Several species of the 'blue-winged duck' group lack pure whistles; in the Garganey *Anas querquedula* the male courtship call is a rattling noise produced by broken bursts of 'wooden' sounds having a pulse rate of about 50 per second, somewhat like the rattling sounds of the Mute Swan and the Cereopsis. However, a definite bulla is present in males of this species and of the shoveler group.

In contrast, males of the wigeon group lack *'raeb'* notes and produce only whistled calls. The Chiloe Wigeon *Anas*

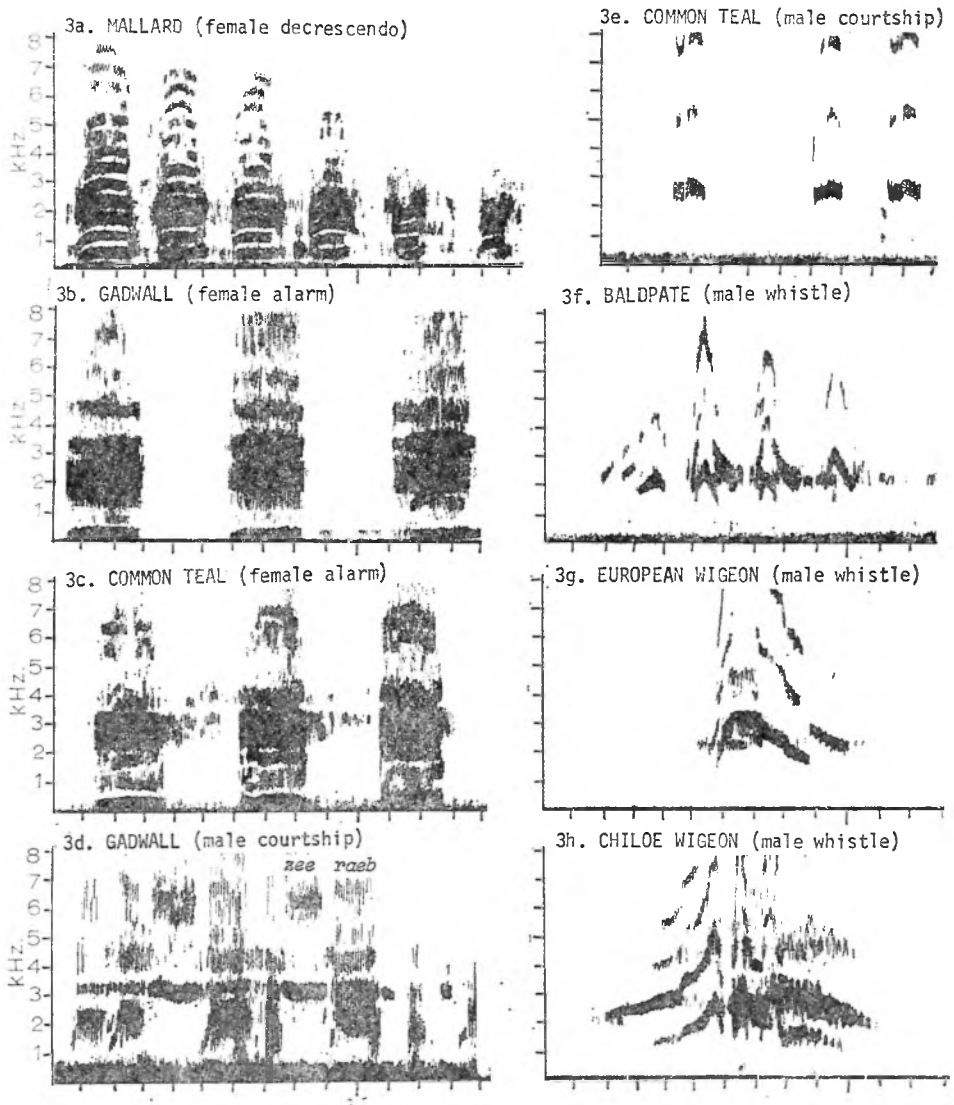


Figure 3. Sonagrams of representative dabbling ducks.

sibilatrix has the loudest calls and the largest tracheal bulla. The American Wigeon *A. americana* has the smallest bulla and the weakest whistles, and the European Wigeon *A. penelope* is intermediate in both regards (Figures 3f-3h). Interestingly, the whistles of the American Wigeon consist of a series of three or four simple ascending and descending notes, with several harmonics and major amplification between 2,000 and 3,000 Hz. The male European Wigeon begins with a weak ascending note, followed by a much louder rapidly ascending note that 'plateaus' in fundamental frequency at about 3,400 Hz. It then gradually drops off in a *glissando* of descending frequency, passing through a zone of increase amplitude at about 2,500 Hz. before dying out completely. Finally, in the Chiloe Wigeon, the call is a nearly continuous flow of sound energy lasting approximately one second. It starts with a rise in fundamental frequency from about 1,000 Hz. to 2,500 Hz., where a *vibrato* effect begins and the call gradually diminishes in amplitude and fundamental frequency. In all three species major amplification occurs in frequency zones around 2,000, 4,000 and 8,000 Hz., which would be best accounted for by a tracheal tube some multiple of 9 cm. long.

Tribe Aythyini (Pochards)

As described previously (Johnsgard 1961), the tracheal anatomy of the pochards is of unusual interest, owing to the variations in the diameter of the tracheal tube of males, and the partially membraneous syringeal bulla. The acoustical functions of both adaptations remain obscure, although it may be presumed that gradually varying tracheal tube diameters would somewhat affect the efficiency of the resonating characteristics of the trachea, whereas abrupt changes in diameter, as in the Rosybill *Netta peposaca*, might have quite different acoustical effects.

Pochard calls are usually both relatively weak in amplitude and low in pitch, and are thus difficult to separate from background noises. The greatest zone of amplification of the male calls available appears to be at or the fundamental frequency, under 1,000 Hz. For example, the courtship call of the male Canvasback *Aythya valisineria* exhibits greatest amplification at about 750 Hz., with minor resonant amplitude two harmonics above at 3,000 Hz.. but virtually no harmonic development above that frequency. Female calls show similar amplitude characteristics. By contrast, the male calls of the Redhead *Aythya americana* are more prolonged and have strong amplitude development not only at 750 Hz., but also at 2,200 and 3,000 Hz., and progressively weaker harmonics at higher frequencies. Most striking of all is the male call of the European Pochard *Aythya ferina*, which is unusually prolonged (1.4 seconds) and has remarkable harmonic development. As may be seen on the sonagram (Figure 4a), the call gradually rises in frequency, makes a sudden dip near the middle (compare Chiloe Wigeon, Figure 3h); this is followed by a point of maximum frequency (fundamental frequency ca. 780 Hz.), and is terminated by a gradual *glissando* to the starting point. Individual harmonic bands increase and decrease in amplitude as they pass in and out of zones of resonant frequencies. These appear to be approximately 700 Hz. apart, suggesting a resonating tube length of about 24 cm.

Calls of female pochards are acoustically much like those of female dabbling ducks. Thus, the alarm call of a female Lesser Scaup *Aythya affinis* has the same paced cadence and low fundamental frequency evident in Gadwall, Mallard, and Green-winged Teal. These notes have maximum resonant amplification of harmonics in the zone between 1,900 and 2,900 Hz. (Figure 4c). The inciting notes are acoustically similar (Figure 4b). In the Canvasback at least, inciting calls appear similar to inciting notes of *Anas* females, having wide frequency content and relatively poor harmonic development. Decrescendo calls are virtually lacking in this group (Johnsgard 1965).

Tribe Mergini (Sea Ducks)

All of the problems posed by the Aythyini are present in the sea ducks, including variably enlarged tracheal tubes, complex and partially membranaceous bullae, enlarged bronchial tubes, and in the case of one genus (*Polysticta*), unusually well developed *sternotrachealis* muscles.

The typical eiders (*Somateria*) provide a special problem. Male vocalizations of all species are low cooing sounds, which involve the inflation of the throat region with air presumably, but not definitely, resulting from inflation of the interclavicular air sac. This would require that the vocalization occurs during inhalation, which is not yet definitely proven for birds but may well occur (Kelemen 1963).

However, sounds of the same 'booming' quality are produced by male Pinnated Grouse *Tympanuchus americanus* by inflation of the oesophagus with air expelled from the tracheal tube. This, in the case of the grouse, has the acoustical effect of adding an expansible chamber to the end of a resonating tube, the greatly increased volume allowing for a more effective resonance of very low frequency sounds.

The 'cooing' sounds of male Common Eiders *Somateria mollissima* certainly support the view that these low frequency harmonics are most effectively amplified. The fundamental frequency appears to be under 600 Hz. even at the call's point of highest pitch, and the lowest frequency band has the greatest amplitude. These low frequencies are best illustrated by a narrow-band filter display on the sonagram (Figure 4h). It is suggested that, whatever the eiders may use as inflatable structures, this behaviour effectively amplifies low frequency sounds, which otherwise would require an open-tube resonator of 35 cm. or longer. Calls of female eiders also have low fundamental frequencies but little harmonic structuring (Figure 4h).

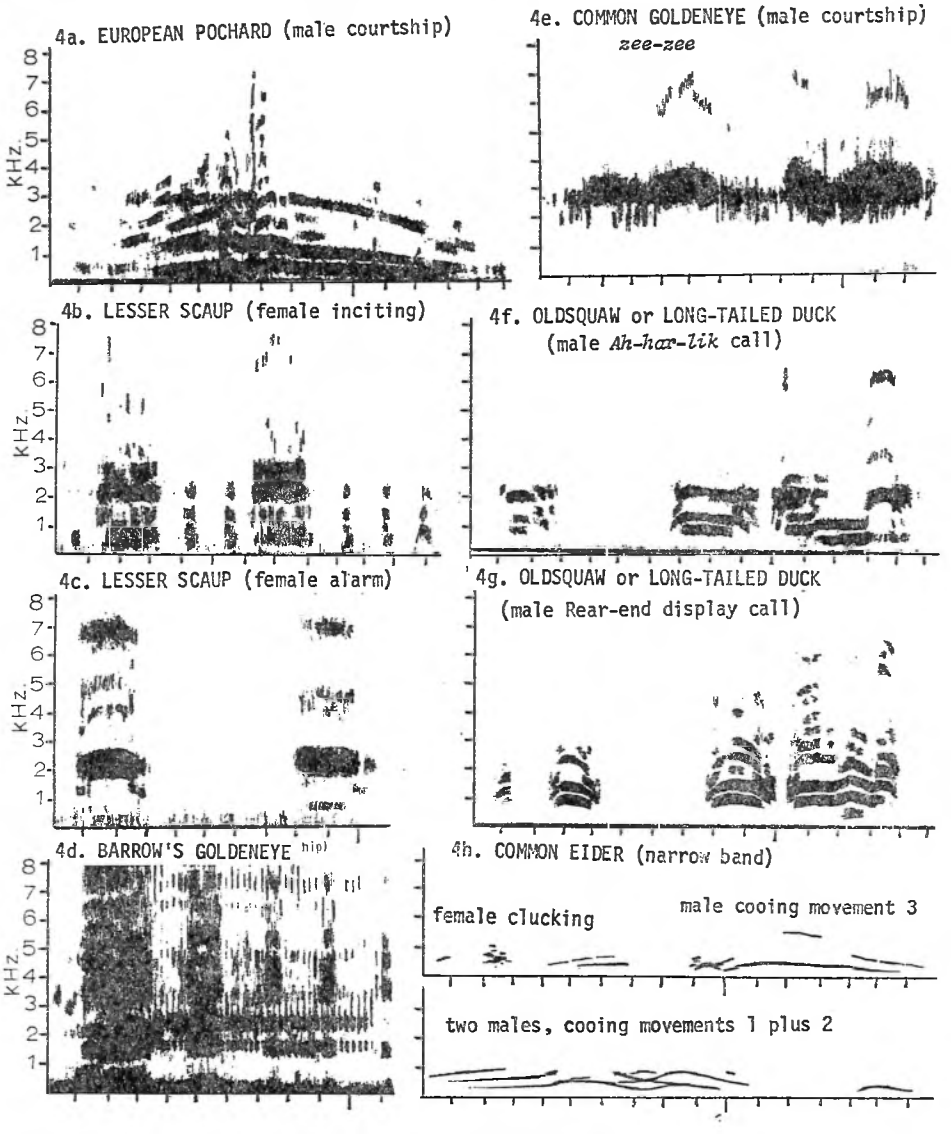
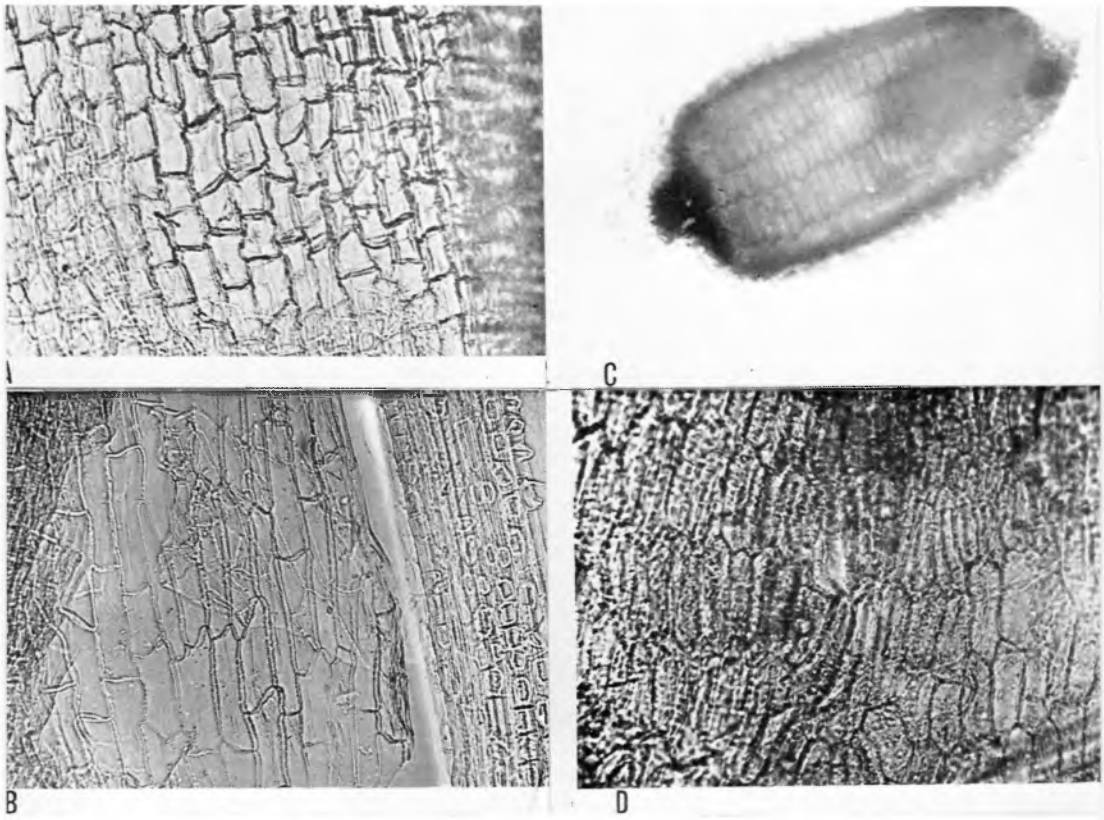


Figure 4. Sonagrams of representative pochards and sea ducks.



E. E. Jackson

Plate V. (a) Identification of seed and stolon fragments recovered from goose faeces (see pp. 114-119). A. The surface of a clover stolon (x 220). B. Clover petiole (left) and stolon vascular tissue (right) (x 220). C. A whole seed of *Juncus gerardii* (x 120). D. Surface of *J. gerardii* inflorescence bract (x 220).
(b) Common Eiders *Somateria mollissima* swimming above mussel beds excavate craters by rotating on their axes as they dig for the shells (see pp. 100-106).

P. V. Player

Kiyoshi Honda, Niigata, Japan

Plate VI. (a) Hyoko in Japan has become the winter home of hundreds of Whooper Swans *Cygnus c. cygnus* (see pp. 120-121). Despite the proximity of a small town it also harbours thousands of Teal *Anas c. crecca.* (b) Shigeo Yoshikawa, the swan-father of Hyoko, is accorded the trust of a wild cygnet feeding from his hand.

Kiyoshi Honda, Niigata, Japan

Kiyoshi Honda, Niigata, Japan

Plate VII. (a) Four Whooper Swans flying into Hyoko against the background of snowy hills. (b) Intense interest is demonstrated when an injured swan is returned to the lake after surgical treatment. It is one of the small number of Eastern Bewick's Swans *Cygnus columbianus jankowskii* which mingle with the Whoopers.

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Philippa Sc

Plate VIII. These two races of the Spotbill are quite distinct in their plumage markings. (a) The Indian Spotbill *Anas poecilorhyncha zonorhyncha.* (b) The Chinese Spotbill *A. p. poecilorhyncha.*

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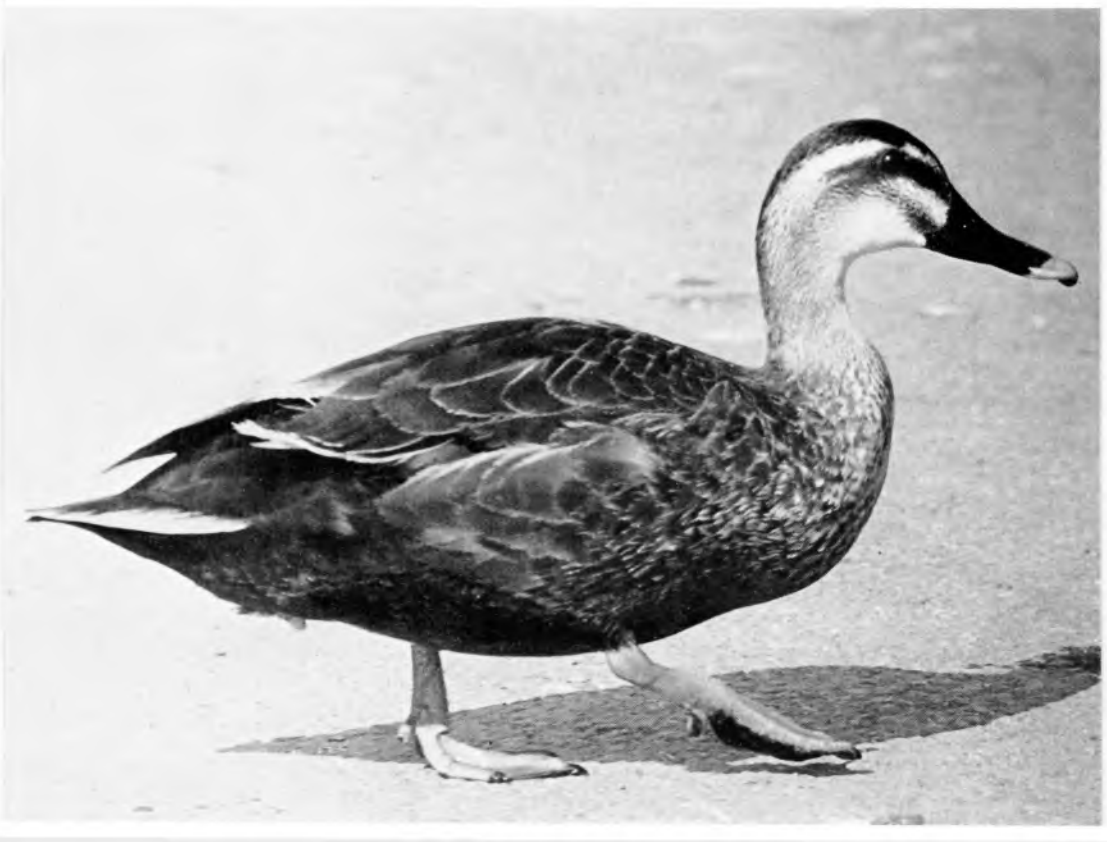

The male calls of Long-tailed Ducks (Oldsquaws) *Clangula hyemalis* provide an interesting contrast (Figures 4f and 4g). The rich and penetrating calls have harmonic contents similar to those of some long-necked geese and swans. The fundamental frequency does not vary appreciably; instead there is considerable syllable emphasis and amplitude variation of harmonics that produces a melodic rhythm. The fundamental frequency in the part of the '*Ah-har-lik*' call that has maximum resonating harmonic development is approximately 440 Hz., with the greatest amplitude evident around 2,200 Hz. (Figure 4f). A second zone of well-amplified sounds occurs at about 6,500 Hz. In this loudest part of the call the fundamental frequency is apparently raised from a level that is best amplified at about 1,100 Hz. to an amplification of the next higher resonating frequency. A tracheal length of about 15 cm. would account reasonably well for these two resonating frequencies. A similar call (Figure 4g) with slightly different cadence characteristics, is associated with the 'Rear-end display' (Johnsgard 1965). A better match of fundamental and resonating frequencies may be seen through most of the call. The greatest amplitude is in two harmonics between 900 and 1,800 Hz., which are apparently the first two harmonics above the fundamental frequency, rather than in the fourth or fifth harmonic as evident in the other call. It would seem that only distinctly different degrees of neck-stretching could account for these marked differences in harmonic amplification.

Relatively little can be said about goldeneye (*Bucephala*) calls, other than to note that they appear to have little harmonic structuring. One call from a female Barrow's Goldeneye *B. islandica* has a low fundamental frequency with maximum amplification between 2,000 and 2,500 Hz. One male call, the clicking noise produced during various displays such as the 'Crouch' (Johnsgard 1965), exhibits (Figure 4d) an interesting combination of a simultaneous series of pulsed syringeal noises and an unbroken train of clicks. The clicks are produced at a rate of about 48 per second, while the fundamental frequency of the basic vocalization seems to be around 130-140 Hz. The two sounds seem to be differentially resonated, the strongest amplification of the clicks being at 2,500 Hz., with lesser amplification at 1,700 and 3,400 Hz., whereas the basic vocalization is best amplified at 1,700 and 3,400 Hz. This is in strong contrast to the '*zee-zee*' call of the male Common Goldeneye *B. clangula*. This, in spite of an apparently quite low fundamental frequency of under 1,000 Hz., is strongly amplified between 2,800 and 3,800 Hz., with another minor harmonic zone reappearing between 600 and 700 Hz. (Figure 4e).

Calls of the other sea ducks, such as the mergansers (*Mergus*) and scoters (*Melanitta*), are not available for comment.

Discussion

Sonagrams of calls from species representing most of the major waterfowl tribes clearly support the contention that the tracheal tube is a functional resonator. It appears to act as an open rather than a closed tube, as already concluded by Sutherland and McChesney (1965). Not surprisingly, this resonating ability is most evident in the larger species, for at least two reasons. First, the longer the tracheal tube, the greater the number of resonant frequencies available for matching the fundamental frequency or its harmonics (Figure 5). Secondly, the larger species are more likely to have a syrinx with a fairly large tympaniform membrane area, and thus a lower fundamental frequency; this would allow a larger number of harmonics within the zone of audible sound. In general then, large species would be expected to produce vocalizations with low fundamental frequencies and rich development of harmonics. Short-necked and relatively small species should be more able to produce high-pitched tones with few harmonics, and thus be able better to avoid the 'tuning' effects of the tracheal tube, and have greater abilities for continuous rather than stepped frequency changes during calling.

No clear function for the variations of the tracheal diameter in males of many duck species is yet apparent, but it must be assumed that these affect resonating characteristics of the tracheal tube in some manner. Similarly, it is believed that the function of the bulla in male ducks is to 'emancipate' the male from the tuning effect of the trachea and the low fundamental frequency characteristics of the source-generated (syrinx-produced) calls. If the bulla in fact acts like an aeolian whistle, species specificity in male calls could be readily achieved by varying the size and shape of the male's bulla through genetic and/or hormonal controls (Lewis and Domm 1948) without influencing the basic anatomy of the female's

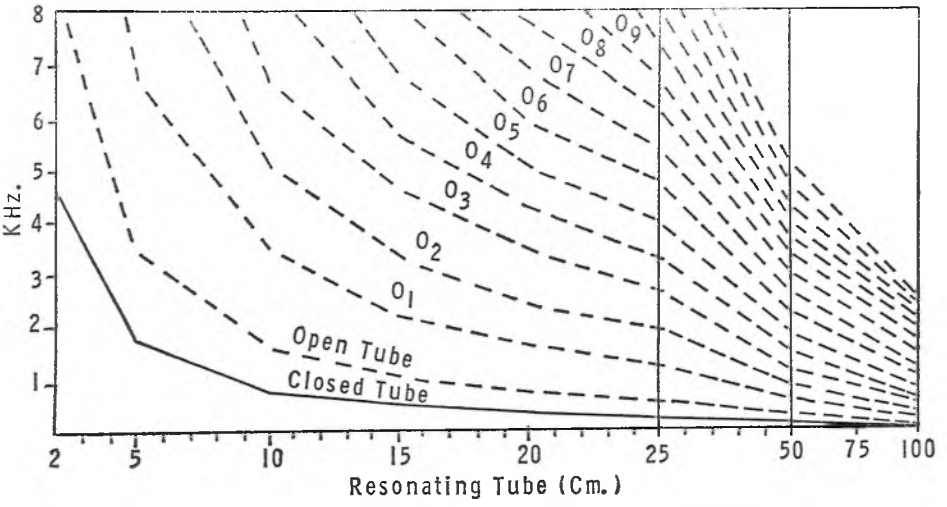

Figure 5. Calculated zones of tracheal resonance (up to 8,000 Hz.) for various tracheal tube lengths, showing the expected resonant frequencies for the first 15 resonant frequencies in an open-tube acoustic system. A closed-tube system would resonate frequencies represented by the solid line and all of its multiples (i.e. the broken lines as well as mid-points between these lines).

syrinx and vocal requirements. Male bullae are poorly developed in very small species such as pygmy geese; here apparently the syrinx is already so small that nearly pure and high-pitched whistled tones can be generated by rapid vibration of the tympaniform membranes. It should be noted, however, that although even downy male ducklings exhibit a bulla, the vocalizations of juvenile birds exhibit no sexual differences (Kear 1968). The whistle-like sounds produced by male ducks are used for the most part in social courtship, although a few species (such as wigeon) have apparently adapted them to all communication functions.

In the eiders, a second and somewhat contrasting vocal adaptation has evidently been achieved by males. The male bulla of these species is quite small and the trachea lacks enlargements, but its effective resonating length is seemingly increased to the point that fundamental frequencies of under 600 Hz. are effectively amplified. Inflation of either the air sacs or possibly the oesophagus during calling is probably responsible.

Acknowledgements

This paper was written while the author was supported by N.S.F. grant GB-7666X, which also financed purchase of the Sonagraph and associated equipment. Most of the sonagrams were prepared by Raymond Goldstein, and assistance was otherwise provided by James Tate, Jr., Dr. Janet Kear, and Daniel Hatch. I additionally would like to thank the Cornel University Laboratory of Ornithology for copies of tape recordings of the Magpie Goose and Coscoroba Swan (D. S. McChesney recordings at Slimbridge, 1962).

Summary

A comparison of inter-species variations in the tracheal anatomy and acoustical characteristics of anatid vocalizations supports the contention that the trachea serves as a resonating tube, thus allowing for differential amplification of the syrinx-generated fundamental sound frequencies and their associated harmonics. The trachea apparently acts acoustically like an open-pipe, rather than a close-pipe, resonating instrument. Species having longer tracheal tubes seem to exhibit a greater degree of tracheal tuning effects and more ability to resonate lower sound frequencies than can species having shorter tracheal tubes. The extreme elongation of some species' tracheal tubes by convolution, as found in the genera *Anseranas* and *Cygnus*, is a functional acoustic adaptation for long-distance communication by low-frequency sounds. The evolution of tracheal bullae by males of most Anatinae species is a method of 'emancipating' the male sex from the relatively uniformly low-pitched and harmonic-rich calls of female ducks. Male courtship calls thus acquire greater species-specificity as well as relatively harmonic-free tones, and are primarily uttered in social situations at short distances.

References

AMADON, D. 1970. Variation in the trachea of the Cracidae (Galliformes) in relation to their classification. *Nat. Hist. Bull. Siam Soc.* 23 : 239-48.

AUDUBON, J. J. 1840-1844. *The Birds of America.* 7 vols. New York and Philadelphia.

BOSWALL, J. 1961. Voice recordings of the Anatidae. *Wildfowl Trust Ann. Rep.* 12 : 147-52.

BOSWALL, J. 1963. Additional voice recordings of the Anatidae. *Wildfowl Trust Ann. Rep.* 14 : 137-40.

FOUQUETTE, M. J., JR. 1960. Call structure in frogs of the family Leptodactylidae. *Tex. J. Sci.* 12 : 201-15.

FRITH, H. J. 1967. *Waterfowl in Australia.* Honolulu: East-West Press.

GREENEWALT, C. H. 1968. *Bird Song: Acoustics and Physiology.* Washington: Smithsonian Institution Press.

HARRIS, C. L., W. B. GROSS and A. ROBESON. 1968. Vocal acoustics of the chicken. *Poult. Sci.* 42 : 104-112.

HEINROTH, O. 1911. Beiträge zur Biologie, namentlich Ethologie und Psychologie der Anatiden. *Verh. V. Int. Orn. Kongr. Berlin, 1910* : 598-702.

HERSCH, G. L. 1966. Bird voices and resonant tuning in helium-air mixtures. Ph.D. dissertation, Univ. of California, Berkeley.

JOHNSGARD, P. A. 1961. Tracheal anatomy of the Anatidae and its taxonomic significance. *Wildfowl Trust Ann. Rep.* 12 : 58-69.

JOHNSGARD, P. A. 1965. *Handbook of Waterfowl Behavior.* Ithaca: Cornell University Press.

JOHNSGARD, P. A. 1967. Observations on the behaviour and relationships of the White-backed and the stiff-tailed ducks. *Wildfowl Trust Ann. Rep.* 18 : 98-107.

KEAR, J. 1968. The calls of very young Anatidae. *Beihefte der Vogelwelt* 1 : 93-133.

KELEMEN, G. 1963. Comparative anatomy and performance of the vocal organ in vertebrates. Pages 489-521, in *Acoustic Behavior of Animals.* New York: Elsevier Pub. Co.

LEWIS, L. B. and L. V. DOMM. 1948. A sexual transformation of the osseus bulla in duck embryos following administration of estrogen. *Physiol. Zool.* 21 : 65-69.

MCALISTER, W. H. 1959. The vocal structures and methods of call production in the genus *Scaphiopus* Holbrook. *Tex. J. Sci.* 11 : 60-77.

MYERS, J. A. 1917. Studies on the syrinx of *Gallus domesticus. J. Morph.* 29 : 165-214.

RÜPPEL, W. 1933. Physiologie und Akustik der Vogelstimme. *J. Orn.* 8 : 433-542.

SUTHERLAND, C. A. and D. S. MCCHESNEY. 1965. Sound production in two species of geese. *The Living Bird* 4 : 99-106.

THORPE, W. H. 1959. Talking birds and the mode of action of the vocal apparatus in birds. *Proc. zool. Soc. Lond.* 132 : 441-55.

WÜRDINGER, I. 1970. Erzeugung, Ontogenie und Funktion der Lautäusserungen bei vier Gänsearten (*Anser indicus, A. caerulescens, A. albifrons,* und *Branta canadensis*). *Zeitschrift für Tierpsychologie* 27 : 257-302.

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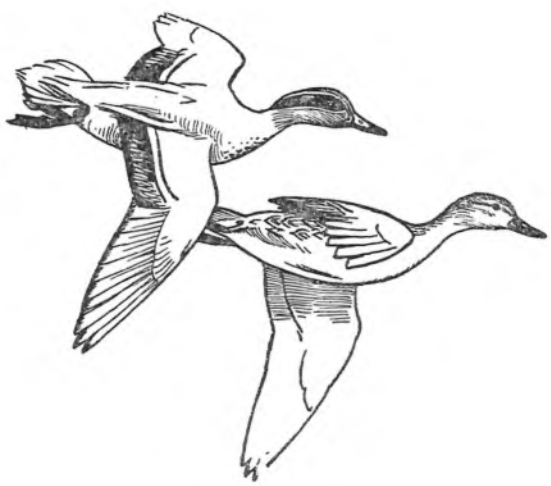

Parental carrying of young by Goosanders

ANTHONY J. ERSKINE

Johnsgard and Kear (1968) have reviewed the subject of waterfowl carrying their young. They concluded that carrying of young on the back is well documented for some species, though uncommon in many others, and that the possibility of carrying young in the beak or in other ways should not be dismissed.

The following observations were made in Inverness County, Nova Scotia, Canada. On 26th June 1961, on the NE. Margaree River above Portree, I saw a female Goosander *Mergus merganser* with five small young swimming upstream. A few minutes later the female reappeared drifting downriver with the entire brood on her back. On 8th July 1961, a female with eight small young was alarmed near the mouth of Trout Brook. As she led the brood out on Lake Ainslie, through waves 20-30 cm. high, at least three of the young ran up on to her back. One of nine small young in a brood watched on the delta of SW. Mabou River on 2nd June 1966 rode on the back of the parent for a few minutes. In all these observations the young were very small, only a few days out of the nest, as were those watched by Nuttall (*in* Baird, Brewer and Ridgway 1884)—'not larger than the egg of a Goose'.

Goosanders are hole-nesting birds. Their young hatch in a confined space, usually within a tree trunk, and cannot wander around as can young of ground-nesting species. They can, however, climb on to the back of the parent. I have twice seen downy young of Buffleheads *Bucephala albeola* sitting on the back of a brooding female in a tree hole, in British Columbia. It is plausible that many young Goosanders have had similar experiences before they left the nest. However, it is very unlikely that young of tree-nesting ducks could routinely be carried from the nest on the back of the parent, since the latter often has to wriggle through a small aperture on leaving.

Young Goosanders go ashore very willingly. The brood watched in 1966 was being led across the delta by the female. The young ran across tiny grassy islets around which the female swam. When she paused near such islets, the young at once went ashore. It is possible that this brood had just been brought down river and were thus unusually tired. But Goosanders continue to rest on shore at all ages, and their reaction when alarmed is to hide on shore, at least until they are large enough to be confident of escaping by scampering across the water or by flying.

Young of the typically tree-nesting ducks would also be equipped for climbing in order to leave the nest. It seems obvious that to such a recently hatched duckling, a swimming female represents a familiar perch in the context of a floating island. The female can only accommodate a few members of the brood, and while the young are very small.

Johnsgard and Kear (1968) regard the advantages of parental carrying of young as self-evident, provided that the entire brood can be accommodated. But most ducks of the tribes Dendrocygnini, Anatini, Mergini, Cairinini (especially *Aix*), and Oxyurini typically lay clutches of seven to 12 or more eggs. It is unlikely that even seven newly hatched young of these species could find secure riding positions on a single female, which may partly explain why selection for this trait has not occurred.

References

BAIRD, S. F., T. M. BREWER and R. RIDGWAY. 1884. *The Water Birds of North America.* Vol. 2. Boston: Little, Brown & Co.

JOHNSGARD, P. A. and J. KEAR. 1968. A review of parental carrying of young by waterfowl. *Living Bird* 7 : 89-102.

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Pre-dusk rafting flights of wintering Goldeneyes and other diving ducks in the Province of Quebec

AUSTIN REED

Since 1956 observations have been made on a wintering population of American Goldeneyes *Bucephala clangula* inhabiting a portion of the St. Lawrence River near Montreal, Quebec. Periodic counts since 1963 gave totals of some 1,200 to 2,900 birds. Smaller numbers of Goosanders (Common Mergansers) *Mergus merganser*, Black Ducks *Anas rubripes* and Mallards *A. platyrhynchos* also winter in these waters kept free of permanent ice by fast river currents.

During daylight hours the Goldeneyes and Goosanders are widely dispersed over the available open water but as dusk approaches they fly, singly or in small flocks, to a gathering site in the lee of a small island near the upstream extremity of the ice free portion of the river (Figure 1). As darkness falls the ducks crowd still closer, forming a very dense raft in the form of a spoon (similar to that described by Linsell 1969) with the broadest portion of the flock towards the upstream edge.

Pre-dusk gathering of Goldeneyes during the winter occurs in England (King 1961; Linsell 1969) and in the central United States (Breckenridge 1953). In Britain the birds generally swim to the rafting site, but this gathering does not occur until mid-February and becomes most pronounced in March (Linsell 1969). In Minnesota, as in the present study area, night rafts are formed from December through March, with the birds flying to the gathering site (Breckenridge 1953). The studies of Breckenridge and Linsell suggest that British Goldeneyes congregate at an earlier time of day than their Minnesota counterparts; peak arrival of birds in the former area occurs prior to sunset; in the latter most birds arrive after sunset. On average, arrival times in my study area correspond with those from Minnesota. There is, however, some indication that arrivals occur earlier (in relation to sunset) as the season progresses (Figure 2); data recorded on 9th March 1971 showed that a substantial proportion of the flock congregated before sunset, more or less corresponding with the British situation at this period.

It has recently been found that American Goldeneyes and Buffleheads *Bucephala albeola* also perform rafting flights in the St. Lawrence Estuary near the

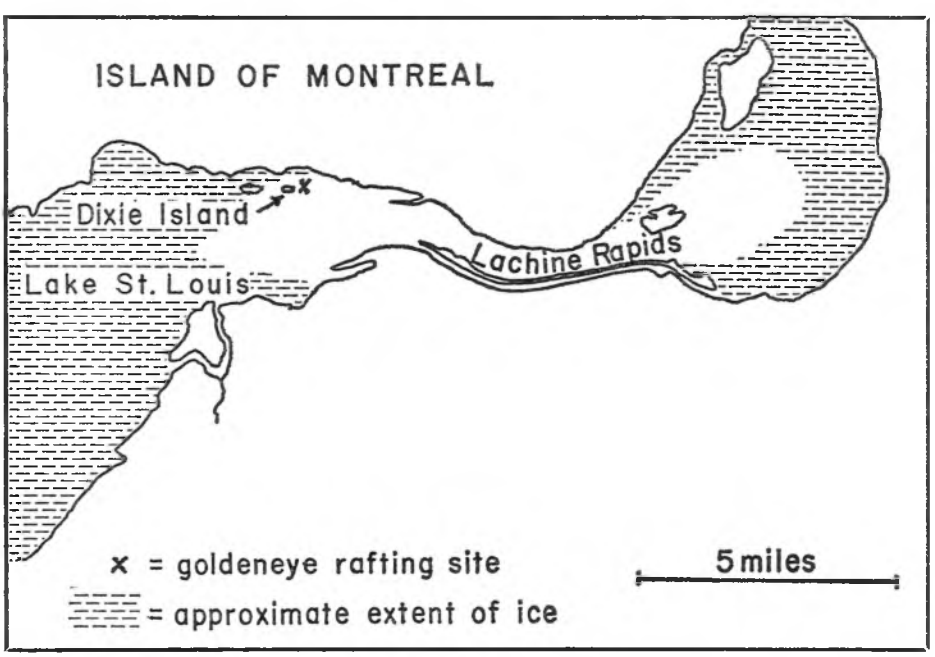

Figure 1. The St. Lawrence River south of Montreal, Quebec.

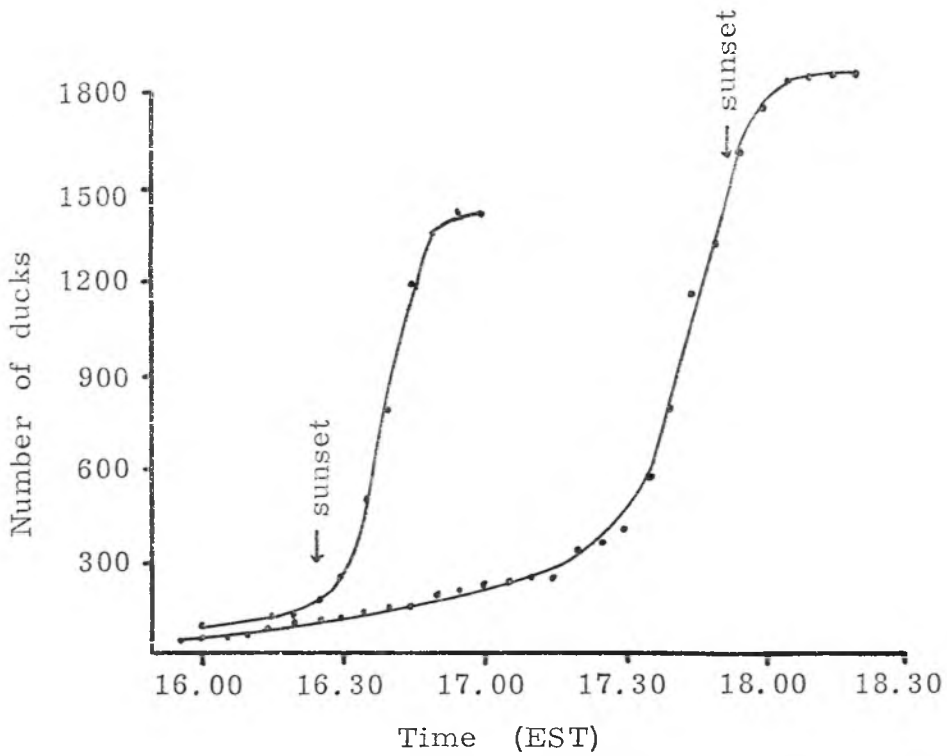

Figure 2. Cumulative build-up of diving ducks (mostly Goldeneyes) at rafting sites near Dixie Island, Quebec, on 6th January (left hand line) and 9th March (right hand line) 1971.

Saguenay River mouth. Pre-dusk gathering of Goosanders and Buffleheads has not been previously reported, but has for Pochards *Aythya ferina* and Tufted Duck *A. fuligula* (King 1961).

Pre-dusk flights of Goosanders have proven harder to study as that species forms only a small part of the rafting birds and dim light has often prevented accurate species identification. However, of the 1,839 birds recorded on 9th March 1971 (Figure 2) it was confidently estimated that 103 were Goosanders; their cumulative numbers built up in linear fashion with no apparent peak of arrivals.

The ecological significance of these daily movements by Goldeneyes and other diving ducks is not at once evident from the few published reports. Goldeneyes in the Montreal area, however, seem clearly to be taking advantage of various features of the environment which permit them to conserve energy: rafted in the lee of the island they are sheltered from the dominant winds, from drifting ice and from the stronger currents which prevail elsewhere. The closeness of the rafted birds may provide a measure of heat conservation. Conceivably a similar reduction in energy loss could be attained by climbing ashore and huddling on stationary ice (as other species of ducks often do) but Goldeneyes are remarkably clumsy on ice and rarely climb out of water during winter. By rafting on open water they gain additional protection from ground predators.

Acknowledgements

Some of my observations were made while I was employed by the Quebec Wildlife Service. R. Ouellet, Quebec Wildlife Service, A. Bourget, Canadian Wildlife Service, and my wife, Henriette, provided field assistance. H. Boyd, C.W.S. was most helpful in the preparation of the manuscript.

References

BRECKENRIDGE, W. J. 1953. Night rafting of American Goldeneyes on the Mississippi River. *Auk* 70 : 201-4.

KING, B. 1961. Pre-dusk gathering of Goldeneye. *Wildfowl Trust Ann. Rep.* 12 : 166.

LINSELL, S. E. 1969. Pre-dusk and nocturnal behaviour of Goldeneye, with notes on population composition. *Wildfowl* 20 : 75-77.

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The numerical distribution of some British breeding ducks

BARBARA YARKER and G. L. ATKINSON-WILLES

During the six seasons between 1965 and 1970 the Wildfowl Trust initiated an investigation into the numbers of breeding and summering wildfowl in England, Scotland and Wales. Unlike the winter counts, which are designed primarily for the long term study of trends, this new venture aimed at completion within a relatively short period. Its purpose was to assess the size and importance of the breeding populations in each district, and to determine whether any of them deserved special measures of protection. It was also hoped that the survey would give some indication of important moulting areas, and of the ratio between native and immigrant birds in the autumn and winter flocks.

In the first instance the survey was envisaged as a purely national study, but with the introduction in 1967 of the International Wildfowl Censuses, it assumed a wider significance. As our knowledge of the winter distribution of wildfowl in Europe begins to improve, it becomes increasingly important, from the conservation viewpoint, to locate the main breeding areas of the various species, and to assess their contribution to the common stocks. A great deal is already known about the numbers and distribution of wildfowl breeding over a wide area of central Europe (Bauer and Glutz 1968-1969); before long, therefore, it should be possible to compile a set of summer distribution maps, similar to the January series which was published recently (Atkinson-Willes 1969).

In 1968, when the Wildfowl Trust's survey had been in progress for three years, the British Trust for Ornithology launched the ambitious plan of compiling an Atlas to show the distribution of all species of birds breeding in Britain. Although the two projects had an obvious similarity, they differed in one important detail. While the Wildfowl Trust was attempting to record the numbers of birds breeding in each district, the B.T.O. was concerned only with their presence or absence. It was nonetheless clear that the two organisations, each with their network of voluntary observers, would benefit greatly from exchanges of information. This has certainly been so in the case of the Wildfowl Trust, whose observers are concentrated around the important winter centres, and tend to be sparse elsewhere. We are indebted, therefore, to the B.T.O. for allowing us to make use of their records, in advance of their own publication. The extent to which they have helped us is clearly shown in Figure 1. The full black circles indicate the areas from which the Wildfowl Trust has collected quantitative data, mainly during the period 1965-1970; the areas marked by open circles are those for which the B.T.O. has provided records of presence or absence in the seasons 1968-1970.

Both the B.T.O. and the Wildfowl Trust have adopted the 10 km. square of the National Grid as the standard unit of area. In the squares for which quantitative data are available, the records from the various waters have been combined to give the total numbers of each species breeding in each square. These totals are compiled from the highest numbers observed at each site, irrespective of the year in which the records were obtained; they represent, therefore, the potential, rather than the actual population of the squares concerned. For instance, a breeding pair may be found on one pool in one year but on a neighbouring pool in the next. Since both sites are known to be capable of supporting a brood, the square in which they lie has an evident capacity of at least two pairs. This procedure may occasionally lead to exaggeration, but for the most part the result is probably nearer to the truth than estimates based on annual maxima for the square, or on the addition of averages from various sites. Even in well covered areas, the observers have been able to visit only a proportion of the available breeding habitat, and the counts, however presented, must be regarded as minima.

The information on the squares covered by the B.T.O. was provided under the three headings of breeding possible, probable and proven; there was no record of the number of pairs breeding, or of the number of sites occupied. In the absence of these details, the proven records have, perforce, been placed in the category of '1-3 pairs only', although in some squares the true total could well be much higher. An absence of records is probably a true indication of the absence of breeding pairs.

The combined results of the two surveys are presented in Figures 2-6. The species reviewed here are Wigeon,

Shoveler, Tufted Duck, Pochard and Shelduck. These were chosen because they afford the best opportunity of exploiting the quantitative data assembled by the Wildfowl Trust. With other species the information has stemmed predominantly from the B.T.O., or is incomplete numerically. In both instances the B.T.O. Atlas, which is not concerned with numbers, is the obvious medium of publication.

The maps presented here are believed to reflect the current situation with reasonable accuracy, but there are doubtless many discrepancies, both large and small, which we hope will be brought to our notice. Indeed, one of the purposes of this paper is to stimulate criticism. Although the Wildfowl Trust has now closed its side of the investigation, there will be ample opportunities for revision when the European distribution maps are being compiled.

Wigeon *Anas penelope* *Figure 2*

The early breeding records of Wigeon, and other wildfowl, are documented in some detail in the county bird books, and other standard works. There are also several summaries of the changes in status and distribution which have taken place over the past 150 years. The most recent of these is the work by Parslow (1967) which provides an admirably balanced review of events, mainly since 1940. The earlier account of Scottish breeding ducks by Baxter and Rintoul (1922) is another invaluable source of information, especially on Wigeon. In common with most other wildfowl, this species had increased greatly as a breeding bird during the previous 80 years, and had extended its range to many new areas. To some extent, the rapid spread of records at that time can perhaps be attributed to an increase in observers and to the greater ease of access afforded by the railways. By the 1920's, however, the accumulation of data was large enough to provide a remarkably clear impression of the general pattern of expansion and current distribution.

The number of Wigeon at present breeding in Britain is estimated tentatively at about 350 pairs, compared with a winter population of around 170,000 birds. The great majority of the nesting pairs are located along the upland spine of England and Scotland, from Yorkshire north to the Pentland Firth. Within this stretch there are several well defined groups, some of which have offshoots to east or west. The main centres are on the north Pennine moors, in the hills above Selkirk, in central and eastern Perthshire, on upper Speyside, in central and eastern Sutherland, Caithness and Orkney. In several of these areas, especially in the Highlands, the size and extent of the groups may well be greater than the map suggests. Many of the squares at present marked 'probable' are almost certainly occupied by nesting birds, and some at least of the 'positive' squares almost certainly hold more pairs than the symbols indicate. In Sutherland, for instance, there are records from at least two places of parties of a dozen or more 'attendant' males, and similarly on Speyside and in Perthshire the counts of adults are well in excess of the actual records of breeding.

The situation in England is quite the reverse. Except in the north, and possibly in East Anglia, very few of the adults recorded in summer are regarded as potential breeders. The positive records, particularly in the south and west, may well refer to feral stocks.

In general, the present pattern of distribution is much the same as 50 years ago. There is, however, some indication of a shift to the east in the central highlands of Scotland. In 1895 the species was described as abundant and breeding regularly on the Moor of Rannoch and the lochs of Black Mount (Baxter and Rintoul 1922). The present survey gives no hint of breeding on this scale; indeed, even the most suitable sites are apparently deserted. This absence of records is emphasised by the frequency with which the species is found in the more cultivated districts some 50 km. to the east, and by the increases which have occurred still further to the east, in areas as far apart as Kinross and Aberdeenshire. Loch Leven has long been in regular use, but up to 1920, at any rate, the numbers appear to have been small, probably not more than 3-4 pairs. There are now some 30-35 pairs breeding annually. The spread into Aberdeenshire has apparently occurred within the last 30 years, and certainly within the last fifty (Berry 1939). The present survey has produced confirmation of breeding from two separate sites, both adjoining the coast, and another small group is almost certainly established on Deeside, on the lochs around Dinnet.

Although these local gains are evidence that the Wigeon is holding its own as a breeding species, it seems unlikely that the total number of pairs is increasing to any marked extent. The population is still largely confined to the areas which were used 50 years ago, suggesting that further expansion is restricted by the

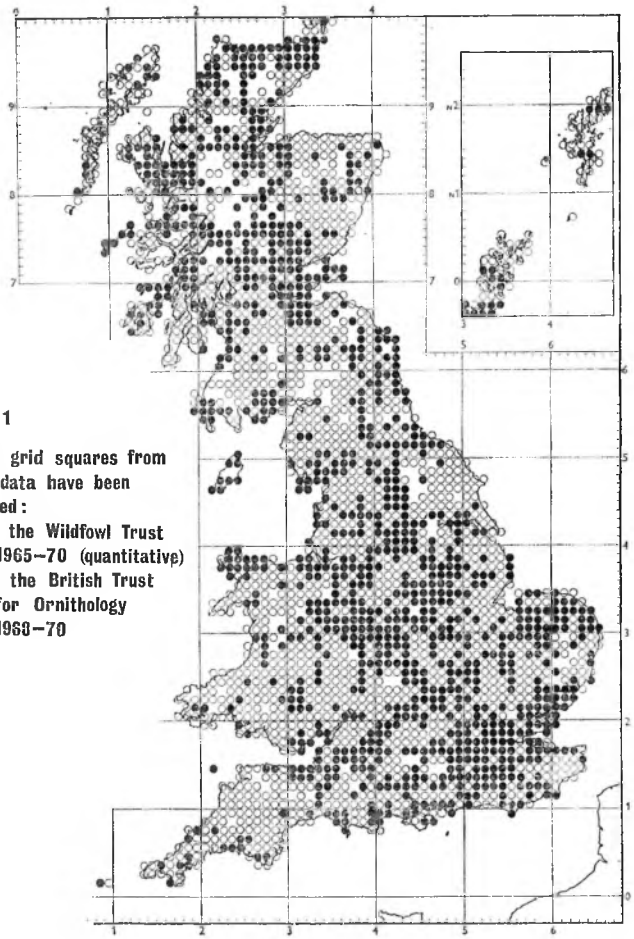

Figure 1

10 km. grid squares from which data have been collected:

- **by the Wildfowl Trust 1965–70 (quantitative)**
- **by the British Trust for Ornithology 1968–70**

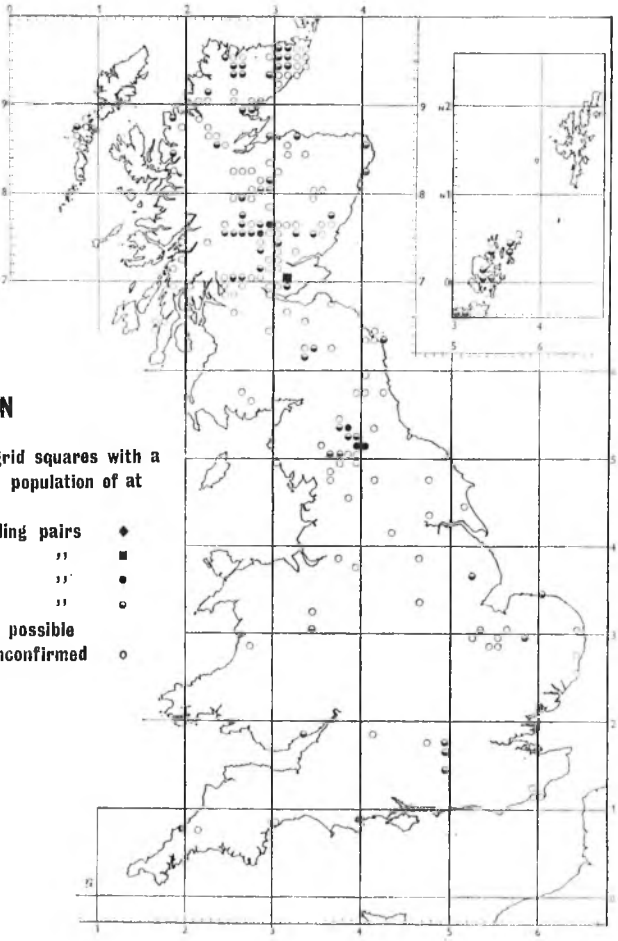

Figure 2

WIGEON

10 km. grid squares with a potential population of at least:

50 breeding pairs	◆
15 " "	■
4 " "	●
1 " "	○
Breeding possible but unconfirmed	○

absence of some critical requirement. If this is so, the increasing disturbance from fishing and tourism may well result in a future decline.

Shoveler *Anas clypeata* *Figure 3*

At first sight the Shoveler appears to be widely distributed over much of central and eastern England, but as with the Wigeon, the bulk of the breeding population is concentrated into a series of well defined localities. This is particularly noticeable in East Anglia, north Wales and Northumberland, and in the eastern lowlands of Scotland. In the areas surrounding the main centres there are frequent records of adults occurring in early summer, but only a few of these are probably indicative of breeding.

During the late 19th and early 20th centuries the Shoveler increased remarkably as a breeding species, not only in Britain but over much of western Europe (Parslow 1967). By 1950, however, the impetus had waned, and the changes in recent years have been restricted mainly to local gains and losses within the areas already colonised. One of the few notable expansions has been the adoption of Chew Valley Lake in Somerset, where up to five pairs now breed regularly. A recent increase has also been noted on the Shropshire meres. Over the country as a whole the population seems to be more or less stable, although in many districts the distribution is being slowly curtailed by the loss of suitable habitat through drainage and other developments. In the Trent valley, for instance, the number of breeding pairs has decreased sharply following the reclamation of marshland and the modernisation of Nottingham sewage farm.

The number of Shoveler breeding in Britain is certainly less than 1,000 pairs, and probably less than 500. Many of these native birds apparently move southwards in autumn into France, Spain and Italy, and are replaced by immigrants from eastern Europe (Ogilvie 1962). By February (when the winter population reaches a peak of 8-10,000) the proportion of native birds is probably negligible. It may be, however, that the small isolated populations on Tiree and North and South Uist are largely sedentary.

Tufted Duck *Aythya fuligula* *Figure 4*

The Tufted Duck ranks as one of the most successful of British breeding wildfowl. Since the late 19th century the population has increased and expanded dramatically, and in many areas the trend is still continuing, though much more slowly. Increases have also been noted in many districts of central and western Europe. As in other wildfowl, the initial expansion was probably stimulated by climatic change; more recently, however, the species has benefited greatly from the large areas of additional habitat provided by the new reservoirs and gravel pits. This factor, in particular, has enabled the breeding population to maintain the impetus of its expansion for much longer than would otherwise have been the case (Parslow 1967).

At the present time the Tufted Duck is widely, and in places densely, distributed over much of England and throughout the central lowlands of Scotland. There are several areas, however, from which it is virtually absent, notably in the north and west. In some cases the limiting factors are fairly easy to identify: it is found for example, that the species does not normally breed at an altitude of more than 400 m., nor does it occur on pools of less than a hectare in extent; it is also apparent from the scattered occurrences in north-west Scotland and elsewhere that the distribution is dependent upon the proximity of limestone or other non-acid formations.

The Tufted Duck is in many respects an easy subject for a survey such as this: its choice of the larger waters makes it relatively simple to find, and its habit of resting and feeding in the open makes it easy to count. On the other hand it nests much later than most other species, and broods are seldom seen much before July. Additional visits are, therefore, needed to obtain confirmation of breeding, and this may perhaps have led to an under-estimate of the number of successful pairs. Many of the squares at present marked 'probable' are doubtless supporting at least one breeding pair, and some of the symbols in the positive squares may also need up-grading.

Parslow (1967) has estimated the number of breeding pairs to the south of the Mersey and Humber at over 500; this agrees with the present finding, though a figure of over 600 is not impossible. His estimate of over 1,000 pairs in the British Isles, including Ireland, is certainly too low. The figure for England, Scotland and Wales alone is probably in the order of 1,500 and could be nearer 2,000. In several areas the species breeds colonially, notably at Loch Leven, Kinross-shire, where up to 500 pairs nest annually (though few of the young appear to survive). Chew Valley Lake, Somerset,

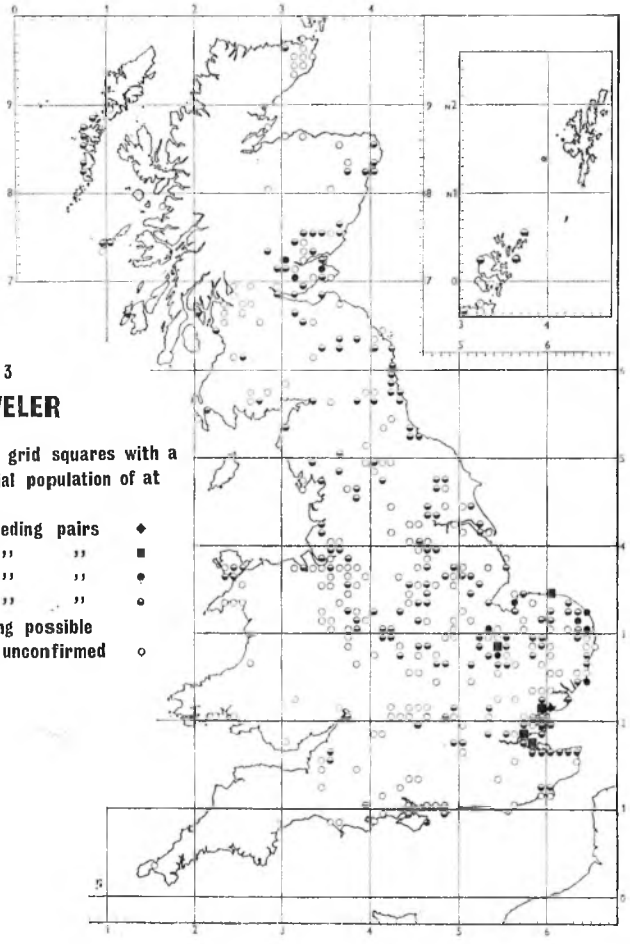

Figure 3

SHOVELER

10 km. grid squares with a potential population of at least:

50	breeding pairs	◆
15	,, ,,	■
4	,, ,,	●
1	,, ,,	○
Breeding possible but unconfirmed		○

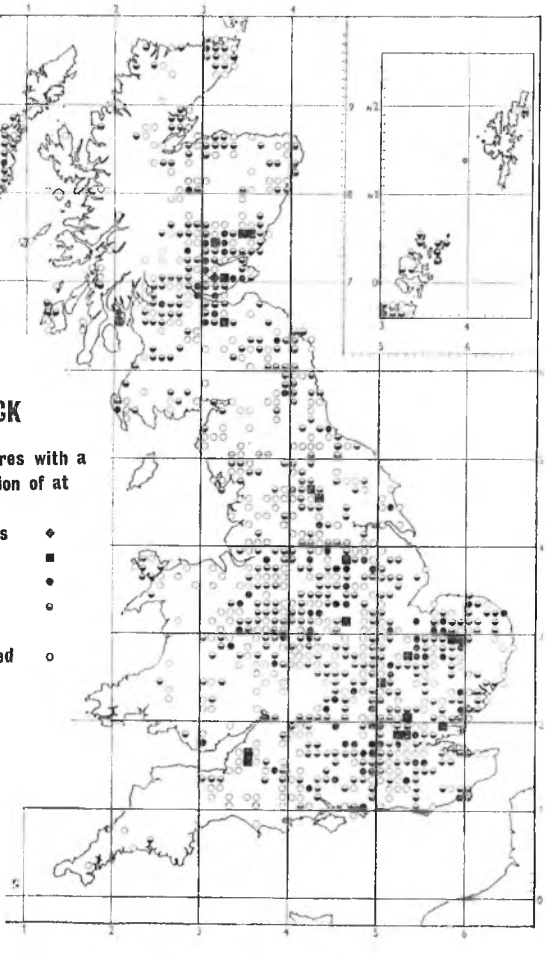

Figure 4

TUFTED DUCK

10 km. grid squares with a potential population of at least:

50	breeding pairs	◆
15	,, ,,	■
4	,, ,,	●
1	,, ,,	○

Breeding possible but unconfirmed ○

is another important centre where up to 60 pairs have bred in some years, and several other places in both England and Scotland hold colonies of 10-15.

The movements of the native population during autumn and winter are still obscure. Many of the birds from Loch Leven are known to move into Ireland, but apart from this there is no evidence, either positive or negative, of a major exodus. If, as seems likely, the birds in most areas are largely sedentary, the number of adults and young remaining in Britain might be as high as 5,000, or rather more than 10% of the winter population. In the international context, the British contribution is scarcely significant, comprising less than 1% of the estimated population in the north-west European flyway.

Pochard *Aythya ferina* *Figure 5*

The Pochard has a good deal in common with the Shoveler. Both species have increased and extended their range very substantially during the present century; both show a marked preference for particular types of breeding habitat, and both are still confined mainly to the eastern districts of England and Scotland.

Despite a possible decline in Scotland, the number of Pochard breeding in Britain appears to be still increasing. During the past 25 years there have been several instances of new colonies being formed, and of sporadic breeding becoming regular. On the north Kent marshes, where two or three pairs began to breed annually in the late 1940's, there are now as many as 70 pairs nesting in some years. This increase has been accompanied by a marked spread from the original site, notably to the Isle of Sheppey, which was colonised in 1955. An account of the development of this colony, and its breeding biology, is provided by Hori (1966a). In Hampshire a similar expansion has taken place since breeding was first recorded in 1961. At the present time the species is firmly established along the lower Test, and is spreading eastwards into the valley of the Itchen. Chew Valley Lake, in Somerset, is also providing a new local centre, and in London a sizeable population is now ensconced on a number of park ponds and reservoirs. In the latter instance, and also in Hampshire, the breeding tradition may perhaps have been started by feral stock (London N.H.S. 1957).

Parslow (1967) has estimated the British breeding population of the Pochard at about 200 pairs, a figure which is confirmed by the present survey. There is also a very considerable summering population, especially in East Anglia. At Abberton Reservoir more than 3,000 Pochard are normally present in July, the great majority of which are males. This is quite a recent development, and is one of the very few examples in this country of an inland water providing a major moulting ground for wildfowl of any species. The status and origin of the birds assembling here (and at similar moulting areas in the Netherlands and southern Germany) is not yet known; obviously they are far too numerous to be related to the local breeding population. In winter the British population reaches a peak of around 40,000.

Shelduck *Tadorna tadorna* *Figure 6*

The Shelduck is probably the only species of wildfowl in which the British breeding population makes a vital contribution to the European stocks. Unlike most other wildfowl, the Shelducks in northern and western Europe are wholly discrete from the neighbouring populations in Asia and the eastern Mediterranean, and are confined throughout the year to a relatively small range along the Baltic, North Sea and Atlantic coast. The total number of birds within this area has been estimated, from both summer and winter censuses, at just over 100,000. Of these about half are concentrated in the British Isles from January until July, and can thus be described as native stock. Observations in Kent and Lancashire suggest that the proportion of breeding birds is rather less than half (Hori 1966b). This implies a total of about 12,000 nesting pairs in the British Isles as a whole. If this is correct, the total for England, Scotland and Wales is probably in excess of 10,000.

Not more than one-third of this number of pairs has been recorded in the present survey. Nevertheless, Figure 6 seems to provide a reasonable indication of the relative importance of the various districts. The largest errors are likely to be the areas where the species is most common. This is certainly so in parts of East Anglia, and more especially in west Sussex, where the number of pairs is said to exceed 500 (Parslow 1967). The population in districts other than those marked by symbols is probably negligible. Most of the squares concerned contain long stretches of cliff coast, or are otherwise unsuitable. The distribution map in fact reflects the availability of habitat with remarkable accuracy; except possibly in

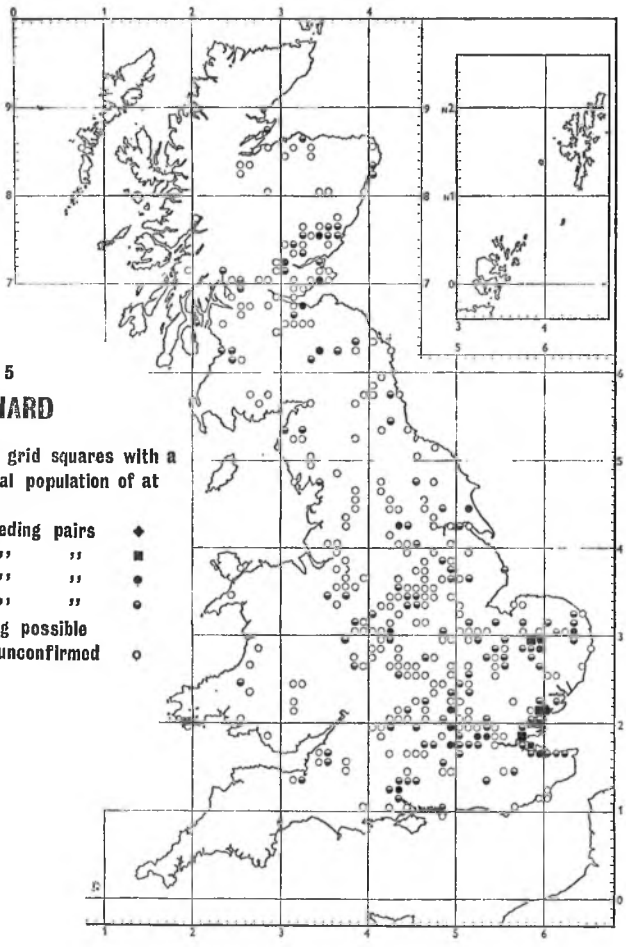

Figure 5

POCHARD

10 km. grid squares with a potential population of at least:

50 breeding pairs ◆
15 ,, ,, ■
4 ,, ,, ●
1 ,, ,, ○

Breeding possible but unconfirmed ○

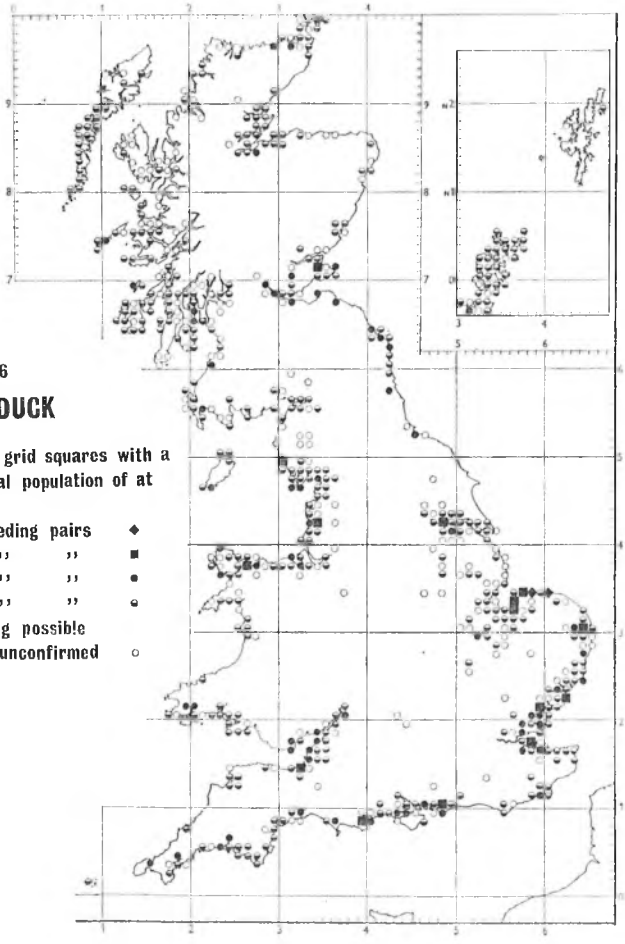

Figure 6

SHELDUCK

10 km. grid squares with a potential population of at least:

50	breeding pairs	◆
15	,, ,,	■
4	,, ,,	●
1	,, ,,	●
Breeding possible but unconfirmed		○

the more remote districts of Scotland, there are scarcely any likely areas which have failed to produce at least an unconfirmed record of breeding. This in itself is a reflection of the marked success of the species over the past 50 years. Big increases have been reported in many areas, and despite some local decline, the level of population is apparently still rising. An interesting facet of this expansion, which shows up well on the distribution map, is the growing tendency for pairs to nest inland (Parslow 1967).

Acknowledgements

The data on which this survey is based have been collected with considerable effort, and we hope also with enjoyment, by a very large number of amateur ornithologists. To them we extend our warmest thanks. In particular we would like to thank the members and staff of the British Trust for Ornithology for allowing us to include their data in our survey, thereby enabling us to provide a much more complete review than would otherwise have been possible.

The research and the writing of this paper was undertaken while both of the joint authors were holding posts grant-aided by the Natural Environment Research Council.

Summary

Between 1965 and 1970 the Wildfowl Trust organised an investigation into the numbers and distribution of wildfowl breeding in Britain. During part of this period the British Trust for Ornithology has also been conducting a survey of the breeding distribution of British birds, though not on a quantitative basis. Although the latter is unfinished, the data obtained up to 15th March 1971 have been made available for inclusion in the present paper.

Maps to show the number of pairs breeding in each 10 km. square of the National Grid have been compiled for Wigeon *Anas penelope,* Shoveler *A. clypeata,* Tufted Duck *Aythya fuligula,* Pochard *A. ferina* and Shelduck *Tadorna tadorna.* These are accompanied by estimates of total population, and a résumé of recent changes.

References

ATKINSON-WILLES, G. L. 1969. The mid-winter distribution of wildfowl in Europe, northern Africa and south-west Asia. *Wildfowl* 20 : 98-111.

BAUER, K. M. and U. N. GLUTZ V. BLOTZHEIM. 1968-1969. *Handbuch der Vögel Mitteleuropas.* Vol. 2 and 3. Frankfurt am Main: Akademisches Verlagsgesellschaft.

BAXTER, E. V. and L. J. RINTOUL. 1922. *Some Scottish breeding duck, their arrival and dispersal.* Edinburgh: Oliver and Boyd.

BERRY, J. 1939. *The status and distribution of wild geese and wild duck in Scotland.* Cambridge: University Press.

HORI, J. 1966a. Moult migration of second-summer Shelduck. *Bird Study* 13 : 99-100.

HORI, J. 1966b. Observations on Pochard and Tufted Duck breeding biology with particular reference to colonisation of a home range. *Bird Study* 13 : 297-305.

LONDON NATURAL HISTORY SOCIETY. 1957. *The Birds of the London area since 1900.* London: Collins.

OGILVIE, M. A. 1962. The movements of Shoveler ringed in Britain. *Wildfowl Trust Ann. Rep.* 13 : 65-69.

PARSLOW, J. L. F. 1967. Changes in status among breeding birds in Britain and Ireland. *Brit. Birds* 60 : 2-47 *et seq.*

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Mute Swan flocks

C. D. T. MINTON

Introduction

An intensive study has been made of the Mute Swan *Cygnus olor* population in an area of 550 sq. miles (1,440 sq. km.) in south Staffordshire. The area is based on National Grid co-ordinate SO 900900 and extends 40 squares (km.) north and 36 east. A previous paper (Minton 1968) gave details of the pairing and breeding behaviour determined from the first seven years of the study. The present paper deals with the flocks and, in particular, considers their size, age structure and status at different times of the year, and changes which have taken place over the ten-year period since the study was originated in 1961. In addition, movements of swans both between the flocks in the study area and over greater distances are analysed. A total of 2,568 swans were ringed in the course of the study, up to the end of 1970. Coloured ring codes were employed indicating the year of birth when known, the flocks in which the bird had been and whether it had been paired at any time. In the most recent years the large-numeralled Darvic rings developed for Bewick's Swans *Cygnus columbianus bewickii* (Ogilvie 1968) have greatly facilitated individual identification.

During the study period there has been a considerable local and national decline in the Mute Swan population (Ogilvie 1967). It was thus especially interesting to see how this change might be reflected in the flocks, particularly as a considerable proportion of the population are non-breeders, remaining in them throughout the year.

An additional feature studied was the effect of a major oiling incident in July 1966 which wiped out the majority of the moulting flock at Burton-on-Trent—the largest in the study area. The subsequent gradual recovery of its numbers and the permanent changes in its composition are detailed.

Flock catching techniques

The main techniques for catching, and the colour ringing schemes adopted, have previously been outlined (Minton 1968). The ease of rounding up a complete flock depends on the geography of the site and on the weather conditions.

Although the flock at Burton-on-Trent was the largest in the study area it was the easiest to catch, being situated on a river complex with confined backwaters into which the birds could be shepherded. At Tamworth catching was most successful when the water level of the river was low enough for it to be waded, so that a barrier of swan catchers could be formed across it. However, over the years the Tamworth swans grew wise to the procedure and became increasingly difficult to catch, tending to call the swan catchers' bluff and take to the wing before they could be cornered. The whole flock adjourned to Alvecote Pools, three miles away, for the flightless period, when it was still possible to catch the majority of the birds. However, this was not possible at other times of the year when there was also a considerable movement of birds between Alvecote and Tamworth.

At Cannock, where the third main flock in the study area is situated on a small reservoir, complete rounding up has only been possible during the flightless period each year and during the severe winter of early 1963. On the latter occasion the birds were confined to a small area of open water in the frozen reservoir. In the early years of the study the small Stafford flock, located on a shallow section of the river Sow, was easily caught but as the numbers gradually decreased the few remaining birds became more scattered in less catchable areas on both sides of the town.

The flock at Rugeley, located on a wide and deep section of the Trent outside the town, was uncatchable. These swans lived exclusively by grazing on pasture land, were not interested in bread, and were completely unapproachable. Fortunately, like the birds at Stafford, they adjourned to nearby Blithfield Reservoir for the moulting period and there rounding up was practicable with the aid of motor boats.

Apart from the major round-ups outlined above, regular visits were paid to all the flocks throughout the year, maintaining an almost 100% ringed population in the study area. On such visits priority was given to catching unringed birds, particularly those in their first year, using a 12-18 ft. swan pole and bread as bait. Second priority was given to catching individuals which had not previously been recorded in that particular flock—these being identified by the lack of the local colour ring. Although the most detailed knowledge of the age structure

of the flock and the history of the movements of the individuals in it at any time could only be determined from the complete round-ups, some information could be obtained solely by examination of the colour rings.

Population changes 1961-1971

The numbers in a flock were recorded on each visit. It was therefore possible to determine fairly accurately the total number of Mute Swans in the flocks at any time. In addition synchronised counts were made of all the flocks each January, April and July to determine the winter, the spring non-breeding (more strictly, non-pairing) and the moulting flock populations respectively. The number of birds paired each spring and the number of young which they subsequently reared to the flying stage have been given up to 1967 by Minton (1968) and are now included up to 1970. Details of all these counts are shown in Figure 1.

January flocks

It might have been expected that the mid-winter flock counts would be the best indicator of the total swan population level. However, although the January figures show a general decline over the years, the pattern is extremely irregular and does not relate closely to the flock population at other times of the year. There is some correlation with the output of young in the previous year—a large winter flock population tending to follow a year of higher than normal production of young. However, the main factor affecting the January population in flocks appears to be the weather. In years when the count was made during or immediately following a spell of severe frost the population was significantly higher than in adjacent years when the weather was mild. Thus the highest population of all was recorded in the exceptionally cold spell in early 1963 when most paired birds and their offspring had to seek refuge in the flocks. Although some young birds and their parents begin to appear in the flocks in October, the main influx does not normally occur until much of the static water freezes and birds move from their breeding areas into the warmer unfrozen rivers in the towns. In open winters the final influx of young may be delayed until February when their parents drive them away in preparation for the new nesting season. Only the 1967 dip in the graph is associated with a real, marked and abnormal change in the swan population, following the destruction after oil pollution of about 75 swans in the moulting flock at Burton-on-Trent in July 1966.

The overall decline of the January flock population from 305 in 1962 to 164 in

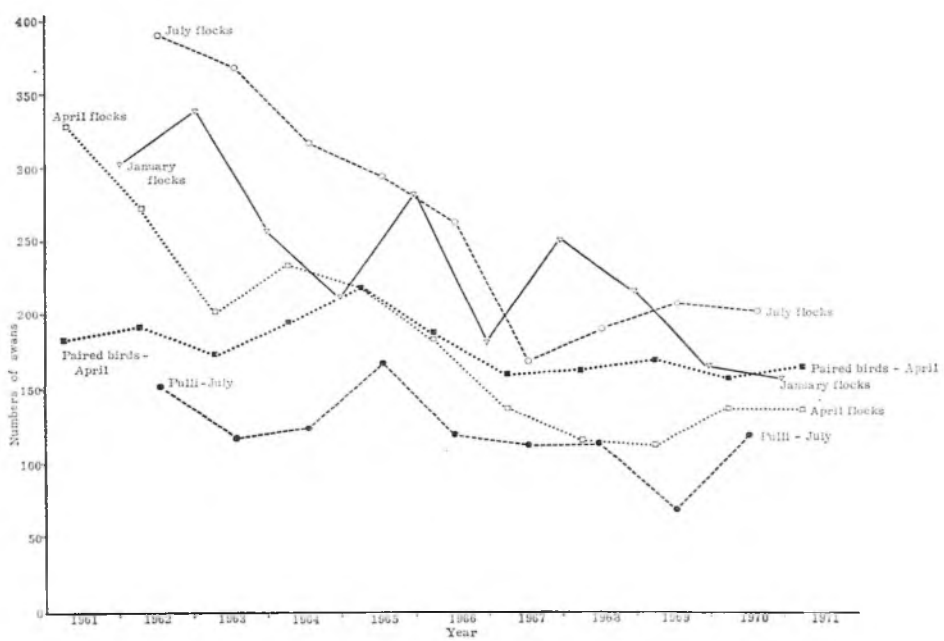

Figure 1. Mute Swan flock population changes in south Staffordshire, 1961-1971.

1971 represents a reduction of 46% in nine years—about 5% per annum.

April non-breeding flocks

The flock populations in the spring normally reach a minimum during the first half of April when almost all those birds which are going to pair that season have left to take up territories. Thus the flocks at this time represent the non-pairing portion of the total population.

The number of birds in the April flocks has shown a fairly steady decline since 1961 although there is some indication of a slight recovery in recent years. There were exceptionally large reductions in 1962 and 1963, following the severe winters, and a slight recovery in 1964, after which the decline resumed. The slight increase in 1970—unexpected since the production of young the previous year had been exceptionally low—may have been due to the late spring and cold weather, which continued right up to the end of April, discouraging some birds from pairing. However, this level was maintained in April 1971—helped by a mild winter and a better production of young the previous year—indicating that the general population decrease may have now ceased. The decline from 330 birds in the flocks in April 1961 to 139 in April 1971 represents a reduction of 58% in ten years—nearly 6% per annum. The whole of this net change took place in the first six-year period when the rate of decrease in the non-breeding flock population was nearer 10% per annum.

July moulting flocks

The flocks which gather to moult in July and August are composed of the non-pairing birds from the April flocks together with many of the birds which paired in the spring but did not subsequently nest. Some birds which nested but failed to breed also moult communally but others moult on their territory.

The July flock population showed a steady decline from 1962 to 1966 followed by a very steep fall in 1967. This latter reflects the wiping out by oil of the majority of the Burton-on-Trent moulting flock in July 1966. The subsequent increase in the moulting population in 1968 and 1969 is associated with the recovery of the Burton-on-Trent flock which, although it no longer moulted at Burton-on-Trent itself, did largely moult within the study area.

It appears that by 1969 the July population had recovered to the level it would have been expected to be at if the steady annual decline had continued. In the eight years from 1962 to 1970 the July flock population decreased by 47% from 390 to 207—6% per annum.

Paired population and production of young

Whilst the flock population has been decreasing at an average of 5-6% per year the paired population has been much more constant. Between 1961 and 1967 the paired population decreased by 10% from 186 to 168. From 1967 to 1971 it has been relatively constant. The average rate of decrease over the whole period has been only 1½% per annum.

In spite of the many different factors controlling the production of young the number reared to fledging each year has remained relatively constant. In six of the nine years for which complete data are available the number of young produced was between 115 and 125. In 1962 and 1965 it was well above this and in 1969 it was 40% less than the previous lowest total. Rather surprisingly the latter doesn't appear to have subsequently been reflected in the population levels of the flocks.

Total population

The total number of swans in the study area is the sum of the paired birds and the April flock population. The overall population was therefore 516 in April 1961 and this had declined to 307 in April 1971—a total of 40% in ten years corresponding to an average annual rate of decrease of 4%, though in fact most of this took place in the period up to 1967 when the rate was nearer 7% per annum.

The different rates of decrease have resulted in a steadily increasing proportion of the total population being paired each spring. In 1961 only 37% of the population was paired in the spring whereas by 1971 55% was paired. The maximum was 60% in 1969.

Changes in individual flocks

The overall decline in the swan population has been reflected differently in the various flocks (Table I). If the winter maxima at the beginning of the study period are compared with those of 1970-71 it can be seen that the main decreases have been in the smaller flocks —Lichfield and Rugeley have completely disappeared—and in the largest, at Burton-on-Trent.

The marked decrease of the smaller flocks, which presumably were in the less

Table I. Changes in size of Mute Swan flocks 1961-1971.

Place	*Winter maximum* 1961-62	1970-71	*Moulting (July)* 1962	1970
Burton-on-Trent	160	82	130	—
Tamworth/Alvecote Pools	57	50	45	120
Cannock Reservoir	30	23	52	52
Stafford	28	9	6	—
Rugeley	22	—	—	—
Blithfield Reservoir	—	—	128	35
Lichfield	7	—	—	—
Others	—	—	31	—
	304	164	392	207

suitable habitats, could be expected with a decreasing population. But other factors such as the removal of a weir, which lowered the water level on the Trent at Rugeley, and the cleaning out of the river at Stafford, which destroyed one of the most favoured resting places, may also have had an influence. The Lichfield site was not situated close to any natural river valley or swan 'flyways' and the scarce natural food supply and comparative lack of bread feeding by the public compared with other flock sites made it relatively unattractive to swans.

The habitat and the massive bread feeding by the public at Tamworth and at Cannock Reservoir have remained fairly constant over the study period and no significant change in the winter flock population at either has occurred.

At Burton-on-Trent dredging of exposed mudbanks and removal of a weir in 1964-65 has reduced the most suitable 'sitting out' areas on the main river where one-half of the population used to reside. Flocks now only occur on the smaller river where the geography is still unchanged, with ample resting areas. Bread feeding still continues on a large scale but presumably the smaller contact area with the public has reduced the total artificial food supply available and therefore the size of population which can be supported. Another factor which may help account for the halving of the Burton-on-Trent winter population over the ten year period is the large increase in the number of power lines in the Trent valley in and close to the town. Power lines are so often situated in river valleys for landscaping reasons, and power stations have to be situated adjacent to ample supplies of cooling water. The power station complexes at Drakelow and Willington are both within three miles. Ogilvie (1967) showed that nearly half the reported swan deaths are due to collisions with wires. The oiling accident in 1966 may also have contributed to the decline since the nucleus of highly resident and on the whole non-breeding swans was wiped out. Furthermore the loss of so many other potential breeders will have lowered the production of young in the area around.

Changes in the numbers have been even more marked in the various moulting than in winter flocks. The largest, at Burton-on-Trent, has never re-established itself after being completely wiped out in July 1966. Prior to that a large proportion of the wintering population remained at Burton-on-Trent to moult, with most of the remainder moving to Blithfield Reservoir and a few to Alvecote Pools Nature Reserve. Only that part of the population which left Burton-on-Trent annually to moult survived, because it was away at the time of oiling. It appears that the new birds which have gradually filled the vacuum created at Burton-on-Trent have followed the lead of the survivors in moulting elsewhere. However, in recent years Alvecote Pools has become the main moulting area for the Burton-on-Trent swans and the Blithfield Reservoir flock has decreased considerably.

It was thought possible that the catching techniques used at Blithfield Reservoir—following the individual flightless swans with motor boats—had caused the birds to go elsewhere to moult. This apparently happened at Abberton Reservoir in Essex when a similar technique was used. However, the same technique has been used at Blithfield in recent years and the flock has started to build up again, so this is therefore discounted as the main reason for the change in moulting population. Much of the decrease must be associated with the disappearance of the Stafford and Rugeley flocks which used Blithfield Reservoir as a moulting area.

The moulting flock at Cannock Reservoir—which is geographically rather isolated from the other flock sites in the study area—has remained almost constant over the whole period of the study.

Age structure of the flocks

After the first few years of the study the majority of the birds were of known age, having been originally ringed as pulli or first year birds. From the major round-ups of flocks it was thus possible to obtain an accurate knowledge of their age structure. Experience has shown that most unringed birds caught in the flocks which are not in first year plumage are in their second year—this being indicated by their dull beak colour and the occasional brownish rump feathers—hence the probable age of many other birds in the flock can be estimated. Younger swans tend to move around more and are therefore more likely to come into the study area from outside. Swans become more sedentary once they have paired for the first time at the age of two or three. Thus, although for detailed analysis the birds of known age were distinguished from those in which only the minimum age was known, for the general examination of age structure the two groups were amalgamated to increase the sample size, for example, birds of 'minimum age 2' were assumed to be two years old (Table II).

Winter flocks

The overall proportion of first year birds in the January flocks has remained remarkably constant at about 20% over the whole ten year period of the study, ranging only between 18% and 24% in spite of the variation in the production of young from year to year. Since the overall January flock population has decreased by 46% since 1962 while the average annual production of free flying young has decreased only slightly (except in 1969) it would appear that some factor is causing an increased mortality of the young before their first January. This is most likely to be the increased number of electricity and other wires since they form an especial hazard to young swans in their first few months of flight.

There have been some changes in the percentage of first year birds in the individual flocks over the years. Before the oiling incident at Burton in July 1966 the percentage of first year birds there in January averaged 17% but since then it has been 25-30%. This is because many of the old resident birds at Burton were killed. There has been a decrease in the proportion of first year birds in the Tamworth and Cannock flocks—which occasionally in the past would contain up to 30% in mid-winter—probably as a result of the somewhat reduced production of young locally.

The proportion of second year birds in the January flocks is higher than first year birds, presumably because many of the latter have still not left their family parties. The Tamworth flock averaged 45% second year birds whilst that at Burton averaged 30-40% up to 1966 and about 40% since then. Looking at the older end of the age scale the Tamworth

Table II. Totals and percentage age composition of Mute Swan flocks rounded-up, 1962-1970.

	Year								
	1962	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*
JANUARY									
Localities			BT	BT	BT	B	B	B	B
Total			190	138	195	90	144	41	52
% 1st year			*21*	*18*	*21*	*28*	*23*	*29*	*35*
% 2nd year			*43*	*37*	*35*	*36*	*42*	*37*	*44*
% 3rd year			*14*	*14*	*13*	*14*	*16*	*15*	*10*
% 4th year or older			*22*	*31*	*31*	*22*	*19*	*19*	*11*
APRIL									
Localities		T	BT	B	BTC	B		B	B
Total		39	156	105	105	44	—	53	82
% 1st year		*59*	*42*	*40*	*48*	*66*		*53*	*41*
% 2nd year		*23*	*26*	*30*	*29*	*18*		*30*	*41*
% 3rd year		*13*	*12*	*9*	*4*	*5*		*11*	*7*
% 4th year or older		*5*	*20*	*21*	*19*	*11*		*6*	*11*
JULY									
Localities	BCR	BR	BCR	BCR	BTC	TC	TCR	TCR	TCR
Total			252	206	121	115	145	191	187
% 1st year	*30*	*34*	*36*	*26*	*24*	*41*	*34*	*39*	*31*
% 2nd year			*24*	*33*	*32*	*30*	*35*	*23*	*28*
% 3rd year			*17*	*14*	*18*	*12*	*14*	*21*	*16*
% 4th year or older			*23*	*27*	*26*	*17*	*17*	*17*	*25*

B=Burton-on-Trent; T=Tamworth/Alvecote Pools; C=Cannock Reservoir; R=Blithfield Reservoir

flock in January usually contained 10-20% which were four or more years old. The Burton flock on the other hand had 35% four or more year olds up to 1966 and 20% since then.

The average January flock composition in the study area at present can thus be summarised as: 1st year, 20%; 2nd, 40%; 3rd, 20%; 4th year and older, 20%.

April non-breeding flocks

By April most of the older birds and a proportion of the three and even of the two year old birds have paired and moved out to take up territories. The age structure of the non-breeding flocks remaining therefore shows a significant difference compared with mid-winter.

The percentage of first year birds is increased and has varied between 40% and 60% between 1962 and 1970—two or three times the winter level. In the earlier years the percentage was normally 50-60%, but in the last three years it has averaged only 40%. At both Tamworth and Cannock Reservoir the percentage of first year birds was close to 60% in the earlier years of the study but this has fallen steadily since 1966 and in the last two years has averaged about 30% at Tamworth and only 15% at Cannock (it was in fact only 11% in 1970). This pattern again suggests that fewer birds are surviving their first year than previously, although the slightly lower average production of free flying young is also a factor.

At Burton-on-Trent the normal percentage of first year birds in the April flock was 35-40% prior to the 1966 oiling incident. However, in 1967 it rose to 66% due to the loss of many second year or older birds the previous year and the fact that a large proportion of the newcomers which moved in to fill the vacuum were first year birds. The proportion dropped to 50% by 1969 and to 40% by 1970, but the latter will in part have been influenced by the exceptionally low number of young fledged in 1969 and therefore does not necessarily mean that the Burton-on-Trent flock has completely returned to its pre-oiling incident structure.

Up to 1966 about a quarter of the flock at Tamworth in April was second year birds. Since then no complete round-ups have been possible at that time of the year but an examination of the colour rings of the birds there, and at nearby Alvecote Pools, in April 1970 indicated that 35-40% were two year old birds. At Burton-on-Trent about a quarter of the population at that time of year in 1961-66 was aged two, but in 1967 the percentage dropped to only 18% as a result of the loss of many one year olds in the oiling disaster. The number has gradually increased since then and reached 40% in 1970—higher than before 1966 because of the loss of many of the old sedentary non-breeders from the Burton-on-Trent flock.

There was a substantial number of swans four or more years old in the April flocks in spite of the fact that most ought to be mature enough to breed. At Tamworth the percentage was only 5-10% but until 1966 it was normally 20-30% at Burton-on-Trent. However, with the influx of a new and younger population there the percentage has dropped to 10%.

The age structure of the present April non-breeding flocks is approximately: 1st year, 40%; 2nd, 40%; 3rd, 10%; 4th year and older, 10%.

July moulting flocks

The proportion of birds four or more years old is higher in July than April because some of the paired population return to the flocks to moult. Before the oiling incident at Burton-on-Trent in 1966 about a third of the population in July was more than four years old—similar to the mid-winter situation. At Alvecote Pools the proportion has been much lower, averaging 14% in 1966-1968 but rising to 18% in 1969 and to 22% in 1970. The absence of a hard core of old birds in the flock (as at Burton-on-Trent) accounts for the lower figure for Alvecote Pools and the gradual increase in recent years is associated with the ageing of the 'new generation' from Burton-on-Trent which goes there to moult. The percentage at Blithfield Reservoir has been variable but averaged only 15% over a seven year period—these birds being almost entirely failed local breeders. At Cannock Reservoir there is always a high proportion of swans in the July flock which have been paired in the previous spring and consequently the percentage aged four or more has been rather greater than in most of the other flocks, usually being between 20 and 30% and averaging 25%.

The proportion of one year old birds in the moulting flocks has varied in a way which does not appear to correlate with the production of young in the study area the previous year—although all one year old birds are in the flocks at this time. In 1962-1964 a third of the July population was in its first year; the proportion fell to 25% in 1965-66 and then rose to 40% in

1967-1969. However, the fall to 31% in 1970 did correspond with the exceptionally low number of young fledged in 1969. Apart from this the increase in recent years can be attributed to a fairly constant annual production of young in a declining population. But the changes in earlier years have no obvious explanation. There were no major consistent differences between any of the flocks.

The percentage of second year birds in the moulting flocks has varied around 30% at Burton-on-Trent and Alvecote Pools and 25% at Blithfield and Cannock Reservoirs. However, in 1965 it reached the exceptionally high figure of 53% at Cannock Reservoir, there being no obvious explanation.

The age structure of the July moulting flocks in recent years has thus been approximately: 1st year, 40%; 2nd, 25%; 3rd, 15%; 4th year and older, 20%.

Occurrence of paired birds in the flocks

Many paired birds remain on or near their territories throughout the year, even when they do not breed successfully. Others return to the flocks during the winter (especially in severe weather when their territory may be frozen over) or for the moulting period (particularly when they have not bred or have bred unsuccessfully). However, a few which have paired or even bred in the past will remain in the non-breeding flocks in the spring in a subsequent year. Thus swans which have been paired can be found in the flocks at any time of the year.

January

Since the Burton-on-Trent flock is situated close to the boundaries of the study area it is estimated that only about a third of the birds which leave there to breed take up territories inside the study area. The figures for the occurrence of previously paired birds in the flock have therefore been trebled to give a truer picture. Nevertheless, in most winters only 10% of the Burton-on-Trent flock has previously been paired. In the early years this rather low percentage was probably caused by the significant proportion of eligible birds in the flock which did not appear to take mates in the spring. A rather high proportion (21%) of previously paired birds occurred in January 1966 in a cold spell—which also caused a high overall flock population—due to many birds being frozen off their territories. In January 1967 the proportion was also higher than normal (18%) but this was an effect of the oiling incident; the *number* of previously paired birds was of the usual level (since they were mainly away on their territories at the time of the oiling) but the total flock was smaller.

At Tamworth nearly a quarter of the flock during the 1963 cold spell was composed of birds which had been known to be paired at some time previously. In other years the January flock contained only about 10% previously paired birds except in 1966 when (as at Burton-on-Trent) it was higher (at 16%) due to a short but severe cold spell.

April

Rather surprisingly the percentage of previously paired birds in the flock at Burton-on-Trent in April was no lower than that in January. This was partly due to the nucleus of swans in the flock which appeared to be disinclined to pair or only took mates irregularly. Some individuals even remained in the flock for several years without re-pairing. These flock residents were the main casualties of the 1966 oiling disaster with the result that in April there were no previously paired birds in the flock—in marked contrast to the situation in January 1967 when the figure was above average. Since then the April percentage has returned to the normal level of about 10%.

At Tamworth also the April flocks each year contained a small number of swans which had been paired in previous springs, averaging 5-10%. Most of these were individuals which had lost a mate and had not yet found a replacement and there was no hard core of reluctant breeders as at Burton-on-Trent.

July

During the moulting period flocks generally contained a higher percentage of previously paired birds than at any other time of the year. A large proportion of the pairs which did not have any young left their territories and retired to the major moulting sites. There is probably some advantage in leaving the limited confines of their territory for the security of one of the larger static waters generally favoured as moulting grounds.

At Burton-on-Trent in 1962-1966 about 15% on average of the July flock had been paired at some time previously. At Alvecote Pools in 1966-1970 the average was probably rather over 20% if some allowance is made for the proximity of the site to the edge of the study area and the consequent unknown paired birds which will have come to moult there

from outside. The percentage in the Blithfield Reservoir moulting flock was smaller and more constant, at about 12%, possibly a reflection of the generally higher breeding success of the swan pairs in the country areas more remote from human predation.

Cannock Reservoir, situated near the centre of the study area and relatively isolated from the main swan flight lines, provides birds which nearly all take up their eventual territories inside the study area. This region is the most plagued by human interference with nests and the failed breeders, as well as the non-breeding pairs, nearly all rejoin the flock to moult. Almost a third of the July flock had been paired at some time previously. The range was 20-44% the highest tending to correlate with years of poor breeding success (for example 1969).

As well as finding many known previously paired birds in the moulting flocks it was noticeable that in many new pairs caught in the spring both birds had been present in the same moulting flock the previous summer. It would appear that new partnerships are often first established in these moulting congregations and this accounts for the notable number of new pairs in early autumn. Such birds leave the moulting grounds together in September and spend several weeks moving around as a pair before re-entering the flocks for the midwinter period. A tenuous pair bond must still be retained, just as in other established pairs which adjourn into the flocks. These appear to submerge their aggressive instincts and pair bonds, yet often reappear still paired together the following spring.

It is noticeable that the only birds which have difficulty in replacing a mate are those whose territorial instincts are so strong that they never leave their old territory—and sometimes even drive off visiting unpaired swans which could perhaps be potential mates.

Movements

Although Mute Swans in Britain move around only locally, a small number travel quite long distances, occasionally crossing to the Continent. The information gained in the present study has therefore been analysed in an attempt to quantify the extent of movements, both between neighbouring flocks and over greater distances.

Of the total of 2,568 swans ringed in the study area and a further 86 swans ringed by others outside the area, and recaptured within it, three-quarters were subsequently heard of again, being retrapped, or reported via the British Trust for Ornithology ringing scheme. On average each bird was recorded three times subsequent to being ringed and therefore the total number of individual capture records was around 10,000 during the ten-year period. One individual was retrapped twenty times and quite a number more than ten times.

Local movements

There were approximately 2,000 records, involving around 1,000 individuals, of swans moving more than three miles (4.8 km.). However, the majority of birds were originally ringed in the flocks and must have in many cases already made a journey from their birthplace of greater than three miles.

Once in a flock however a small proportion of swans do remain remarkably static for several years. This was particularly true of the Burton-on-Trent flock until the 1966 oiling incident wiped out the most sedentary. One bird was captured nineteen times there between November 1960 and January 1967 and apparently only moved away from the area for the first time in April 1967. Another was recorded seventeen times between August 1961 and its death (due to oiling) in July 1966. Both these birds took a mate, but did not nest, in one or more years but only moved to a nearby backwater on the river to take up territory.

Numerous other birds were recorded for several years only in the Burton-on-Trent flock. Some may have moved at times to the east and north outside the boundaries of the study area. However, many appeared to remain stationary as they were recaptured both in the spring round-ups of non-breeding birds and in the summer moulting flock—the times at which one could most expect a mobile bird to be absent.

One bird, ringed as a paired bird in 1961 in Lichfield, moved to Cannock Reservoir 5 miles (8.0 km.) away in 1962 and was still present there in 1970. It had been caught seventeen times in the intervening period, mainly in the flock although it did take a mate on a nearby pond in several years.

The sedentary behaviour of birds in flocks over a long period may in part have been influenced by the proximity of the site to the territory which was occupied when paired. It is more normal for paired birds to take up territories rather further

away from the flocks and then only to occur irregularly in the flocks—generally when they have bred unsuccessfully. Thus the majority of birds make at least one other than local movement subsequent to the time when they were first recorded in one of the flocks.

Movements between flocks inside the study area

(*a*) Pattern of movements

In this section the movements between five main flocks in the study area are examined to determine the extent and pattern of intermingling of the population. A sixth flock, at Rugeley, was never catchable and disappeared in 1964. Only journeys which both start and finish in one of the flocks are included. Each movement is used and therefore a particular bird may be counted several times.

The numbers of individual movements between each flock are shown in Figure 2. It is apparent that there was most interchange between Burton-on-Trent and Tamworth/Alvecote Pools and between Burton-on-Trent and Blithfield Reservoir. There was also a substantial interchange between the Stafford and Blithfield Reservoir flocks, especially considering that the Stafford flock had always been smaller than the others and has virtually disappeared since the 1963 cold winter. Less extensive movements take place between the Cannock Reservoir flock and both the Burton-on-Trent and Tamworth/Alvecote flocks.

The most striking feature of the pattern of movements is the lack of interchange between the Cannock Reservoir and either the Blithfield Reservoir or Stafford flocks. These are all within ten miles (16.1 km.) of each other and form the closest group in the study area.

The pattern of movements appears to correlate closely with the height of the ground separating the various flocks. The 250 ft. and 500 ft. contours (76 m. and 152 m.) are shown in Figure 2. Burton-on-Trent, Tamworth/Alvecote, Blithfield Reservoir and Stafford are all connected directly by river valleys in which the ground level is below 250 ft.; these correspond exactly with the densest pattern of movements. Cannock Reservoir does not lie near a river system but is accessible from the east without traversing the 500 ft. contour: hence the moderate amount of interchange with the Burton-on-Trent and Tamworth/Alvecote flocks. Blithfield Reservoir and Stafford are separated from Cannock Reservoir by a barrier of ground over 500 ft.—Cannock Chase—

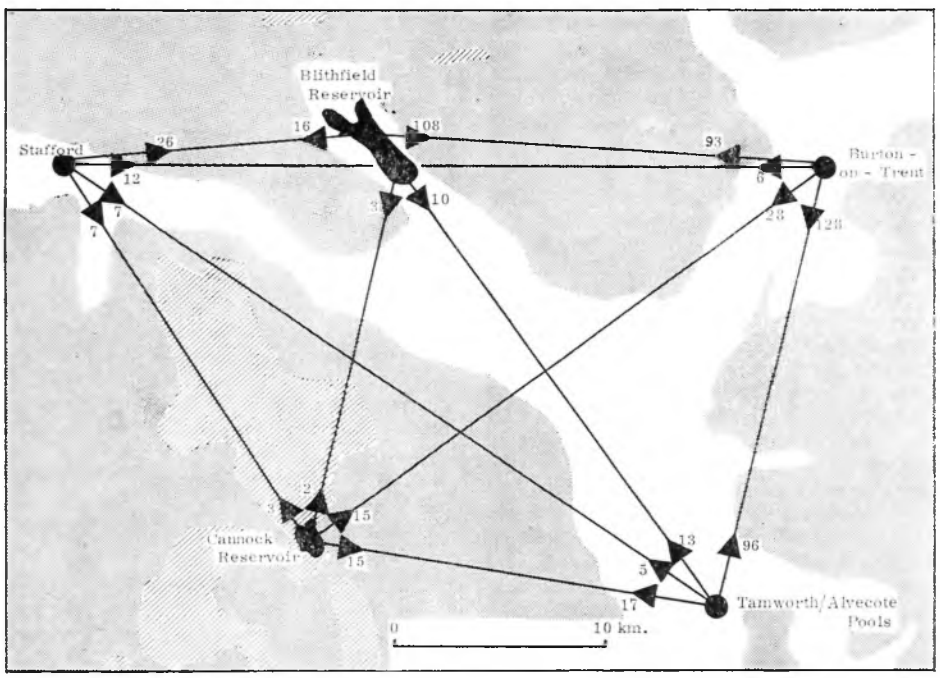

Figure 2. Movement between the main Mute Swan flocks. The hatched area is land over 500 feet (152 m.) and the stippled area is land over 250 feet (76 m.).

which appears to be the main inhibitor of movements between these flocks.

Several swans have visited a number of different flocks during their life. One did a circuit of four in only a year and a half:

25.2.62	1st winter	Tamworth
26.5.62		Alvecote Pools
19.1.63		Cannock Reservoir
10.3.63		Stafford
28.7.63	(moulting)	Blithfield

Another oscillated mainly between two sites over nine years:

23.10.60	juvenile in family	Alrewas 6 miles (10 km.) SW. of Burton
14. 1.62		Burton
19. 5.62		Burton
28. 7.62	(moulting)	Blithfield
28. 7.63	(moulting)	Blithfield
25. 4.64	(alone)	Kings Bromley 4 miles (6 km.) SE.
26. 7.64	(moulting)	Blithfield
24. 1.65		Burton
25. 7.65	(moulting)	Blithfield
16. 1.66		Burton
1. 1.67		Burton
17.12.67		Burton
13. 1.68		Burton
25. 5.68	(paired)	Blithfield
27. 4.69	(paired)	Blithfield

Movements between the different flocks take place throughout the year, except of course during the flightless period of July and August. The Blithfield Reservoir flock is however only present during the summer months and it appears therefore that this flock, which assembles primarily for the annual moult, is drawn mainly from the Burton-on-Trent and Stafford populations. A proportion of the movements from Burton-on-Trent to Tamworth/Alvecote Pools are also moulting movements. Since the July 1966 oiling incident part of the new Burton-on-Trent population has tended to adjourn to Alvecote to moult instead of remaining throughout the summer. It thus appears that moulting congregations are largely drawn from specific flocks rather than being a random collection of all the birds from within a given radius.

Many swans have moved backwards and forwards between one flock and another several times. This is particularly true of birds undertaking a moulting movement. For instance many birds which have moved from Burton-on-Trent to Blithfield Reservoir or Alvecote Pools to moult have subsequently been recaptured back in Burton-on-Trent. Two extreme examples are:

(1)	14. 1.62	2nd winter	Burton
	15. 4.62		Tamworth
	28. 7.62	(moulting)	Blithfield
	23. 2.62		Burton
	28. 7.63	(moulting)	Blithfield
	12. 1.64		Burton
	18. 4.64		Burton
	26. 7.64	(moulting)	Blithfield
	1. 5.65		Burton
	25. 7.65	(moulting)	Burton
(2)	22.10.66	juvenile in family	Polesworth 11 miles (18 km.) S.
	30. 4.67		Burton
	29. 7.67	(moulting)	Alvecote
	17.12.67		Burton
	13. 1.68		Burton
	24. 3.68		Burton
	20. 7.68	(moulting)	Alvecote
	16. 2.69		Tamworth
	1. 3.69		Tamworth
	30. 3.69		Burton
	9. 8.69	(moulting)	Alvecote
	9. 8.70	(moulting)	Alvecote

The first bird eventually changed its moulting site to Burton-on-Trent after three years at Blithfield Reservoir. Although most birds were consistent a few such changes occurred each year. Some even reverted back to their original moulting site after making a change. For instance a bird which moulted at Blithfield in 1964 and 1965, and at Alvecote in 1966 went back to Blithfield in 1968. In each year it was recaptured at Burton-on-Trent during the winter.

An example of the consistency of some moulting movements over quite long distances concerned two birds which were in the Alvecote Pools moulting flock in 1967. In the spring of 1968 they were paired together near Stafford (25 miles (40 km.) NW.) but after failing to breed they moved all the way back to Alvecote again to moult. In 1969 they were back at Stafford and having nested successfully did not have cause to return to Alvecote again. The female had originally been ringed as a pullus in the Stafford area (the male in the Burton-on-Trent winter flock) and it would appear that this may have accounted for this comparatively long regular movement.

(*b*) Composition of winter and spring flocks

In order to quantify the overall extent of movements the proportions of birds in each flock which have been recorded at some previous date in another flock have

Philippa Scott

Plate IX. (a) The central area of Welney Refuge, Norfolk, is screened from disturbance by half a mile of earth bank. At intervals there are small pre-moulded fibreglass hides. Josh Scott, the Warden, follows Peter Scott into one of them. (b) In the centre of the boundary bank is a fine large Observatory, connected to the road by a screened bridge over the Hundred Foot Drain. It was opened on 7th November 1970 by Mrs. E. Kleinwort (see p. 150).

E. E. Jackson

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Plate X. (a) Within the well-appointed Observatory at Welney, Peter Scott and Tim Sparrow, the Trust's Controller, look out over the excavated lagoon. The inward-sloping windows reduce rain-smearing.
(b) Bewick's Swans have already been attracted to the Observatory lagoon by the patches of water kept open by submerged impellers, and by the provision of grain.

Philippa Scott

been calculated. This was possible with the Burton-on-Trent and Tamworth flocks since virtually the whole population was rounded up several times a year at each place. At the other sites the whole flock was usually only caught up at the moulting time and therefore the analysis of the flock composition is mainly confined to the summer period. In all cases the percentages quoted refer only to the ringed birds of the flock, usually being a high proportion of the total.

At Burton-on-Trent about three-quarters of the flock rounded up each January was already ringed. In the period 1963 to 1966 about 15% of these previously had been recorded at Blithfield Reservoir and about 8% at Tamworth/Alvecote Pools. The proportion from Cannock Reservoir or Stafford was never more than 3%. Thus only about a quarter of the birds already carrying rings had previously been recorded in another flock. Another 15% of the ringed birds had been recorded away from Burton-on-Trent, mainly as pulli in their family parties at their birthplace, not in one of the other flocks.

Similar proportions of birds recorded in other flocks were present in the non-breeding flocks at Burton-on-Trent during April and May, except that the proportion from Tamworth had risen to 13%. This probably represented a genuine increase in movement during the spring between these flocks along the Trent/Tame valleys.

After the July 1966 oiling, the January flock composition changed quite markedly. The proportion from Tamworth/Alvecote more than doubled (to 18%). The percentage from Blithfield was rather variable, partly due to the decline in that flock, but in general it also increased averaging 21% in 1967-1970. Even the proportion of birds from Cannock and Stafford doubled—to a total of 7% on average in the period 1967-1970. The most striking increase of all, however, was in the percentage of the new Burton-on-Trent flock which had previously been recorded elsewhere in the study area, as pulli at their natal sites, or from outside the study area—in 1967 it was 32% and it remained around 40% in each year up to and including 1970. It would appear that the vacuum created by the loss of more than half the total population normally using Burton-on-Trent during the winter had created conditions which encouraged itinerant swans to stay. In all, about 70% had been recorded outside Burton-on-Trent at some time. The composition of the spring non-breeding flock after 1966 was also correspondingly more varied than previously.

The flock at Tamworth normally contained few birds from other flocks in the study area except Burton-on-Trent. The percentage which had at some time visited the latter was about 10% in mid-winter rising to 20% in the spring—the increase being due to greater movements at that time of year and also to the departure of the more sedentary local birds to breed. About a third of the flock had normally also been recorded at other places outside Tamworth—mainly as pulli at their natal sites.

The flocks at Cannock Reservoir and Stafford were not rounded up in the winter or spring frequently enough for any quantitative analysis of the origins of the birds but examination of the colour rings indicated that comparatively few of the swans in the former had previously visited other flocks in the study area.

(*c*) Composition of the summer moulting flocks

The size of the moulting flock at Burton-on-Trent in the period 1962-1966 was usually only a little smaller (up to 25%) than the peak numbers in the preceding winter. This was because the exodus of some birds to Blithfield to moult was counteracted by an influx of failed local breeders and of those one year old birds which had not joined the main flocks in midwinter. The composition of the flock was not dissimilar from that at other times of the year with about 9% from Tamworth and about 3% from Cannock and Stafford combined. The percentage of Blithfield birds was much smaller than in midwinter, due to these birds largely returning again to moult at Blithfield in subsequent summers. However the percentage ex-Blithfield did rise steadily, from 4% in 1963 to 11% in 1966, probably reflecting the increased sedentariness of birds as they got older and subsequently paired or bred in the area.

As already mentioned, the July 1966 oiling incident destroyed the moulting flock and there has not been a summer one at Burton-on-Trent since then. It seems as if the only survivors were those which were away moulting at Blithfield or elsewhere and that many new immigrants already had an established moulting area. One year old birds which had no previous moulting ground were presumably carried along in the exodus.

The Tamworth population moves completely to Alvecote Pools, three miles

(4.8 km.) away, to moult. The movement starts in mid May and all birds have usually transferred by mid June. The return largely takes place in September and during the period 1962-1966 the flock was not normally above about 50 birds, similar to that in midwinter. It was almost certainly predominantly made up of that population and the local failed breeding birds or non-breeding pairs. It was not possible to round up this flock until 1966 but in that year about a quarter of the ringed birds had at some time been in Burton-on-Trent—rather more than in the spring flock at Tamworth and this indicated some specific moulting movements. One bird had moulted at Burton-on-Trent in both the preceding years and another in 1965 only and both had therefore changed their moulting area. Another had moulted at Blithfield Reservoir twice before.

Recently there has been a steady increase in the size of the Alvecote Pools moulting flock, the July populations being 83, 105, 115 and 120 respectively in the years 1967-1970. This has in part been due to the lower success of breeding pairs at Alvecote, leaving a greater area of water free from aggressive adults. However, the main reason has been the adoption of Alvecote as the main moulting area for the swans which recolonised Burton-on-Trent after the 1966 oiling disaster. Thus in 1967 the percentage of Alvecote moulting birds which had been recorded at Burton-on-Trent had doubled (to 50%) compared with 1966 and in 1968-1970 it averaged 35%. In most years there were birds from Cannock Reservoir, Stafford or Blithfield Reservoir but these never amounted to more than 5% of the population. The Alvecote moulting flock is thus largely made up of the whole of the non-breeding population from the Tamworth flock, a large part of the Burton-on-Trent flock, and local failed breeders or non-breeding pairs.

The Cannock Reservoir flock was rounded up in the July in each of the years 1962-1970 except for 1963. The size of the moulting population remained remarkably constant, between 40 and 55, throughout this period. The majority of the flock was composed of the non-breeding birds present there throughout the winter and spring, and from the local paired birds which had either not bred or had failed in their breeding. On average only 8% had previously been recorded at Tamworth and a similar percentage at Burton-on-Trent—although the percentage from the latter averaged 12% in the 1968-1970 period reflecting the wider moult dispersal of the 'new generation' at Burton. There was never more than one bird from either Stafford or Blithfield Reservoir, indicating that the high ground of Cannock Chase is a deterrent to moulting movements as well as to movements at other times of the year. Compared with the other flocks in the study area the Cannock Reservoir flock is thus an almost closed community which has maintained its numbers during a period of general population decline.

The Blithfield Reservoir moulting flock has varied considerably in size. From 130 in 1962 it decreased to 70 in 1964, but after a slight rise to 90 in 1965 it showed a steep decline to 40 in 1966 and only 10 in 1967. The decrease is much more marked than in the population as a whole but this can, in part, be accounted for by the almost complete elimination of two of the flocks—at Stafford and Rugeley—which previously moved totally to Blithfield to moult. Thus the proportion of the Blithfield population which was known to have come from Stafford declined steadily from 30% in 1962 to 7% in 1965, after which no Stafford birds were recorded. This left only Burton-on-Trent as a principal source for the moulting population. The proportion from Burton-on-Trent rose from 34% in 1962 to 52% in 1965. The percentage from Tamworth was always small, averaging 6%, although in 1964 it was unusually high at 17%. Only the occasional bird from Cannock was recorded. The balance of the Blithfield moulting flock was made up of about 15% local failed breeders or non-breeding pairs and about 20% of birds from outside the study area. The latter were never seen between moulting seasons and had probably spent the intervening period in flocks at Stone or Stoke-on-Trent to the north-west outside the study area boundary.

The 1967 crash in the Blithfield population appears to have been an indirect result of the 1966 oiling incident at Burton-on-Trent. The draw to Alvecote Pools by the new population forming at Burton-on-Trent seems to have been greater than that of the survivors which returned from Blithfield.

Since 1967 there has been a gradual increase in the Blithfield moulting population again from 17 in 1968 to 35 in 1970. Nine of the eleven ringed birds in the 1968 population had come from Burton-on-Trent indicating the major

dependence of the Blithfield flock on that source. In 1969 70% of the flock was from Burton-on-Trent and in 1970 it was still 56%; in neither of these years was there a significant number of birds from any of the other flocks in the study area. It would thus appear that the capacity for any further increase in the Blithfield Reservoir flock is limited as the Burton-on-Trent population seems to have now re-stabilised itself and established a tradition that the major proportion uses Alvecote as its moulting area.

Movements over longer distances

(*a*) Distance of movements

During the ten-year study period only 75 movements greater than 30 miles (48.2 km.) were recorded from the 2,568 birds ringed in the study area, i.e. 3%. A further 48 birds ringed elsewhere were recaptured inside the study area after coming from distances of over 30 miles. Adding these to those mentioned above gives a figure of 5% of the total population captured in the study area moving more than 30 miles.

The number of swan movements falls off sharply with distance (Table III). About 60% of all the movements were controls, i.e. birds recaught by another ringer. However, as this percentage was the same for birds in both the 30-50 mile and the over-50 mile range it is not considered that the distribution of swan ringing activity has biased the apparent pattern of movements. Intensive ringing by J. A. Hardman at the Stratford-on-Avon flock, situated between 30 and 50 miles (48.2 and 80.4 km.) from the study area, produced only 16 birds from Staffordshire in eight years.

Table III. Long distance movements of Mute Swans.

Distance moved (*miles*)	(*km.*)	*Number of movements*
30-39	48-63	47
40-49	64-79	31
50-59	80-95	18
60-69	96-111	12
70-79	112-127	4
80-89	128-143	3
90-99	144-159	1
Over 100	over 160	7
		123

Although long movements seem to relate largely to individual wanderers, on one occasion three birds from Tamworth turned up together at Stratford and had presumably travelled there as one party.

Seven birds returned to their original ringing place after making a journey of over thirty miles. Two of these birds made such movements in changing their moulting sites. One moulted at Blithfield in 1965, at Stratford-on-Avon (43 miles (69.1 km.) SSW.) in 1967, and back at Blithfield again the following two years. The other moulted at Stratford-on-Avon in 1966, at Alvecote Pools (30 miles (48.2 km.) N.) in 1967 and again at Stratford in 1968.

There were seven movements of over 100 miles (161 km.). The longest, of 140 miles (225 km.), was from Potter Heigham, Norfolk, to Tamworth. This bird was ringed in October 1962 and recaptured in January 1963, and therefore the long movement could have been partly due to the severe weather conditions. The other six were all caught in the summer at Barrow-in-Furness, Lancashire — a distance of 115-120 miles (185-193 km.). The four movements *to* Barrow all referred to birds caught in the study area in the winter and spring. Similarly both birds which moved *from* Barrow were recaptured in the study area in the winter. It is thought that these movements constitute a moult migration since birds from other parts of England have been caught at Barrow and the flock only forms there during the summer moulting period. One of the birds had originally been ringed in Oxford in March 1965 and was recaptured in the study area in May, presumably on its way to Barrow where it was recorded in July 1965. Another bird was recorded making the journey in both directions—ringed in August 1965 at Barrow it was captured at Tamworth in February 1967 and had returned by January 1968 to Barrow where it later nested. The other Barrow-ringed bird was also subsequently found nesting, but this time in the Midlands—ringed in September 1965 it bred in 1967-1969 at Walsall, Staffs.

(*b*) Direction of movements

The direction of movement of the 78 birds travelling 30-50 miles (48.2-80.4 km.) is shown in Figure 3. Birds from all the main flocks have shown these movements roughly in proportion to the numbers ringed, except for the Cannock Reservoir flock which appears to be rather less prone to long distance movements. Although the movements show a considerable spread there is a clear inhibiting effect of ground over about 500 ft. (152 m.), as was shown up in the examination of the more local movements.

Figure 3. Mute Swan movements of between 30 and 50 miles (48.2 and 80.4 km.). Land over 500 feet (152 m.) is hatched.

Thus there is an almost complete absence of northward movements due to the Pennines, and of long south-westward movements due to the Long Mynd, Clee and Malvern Hills. Movements to the south-east are sparse due to the Northamptonshire and Rutland extensions of the Cotswold range. In contrast there is a heavy concentration of movements across low ground along the Trent Valley, over into the Avon and Severn valleys, and to Shropshire and the Cheshire Plain.

The pattern of movements of the 45 birds which moved more than 50 miles is even more markedly affected by geographical features than the shorter movements (Figure 4). The heaviest concentration is to the north-west where there is uninterrupted low ground across Cheshire and Lancashire right up to Barrow-in-Furness. The Pennines again appear to be a complete bar to direct northward movements. Long westerly movements are inhibited by the mountains of Wales, the only recovery in that direction being at Welshpool, still in the Severn Valley. There is a fairly random scatter in an easterly and southerly direction, although the southern end of the Coltswold range appears to be another definite barrier. The concentration of movements between the study area and Oxford is probably over-stressed by the extensive ringing activity there (Perrins and Reynolds 1967) for although there is a direct route below 500 ft. most of the ground between is above 250 feet and comparatively waterless. One bird was caught at Stratford prior to Oxford and it is possible that most travelled that route. The movement from Alvecote to London is rather surprising since the Chiltern Hills lie between. Since five years elapsed between ringing and recovery it is possible that the journey was via Oxford and the Thames Valley. Movements into the Fens presumably took place via the gaps in the intervening high ground.

A notable feature is the lack of movements down the Trent Valley beyond Newark in spite of the extensive low ground in Lincolnshire right up to the Humber estuary. There have been no recoveries at all in north Lincolnshire or Yorkshire, in sharp contrast to the extensive movements into Lancashire. It would appear therefore that long movements to the north-east from the study area are inhibited by some other factor.

Most birds undertaking long movements and captured several times had either shown a consistent movement in

one general direction or had retraced their paths back to their point of origin. However, one bird was recorded making notable journeys in markedly different directions. Ringed as a first winter bird in Nottingham in January 1964, it was recaptured (moulting) 22 miles (35.4 km.) WSW. at Burton-on-Trent in July. It remained there until at least the following May but was subsequently caught 55 miles (88.5 km.) east at Deeping St. James, Lincs., in July 1966.

(*c*) Age at movement

Ninety of the 123 birds which moved more than 30 miles were of known age when ringed. For 50 birds the exact year of movement was known—the year being taken as June to June since most young are hatched by the end of that month. Almost equal numbers moved in the first and second years (23 and 21) and hardly any in the third and fourth (4 and 2). Since there are fewer two year old than one year old birds, long movements tend to occur most frequently during a swan's second year of life. Both birds which moved in their fourth year were returning over a route previously travelled and were therefore not breaking new ground.

In a further 27 birds the year of movement could be tied down to a two year period, i.e. first or second (14), second or third (12), third or fourth (1). All but one *could* have moved during their first two years of life. The remaining 13 birds were in their first two years when ringed but as they were not recovered for three or more years it is not possible to determine the age at which the major movement occurred.

Among the few birds which continued to make further major journeys after their second year was one with the following history:

12.12.61	1st winter	Bewdley (48 miles (77.2 km.) S.)
28. 7.62	(moulting)	Blithfield Reservoir
28. 7.63	(moulting)	Blithfield Reservoir
12. 1.64		Burton-on-Trent
11. 7.65	(with brood)	Leicester (25 miles (40.2 km.) ESE.)

Another which moved from Chester to Burton-on-Trent (58 miles (93.2 km.) SE.) by the time it was two and a half years

Figure 4. Mute Swan movements of more than 50 miles (80.4 km.). Land over 500 feet (152 m.) is hatched.

old subsequently moved on a further 44 miles (70.7 km.) SW. to Droitwich.

The relationship between mobility and age generally fits in well with the known features of swan behaviour. Cygnets normally remain with their parents for six months (some even remain nine months) and thus the opportunity for movement in the first year is somewhat restricted compared with the second year. Furthermore, the first movement of significance is usually into the nearest non-breeding flock where the birds often remain for a while.

It appears as if the maximum mobility occurs in the spring and also during the moulting movements in early summer. However, in mid-winter swans may move out to take advantage of newly flooded pastures, intermingle with birds from other flocks and sometimes return in company with them to new places.

The study of the paired and breeding segment of the population (Minton 1968) showed that its movements were very circumscribed, particularly once nesting had actually taken place. Half the birds first pair at the age of two, and over 80% by the time they are three. It appears therefore that the growth of territorial instincts causes the decline in long movements after the second year of life. Many birds which had moved long distances into the study area from outside subsequently stayed to breed there and became relatively sedentary.

The 1966 oiling pollution at Burton-on-Trent

Several mentions have already been made of some of the consequences of the oiling disaster at Burton-on-Trent but it seems desirable to bring this information together to present a comprehensive account of the history of the flock there since the incident.

The oiling took place on 5th July 1966 as a result of a major oil spillage into the River Trent at Drakelow Power Station, two miles (3.2 km.) upstream from Burton-on-Trent. The flock numbered about 90 at the time and 75 of these (64 carrying rings) were so badly oiled that they had to be destroyed. Most of the swans which normally left Burton-on-Trent to moult elsewhere (for example Blithfield Reservoir) had already departed and all the failed local breeders had not moved in.

Eighteen of the ringed birds had been caught at least six times there (eight of them more than twelve times). Thirty-seven had moulted at Burton-on-Trent before, ten of them in each year since 1962. Twenty-one of the sixty-four ringed birds were aged four or more and many of these had never been known to have taken a mate. Thus the main casualties were highly resident flock birds, some of which had been at Burton-on-Trent for several years.

The size of the flock at Burton-on-Trent from 1961-1971 is shown in Figure 5. After the oiling the few survivors moved off and it was not until October that the first swans returned. These were presumably some of those which had been away to moult but they soon began to attract other passing swans and the juvenile birds which had left their family parties locally. From a maximum of 20 birds in October the flock built up to 40

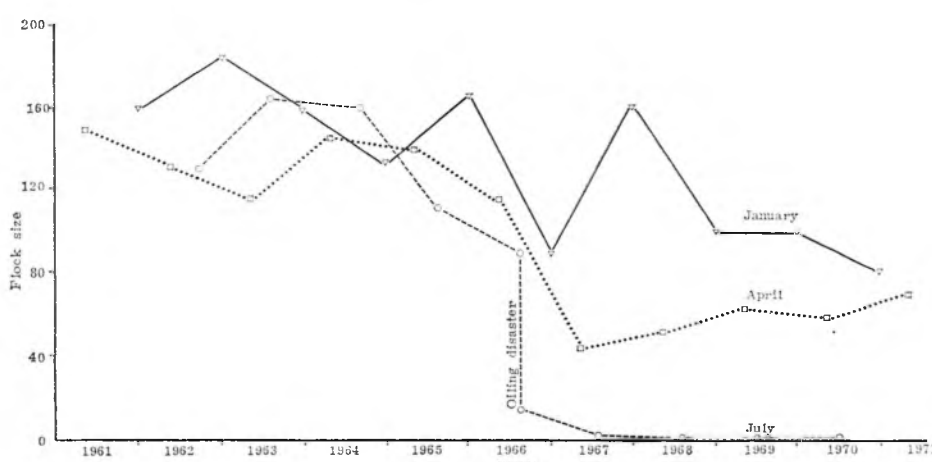

Figure 5. Mute Swan flock sizes at Burton-on-Trent, 1961-1971.

in November and to 90 in January. This was still 75 below the previous January. There were rather more birds than usual from the distant parts of the study area (for example Cannock Reservoir) and immigrants from further afield had come from Nottingham, Leicester and Chester.

The non-breeding flock in April 1967 numbered only 42, or 74 down on the previous year. New long distance immigrants had come from Leicester and Prestwich, Lancs. In July only four swans stayed to moult. Thus in the first year after pollution the Burton-on-Trent flock remained well below its previous level and only a small proportion of the loss was made good by an additional influx of swans from elsewhere inside and outside the study area.

Since 1967 there has been a continual slow increase in the flock numbers. This is best illustrated by the April figures, which recovered to 70 in 1971—a figure which the original population might well have reached in view of the gradual overall decline. The January figures have usually not exceeded 100—well down on the average of 160 in the first five years of the study. The exception was January 1968 when a hard spell caused most of the paired birds and their offspring to leave their territories and join the flock. In this flock of 160 were many more birds than usual from far afield—from Worcester, Oxford, Lincoln, Leicester, Prestwich, Chester and Winsford. It would appear that the vacuum created by the loss of a significant portion of the Burton-on-Trent flock has caused more of the passing wandering swans to remain, presumably because the food supply (mainly bread fed by the public) was sufficient. However, the immigrants have never re-established the July moulting flock and this is the main permanent change caused by the oiling disaster.

The total swan population in the study area is probably now little different from what it would have been if there had been no pollution in 1966. However, the character of the Burton-on-Trent flock has changed considerably. The flock composition is now more similar to that of other flocks in the study area, with an average age well below that of the flock before 1966. This is particularly true of the spring non-breeding flock which now contains few old birds. It is not clear what kept so many old (aged four or more) birds from pairing in the past and it is a pity that the study did not run an uninterrupted course to see if such birds did eventually pair. With the present lower population at Burton-on-Trent, pairing does not seem to be inhibited. But one cannot easily see why the previous larger population should have restricted pairing. Although the problem of finding a suitable territory near Burton-on-Trent would have been greater with the bigger flock, birds in the flock would not have known this until *after* they had paired and flown out of the flock to look for a territory. And in every year there have been many apparently suitable waters—both static and flowing—in the Burton-on-Trent area (as well as elsewhere in the study area) which have not been occupied. Both before and after 1966, shortage of territories would not appear to be the main factor controlling the size of the non-breeding flocks in spring. It remains to be seen whether the Burton-on-Trent flock will grow any further and if a new nucleus of old, non-pairing birds will build up in the future.

The future

The Mute Swan population in south Staffordshire is still in a state of flux, though the major changes of the early part of the last decade have apparently slowed down considerably. The main factors which caused the population decline were probably:—

a the increased number of overhead wires to which first and second year swans appear especially vulnerable;

b the exceptionally severe weather in the 1961-62 and (especially) the 1962-63 winters (again, the younger birds are less likely to obtain food when competition is intensified);

c the lower production of young due to increased destruction of the nests by humans.

These suggestions are consistent with the greater decline in the flock population than the paired population. Recent mild winters have provided every opportunity for maximum survival and it remains to be seen what course the population takes in the future and what factors affect it.

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Finally, I must thank my family who not only help with the field work but all too often have to put up with me sitting at my desk doing 'swan paper work'.

Summary

This paper considers all aspects of the nature and function of the Mute Swan *Cygnus olor* flocks in a 550 sq. mile (1,440 sq. km.) area of south Staffordshire studied from 1961-1971. During this period the flock population has declined at an average of 5-6% per year and several of the smaller flocks have disappeared. With the spring paired population decreasing at an average of only 1% per year there has been a change from nearly two-thirds of the population being unpaired each spring in the early years to less than a half in recent years. The age structure of the flocks at various times of the year has been detailed and major differences between flocks illustrated. Birds which have previously been paired occur in the flocks at all times of the year, being at a peak in the summer moulting congregations. Swan movements are mainly governed by a reluctance to traverse ground above 500 feet (152 m.) and a strong preference to travel along river valleys and low ground below 250 feet (76 m.). Significant interchange takes place between flocks up to about 15 miles (24 km.) apart, but only about 5% of the population moves further than 30 miles (48.2 km.) and only 1-2% more than 50 miles (80.4 km.). The majority of long movements take place in the first two years of life, particularly the second year. Regular movements to special moulting sites occur annually. The oiling disaster at Burton-on-Trent in July 1966 wiped out a large proportion of the resident flock and the subsequent gradual recovery of numbers has been recorded. The total population in the study area may now have stopped declining.

References

MINTON, C. D. T. 1968. Pairing and breeding of Mute Swans. *Wildfowl* 19 : 41-60.

OGILVIE, M. A. 1967. Population changes and mortality of the Mute Swan in Britain. *Wildfowl Trust Ann. Rep.* 18 : 64-73.

OGILVIE, M. A. 1968. The Bewick's Swans, 1967-68. *Wildfowl* 19 : 162-4.

PERRINS, C. M. and C. M. REYNOLDS. 1967. A preliminary study of the Mute Swan, *Cygnus olor*. *Wildfowl Trust Ann. Rep.* 18 : 74-84.

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Differential migration of the sexes and other aspects of the recovery overseas of Mallard ringed at Borough Fen Decoy, Northamptonshire

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Introduction

Large numbers of Mallard *Anas platyrhynchos* are ringed in Britain each year by the Wildfowl Trust, which operates the five principal duck ringing stations. The most successful station for catching Mallard is Borough Fen Decoy, Northamptonshire, where an average of 1,800 are ringed each season between July and March.

The conversion of Borough Fen Decoy from commercial catching began soon after the War but it did not become fully operational as a ringing station until the summer of 1957. Some of its earlier recoveries were included in the analysis of Boyd and Ogilvie (1961). They examined recoveries, by date and location, of all Mallard ringed in southern England. They showed that a considerable proportion of these Mallard originated from breeding areas on the continent of Europe, embracing a wide zone round the Baltic. These immigrants showed marked traditional preferences for wintering in the same parts of England each year. There they joined a larger, mainly sedentary population which rarely wandered more than 50 miles in the course of their lives.

It is the intention to bring all this material up to date, and to make annual analyses, now that Automatic Data Processing facilities are becoming available at the Nature Conservancy's Biological Records Centre, Monks Wood, Huntingdon. Meanwhile, and pending the development of an appropriate computer programme, a hand-analysis has been made. This paper deals with one aspect, the recoveries overseas.

Detailed analyses were required to provide a sound basis for deciding whether there could usefully be a restriction of catching to save work and expense at the central office of the ringing scheme operated by the British Trust for Ornithology. This analysis will also provide the background to the continuing series of investigations into Mallard 'nonsense' orientation undertaken since Matthews (1963). These had indicated orientation patterns at release which clearly varied through the season at Borough Fen, and were probably related to the geographical origins of the birds concerned. It was further hoped to throw more light on the perplexing problem of abmigration, whereby ducks mate with migrants from a 'foreign' area and return with them to breed. The phenomenon has been much discussed since it was indicated by Thomson (1931), but relatively little factual data have been put forward.

Material and methods

The ringing activity at the Borough Fen Decoy, basic to the study, is shown in Table I. Here the numbers ringed each month are set out for the ten seasons 1957-58 to 1966-67. The reason for not considering more recent ringing is given below. Following an earlier, unpublished analysis, efforts have been made to increase the catch in July and August, to provide a larger sample of British-bred

Table I. Numbers of Mallard ringed each month at Borough Fen Decoy, Northamptonshire, 1957-58 to 1966-67. Also given are the overall sex ratios.

Season of ringing	*Month of ringing*										
	July	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Total*	*% male*
1957-58	0	5	736	102	211	190	73	57	34	1408	*48.5*
1958-59	0	78	592	386	341	207	63	36	39	1742	*47.6*
1959-60	0	322	1031	548	331	164	105	66	7	2574	*47.2*
1960-61	3	130	515	238	67	28	59	29	10	1079	*48.0*
1961-62	0	516	479	271	187	65	90	102	73	1783	*47.7*
1962-63	10	88	663	257	170	50	0	0	20	1258	*49.8*
1963-64	14	209	648	338	170	42	95	46	29	1591	*51.0*
1964-65	135	531	1027	454	326	22	26	21	54	2596	*50.8*
1965-66	112	301	523	123	17	14	25	14	13	1142	*46.8*
1966-67	24	457	986	217	209	108	53	81	32	2167	*52.8*
Totals	298	2637	7200	2934	2029	890	589	452	311	17340	*49.2*
% male	*43.3*	*52.2*	*50.4*	*48.6*	*46.8*	*43.9*	*42.4*	*46.7*	*53.1*		

birds before the shooting season opened on 1st September. Attempts have also been made to increase the catch at the end of the season. Other fluctuations are due to factors beyond the decoyman's control. These may include variations in breeding success, floods, frosts and farming activities.

Recoveries received up to April 1970 have been included in the analysis. With an annual adult mortality rate of around 48% and a juvenile mortality around 68% (Bauer and Glutz 1968), the bulk of ringed birds will soon be dead. Only three seasons will account for some 90%, so analysis for factors other than longevity can begin after such an interval. However, the actual recoveries overseas build up rather more slowly, since most of the first season mortality takes place in Britain, few birds moving abroad before the shooting season ends. This is well illustrated in Table II where the cumulative overseas recoveries for the first three seasons of ringing at Borough Fen Decoy are shown. Only 6.4% of the recoveries were in by the end of the first season whereas more than half the birds ringed were probably already dead. The 81.8% overseas recoveries reported by the end of the fourth season is clearly highly representative. This study therefore can consider ringing up to and including the 1966-67 season, the fourth season recoveries of which will have been notified by the cut-off date of April 1970.

Table II. Overseas recoveries of Mallard ringed at Borough Fen in 1957-58 to 1959-60 and recovered each season since ringing, up to April 1970.

	Season										
	Same	*2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*	*8th*	*9th*	*10th*	*11th*
Number of recoveries	19	121	58	46	20	10	8	5	4	5	2
Cumulative percentage	6.4	47.0	66.5	81.8	88.5	92.0	94.6	96.2	97.6	99.3	100.0

Since the bulk of overseas recoveries are of birds which are then adult, there is no need, in the general analysis, to differentiate according to age at ringing. New techniques of determining age by plumage examination were introduced during the period under review. It is now possible to allocate females into juvenile or adult categories with some confidence right through the catching season; there is still no certain method of ageing males beyond about November. So the proportion of birds which could be correctly aged would in any case vary according to sex and the year or month in which caught.

The sex of Mallard was, however, easily distinguished throughout the study and at all times of year, by plumage and/or cloacal examination. Overall the sexes are ringed in almost equal numbers (males 49.2%) with minimal variation from season to season (Table I). Within seasons there is a distinct shift in the ratio, reflecting the later migration of females and, possibly, differential susceptibility to different catching methods, by 'dogging' or feeding. In Britain itself, 3,347 subsequent recoveries of Borough Fen Mallard had a slightly higher proportion of males, 51.7%. Overseas recoveries, however, had a much greater imbalance of the sexes, the investigation of which is a major aim of this paper.

The general method of analysis used is to relate the location of a recovery with the date of ringing (rather than that of recovery). Thus the basic assumption is made that the immigrant is ringed soon after its arrival in Britain. Then we can investigate the way in which the migration to Britain proceeds, from different geographical areas.

The range of overseas recoveries has been divided into three areas, following national boundaries for convenience:—

Area 1: Soviet Union, Finland, Sweden, Norway (244 recoveries)

Area 2: Poland, East Germany, West Germany, Denmark (201 recoveries)

Area 3: Netherlands, Belgium, France (214 recoveries).

Only a small number of recoveries fell outside these three areas and were excluded from this analysis.

The number of recoveries will obviously bear a relation to the number of birds ringed. This is taken into account by using the parameter number of recoveries per thousand birds ringed in the appropriate category. Of course, the birds ringed will include a probable majority of British-bred birds. If the British breeding success varied widely from season to season this might result in apparent, but false, variations in the proportion of foreign immigrants. However, the Wildfowl Counts (Atkinson-Willes and Frith 1965, and unpublished)

gave a valuable clue here. The September index of the British Mallard population has varied from September 1957 to 1967 as follows: 75, 74, 100, 85, 114, 85, 92, 90, 92, 105, 126. Only in the first two and the last years were there major departures from the mean index, of 94, which might have led, respectively, to over-estimates and an under-estimate of the importance of Continental immigration.

We cannot so readily allow for variations in the likelihood of Mallard being shot and/or reported in the different areas overseas. Fortunately we are dealing with the North-west European flyway made up of conservationally progressive countries with reasonably short shooting seasons, except for France. Some of the countries to the north and east used to indulge in spring shooting, particularly of male Mallard, but this is now largely abandoned. The details of current European shooting seasons have been published by Lampio and Michaelis (1971).

Recoveries in Area 1

The easternmost area is the simplest to deal with as the recoveries reported will be of birds that bred within it, and will not include any passing through to other areas.

Earlier, Matthews (1963) had demonstrated that Mallard from this area did not reach Britain in appreciable numbers until November. He found that of the 61 Mallard ringed in Area 1 from 1911 to April 1962 and recovered in Britain, only 5% were before the end of October. He checked this conclusion by examining all recoveries in Area 1 of Mallard ringed in southern England from 1947 to April 1962. Again only a small proportion had been ringed early in the season.

If we examine the Borough Fen data, as in Table III, we see that the females confirm Matthews' finding, the bulk clearly arriving in Northamptonshire after the beginning of November. Only recoveries made in the first four seasons after ringing are used so that the data for each ringing season are more nearly comparable. The males give quite a different picture, at least for the last seven years of the period under investigation. Now there appears little difference in the proportion present before and after 1st November. However, the first three seasons do appear to have been quite different, with much greater influxes of males after 1st November. This state of affairs perhaps was normal in earlier years. To check this we re-examined the Mallard ringed in Area 1 between May and October (mostly as pulli) and recovered in Britain, of which 95 are now available. Unfortunately, in only 27 cases was the sex given. If we exclude the 12 known females, the combined recoveries, split at 1959-60, are given in Table IV. This does suggest that in the earlier years more Mallard from Area 1 were coming to Britain later than they did after 1959-60. The difference is not significant, but might

Table IV. Recoveries of Mallard ringed in Area 1 and recovered in Britain up to December 1968. Known females (12) excluded.

Month of recovery	*Ringed up to 1959-60*	*Ringed after 1960-61*
August	1	—
September	—	1
October	1	5
November	9	6
December	18	12
January	15	6
February	5	1
March/April	3	—
	52	31

Table III. Rate of recovery (per thousand ringed) of Borough Fen Mallard in Area 1, for the first four seasons after ringing.

	Males ringed July/October	*Males ringed November/March*	*Females ringed July/October*	*Females ringed November/March*
1957-58	9	72	0	52
1958-59	12	34	7	38
1959-60	10	23	5	32
1960-61	14	11	4	19
1961-62	10	13	0	18
1962-63	12	9	2	38
1963-64	13	11	0	25
1964-65	10	14	2	13
1965-66	2	0	0	100
1966-67	14	9	4	32
All seasons	11	24	3	33
Total No. recoveries	70	47	17	76

have been more marked if other females could have been removed from consideration.

It is possible that the late-arriving males came from areas where spring shooting was previously practised. It has not been possible to get a clear understanding as to when spring shooting in the Soviet Union was effectively brought to a stop, but such a change might reduce recoveries in the way observed. Alternatively, of course, the males might just be wintering further east.

The proportion of male Borough Fen Mallard recoveries are shown in Table V.

Table V. The proportion of males in overseas recoveries of Borough Fen Decoy Mallard in different geographical areas (defined in text).

Season of ringing	*Area 1*		*Area 2*		*Area 3*	
	No.	*% male*	*No.*	*% male*	*No.*	*% male*
1957-58	46	*48*	22	*82*	25	*60*
1958-59	40	*50*	29	*65*	30	*60*
1959-60	43	*47*	30	*67*	33	*55*
1960-61	12	*67*	15	*80*	22	*68*
1961-62	19	*63*	21	*76*	19	*53*
1962-63	15	*33*	11	*91*	10	*90*
1963-64	18	*61*	17	*59*	15	*67*
1964-65	19	*74*	20	*80*	27	*78*
1965-66	6	*17*	16	*81*	16	*50*
1966-67	26	*58*	20	*85*	17	*77*
	244	*54.6*	201	*75.0*	214	*63.0*

In Area 1, with an overall 54.5%, the sex ratio is only slightly more biased towards the males than for recoveries in Britain. Certainly the small difference could be explained by such factors as the males completing their moult, and so coming under fire, earlier in the season than the females.

Recoveries in Area 2

Mallard recovered in Area 2 are clearly of mixed origin. Some are local breeding stock, others will be passing through to or from Area 1. The recovery rates for the first four seasons after ringing are set out in Table VI. This indicates that Area 2 males are present in Northamptonshire in numbers similar to, though somewhat greater than, those from Area 1. From November onwards Area 2 males nearly double in proportion to the situation in the early part of the season. There is no indication of any abrupt and continuing change around 1960. There are, however, indications of massive changes in individual seasons, very few immigrants in 1964-65, unusually many in 1966-67. These presumably relate to weather conditions in the years concerned.

The Area 2 females appear to be present in Northamptonshire in only small numbers before November. Thereafter they fluctuate widely from season to season, but the usual situation seems to be that many fewer come than do from Area 1. The seasons of influx, 1958-59, 1959-60, 1963-64, 1965-66, do not coincide with those of the males.

The outstanding feature of Area 2 recoveries is the astonishing imbalance

Table VI. Rate of recovery (per thousand ringed) of Borough Fen Mallard in Area 2, for the first four seasons after ringing.

	Males ringed July/October	*Males ringed November/March*	*Females ringed July/October*	*Females ringed November/March*
1957-58	16	30	3	6
1958-59	16	22	2	22
1959-60	13	17	2	19
1960-61	21	22	4	0
1961-62	13	17	3	7
1962-63	10	27	0	7
1963-64	10	22	3	25
1964-65	11	9	2	4
1965-66	22	30	2	20
1966-67	7	47	3	4
All seasons	13	23	2	12
Total No. recoveries	84	46	15	28

of the sex-ratio. Table V shows this to be consistent through the years and, overall, that there are 75% males, three to every female. One would not expect such a difference from Area 1 (55% males) because many of the explanations for the Area 2 ratio would also seem to apply to Area 1. For instance, adult males are on the wing earlier in the autumn than the females, so more males are at risk at the beginning of the shooting season, when shooting pressure is likely to be at its highest.

Abmigration could be biasing the sex-ratio if sedentary British males were selectively pairing with foreign females and following them on migration. But there appears little difference in the numbers of Area 2 and Area 1 females arriving in Britain before November, and thereafter Area 1 females are much more plentiful. Again, the seasons when there were late influxes of Area 2 females do not consistently coincide with or precede seasons with large numbers of male recoveries. Another postulate is that males of sedentary British stock, although willing to pair off with a foreign female, have an inbuilt resistance to flying long distances. A mixed pair might thus come to rest in the intermediate area as a compromise between conflicting tendencies.

Recoveries in Area 3

The Mallard recovered in this Area will be of the most mixed origins, including not only those breeding there but others passing through on the way to and from both Areas 2 and 1. The recovery rates are set out in Table VII. These indicate that before November males from Area 3 are about as plentiful in Northamptonshire as those from the other two areas. From November onwards they are rather more likely to be present, but not markedly so. Some fluctuations between seasons are indicated but on the whole the results are pretty homogenous.

The females again lag behind the males in coming to England, but rather more have reached us by the end of October than from the other areas. This probably reflects an early completion of the breeding season. However, no more seem to come from November onwards than from the more distant Area 2. Likewise, there are wide fluctuations from season to season.

The males are still predominant among the recoveries, comprising 62.9%. However, this is unexpectedly lower than that for the more distant Area 2. If abmigration is playing a part it would seem that the rather higher incidence of Area 2 females early in the season would provide more, not less, opportunities for inter-population crosses. However, it might be also argued that, if the Area 3 females finish breeding earlier, there is more chance of them mating up with their own males and migrating with them to England. The situation can hardly be said to be clear.

Further considerations on abmigration

If abmigration is a possible explanation of the sexual imbalance of the overseas recoveries, it might be expected to show more clearly in juvenile males. These could be expected to have less attachment to their homeland than mature birds that had bred there for at least one season. It was explained earlier that the ageing of males was not a reliable technique after the end of October, which greatly reduces the sample available for comparison. This does show a slight tendency for juvenile males to have a higher recovery

Table VII. Rate of recovery (per thousand ringed) of Borough Fen Mallard in Area 3, for the first four seasons after ringing.

	Males ringed July/October	*Males ringed November/March*	*Females ringed July/October*	*Females ringed November/March*
1957-58	9	29	5	12
1958-59	8	37	7	16
1959-60	10	23	6	13
1960-61	16	78	9	20
1961-62	8	21	8	11
1962-63	10	18	2	0
1963-64	8	22	3	10
1964-65	10	32	3	9
1965-66	14	30	11	40
1966-67	11	9	4	4
All seasons	10	27	6	12
Total No. recoveries	67	54	36	36

rate abroad, though the difference is not significant in itself (Table VIII). However, one must take into account the much higher mortality among juveniles. For birds ringed before the end of October, this will mostly be in the autumn and winter in Britain. There will thus be proportionately less birds marked as juveniles left to give overseas recoveries. If we express the latter not per thousand ringed but per estimated thousand ringed and surviving to, say, the following April, we have overall rates juveniles 89, adults 66. This does provide some rather stronger suggestion that the juveniles are more prone to abmigrate.

Table VIII. Rate of recovery (per thousand ringed) of Borough Fen Mallard males, ringed July/October.

	Juveniles		*Adults*	
	No.	%	*No.*	%
Area 1	64	*11*	6	7
Area 2	70	*12*	10	*12*
Area 3	72	*12*	10	*12*
All areas	206	*35*	26	*29*

Rather few wild Mallard are ringed in England as pulli and thus of undoubted English origin. However, the Wildfowlers' Association of Great Britain and Ireland (W.A.G.B.I.) have reared over 126,000 young Mallard of wild stock over the last twelve years. These have been ringed and released on reserves, i.e. not for immediate shooting. Nearly 9,000 subsequent recoveries have been reported. Post-fledging dispersal may carry some birds, especially from the southern English counties, overseas to the mainland continent. Harrison and Wardell (1962) therefore restricted the term abmigrant to those recoveries overseas made after the end of the year of release. Wardell (1967) reviewed the situation when 130 such probable abmigrants were known and records in succeeding W.A.G.B.I. Annual Reports to 1969-70 have raised the total in this category to 150 recoveries. But since by no means all of the birds have been sexed on release (giving a sex-ratio near unity), only 79 are useful for our present purpose. In Area 1 there were 12 males against seven females; in Area 2, 16 males against six females. As far as they go these figures would confirm the selective abmigration of males, even to the higher ratio in Area 2. However, the recoveries in Area 3 completely confuse the issue for here there were 13 males and 25 females. One would need to postulate that not only were post-fledging dispersals predominantly in this area, but also that young females were more prone to wander than males. It would seem safer at present to accept the indication of the overall sex ratio of the recoveries, 41 males: 38 females, that abmigration is not predominantly confined to males.

The W.A.G.B.I. results did indicate a higher proportion of abmigrants (2.8-5.0 per thousand birds released) from the eastern regions of Britain than from the midland and western regions (0.4 to 1.9 per thousand). This accords well with the observation that Continental immigrants are recovered mainly in eastern Britain (Matthews 1963), i.e. where they provide greater opportunities for inter-population crosses.

Variation of immigration within and between seasons

The data are not extensive enough to allow a consideration of immigration influxes on a monthly basis Area by Area. However, we have seen that, apart from the first three seasons in Area 1, the males from the three areas have given rather similar results. We can, therefore, with some confidence, combine the results for the males for consideration on a monthly basis (Table IX). Those months marked

Table IX. Rate of recovery (per thousand ringed) overseas of Borough Fen male Mallard, for the first four seasons after ringing.

	Males ringed in										*Total*
	July	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Year*	*recoveries*
1957-58	x	x	35	26	144	48	257	x	x	67	46
1958-59	x	79	31	55	72	85	x	x	x	58	48
1959-60	x	20	42	27	43	30	72	200	x	40	49
1960-61	x	0	69	80	64	x	x	x	x	62	32
1961-62	x	14	68	0	38	x	48	38	79	47	31
1962-63	x	96	27	34	38	x	x	x	x	33	22
1963-64	x	23	36	25	70	x	68	x	x	35	29
1964-65	16	48	28	32	25	x	x	x	124	36	46
1965-66	22	7	59	54	x	x	x	x	x	39	21
1966-67	x	28	32	63	55	38	x	108	x	39	45
Ten years	16	29	40	38	57	47	96	86	90	37	
Total recoveries	2	40	143	54	54	19	24	18	15		369

(x) are when insufficient birds were ringed to give a reasonable chance of a recovery. The limit has been taken, rather arbitrarily, as 30 birds per month (see Table I).

Taking the male ten-year figures first, it is clear that the foreign element is lowest in July and August and slightly larger in September and October. It rises sharply in November, falls again in December (perhaps as migrants disperse or pass through) and reaches its highest value in January and February and maintains it in March. When we consider the results season by season, the foreign element has been remarkably stable in the more recent years, settling down from the early high level, due mainly, as we have seen, to the change in the Area 1 pattern.

Turning to the consideration of months within particular seasons, it is noticeable that for males August is a month of wide variations. However, the August values, high or low, are not continued on through the succeeding months and it is probable that movements separate from the main seasonal migration, e.g. the moult migration, are involved. September is a homogenous month, with only two values deviating widely from the mean. In 1960 the high value was continued into October and we can properly speak of an unusually marked early autumn wave of migrants. In 1961, however, the October value was low. There was another low October in 1963 and a high one in 1966. November values were not widely spread, but there were obviously extraordinarily many foreign males in 1957 and rather few in 1964.

From December onwards the picture with regard individual months largely collapses because of inadequate numbers of birds caught. This is a serious weakness of duck decoys, that their catches of Mallard fall away at the interesting time of the year as far as foreign immigrants are concerned. As can be seen from Table I efforts have lately been made to boost the catch at Borough Fen during the winter months. An inland decoy faces particular difficulties in severe weather since not only will the pond freeze, but the Mallard will tend to move coastwards to the still open estuaries. The Trust's recently-acquired decoy at Nacton, Suffolk, may be better placed in this respect and clearly emphasis will have to be laid on late winter catches here and at the trapping station on Abberton Reservoir, Essex.

Turning to the females, one should exercise more caution in combining the results from the three areas, when quite considerable differences have been detected between their migratory patterns. However, for the sake of completeness, and to draw comparisons with the males, this has been done in Table X.

The ten-year figures indicate that the foreign female element is lower than the male in every month except December. It builds up more strongly and smoothly to a peak in that month which is carried over into January and February. Unlike the males, there is a drop in March. As with the males, the female foreign element has remained remarkably consistent from season to season, after dropping from a high level in the first two. We have seen, however, that a low British-bred Mallard population in those years may have inflated the apparent proportion of foreign birds present.

On the individual months level, August is again variable, but the female high and low incidences seldom coincide with those of the males. Likewise September is more homogenous for arrivals and a high value

Table X. Rate of recovery (per thousand ringed) overseas of Borough Fen female Mallard, for the first four seasons after ringing.

	Females ringed in										*Total*
	July	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Year*	*recoveries*
1957-58	x	x	12	16	55	75	48	88	x	35	26
1958-59	x	25	12	37	48	89	88	x	x	41	37
1959-60	x	18	15	7	24	41	176	111	x	28	37
1960-61	x	0	20	32	56	x	0	x	x	22	12
1961-62	x	8	12	13	28	26	20	80	29	18	17
1962-63	x	0	6	0	44	x	x	x	x	14	8
1963-64	x	24	3	12	20	x	59	x	x	20	16
1964-65	0	0	10	10	24	x	x	x	x	10	13
1965-66	15	13	15	0	x	x	x	x	x	24	15
1966-67	x	15	6	19	20	89	29	0	x	18	18
Ten years	6	10	11	15	33	72	75	74	62	19	
Total recoveries	1	13	39	22	36	36	25	18	9		198

for 1960 is recorded for females as well as males, and again carries forward into October. The rest of that month appears more variable than, and not coincident with, the male pattern. In November the high and low of the males in 1957 and 1964 are matched by the females, but the latter's high in 1960 is more exaggerated. From December onwards the monthly picture is again incomplete.

The general lack of coincidence between male and female peaks and lows suggests that they do not reflect population changes but, rather, changes in weather conditions. As the males and females time their migrations differently, they will seldom be influenced by the same weather unless it is very widespread.

Conclusions

It is clear that in any programme of research, or management, concerned with the immigration of foreign Mallard into Britain, we must differentiate between the sexes.

If the requirement is to study definitely British-bred stock then it is best to concentrate on females from July to September though even as late as October their foreign element is small. It is relatively high in the males throughout the season, though much higher after the turn of the year.

There has been relatively little variation in the foreign element over ten years and it is probable that, as in Britain itself, there are seldom wide fluctuations in the breeding success of Mallard in the North-west European flyway.

The problems of abmigration appear to have been added to, rather than solved by the present study. The extraordinary imbalance of the sexes in Area 2 remains a mystery.

As far as planning of the ringing effort is concerned it is clear that the late-winter results are inadequate and must be increased, in conjunction with the east coast stations. A theoretical alternative would be to abandon late winter ringing in Britain and rely on the birds coming to us being adequately ringed in their natal areas. However, international co-operation is not yet sufficiently far advanced for such a rationalisation.

It has been suggested that ringing of Mallard could be reduced earlier in the season to cut administrative costs at the ringing office. The companion study of the recoveries in Britain will enable decisions to be made on the quota of birds needed to be ringed per unit time to provide statistically satisfactory data on such aspects as changes in dispersion and mortality from year to year. The indications already are that current levels are seldom enough when one researches in depth. What the present study does show is that there are no grounds for cutting down on any one autumn month because the birds caught then are particularly mixed in their origins. October in fact differs little from September in this respect. The foreigners really only start to mount up in November, by which time the difficulties of catching are already providing their own ceiling.

Acknowledgements

We would like to thank the British Trust for Ornithology for making available all the recovery information on which this paper is based. Robert Hudson, of the B.T.O., kindly allowed access to details of recoveries in Britain of Mallard ringed abroad. T. A. Gibson carried out the laborious task of compiling several large tables of basic data. Prof. G. V. T. Matthews greatly improved an early draft of the paper. Finally we are grateful to the shooters of north-west Europe for returning the rings.

This study was carried out while the authors were employed by the Wildfowl Trust, financed by grants from the Natural Environment Research Council.

Summary

Mallard *Anas platyrhynchos* ringed at Borough Fen Decoy, Northamptonshire, include a proportion of winter visitors of foreign origin. The sex ratio at ringing is close to 1 : 1 but the overseas recoveries show a marked preponderance of males in Denmark, Germany and Poland (75%) but only slightly larger numbers in France and the Low Countries or in Scandinavia and the U.S.S.R.

Much larger numbers of males from the most eastern area came to Britain after 1st November in the first three years of the study (1957-58 to 1959-60) than have since. Recoveries in Britain of Mallard ringed overseas appear to confirm this finding. No such changes have occurred relating to areas closer to Britain.

Abmigration may be a cause of the sexual imbalance of the recoveries.

Differences between seasonal recovery patterns are examined.

Philippa Scott

Plate XI. Two recently acquired species in the Slimbridge collection. (a) Young male Musk Duck *Biziura lobata* from Western Australia, with the incipient lobe under its bill. (b) Male White-winged Wood Duck *Cairina scutellata* from Assam, preening its wing coverts.

Philippa Scott

Philippa Scott

Plate XII. (a) Barnacle Geese *Branta leucopsis* flying over Eastpark Farm, Caerlaverock, against the loom of Criffel. The Trust took the lease of the farm in June 1970 (see pp. 150-153).
(b) The fine new entrance building and shop at Peakirk were opened by H.R.H. the Duchess of Gloucester in April 1970.

E. E. Jackson

References

ATKINSON-WILLES, G. L. and J. C. FRITH. 1965. Trends in the populations of British wintering ducks 1961-64. *Wildfowl Trust Ann. Rep.* 16 : 21-29.

BAUER, K. M. and U. N. GLUTZ VON BLOTZHEIM. 1968. *Handbuch der Vögel Mitteleuropas.* Vol. 2 : 408-10. Frankfurt am Main: Akademisches Verlagsgesellschaft.

BOYD, H. and M. A. OGILVIE. 1961. The distribution of Mallard ringed in southern England. *Wildfowl Trust Ann. Rep.* 12 : 125-36.

HARRISON, J. G. and J. WARDELL. 1962. W.A.G.B.I. hand-reared Mallard as abmigrants. *W.A.G.B.I. Ann. Rep. 1961-62* : 29-33.

LAMPIO, T. and H. K. MICHAELIS. 1971. Wildfowl hunting seasons and methods in Europe 1969-70. *Proc. Int. Conf. Conservation Wetlands and Waterfowl, Ramsar.*

MATTHEWS, G. V. T. 1963. 'Nonsense' orientation as a population variant. *Ibis* 105 : 185-97.

THOMSON, A. L. 1931. On 'abmigration' among the ducks: an anomaly shown by the results of bird-marking. *Proc. 7th Int. Orn. Congr., Amsterdam.*

WARDELL, J. 1967. W.A.G.B.I. hand-reared Mallard as abmigrants. *W.A.G.B.I. Ann. Rep. 1966-67* : 51-53

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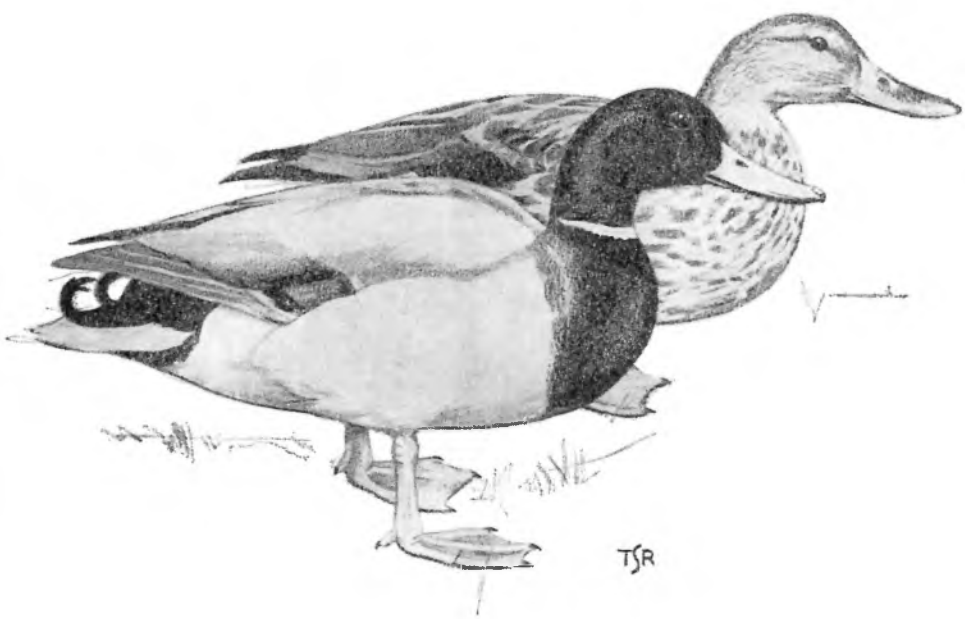

Further experiments in dispersal of phytoplankton by birds

KATHLEEN M. ATKINSON

Introduction

In an attempt to see whether planktonic algae could be dispersed through transport in the gut of waterfowl, cells of the freshwater planktonic diatom *Asterionella formosa* Hass. were fed to Mallard *Anas platyrhynchos* (Atkinson 1970). No viable cells were found in the faeces. Traces of only a few *Asterionella* cells were found either in the droppings or in the cultures made from these droppings, although several thousand cells had been ingested. The diatoms have a complex poroid siliceous wall, so the cells have a characteristic shape and wall markings even after death. It had been expected that these silica 'shells' would be readily seen in the duck faeces, especially after acid cleaning with a mixture of nitric and sulphuric acids to remove organic debris. It did not seem likely that all the cells were being ground up in the gizzard (larger fragments of food grains were often found in the faeces) nor was it likely that the silica would be digested by the duck. However, it was possible that the *Asterionella* shells might have been eliminated before or after the time (4-20 hours later) at which the droppings were collected. A further set of experiments was therefore carried out to test this point.

The experiments

Four female Mallard were isolated in a closed room and fed on grain. The organisms to be tested were added to the drinking water, and observation was kept on the ducks until they had been seen to drink. The methods of collection and treatment of the droppings were as described previously (Atkinson 1970).

Preliminary observations were made by feeding Mallard with *Lycopodium* spores, which are easily detected in the faeces by microscopic examination and have been successfully used for this purpose in chickens (Harwood 1937). Many *Lycopodium* spores were seen in droppings collected 1-3 hours after the drinking water containing the spores had been removed from the duck. Many continued to be observed in droppings collected up to 25-27 hours later, a few even up to 51 hours. A repeat experiment carried out six days later gave similar results. It therefore appeared that droppings collected any time from 1-27 hours after the ducks had been fed with planktonic diatoms might be expected to contain diatoms or their silica 'shells'.

Pairs of a species of Cyanophyta and of five diatom species—all common planktonic algae—were fed to the four ducks, which were allowed access to the culture for one hour. The species used as test organisms were:

Cyanophyta
- *Oscillatoria* sp.

Bacillariophyta
- *Asterionella formosa*
- *Fragilaria crotonensis*
- *Melosira* sp.
- *Tabellaria flocculosa* (Roth) Kütz, var. *flocculosa* (*Tabellaria* A)
- *T. flocculosa* var. *asterionelloides* (Grun. in V.H.) Knud. (*Tabellaria* B)

The droppings were collected at times varying between 1-23 hours after withdrawal of the plankton. The results of the experiments are shown in Table I. By direct observation of a 3 ml. sample of the droppings, a very few cells were seen in only two of the seven samples examined. On acid cleaning half of the preserved faeces from each experiment, *Melosira* threads (usually 2-6 cells long) and single cells of *Asterionella* and *Tabellaria* were seen in all six samples examined. (*Oscillatoria* would be destroyed by acid cleaning as the cell walls are not silicified.)

In cultures of samples made from the droppings no sign of growth of any of the test species was directly observed, although in all the cultures *Chlorophyceae* were growing well. Acid cleaning of these cultures however, in every case, showed up cells of the different diatom test species and many of these cells were apparently undamaged externally. In the first two experiments the numbers of *Melosira* cells found on acid cleaning were considerable and suggest that there may have been growth of *Melosira* not seen by direct observation, at least in Experiment 1B. The numbers of *Asterionella, Fragilaria* and both *Tabellaria* spp. were small in each culture and there had probably not been any growth. *Asterionella* and *Tabellaria* were found only as

Table I. Results of experiments.

Expt. No.	*Food*	*Time after feeding (hours)*	*Droppings direct observation*	*Droppings acid cleaned*	*Culture (acid cleaned)*
1A	*Melosira* and *Oscillatoria*	1 - 3	*Melosira* 3 cells *Oscillatoria* (3 threads)	*Melosira* (20-50)	*Melosira* (20-50)
1B	idem	6 - 22	None	Not examined	*Melosira* (1000)
2A	*Asterionella* and *Fragilaria*	1 - 2½	None	*Melosira* (10-20)	*Melosira* (20-50) *Fragilaria* (20-50) *Asterionella* (<10)
2B	idem	4 - 6	*Melosira* (<10)	*Asterionella* (<10)	*Melosira* (60) *Fragilaria* (<10) *Asterionella* (<10)
3A	*Asterionella* and *Tabellaria* A	1½ - 4	None	None	*Asterionella* (10-20)
3B	idem	6½ - 22½	None	*Asterionella* (20-50) *Tabellaria* (<10)	*Asterionella* (<10)
4A	*Tabellaria* B and *Oscillatoria*	1½ - 3½	None	*Tabellaria* (10-20)	*Tabellaria* (20-50)
4B	idem	6 - 22½	Not examined	*Tabellaria* (<10)	*Tabellaria* (20-50) *Asterionella* (10-20)

single cells and not in colonies as is normal under natural conditions. It can be seen from the Table that cells of both *Melosira* and *Asterionella* were still to be found in the acid cleaned cultures or droppings on the day following the feeding of the diatom to the Mallard.

We conclude that while all the test species of phytoplankton were passed through the gut of the Mallard, often apparently undamaged, only *Melosira* had remained in a viable condition.

Acknowledgements

Once again I should like to thank Professor G. V. T. Matthews, for the facilities provided at Slimbridge to enable me to undertake these experiments, and Dr. J. Kear and Dr. M. Owen for advice and helpful discussion throughout.

Summary

Lycopodium spores fed to Mallard *Anas platyrhynchos* as a marker were found in the faeces from 1-51 hours after feeding. Five species of planktonic diatom and one Cyanophyte were fed to Mallard and their cells found in the faeces. Only *Melosira* sp., which was found in very large numbers in one culture, had passed through the gut in a viable condition.

References

ATKINSON, K. M. 1970. Dispersal of phytoplankton by ducks. *Wildfowl* 21 : 110-111.

HARWOOD, P. D. 1937. The frequency of change of cecal contents in fowls. *Proc. Helminth. Soc. Wash.* 4 : 38-39.

Kathleen M. Atkinson, Freshwater Biological Association, Ferry House, Ambleside, Westmorland.

Food and feeding habits of the Common Eider at Seafield, Edinburgh, in winter

P. V. PLAYER

Introduction

The Common Eider *Somateria m. mollissima* is mainly a winter visitor to Seafield, on the Firth of Forth at Edinburgh, arriving at the beginning of October and leaving in the middle of May, although a few may be seen during the summer months. Seafield, as an Eider wintering area, has slowly grown in importance over the last decade. A maximum of 270 birds was recorded in 1959 but in 1967, 2,900 were to be found (D. G. Andrew, pers. com.), a figure which was exceptional at this time. However, at present 2,000 birds are resident for most of the winter, with numbers occasionally reaching 2,900 (Player 1970).

From observations and ringing returns it appears that most of the birds wintering here come from East Lothian and the Farne Islands, two important breeding centres, but some may come from further north. It is possible, although unlikely, that the population is boosted by Continental birds. This occurs in south-east England, but the distances involved are smaller and Eiders tend to restrict their movements to within 200 km. of their birthplace.

Description of the area

Over 90% of the diving ducks wintering on the south shore of the Firth of Forth occur between the shipping entrance to Leith Docks (Grid ref. NT 263787) and Portobello Power Station (Grid ref. NT 316744) (see map Figure 1).

In this area there are five discharges into the sea, of which two are purely industrial—Portobello Power Station discharging cooling water and Scottish Agricultural Industries (S.A.I.) discharging gypsum. The other three pipes send out both industrial and domestic sewage. These are the east and west Water of Leith sewers, and Seafield sewer.

Of these five pipes, Seafield is the only one to have any form of treatment before entry to the sea. Here there is detritus screening and maceration while the others exude untreated matter.

In 1969 approximately 30.5 million gallons per day of effluent entered the sea. Actual figures are not available as there are no gauging stations on the sewers.

The industrial effluents are from paper mills, breweries, distilleries, chemical plants, electrical engineering plants, maltings, and a slaughter house (Anon 1962).

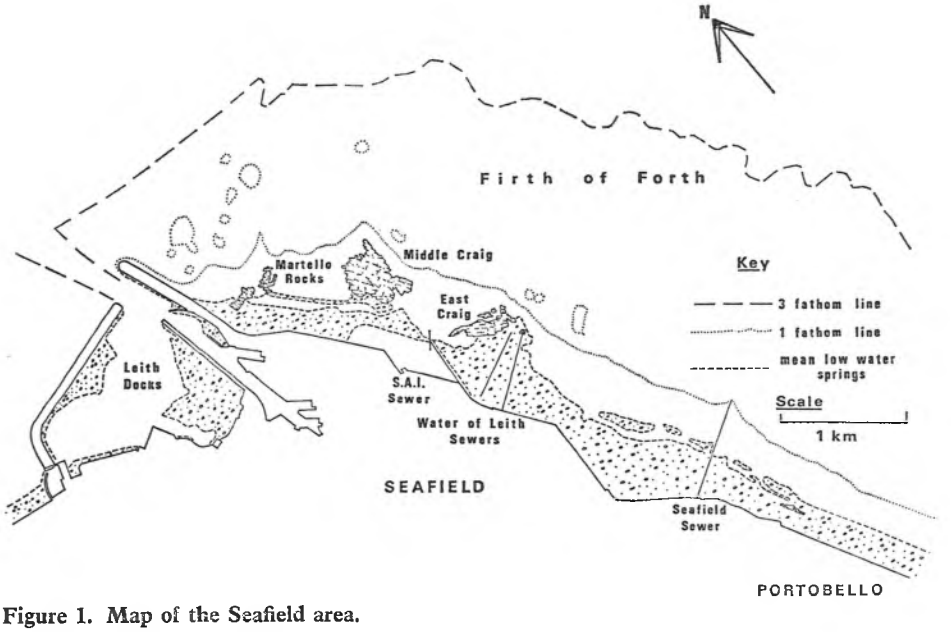

Figure 1. Map of the Seafield area.

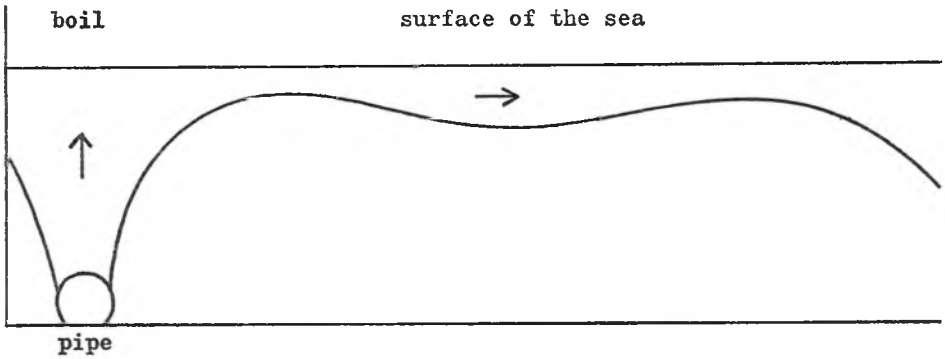

Figure 2. Profile of a sewage slick.

These effluents form a slick, which on a calm day can be seen for several miles out to sea. Figure 2 shows a profile of a sewage slick. As fresh water is less dense than sea water it rises to the surface to form a slick. This slick swings east and west with the tide. The fresh water on the surface has a calming effect similar to, but less distinct from, that of oil.

However, wind is the main factor which affects wave height. It has been found that the sea remains calm if the wind comes from the west to south-east sector, even though it may be blowing at 40 k.p.h. This is due to the protection given by the hill Arthur's Seat (height 250 m.) and by the Leith Dock industrial complex. Table I shows that the wind comes from this sector, or is calm, for over three-quarters of the duck wintering period October to April. It may be that ducks are attracted both by the calm sea and by the large amounts of waste material which enter the Forth every day.

Table I. The direction of the wind from October to April, expressed as per cent.

NW	6		SE	8
N	4		S	11
NE	6		SW	19
E	7		W	25
		Calm 14		

The maximum numbers of each species of duck recorded are: Eider 2,900, Long-tailed Duck *Clangula hyemalis* 762, Goldeneye *Bucephala clangula* 4,000, Scaup *Aythya marila* 35,000, and Pochard *Aythya ferina* 1,000, although it is believed that the entire wintering flock of Pochard at Duddingston Loch 2.5 km. inland (4,000-8,000 birds) come down to feed at night. The greatest number of ducks recorded on the area is 40,000, in January 1970 (D. G. Andrew, pers. com.).

Methods

The methods of analysis of stomach (= gullet + proventriculus + gizzard) contents have been described in detail by Olney (1963, 1970). Eiders were collected when they were feeding. Even so many had only small amounts of food in their stomachs. These were removed in the laboratory a few miles away and placed in formo-saline solution. The various species of food were identified and the number of stomachs in which a species occurred was listed as its 'frequency'. The amount of alcohol which each food species displaced gave its 'volume'. Food items vary in their resistance to the chemical and mechanical processes of digestion. This is especially so in carnivorous birds. For instance, hard crab claws remain for a long time, while the flesh of molluscs rapidly passes into the intestine. Therefore in the present case, and following Madsen (1954), more reliance is placed on the frequency with which food items occur than on their volume.

Results

Fifty birds were collected over the period November 1969-March 1970 consisting of 22 adult males, 8 juvenile males, 10 adult females, and 10 juvenile females, all of which contained food.

The number of different food species observed is plotted against the number of birds examined in Figure 3. With an increase in the number of specimens examined, fewer new food species appear and the curve approaches a horizontal line. New food species are found for

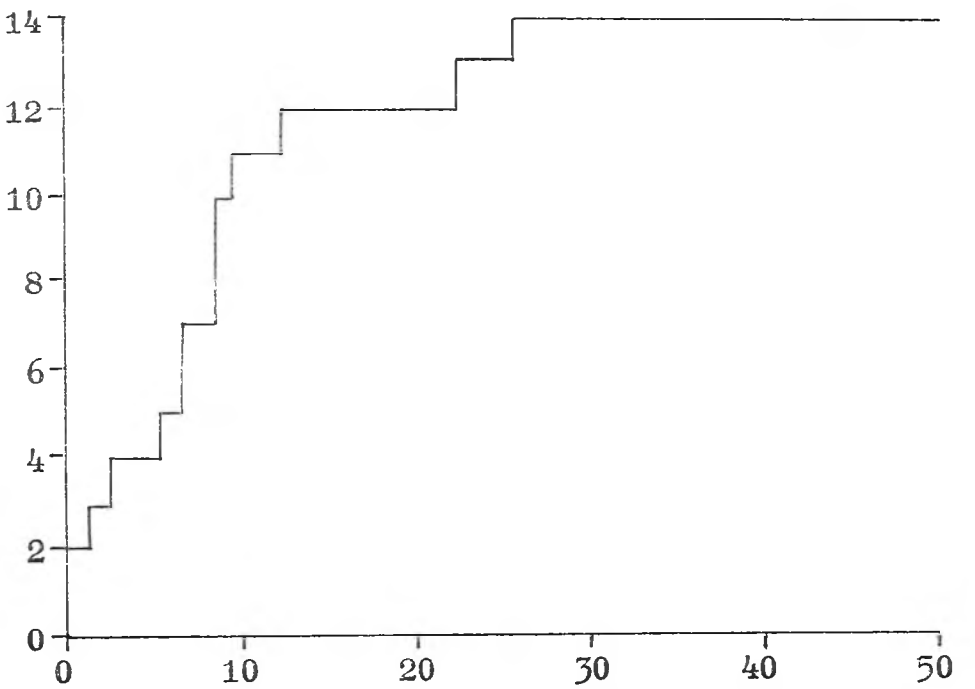

Figure 3. The total number of different food species found (vertical scale) for each additional bird in the sample examined (horizontal scale).

about the first 20 birds examined, after which new items appear infrequently. Hence, the total sample would appear to be large enough to give reliable results on the food of the Eider at Seafield.

Pethon (1967) found a sample of 20 Eiders to be sufficient, but his birds were eating 27 food species compared to the Seafield Eiders' 14. Likewise, Geramisova and Baranova (1960) found 25 food species. The difference may be partially accounted for in that the Norwegian and White Sea samples were collected in the summer when food organisms are more plentiful.

The complete list of food items is shown in Table II.

Molluscs, mainly the Blue Mussel

Table II. Stomach contents of 50 Eiders.

	Frequency	*Frequency %*	*Volume (ml.)*	*Volume %*
ANIMAL MATERIAL				
Mollusca - Bivalvia				
Mytilis edulis	47	94	531.0	70.8
Cardium edule	1	2	—	—
Mollusca — Gastropoda				
Littorina littorea	5	10	2.4	0.3
Buccinum undatum	3	6	1.0	0.1
Crustacea				
Carcinus maenas	12	24	146.6	19.6
Portunus depurator	4	8	38.0	5.1
Hyas araneus	2	4	16.5	2.2
Balanus spp.	2	4	13.0	1.7
Nematoda				
Spirurida spp.	3	6	—	—
Annelida				
Nereis spp.	2	4	—	—
PLANT MATERIAL				
Barley	3	6	0.8	0.1

Mytilis edulis, constituted the principal food of the Eiders in the Forth. They were taken by 47 (94%) of the birds examined and made up the bulk of the stomach contents. 30 stomachs (60%) contained *Mytilis edulis* alone. The size of mussel eaten varied from 1 to 41 mm. Figure 4 shows the size distribution of mussels in the stomachs of the Forth Eiders. The two peaks 4-7 mm. and 10-13 mm. are not due to selection by the birds, but represent two age classes (either separate years or spring and autumn settlement). Prior to the last sample in March the histogram was skewed in favour of mussels of 16 mm. upwards, reaching a peak at 28-31 mm. Of the mussels available on the rocks 65% were over 40 mm. in length. Hence there is selection for the smaller sizes under 30 mm.

The number of mussels in the stomach contents varies and was usually difficult to estimate because some shells were crushed. However, one bird was found to contain 239 mussels ranging in size from 2-24 mm. Madsen (1954) found one Eider had eaten 1,600 mussels varying in size from 3-20 mm. plus 15 Shore Crabs *Carcinus maenas* of up to 20 mm. carapace breadth, and the remains of six small Common Sea Stars *Asterias rubens*. The only other bivalve found in the Scottish sample was the Common Edible Cockle *Cardium edule* which occurred in a single bird.

Periwinkles *Littorina littorea* had been consumed by five birds (10%). Usually, only a single or a few individuals were present in these stomachs. Their size ranged between 12 and 15 mm. The Common Whelk *Buccinum undatum* was taken by three birds (6%) and varied in size from 20 to 38 mm.

Crustaceans were present in 34% of the birds; the commonest being the Shore Crab which had been taken by 24%. The size of this crab ranged from a carapace breadth of 31 to 52 mm.; one bird contained three of size 50, 49 and 43 mm. Other crabs eaten were the Swimming Crab *Portunus depurator* 8%, and the Spider Crab *Hyas araneus* 4%. Crabs were found in nine out of ten birds in the November sample and only three more times in the later birds.

Barnacles *Balanus* spp. were found in two of the stomachs (4%) but had probably been taken in with the mussels on which they live. Nematodes and errant polychaete worms were found in 6% of the birds, probably those feeding near the Middle Craig (Figure 3). Barley husks were taken by 6% of the sample. This was the only vegetable consumed and originated from the sewage.

Gravel and small stones 5 mm. or less in size were found in 31% of all the specimens examined, being present in every bird feeding mainly on crustaceans but in only 60% of those eating molluscs.

Feeding behaviour

The feeding grounds during the winter are on and around the rocks near Leith Docks. The most important is the Middle

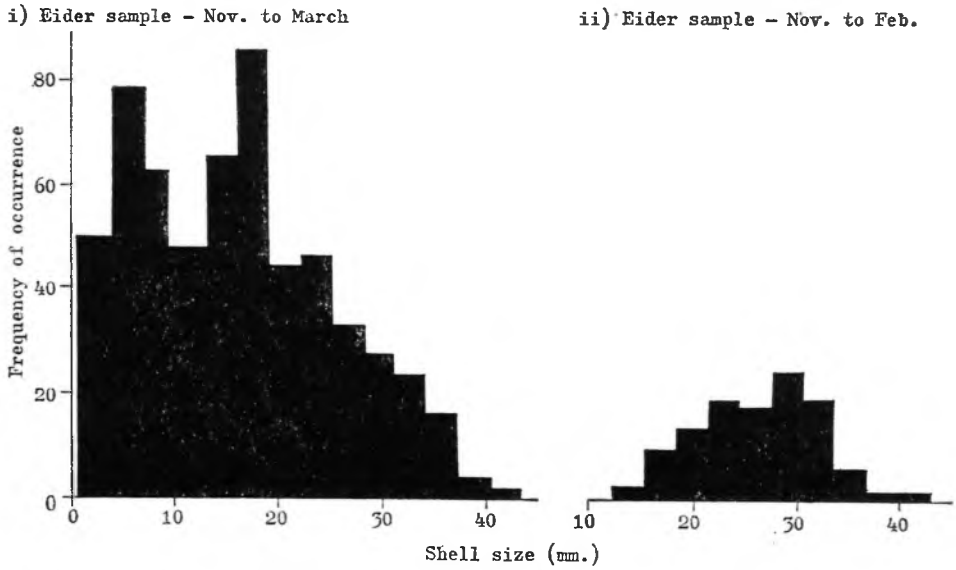

Figure 4. The size distribution of *Mytilus edulis* in the stomachs of Eider Ducks.

Craig where up to 1,500 Eiders may be found feeding over the rocks or resting 100 metres further out.

On a typical day, 6th April 1970 at 06.50 G.M.T. when the tide was going out there were 465 birds feeding in the channel between Middle Craig and the Martello rocks, where 480 were feeding. The channel feeders seemed to prefer about 15 cm. of water where they could dip or up-end like dabbling ducks. Table III gives an estimation of invertebrates has been observed at all states of the tide. The preferred depth is 2-3 metres. When in large parties (over 50 birds) the Eiders do not seem to dive for food, it is usually restricted to groups of 20 or fewer birds. Unlike Pochard, Scaup and Goldeneye, the Eider does not make an initial jump when diving but simply put its head into the water and half opens its wings just before it passes beneath the surface. Millais (1913) found that Eiders swim under the water with their necks slightly

Table III. The invertebrate population in the channel at Middle Craig.

Species	*Depth*	
	0-10 cm.	*10-20 cm.*
	No./1000 cc.	*No./1000 cc.*
Spirurida spp.	600	11,000
Nereis spp.	150	240
Capitella capitella	75	30

on the bottom there, mainly polychate and nematode worms.

When the Eider has eaten many of the invertebrates in the upper layers of the substrate by up-ending or dipping, it digs a crater and thus exposes the richest concentrations. This is done by 'sitting' fairly upright in the water and pushing the dead mussel shells aside with its feet like a hen scratching for insects. The bird then explores with its beak the hole it has just made and continues scratching and searching until it has found sufficient, or until the invertebrates within easy reach have been eaten. In this 'cratering' method of food exploration the bird will often move in a circle around the 'crater'. As the tide ebbs the Eiders move with it, 15 cm. of water seeming the preferred depth (Plate Vb, p. 56).

This method of feeding, so far as I know, has not been recorded before. It is possible that Seafield Eiders alone have evolved this behaviour for feeding on these invertebrates which are plentiful only landward of the Middle Craig and Martello Rocks. However, since wintering birds come from the Farnes and East Lothian, one could expect the behaviour to spread rapidly as happened with Blue Tits *Parus caeruleus* and milk bottles. It has been found that the Eiders nesting around the estuary of the Lothian Tyne show similar behaviour in June when in the company of young, searching for food in mud near the river bank.

It appears that crater feeding, up-ending and dipping are preferred to diving, possibly since less energy is required for such dabbling around. Diving takes place mostly on the open sea and usually at low tide, although it curved and inclined backwards, the wings still half open but not in use, and the feet working alternately.

Daily activity

Pethon (1967) observed Eiders 24 hours a day during the summer months in Norway. He found that the birds spent the night ashore and started feeding at daybreak. Most of his birds fed for about four hours after they had gone to sea. Feeding then slowed down for several hours, usually 09.00-16.00 G.M.T. when half the birds were resting ashore. In the last five hours of daylight some feeding again took place. As the amount of daylight decreased, the midday rest also decreased so that in the winter there might be only one peak feeding period. Hence from this study it may be concluded that the majority of Eider feed once a day at dawn and to a lesser extent at dusk.

In Norway, however, the difference between high and low tide is very small, whereas at Seafield the difference varies between 2.7 and 5.5 metres. The Seafield Eiders prefer to feed at low tide when less effort is required in searching for food. Bent (1926) found Eiders preferred low tide, but when the rising tide forced too great an exertion in diving, they move off to some other feeding ground or rested and played until the tide was favourable once more. He found them resorting to the same rocks every day at certain stages of the tide, as long as the food lasted. Bent suggested that the reason why Eiders do not feed at night was because, unlike other ducks, they were not disturbed on their feeding grounds.

Few birds were found feeding at Seafield at midday even when the tide was out. They do not feed at dusk either, but flight out to sea in a north-easterly direction, returning at dawn. Their feeding cycle is controlled by the tide and the time of day. With a favourable tide Eiders begin feeding at sunrise, cease by 10.00 G.M.T., commence again by 13.00 G.M.T. and leave for the open sea at sunset (Table IV). At high tide during the day, long lines of Eiders, of which only a few are feeding, may be seen 1 km. offshore.

Table IV. The percentage of Eiders feeding during the day (4th May 1970).

Time	*No. of Eiders present on the study area*	*% Eiders feeding*
Before 05.30	0	0
06.00-07.00	551	100
08.00-09.00	621	38
10.00-11.00	834	5
13.00-14.00	653	36
18.00-19.00	712	96
After 19.15	0	0

Low tide at 07.14 and 19.45. Sunrise 05.41. Sunset 19.00 GMT.

Dementiev *et al.* (1952) described how Eiders fed four times daily, at high and low tides, in the summer months in Arctic Russia. However, Mackay (1890) told of a similar situation in America to that at Seafield. He found that the birds flew out to sea after an evening meal and returned before daylight, alighting outside the rocks and swimming in as a compact body. The Seafield Eiders also prefer to alight on the sea and swim in, rather than land on the rocks. This is probably due to the legs of an Eider being situated posteriorly and so making landings on a hard surface more difficult.

During the morning influx 95% of the birds come from the north-east and to a certain extent follow the coastline, so that when approaching the rocks they are coming from an easterly direction. The other 5% come from the west-north-west, probably having spent the night in the sheltered waters of Inchkeith.

Discussion

No attempt at the quantitative analysis of the Eider's winter food in Britain has been made, other than the inadequate study of Collinge (1924). There have been some qualitative accounts such as those of Evans (1909), Robinson (1909) and Florence (1912). However, detailed quantitative studies have been made in Europe and (with the very similar races *S. m. dresseri* and *S. m. borealis*) in North America. Madsen (1954) summarised his own examination of 296 stomachs, together with the results of earlier workers, such as Collinge (1924), Schiøler (1925), Cottam (1939) and Soot-Ryen (1939). He found general agreement that molluscs form the principal food of the Eider and that, in marine habitats, *Mytilus edulis* is the prominent item, constituting between 30% and 60% of the total. Later studies have confirmed Madsen's conclusions. Thus Gerasimova and Baranova (1960) in the Soviet White Sea found the mussel comprising 36-61% of Eider food; McGilvrey (1967) in the NE. United States, 70% (by volume); Pethon (1967) in Norway, 29%; Nilsson (1970) in S. Sweden, 87%. The results of the present study fit in the upper end of the range.

The previous studies also agree with the present one in according second place to crustaceans, especially crabs, but also amphipods. Pethon (1967) reports a seasonal change in diet from mainly *Mytilus* in spring and summer to mainly crustaceans in August to October. The Soviet studies in particular have indicated dietary changes when birds are in the breeding quarters and especially when accompanying young. However, it is not the purpose of this paper to attempt a complete review of the literature. This has recently been done by Bauer and Glutz (1969).

Conclusions

Unlike the majority of studies on the food and feeding habits of birds, this paper investigates such activities in a strongly man-modified environment. The effects of sewage have increased the numbers of food organisms available but reduced their diversity. Molluscs, crustaceans, annelids and nematodes are the beneficiaries of pollution.

So huge is the available food supply that the area holds one of the largest duck

concentrations in Western Europe. However, such a population could easily be wiped out by an accidental oil spillage. In December 1969 between 100 and 200 ducks were killed by an oil slick on the Forth estuary. Fortunately, the slick only affected the eastern end of the Seafield flock; otherwise there would have been a catastrophe. Within the next ten years Edinburgh sewage will be treated before discharge and this is likely to reduce the amount of food available and hence the numbers of ducks to be found in the area.

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Summary

The food and feeding habits of the Common Eider *Somateria m. mollissima* are described, based on stomach analyses of 50 birds collected between November 1969 and March 1970 from Seafield, Edinburgh. A maximum of 40,000 diving ducks and 2,900 Eiders have been recorded there, attracted by a plentiful food supply and a calm sea. The main foods of the Eiders are molluscs and crustaceans, obtained by diving, up-ending, dipping and scratching out craters. Their feeding cycle is controlled by the time of day and by the tide.

References

ANON. 1962. The Lothians River Purification Board Annual Report. Edinburgh.

BAUER, K. and U. N. GLUTZ VON BLOTZHEIM. 1969. *Handbuch der Vögel Mitteleuropas,* Bd. 3 : 199-205. Frankfurt am Main: Akademisches Verlagsgellschaft.

BENT, A. C. 1926. Life histories of North American Wildfowl. *Smithsonian Inst. Bull. U.S. Nat Mus.* 130 : 1-376.

COLLINGE, W. E. 1924-7. *The Food of some British Wild Birds.* York: Collinge.

COTTAM, C. 1939. Food habits of North American diving ducks. *Tech. Bull. U.S. Dept. Agric.* 643 : 1-139.

DEMENTIEV, G. P. and N. A. GLADKOV. 1952. *Birds of the Soviet Union.* Vol. 4. Moscow: Gosudarstvennoe izdatelstvo 'Sovetskaya Nauka'.

EVANS, W. 1909. The food of the Eider. *Brit. Birds* 3 : 165-6.

FLORENCE, L. 1912. The food of birds. *Trans. High. Agric. Soc. Scot.* 24 : 180-219.

GERAMISOVA, T. D. and Z. M. BARANOVA. 1960. Ecology of Common Eider in the Kandalaksha Sanctuary. *Proc. Kandalaksha Game Reserve* 3 : 55-68. (In Russian)

MCGILVREY, F. B. 1967. Food habits of sea ducks from the north-eastern United States. *Wildfowl Trust Ann. Rep.* 18 : 142-5.

MACKAY, G. H. 1890. The American Eider. *Auk* 7 : 315-9.

MADSEN, F. J. 1954. On the food habits of diving ducks in Denmark. *Danish Rev. Game Biol.* 2 : 157-266.

MILLAIS, J. G. 1913. *British Diving Ducks.* Vol. 2. London: Longmans.

NILSSON, L. 1970. Non-breeding ecology of diving ducks in southernmost Sweden. Unpublished thesis, University of Lund.

OLNEY, P. J. S. 1963. The food and feeding habits of the Teal, *Anas c. crecca. Proc. zool. Soc. Lond.* 140 : 169-210.

OLNEY, P. J. S. 1970. Food habits of wildfowl. Pages 86-97 in *The New Wildfowler in the 1970's* (Ed. N. M. Sedgewick, P. Whittaker and J. C. Harrison). London: Barrie and Jenkins.

PETHON, P. 1967. Food and feeding habits of the Common Eider. *Somateria mollissima. Nytt Mag. Zool.* 15 : 97-111.

PLAYER, P. V. 1970. The food and feeding habits of diving ducks at Seafield, Edinburgh. Unpublished thesis, University of Edinburgh.

ROBINSON, H. W. 1909. The food of the Common Eider. *Brit. Birds* 2 : 344.

SCHIØLER, L. 1925. *Danmarks Fugle.* Vol. 2. Copenhagen.

SOOT-RYEN, T. 1941. Undersoklser over erfuglens naering. *Tromsø Mus. Aarsh.* 59 : 1-42.

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Goose feeding and cellulose digestion

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Introduction

The domestic goose *Anser anser*, in common with many of its wild relatives, is primarily a grazer and it can be raised satisfactorily on grass alone (Bögre 1967; Wright 1942). Some naturalists have assumed that the goose has a cellulose digesting mechanism (Lorenz 1952). Such a capacity would seem to be of real advantage to a grazing animal, for, not only would the cellulose represent an energy source, but the dissolution of the cellulose wall of the grass cells would make the cell contents more readily available for digestion. A literature search failed to give evidence with which to judge the validity of such an assumption and so a study of goose digestion was made (Mattocks 1971). An outline of some of this work is given in this paper.

Review of literature

Cellulose is a carbohydrate consisting mainly of glucose units linked together by $\beta 1-4$ bonds (Rogers and Perkins 1968) and, presumably because the molecule is folded into a zig-zag ribbon which itself is wound into a helix (Manley 1964), it is particularly resistant to hydrolytic cleavage. A complex process involving a number of enzymes is thought to be necessary to convert cellulose to glucose (Norkrans 1967; Reese *et al.* 1950; Gascoigne and Gascoigne 1960), a substance which can be readily used by an animal.

Some insects, such as the silver fish *Ctenolepisma lineata*, are undoubtedly able to produce cellulases (Lasker and Giese 1958), while others are suspected of having this ability. Snails have been shown to digest cellulose (Galli and Giese 1959), but whether the cellulases are of molluscan or microbial origin is an issue not entirely resolved. There is general agreement, however, that no vertebrate is itself capable of secreting cellulases (Marshall 1960; Moir 1965). Horses have evolved large colons and caeca, which house a prolific symbiotic microbial population able to carry out cellulose digestion (Davies 1968). In the rabbit it is the caecum and the appendix which are enlarged for the same purpose, and the overall efficiency of the system is increased by virtue of the fact that the animal eats and digests the faecal pellets it produces during the night (Eden 1940). The ungulates, including the cow, sheep and goat, have developed the most efficient methods. They have capacious rumens in which the food is allowed to ferment for about twelve hours. The cellulose is converted by huge numbers of bacteria (up to 10^{14} organisms/ml.) and ciliates into volatile fatty acids, mainly acetic, propionic and butyric acids, which are absorbed directly into the blood stream (Halliwell 1961; Hungate 1950, 1966; Mann 1968; Walker 1968). The microfauna and microflora are subsequently digested in the rest of the digestive tract.

Cellulose digestion in birds has received very little attention except in the domestic hen. Work done in Germany nearly fifty years ago suggested that cellulose digestion did occur (Mangold 1928, 1931, 1934; Radeff 1928; Henning 1929) but Groebbels (1932) disagreed. More recently cellulose has been found to be so consistently indigestible in cockerels that it has been used as a marker to trace the passage of food in the gut (Bolton 1954). The Ruffed Grouse *Bonasa umbellus* apparently has some ability to digest cellulose but lost weight on a diet of the male flower buds of the trembling aspen *Populus tremuloides* which contain a high proportion of cellulose (Hill *et al.* 1968). In the Red Grouse *Lagopus lagopus* no cellulose and lignin digestion was found when the daily intake was about 80 gm. dry matter per day. If the intake was reduced to 60 gm., however, 20% of the cellulose was digested (Moss 1967).

The question arises as to whether or not there is present in the alimentary canal of a bird an organ wherein cellulose digestion can occur.

Characteristically birds possess a lateral pair of blind-ending tubes called caeca which arise at the junction of the small and large intestines (Figure 1). The variations in form and type have been investigated thoroughly (Mitchell 1901; Maumus 1902; Pinchon 1942). In parrots there is no trace of any caecum and in the falcons and hawks it is very much reduced or absent. By contrast members of the grouse family have very long caeca, that of the Capercaillie *Tetrao urogallus* approaching 1 m. in length. Curiously the herons and their relatives are unique among birds in having a single caecum arising latro-ventrally on the right.

There have been many attempts to classify avian caeca, but basically three

kinds are distinguishable: the plain type which is not well vasculated, usually has much lymphoidal tissue and in which the lumen is small and simple and may contain secretions but never ingesta; the sacculate type in which the lumen is well developed and filled with material from the intestines, and a transitional type. A correlation is found between the possession of large sacculate caeca and a vegetable diet. However, the nocturnal owls have pronounced sacculate caeca, whereas their diurnal counterparts, the hawks and falcons whose food is so similar, have no caeca. Wildfowl have, as might be expected, thin walled, sacculate caeca reaching 10 cm. in most ducks and 30 cm. or more in the swans.

It is very tempting to presume that the avian caecum is functionally a kind of rumen with a cellulose digesting function. Howie and Baker (1952) declared that in non-ruminants the part of the gut most resembling the rumen was the caecum. Both organs contain vast numbers of bacteria (Barnes and Shrimpton 1957; Hungate 1966). Certain groups of bacteria—bacteroides (Barnes and Goldberg 1962), streptococci lactobacilli and coliforms (Barnes and Shrimpton 1957) are found in the caecum of the hen and also in the cow rumen (Hungate 1966). Ciliates abound in the rumen but apparently no protozoa live in the avian caecum except as pathogens (G. Monachon, pers. com.).

Alimentary canal of the domestic goose

A number of varieties of domestic goose was studied, but, since no significant differences were found in them, a single description is given. The bill is strong, and lamellae in the upper and lower jaws arranged in two rows parallel with, and lateral to, the edges of the tongue superficially resemble ungulate molars and premolars. The ridges on the lamellae of the upper jaw running across those on the lower jaw presumably enhance their gripping action. No sideways grinding action can take place in the goose. The thick, spatulate tongue which virtually fills the buccal cavity bears a pronounced fringe of backwardly directed hair-like processes.

The oesophagus (35 cm.), although broadening out a little before joining the proventriculus (7 cm.), has no crop (Figure 1). The gizzard (10 cm.) is very large and its walls consist of concentric arcs of thick muscle fibres. Opposed, thick, cornified, bright yellow patches of keratin-like koilin are present on the inner walls. About 15 gm. of stones and sand together with fibrous residue are found in the gizzard lumen. The small intestine (224 cm.) is fairly uniform in diameter and has a small blind-ending process, Meckel's diverticulum, somewhat posterior to the mid-point. At the junction of the small and large intestine, two lateral caeca arise, the left one being

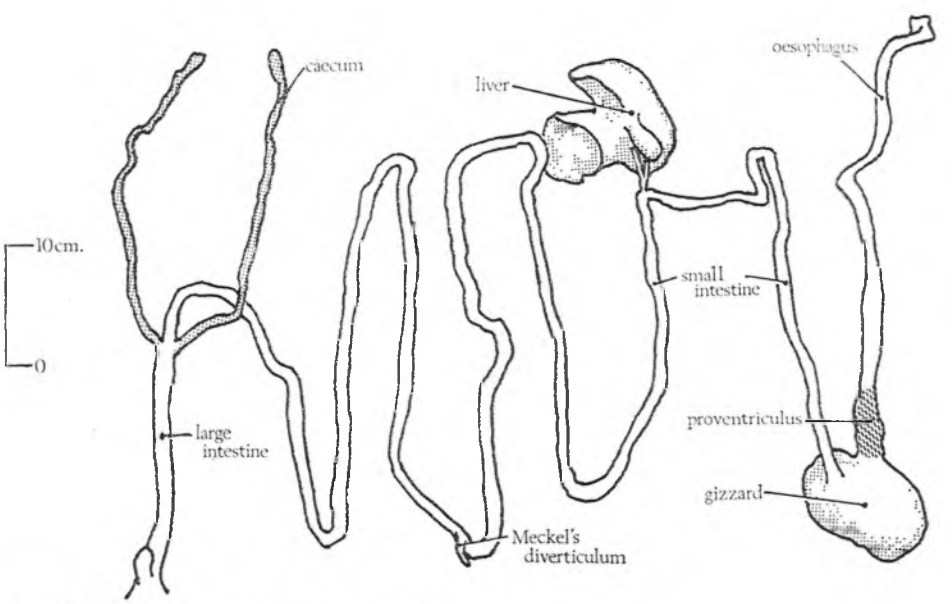

Figure 1. Alimentary canal of a domestic goose.

slightly shorter (21 cm.) than the right one (26 cm.). The lengths given are the average of ten specimens. Most sections of the gut are just under 1 cm. in diameter and variations in length and slight dilations are not uncommon particularly at the distal end. The caeca contain a homogeneous viscous paste with a pronounced smell and of a dark-green, almost black colour. The large intestine or colon is much shorter (about 16 cm.), than the small intestine, but slightly wider in diameter (Figure 1).

Bacteriology of the goose gut

The bacteria present in the various parts of the gut were ascertained by direct microscopical examination of stained smears, and by culturing in various media under anaerobic conditions. Coliforms, relatively plentiful in the oesophagus, decrease in the gizzard and the anterior part of the small intestine, until in the Meckel's diverticulum and onwards they are absent. There is believed to be some form of autosterilisation in the gut (Köhlbrugge 1901; Fuller and Moore 1967), through its own secretions or those of the liver. Lactobacilli were not found, as might be expected in view of the high pH of most of the gut. Faecal streptococci were curiously absent. An abundance of starch-utilizing clostridia was surprising, though their spores probably survive the autosterilisation. It is worth noting that no trace of starch, as determined by the iodine test, was found posterior to the middle of the small intestine. Possibly there is a connection between the rapid digestion of starch and the incidence of clostridia. At no time, in any part of the gut, were protozoa seen, although they were looked for with diligence.

The bacteria of the caeca were examined with especial care in view of their possible function in cellulose digestion. A general habitat-simulating medium (including liver extract, l-cysteine and dithiothretol—Dr. D. J. Jayne-Williams pers. com.) was first used. Sampling was carried out anaerobically in an atmosphere of 99% CO_2 and 1% H_2 the gases having been passed over a cold catalyst to ensure that they were oxygen free. A sterile, needleless, gas-filled plastic hypodermic syringe was used to extract samples below the surface of the exposed caecal contents. Decimal dilution was carried out using small stoppered Astell bottles, gas being passed through continuously whenever the stoppers were withdrawn. Incubation was at 39°C. in Petri dishes placed in McIntosh and Fildes jars containing an atmosphere of 95% H_2 and 5% CO_2 and dry catalysts (palladinised asbestos). The results indicated an overall bacterial count of the order of 10^{10} organisms/gm. wet weight. Niche-simulating media, each suitable for a narrower spectrum of micro-organisms were then used to obtain more specific information. These included Elsden's medium (Elsden *et al.* 1956), ethyl violet medium (Baird-Parker 1957), as modified by Fuller and Lev (1964), Reinforced Clostridial medium, Seeley and Dain (1960) medium and de Man *et al.* (1960) medium. Spread plates were prepared with the ethyl violet and Elsden media and pour plates for the others.

The results, again obtained under carefully anaerobic conditions, indicated that peptostreptococci (2.7×10^9 organisms/gm. wet weight), clostridia (1.7×10^8/gm.), streptococci (2.0×10^7/gm.), bacteroides (9.0×10^4/gm.) and lactobacilli (2.3×10^4/gm.) were present, in descending order of frequency. Clearly the caecum is a congenial place for anaerobic bacteria. Any sterilizing agent produced in the small intestine does not penetrate effectively into the caecum. Starch-utilizing streptococci were found to be about ten times more abundant in the proximal than in the distal end of the caecum; but this ratio was reversed for the bacteroides. The flora of the so-called caecal faeces showed a close correspondence with that of the caecum, confirming their origin.

Tests were now made to see whether any of the anaerobic bacteria present in the goose caecum were capable of cellulose digestion. Bottles containing the medium of Mann (1968) and rolled rectangles, 6 × 5 cm., of filter paper (Whatman's No. 1), were inoculated with caecal material. As before great care was taken to maintain anaerobic conditions during sampling, dilution and incubation. Control bottles were inoculated with the contents of an ox rumen. Both sets were incubated for ten days. The filter paper exposed to goose caecal contents was entirely unchanged. In the ox rumen bottles, however, pits which had appeared in the filter paper within 24 hours continued to increase in size and number and there was production of gas. Microscopical examination revealed concentrations of cocci and other bacteria, all Gram-positive, around the pit margins.

Filter paper is usually considered more susceptible to degradation than its raw counterpart. All factors necessary for

microbial activity were present for not only was their Seitz-filtered rumen liquor present in the medium, but also the initial concentrated inoculum contained plenty of caecal material (0.5 ml.). We can therefore conclude that those bacteria capable of breaking down cellulose which were clearly present in the material from the ox rumen were absent in the goose caecum. Of course there is no guarantee that the medium and technique used was suitable for all kinds of cellulolytic anaerobes.

Goose feeding technique

The birds feed on grass, or meal, for a large proportion of the hours of daylight. The grazing technique is to tilt the head slightly and stretch the neck out to grasp a blade of grass so that it is across the bill. The neck is then withdrawn, the grass fracturing either at the edge of the bill or further down the stem. No mastication of any kind is seen but, by repeatedly moving the head back with the mouth closed and forwards with the mouth open, the birds manoeuvred the grass blade towards the oesophagus. The tongue is also used to manipulate the grass. When feeding on wet meal, no tilting of the head occurs.

Through-put times

The original intention was to determine the time taken for food material to pass through the alimentary canal by using an inert marker. Many such substances have been used including magenta, aluminium powder (Browne 1922), polyethylene glycol (Williams and Wilkins 1968), chromic oxide (Raymond and Minton 1955), lamp black and methylene blue (Kaupp and Ivey 1923). There is some evidence, however, that these substances themselves affect the through-put time (Soergel 1968; Jensen *et al.* 1962) and so other techniques were looked for. Introducing a 'natural' marker gave through-put intervals averaging 82 minutes when grass in meal was used, 122 minutes with cotton strands in grass. X-ray techniques using food containing radio-opaque barium sulphate have been used on the goose (Rybicki 1965) but the adulterant is very dense and the handling of the birds is necessary, so it was thought better to use less drastic methods. Birds killed for dissection in the early morning were all found to have no food left in their alimentary canals. Thus an 'initial' through-put time could be determined by finding the interval between the first morning feed and the passing of the first faeces with food in them. The shortest interval recorded was 26 minutes, but average values were 44 minutes with meal and 71 minutes with grass. If birds which had been feeding on meal only were presented with grass or *vice versa*, the change in faeces was abrupt and easily noted. 'Mid-feed' through-put times on changing from grass to meal averaged 119 minutes and for the reverse change, 137 minutes. All the above averages were based on 10 timings, 5 on one bird, 5 on another. Clearly, food normally stays in the alimentary canal for only about two hours.

Faeces

Four distinct kinds of faeces were produced. The most common was a cylinder of very moist 'chewed' grass with a cap of white uric acid crystals. A small quantity of bile pigment was present but the main colouration was unchanged chlorophyll. The pieces of grass were readily identifiable and apparently very little changed by the bird's digestive processes. The second type appeared when the animal had eaten meal and differed from the first type by being a little shorter and consisting of brown fibrous matter. The uric acid, although present, was less conspicuous than in the grass faeces and there was enough bile pigment to impart a faint green colour to the stool. The third type was very much wetter than the first two types and consisted of a dark brown watery splodge with a pronounced odour and a rich microflora indicating its caecal origin. The last kind consisted of uric acid crystals in a watery mucous medium. The absence of colour or particulate matter other than uric acid crystals suggests that this type is exclusively of renal origin

Discussion

It is clear that in geese no mastication takes place in the mouth. The absence of a crop is to be expected in an animal which grazes most of the day, food being swallowed in small quantities constantly over a long period of time. The oesophagus may, however, serve as a functional crop, particularly towards the end of the day when the rate of feeding tends to rise (Owen 1971). The fact that the grit the gizzard holds contains a high proportion of sand, prompts the suggestion that its principal function is to puncture the grass cells rather than to grind the blades. The appearance of the grass in the faeces shows little evidence of a grinding of the kind exercised by a cow. Lengths of leaf

up to 25 mm. long are quite common and they seem surprisingly intact.

In flying birds, excess weight must be kept to a minimum and so a quick and thorough digestive action is to be expected. Nevertheless, it was a surprise to find that the through-put time for the goose was as short as two hours. In mammals it is measured in days rather than hours, two days being usually quoted for human beings. With such a rapid, piston-like action it is hardly likely that much breakdown of cellulose could take place. The caecum might serve as a reservoir into which food could be shunted to be dealt with in a protracted way, but no trace of any recognisable food-plant tissue nor cells therein were found. Possibly a kind of straining mechanism controlled by the sphincter at the base of the caecum excludes all but the liquid and the most finely divided particles. X-rays of geese fed with meal adulterated with barium sulphate have shown no caecal shadows although traces of barium sulphate left behind in the folds of the oesophagus have been readily seen (Rybicki 1965). It seems unlikely that any large quantity of food enters and is retained by the caecum. The zoning of bacterial types within the caeca argues against any mixing of their contents. In any case, the capacity of the two caeca are less than 20 ml. and they would have to be emptied and refilled many times per day to handle the amount of food ingested.

The failure to find any cellulose-splitting bacteria in the caecum lends weight to the view that cellulose digestion is not a main function of the caecum.

There is a possibility that the caeca assist in the absorption of water or of the soluble products of digestion. Another suggestion has been that excretory nitrogen might be recycled through the caeca. Again, vitamin B_{12} has been shown to be 100 times more plentiful in the caeca of normal chickens than in germ-free ones (Coates *et al.* 1963). Chickens kept on wire, and so prevented from eating their faeces, require a higher proportion in their diet (Shrimpton 1954). It is thus possible that geese might pick up caecal-synthesised B_{12} when grazing on caecally contaminated pastures. In cases where ruminants eat goose-droppings (Kear 1966) one wonders whether the vitamin content might be an attractant as well as undigested grass or phosphates from egested grit.

It might be that the caeca are not concerned with metabolism at all. Ruminants and horses have been shown to contain antibodies in their blood against strains of anaerobic bacteria isolated from the bovine rumen (Sharpe *et al.* 1969). The intestinal flora, providing a small but unremitting source of antigenic stimulation for the production of such antibodies, may be responsible for what might be termed autovaccination. A goose, with its remarkably brief through-put time, would have no resident flora in the alimentary canal. It might be particularly susceptible to an infection were it not for the possession of a cul-de-sac where a prolific flora could be housed.

As a final speculation on caecal function smell seems relevant, for to have kept geese is to be aware that, associated with caecal droppings, there is a pronounced, repugnant odour. Birds mostly have a poor sense of smell and are unlikely to be discommoded. However, geese spend much of their time on the ground and are thus liable to attack by mammalian predators and to competition from mammalian competitors. The caecal discharge might serve the function of deterring such animals, even though Rochard and Kear (1970) have shown any repellent effect is short-lived.

General conclusions

Geese in the wild state are largely, but by no means exclusively, grazers (Kear 1966). It would appear unlikely that cellulose digestion contributes in any significant way to their food up-take. Cell sap appears to be the chief source of nourishment extracted from grass and hence the goose is an inefficient grazer, requiring a much larger *pro rata* intake than a ruminant.

By the reverse token, if geese in captivity are fed on an easily assimilable diet of high calorific value, the through-put rate is so high that the animal is able to grow very rapidly (Monachon 1964). The force-feeding of geese with up to 1000 gm. per day is common on farms in Hungary and France in the interests of the production of *fois gras*.

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Summary

The domestic goose *Anser anser*, a grazing species, takes in considerable quantities of cellulose as part of its food. Investigations were carried out to discover whether cellulose is digested in the gut to any extent. The experiments and techniques for establishing through-put rates are discussed. It is unlikely that cellulose digestion contributes significantly to the goose's food up-take.

References

BAIRD-PARKER, A. C. 1957. Isolation of *Leptotrichia buccalis* and *Fusobacterium* sp. from oral material. *Nature, Lond.* 180 : 1056.

BARNES, E. M. and H. S. GOLDBERG. 1962. The isolation of anaerobic, Gram-positive bacteria from poultry reared with and without antibiotic supplements. *J. Appl. Bact.* 25 : 94.

BARNES, E. M. and D. H. SHRIMPTON. 1957. Causes of greening of uneviscerated poultry carcases during storage. *J. Appl. Bact.* 20 : 273.

BÖGRE, J. 1967. L'importance économique de la race d'oie Landaise. Université des Science Agricoles—chaire de Zootechnie, Gödöllö, Hongrie.

BOLTON, W. 1954. The digestibility of the carbohydrate complex of bran and oats by adult cocks. *Proc. 10th Wld's Poult. Congr. Edinburgh* : 94.

BROWNE, T. G. 1922. Some observations on the digestive system of the fowl. *J. Comp. Path. Ther.* 35 : 12.

COATES, M. E., M. E. GREGORY, J. W. G. PORTER *and* A. P. WILLIAMS. 1963. Vitamin B_{12} and its analogues in the gut contents of germ-free and conventional chicks. *Proc. Nutr. Soc.* 22 : 27.

DAVIES, M. E. 1968. Rôle of colon liquor in the cultivation of cellulolytic bacteria from the large intestines of the horse. *J. Appl. Bact.* 31 : 286.

EDEN, A. 1940. Coprophagy in the rabbit: origin of night faeces. *Nature, Lond.* 145 : 628.

ELSDEN, S. R., B. E. VOLCANI, F. M. C. GILCHRIST and D. LEWIS. 1956. Properties of the fatty acid-forming organisms isolated from the rumen of sheep. *J. Bact.* 72 : 681.

FULLER, R. and M. LEV. 1964. Quantitative studies of the Gram-negative anaerobic bacteria in the pig alimentary tract. *J. Appl. Bact.* 27 : 434.

FULLER, R. and J. MOORE. 1967. The inhibition of the growth of *Clostridium welchii* by lipids isolated from the contents of the small intestines of the pig *J. Gen. Microbiol.* 46 : 23.

GALLI, D. R. and A. C. GIESE. 1959. Carbohydrate digestion in a herbivorous snail *Tegula funebralis*. *J. Exp. Zool.* 140 : 415.

GASCOIGNE, J. and M. GASCOIGNE. 1960. *Biological Degradation of Cellulose.* London: Butterworths.

GROEBBELS, F. 1932. *Der Vögel.* Berlin: Verlag von Gebrüder, Borntraeger.

HALLIWELL, G. 1961. *On Digestion Physiology and Nutrition of the Ruminant.* London: Butterworths.

HENNING, H. 1929. Die Verdaulichkeit der Rohfaser beim Huhn. *Landwn. Vers. Stnen.* 108 : 253.

HILL, D. C., E. V. EVANS and H. G. LUMSDEN. 1968. Metabolized energy of aspen flower buds for captive ruffed grouse. *Wildl. Mgmt.* 32 : 854.

HOWIE, J. W. and F. BAKER. 1952. Rumen and caecal organisms as symbionts. *Proc. R. Soc.* 139 : 193.

HUNGATE, R. E. 1950. The anaerobic mesophilic cellulolytic bacteria. *Bact. Rev.* 14 : 1.

HUNGATE, R. E. 1966. *The Rumen and its Microbes.* London: Academic Press.

JENSEN, L. S., L. H. MERRILL, C. V. REDDY and J. MCGINNIS. 1962. Observations on eating patterns and rate of food passage of birds fed pelleted and unpelleted diets. *Poult. Sci.* 41 : 1414.

KAUPP, B. F. and J. E. IVEY. 1923. Time required for food to pass through the intestinal tract of fowls. *J. Agric. Res.* 23 : 721.

KEAR, J. 1966. The food of geese. *Intern. Zoo Yearbk., Zool. Soc. Lond.* 6 : 96.

KÖHLBRUGGE, J. H. F. 1901. Die Autosterilisation des Dünndarmes und bie Bedeutung des Coecum. *Zentbl. Bakt. Parasitkde* 29 : 571.

LASKER, R. and A. C. GIESE. 1958. Cellulose digestion by the silverfish, *Ctenolepisma lineata*. *J. Exp. Biol.* 33 : 542.

LORENZ, K. Z. 1952. *King Solomon's Ring.* London: Methuen.

MANGOLD, E. 1928. Die Physiologischen Funktionen des Blinddärms, allgemein und besonders bei den Vögeln. *Sber. Ges. naturf. Freunde Berl.*, Dec. : 217.

MANGOLD, E. 1931. Die Verdauung bei den Vögeln. *Proc. 7th Int. Orn. Congr. Amsterdam* : 206.

MANGOLD, E. 1934. Die Verwertung der Planzlichen Rohfaser beim Menschen und den Tieren. *Sber. Ges. Naturf. Freunde Berl.* : 345.

MANLEY, R. ST. J. 1964. Fine structure of native microfibrils. *Nature, Lond.* 204 : 1155.

de MAN, J. C., M. ROGOSA and M. E. SHARPE. 1960. A medium for the cultivation of Lactobacilli. *J. Appl. Bact.* 23 : 130.

MANN, S. O. 1968. An improved method for determining cellulolytic activity in anaerobic bacteria. *J. Appl. Bact.* 31 : 241.

MARSHALL, A. J. 1960. *Biology and Comparative Physiology of Birds.* London: Academic Press.

MATTOCKS, J. G. M. 1971. Some aspects of the problem of cellulose digestion and caecal function in the domestic goose. Unpublished M.Sc. thesis, University of Bath.
MAUMUS, J. 1902. Les Caecums des oiseaux. *Annls. Sci. nat. VIII, Serie Zoologie* 15 : 2.
MITCHELL, P. C. 1901. On the intestinal tract of birds; with remarks on the valuation and nomenclature of zoological characters. *Trans. Linn. Soc. Lond.* 8 : 173.
MOIR, R. J. 1965. *The Comparative Physiology of Ruminant-like Animals.* London: Butterworths.
MONACHON, G. 1964. *Quelque reflexions sur l'élevage et l'habitat des oies.* Domaine Experimental d'Artiguères Banquet, Landes, France.
MOSS, R. 1967. Aspects of grouse nutrition. Unpublished Ph.D. thesis, University of Aberdeen.
NORKRANS, B. 1967. Cellulose and Cellulolysis. *Adv. Appl. Microbiol.* 9 : 91.
OWEN, M. 1971. Some factors affecting food intake and selection in White-fronted Geese. *J. Appl. Biol.* (in press).
PINCHON, R. 1942. Thèses: Contribution a l'étude morphologique des caecums dans la série des oiseaux. Université de Paris.
RADEFF, T. 1928. Uber die Rohfaserverdauung beim Huhn und die Hierbei dem Blinddärm zukommende Bedeutung. *Biochem. Z.* 193 : 192.
RAYMOND, W. F. and D. J. MINTON. 1955. The use of chromic oxide for estimating the faecal production of grazing animals. *J. Br. Grassld. Soc.*, 10 : 282.
REESE, E. T., R. G. H. SIU and H. S. LEVINSON. 1950. The biological degradation of cellulose derivatives and its relationship to the mechanism of cellulose hydrolysis. *J. Bact.* 59 : 485.
ROCHARD, J. B. A. and J. KEAR. 1970. Field trials of the reactions of sheep to goose droppings. *Wildfowl* 21 : 108.
ROGERS, H. J. and H. R. PERKINS. 1968. *Cell Walls and Membranes.* London: Spon Ltd.
RYBICKI, M. 1965. X-ray observations on the passage of food in *Anser anser* L. *Zoologica Polon.* 15 : 2.
SEELEY, H. W. and J. A. DAIN. 1960. Starch hydrolysing streptococci. *J. Bact.* 79 : 230.
SHARPE, M. E., M. J. LATHAM and B. REITER. 1969. The occurrence of natural antibiotics to rumen bacteria. *J. Gen. Microbiol.* 56 : 353.
SHRIMPTON, D. H. 1954. The utilization of the intestinally synthesized riboflavin and vitamin B_{12} by poultry. *Proc. 10th Wld. Poult. Congr. Edinburgh.*
SOERGEL, K. H. 1968. Inert markers. *Gastroenterology* 54 : 449.
WALKER, D. J. 1968. Energy utilization for polysaccharide synthesis by mixed rumen organisms fermenting soluble carbohydrates. *Appl. Microbiol.* 16 : 1672.
WILLIAMS, R. J., and M. W. WILKINS. 1968. Suitability of polyethelene glycol as a dilution indicator in the human colon. *Gastroenterology* 54 : 331.
WRIGHT, M. M. 1942. An observation on the feeding of cut grass to goslings. *Harper Adams Util. Poult. J.* 27 : 117.

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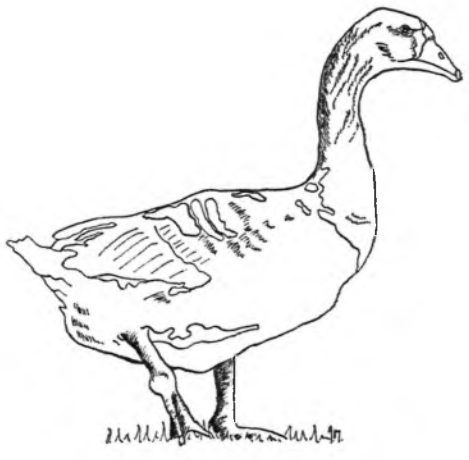


On the autumn food of Barnacle Geese at Caerlaverock National Nature Reserve

MYRFYN OWEN and R. H. KERBES

Introduction

Most British species of geese now feed on agricultural land or on pastures which have been extensively changed by man. The Barnacle Goose *Branta leucopsis* on the Solway Firth spends much of its time on the merseland of Eastpark Farm at Caerlaverock National Nature Reserve (Roberts 1966). The term 'merseland' is applied to pasture subject to tidal flooding and includes low level terraces and high level grazed salting. It is a type of habitat which, although affected by agricultural practice, was in existence before man and his grazing animals modified much of the British lowlands.

The amount of information on the food of Barnacle Geese is extremely small, the only quantitative data published on winter feeding in Britain being those of Campbell (1936, 1946). His results relate to gut analyses of 27 birds shot in the Outer Hebrides in January and February. The most important foods eaten by these birds were grasses, and the most important species red fescue *Festuca rubra.* This species is also eaten by Barnacle Geese elsewhere, and droppings collected by D. Cabot from the islands of Inishkea, Co. Mayo, Ireland, and examined at Slimbridge contained predominantly fragments of *F. rubra.* These droppings were collected from '*Plantago* swards' and also contained remains of the leaves of plantains *Plantago* spp. Recent work at Gotland, Sweden (Bjarvall and Samuelsson 1970) describes Barnacle Geese feeding on saltings in spring. The geese here graze in *Juncus gerardii-Agrostis stolonifera* (mud rush-bent) zones as well as in *Festuca rubra* areas. Stomachs examined contained only leaf and stem material, in which the genera *Festuca* and *Agrostis* were well represented. *Festuca rubra* is the predominant plant species over most of the merseland at Eastpark (Marshall 1962) and has been assumed to be a preferred food of the Solway Barnacle Goose flock. For example Kear (1963) states that 'The Barnacle Goose feeds exclusively on grass, in particular saltmarsh grass *Festuca rubra,* and pasture plants, *F. ovina,* clover, etc.'

The situation at Caerlaverock affords an opportunity of studying a goose in a semi-natural habitat. The technique of faecal analysis allows feeding studies to be carried out without killing the animals under investigation, and is extremely useful in studying a protected species. As part of a study by Kerbes of the movements and feeding habits of Barnacle Geese at Caerlaverock, a number of samples of droppings were collected in 1969 and 1970. This paper is an account of an analysis made by Owen of the droppings samples collected on Eastpark merse on 8th and 9th October 1970. The fact that grazing of the merse was unusually light in 1970 may have caused seed to become abundant and may have affected the habits of the geese. The extent of this effect is not known, but no foods were available in 1970 which are not normally found on the merse.

Method

The technique of faecal analysis to study the composition of the food of herbivores is well known and is reviewed in detail by Stewart (1967). The basic assumptions are that the cuticle and parts of the epidermis of most plants, and particularly grasses, pass unchanged through the alimentary tract of grazing animals and that genera or species of plants can be identified in the faeces by the different patterns of their epidermal cells. It is, however, difficult to make the complete identification of all fragments in a sample which is necessary for quantitative analysis. Stewart (1967) concluded that when the grazed sward had a large number of plant species, accurate quantitative estimation was impossible, but it could be attempted where the diet had few components.

Salting pastures contain relatively few plant species, especially in winter, and in the present study an attempt was made to identify all the components of the droppings. Some foods could only be identified as far as families or larger groupings but these were in the minority (see below). Some species can be eliminated by examination of the sward. For example, *Festuca rubra* fragments in faeces cannot always be distinguished from those of sheep's fescue *F. ovina* but the latter species was not found on the merse. The epidermal characteristics of the two most abundant species are shown in Figure 1, and those of seed and stolon fragments in Plate Va, (facing page 56).

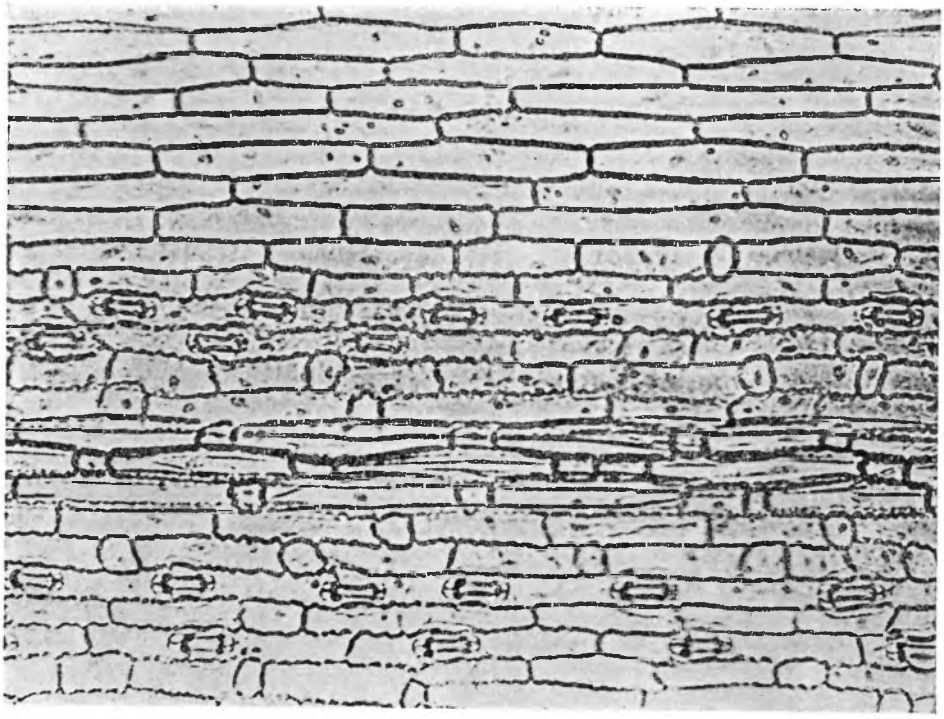
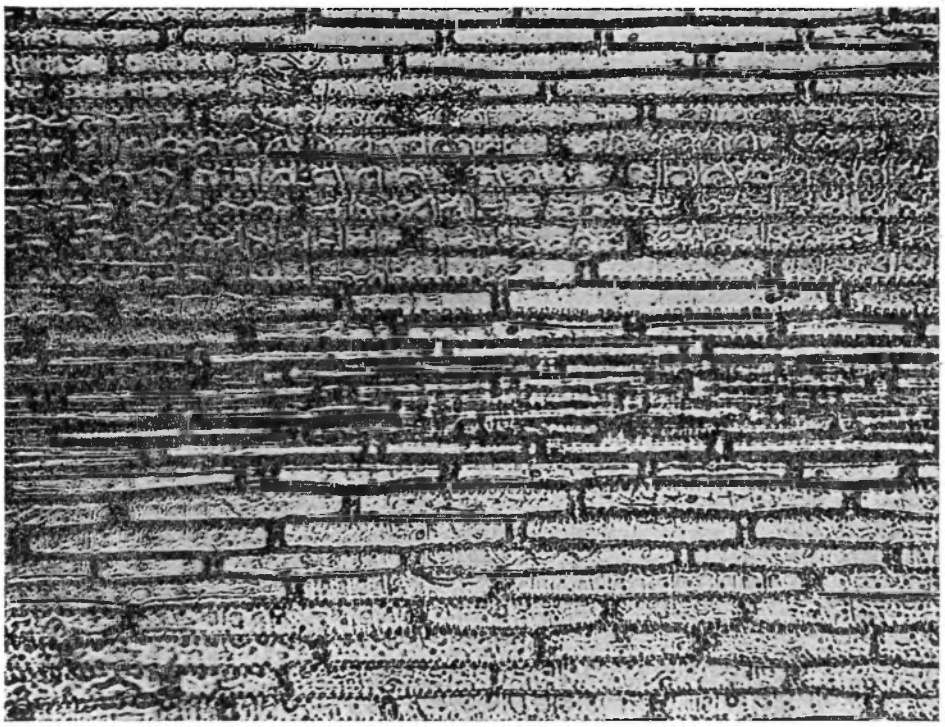


Figure 1. Epidermal preparation of two grass species, *Puccinellia maritima* (above) and *Festuca rubra* (below). The drawings were prepared from photographs by tone destruction. (Magnification × 220.)



Field sampling

It was apparent to the naked eye that there were several different types of droppings present on the merse in October. Some were identified as containing seed remains and others had fragments of clover *Trifolium repens* stolons. Five different classes of droppings were separated in the higher merse and an assessment made of the frequency of occurrence of each class. Samples of twenty dropping of each class were collected for more detailed analysis. These are the 'droppings samples' referred to below.

Coarse separation

Goose droppings which contain clover stolons usually have a number of relatively unbroken stolon fragments, up to 10 mm. in length and 2 mm. in diameter. These are difficult to deal with on microscope slides and have a weight/area ratio much different from that of the other foods. Each droppings sample was thoroughly mixed and two subsamples separated. These subsamples were scanned and all stolon fragments were removed, dried overnight at 90°C., weighed and expressed as a percentage of the subsample dry weight.

Microscopical analysis

This was carried out on subsamples which had had the main stolon pieces removed.

Ten subsamples were taken from each droppings sample and spread on glass slides so that each covered an area of 22 × 50 mm. An attempt was made to spread the fragments so that they covered as much of the area as possible without overlapping. In practice fragments covered just over 50% of the total area.

The sampling of plant fragments on a microscope slide is analagous to field-sampling a plant community with quadrats. An estimate of the area covered by each component is obtained by using a quadrat of no area, i.e. a point (Levy and Madden 1933). Sampling was carried out on two transects along the glass slide, and at points (indicated by cross wires) at 5 mm. intervals. The presence of species was recorded at each point, and if fragments overlapped only the uppermost was recorded. Systematic sampling has the advantage over random sampling in that it is quick and easy, using the microscope stage manipulators. It has no disadvantages provided the interval between points is large in relation to the average dimension of fragments. Duplicate samples analysed by the present systematic method and by a random scatter of points gave exactly similar results. Twenty points were taken on each of ten subsamples, giving 200 points analysed. As overall cover was around 50%, about 100 presence values were usually recorded.

Results

Droppings examined on the high level *Festuca rubra* sward were placed in one of five classes in the field, depending on whether they contained seed fragments, stolons, predominantly grass or were of mixed composition. The frequency of occurrence of each class in 155 droppings classified is shown in Table I. In addition droppings were collected from the lower terraces on the estuary side of the merse which have a sward consisting of predominantly sea poa grass *Puccinellia maritima.* These form a sixth class.

The results of the laboratory analysis of these six droppings samples are shown in Table II. The term 'seed' is used here in a broad sense, to include fragments of rachis, bracts, capsule walls and other parts of the inflorescence, as well as the true seeds.

The composition of the droppings confirms the subjective classification (Table I), although 'stolon' faeces contained substantial amounts of non-stolon material, much of which was clover *Trifolium repens* leaf and petiole fragments. The 'combined composition' is

Table I. The frequency of occurrence of different classes of droppings on *Festuca rubra* merse at East Park, October 1970.

Class	*Description*	*Frequency*	*%*
1	over 90% seed	37	23.8
2	non-stolon, seed	36	23.3
3	stolon, seed	29	18.7
4	stolon, non-seed	12	7.7
5	non-stolon, non-seed	41	26.5
		155	100.0

Table II. The analysis of droppings samples from six classes collected on Eastpark Merse, October 1970.

			Class			
COARSE SEPARATION	*1*	*2*	*3*	*4*	*5*	*6*
Stolon	0.0	0.2	5.8	12.1	0.8	0.0
Non-stolon	100.0	99.8	94.2	87.9	99.2	100.0
MICROSCOPICAL ANALYSIS			*Class*			
Food group[1]	*1*	*2*	*3*	*4*	*5*	*6*
Juncus gerardii seed	68.6	65.3	38.9	4.2	8.1	0.9
Plantago maritima seed			0.9			
Unidentified seed[2]	12.7		0.9	1.1		
Trifolium repens stolon		4.1	31.8	71.3	0.8	0.9
Festuca rubra	3.4	7.1	1.8	1.1	4.1	4.7
Agrostis ?stolonifera	0.9		0.9		7.3	5.6
Puccinellia maritima	5.9		0.9	1.1	58.5	85.1
? Spartina sp.				1.1		
Trifolium repens	1.7	12.3	13.3	10.6	4.9	
Trifolium petiole		2.0	7.0	7.4	3.3	
Dicotyledon sp.						0.9
Cyperaceae sp.		4.1	1.8		4.1	1.9
Unidentified non-stolon, non-seed[3]	6.8	5.1	1.8	2.1	8.9	
COMBINED COMPOSITION			*Class*			
Food	*1*	*2*	*3*	*4*	*5*	*6*
Stolon	81.4	65.2	38.3	4.6	8.1	0.9
Seed		4.3	35.8	74.8	1.5	0.9
other	18.6	30.5	25.9	20.6	90.4	98.2

1. Leaf fragments unless otherwise stated.
2. Probably mostly unidentified portions of *J. gerardii* seed.
3. Possibly unidentified material, sheath, ligule or other part of species already listed.

calculated on the assumption that the separations by weight (coarse separation) and by area (microscopical analysis) are similar, for which there is good evidence (see below).

If the frequency of droppings type (Table I) and the detailed analysis of droppings composition are combined we have the following proportions of the main components of the food taken by Barnacle Geese on the *Festuca rubra* merse: seeds 44.0%, stolons 14.1%, other material 41.9%. Thus at this particular time more than half of the Barnacle Goose diet on the high level merse at Eastpark consists of materials which cannot be obtained by the normal grazing behaviour as described by Markgren (1963).

Discussion

Efficient field sampling is one of the main problems in an analysis of this kind, since only a very small part of the total droppings on the feeding grounds is actually analysed. For example it would be misleading to analyse droppings from 5% of a goose population while the other 95% were feeding elsewhere.

In the present study no attempt was made to estimate accurately the proportion of the droppings on the two sward types, i.e. *Puccinellia* and *Festuca*, except to note that the density of droppings, where they occurred, was similar on both swards. The emphasis has been placed on the composition of the droppings from the *Festuca* sward where the geese have a choice of several food sources. These droppings were collected at random and are thought to be representative.

The initial classification of droppings, although not sufficient in itself, gives a useful guide to droppings content and markedly increases the efficiency of sampling. The proportion of stolons removed in the coarse separation gave a good guide to the stolon content but it was still necessary to make microscopical analysis for stolon material.

The technique of faecal analysis has many limitations as discussed by Stewart (1967), and some of these are relevant when considering the validity of the present results.

(a) Identifiability

Plant species or groups may occur in forms which are difficult to identify because of the differential effects of digestion. This is not very important in geese because most fragments pass

through the digestive tract relatively unchanged, there being little, if any, cellulose digestion (Mattocks 1971). Most errors are likely to arise when comparing the relative abundance of grasses and the more succulent saltmarsh dicotyledonous plants. Most succulents, however, are annuals or overwinter underground and are not present in quantity in October.

(b) Differential fragmentation

Species may be over- or under-recorded in droppings because of differences in the extent to which they break up in the gizzard. This is overcome by using point sampling, as this estimates the area occupied by each species, irrespective of the number of fragments.

(c) Weight/area ratio

The weight of food is the important measure, and only an estimate can be obtained by measuring area of fragments. Serious errors are encountered if the weight/area ratios of the different plant components are markedly different. In the present analysis these errors were minimised by removing the main stolon items before microscopical analysis, and by breaking up any whole fruit capsules of mud rush *Juncus gerardii* which were present. In the final analysis all the fragments recorded were of approximately similar thickness.

The overall composition of the droppings analysed in this study indicates a greater flexibility of winter feeding behaviour in Barnacle Geese than had hitherto been suspected. The use of clover stolons as a source of food by grazing geese had been recorded in European White-fronted Geese *Anser a. albifrons* (Owen in press) and in other species (unpublished data). The use of seeds on the scale found was, however, surprising as seeds, apart from agricultural grain, are not generally regarded as being important foods of short-billed geese. *Juncus gerardii* has very small seeds (approximately 0.5 × 0.3 mm.), but is an abundant constituent of the merse sward. The Barnacles were probably stripping fruit capsules off the inflorescence, which accounts for the pieces of rachis, bracts, and capsule walls present in droppings as well as the seeds. Although other seed heads, for example those of sea plantain *Plantago maritima* and sea arrow-grass *Triglochin maritima*, were abundant in the sward they were little used by the geese.

Whereas winter grass has 20% dry matter content and 10% soluble carbohydrate, most seeds contain 85% and over 50% respectively (Evans 1960). Thus, although the digestion of seeds by Barnacle Geese is inefficient (many seeds survive the process completely), the potential value of this food as an energy source is much greater than that of winter grass. Although Evans provides no data on clover stolons, similarly starchy materials such as couch grass *Agropyron repens* rhizomes, and bracken *Pteridium aquilinum* roots have more than double the carbohydrate content of grass. The use of these high energy foods may allow the birds to replace fat reserves after migration and before the onset of winter.

The composition of the leafy material in droppings indicates that there was some selection within the sward by geese. Thus *Puccinellia maritima* was by far the most important component of non-stolon non-seed droppings (class 5) although *Festuca rubra* is the most abundant plant on the higher parts of the merse. It may be argued that droppings deposited here contained material ingested on *Puccinellia* swards, but although some movement between feeding stations does occur it is not sufficient to produce such a marked difference. For example, the droppings collected on *Puccinellia* terraces (class 6) contained only 1.8% of foods which are not found on this sward (seeds and clover). Clover and seeds do accompany *Puccinellia maritima* in the class 5 droppings. The number of droppings on the *Puccinellia* terraces, although not accurately counted, seemed much more abundant than would occur by chance since the terraces make up a relatively small proportion of the total merse area. This may indicate some preference for the terraces although their distance from disturbance and their closeness to the roost may play a part. Similar preference for *Puccinellia* has been noted in Wigeon *Anas penelope* and European White-fronted Geese at Bridgwater Bay N.N.R., Somerset (Owen unpublished).

Many workers investigating feeding preferences of birds have equated the abundance of a certain food item in the viscera, or on the feeding grounds, with preference for that food. It has been shown that European White-fronted Geese move in sequence through the winter from one vegetation zone to another on salting pasture (Owen 1971) Observations made or droppings samples taken at any one stage during such

a cycle would indicate an apparent 'preference' for particular food plants. However, real preference can only be claimed when food was available on all zones, i.e. in early winter, and the birds concentrated on one zone.

The present paper answers only a few questions relating to food selection in the Barnacle Goose. A more thorough study has been started which might help to establish some of the habitat and food requirements of this interesting species. This includes investigations of the movements of the wintering population on agricultural land as well as feeding behaviour and food composition studies on merseland.

Acknowledgements

This work was carried out while Owen held a post at the Wildfowl Trust financed by the Natural Environment Research Council, and Kerbes was employed by the Canadian Wildlife Service.

Mrs. S. Gagnon helped with the droppings analysis, and Prof. G. V. T. Matthews and Hugh Boyd made useful criticisms of the manuscript. Mr. E. E. Jackson prepared the figures and photographs.

Summary

An analysis of droppings of Barnacle Geese *Branta leucopsis* was made to identify the food of those birds on a wintering area of the Solway Firth in 1970. Their diet consisted of 44% seed, mainly of *Juncus gerardii*, mud rush; 14% *Trifolium repens*, clover, stolons, and 42% grass and other leaf material.

Barnacle Geese are flexible in their feeding behaviour, and their ability to use seeds and stolons, which have much higher energy value than grass, probably allows them to lay down fat before the onset of winter. There are indications that the geese select sea poa grass *Puccinellia maritima* in preference to red fescue *Festuca rubra* from the merse sward.

The technique of faecal analysis as applied to geese is briefly discussed, and it is concluded that the method used here is a promising one for use in feeding studies on wildfowl.

References

BJÄRVALL, A. and A. SAMUELSSON. 1970. Studier över de vitkindade gässens betnung på Gotland. *Zool. Revy.* 32 : 26-33.

CAMPBELL, J. W. 1936. On the food of some British birds. *Brit. Birds* 30 : 209-18.

CAMPBELL, J. W. 1946. Notes on the food of some British birds. *Brit. Birds* 39 : 371-3.

EVANS, R. E. 1960. *Rations for livestock.* London: H.M.S.O.

KEAR, J. 1963. Wildfowl and agriculture. Pages 315-28 in *Wildfowl in Great Britain*, ed. G. L. Atkinson-Willes. London: H.M.S.O.

LEVY, E. B. and E. A. MADDEN. 1933. The point method of pasture analysis *N.Z. J. Agric.* 46 : 267-79.

MARKGREN, G. 1963. Studies on wild geese in southernmost Sweden. *Acta Vertebratica* 2 : 299-418.

MARSHALL, J. R. 1962. The morphology of the upper Solway saltmarshes. *Scottish Georgr. Mag.* 78 : 81-99.

MATTOCKS, J. 1971. Goose feeding and cellulose digestion. *Wildfowl* 22 : 107-113.

OWEN, M. 1971. In press. The selection of feeding site by White-fronted Geese in winter. *J. Appl. Ecol.*

OWEN, M. in press. Factors affecting food intake and selection in White-fronted Geese.

ROBERTS, E. L. 1966. Movements and flock behaviour of Barnacle Geese on the Solway Firth. *Wildfowl Trust Ann. Rep.* 17 : 36-45.

STEWART, D. R. M. 1967. Analysis of plant epidermis in faeces. A technique for studying the food preferences of grazing herbivores. *J. Appl. Ecol.* 4 : 83-111.

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The Whooper Swans of Hyoko

The build-up of the wintering flock of Bewick's Swans *Cygnus columbianus bewickii* at Slimbridge, their decoying in 1964 on to Swan Lake, and the study based on the recognition of individuals by their bill markings have been reported in previous issues of WILDFOWL and is continued in the present issue (pp. 140-143). The story has recently been summarised in a lavishly illustrated booklet (Scott 1970).

By contrast it has been difficult to find out much about a somewhat similar project half a world away, in Japan. In 1967 a Trust Member, Mr. E. H. Gillham, drew our attention to an illustrated article in a Japanese magazine. We wrote to our friend and contact Dr. Yoshimaro Yamashina, who had visited Slimbridge the previous year. He confirmed that there was indeed a place in Japan to which Whooper Swans *Cygnus c. cygnus* had been attracted by protection and feeding. He passed on our request (translated) for further information and, perhaps, an article in WILDFOWL. He feared, however, that the people concerned were not much given to writing, and in this he was correct, for we heard no more.

Meanwhile a summary translation of an article by Yamagiwa (1955) had been run to earth. Then, recently, the World Wildlife Fund headquarters at Morges, Switzerland, were sent some magnificent photographs by Honda (1969) and a popular article by Lesser (1970), with the request that publication to a wider interested audience should be arranged. We are very pleased to provide the medium and the following article has been compiled from these sources. A selection of the photographs are at Plates VI and VII.

Hyoko lies on the outskirts of the small town of Suibara, not far from Niigata City, on the west coast of Japan's main island, Honshu—opposite the smaller island of Sado (where the Japanese Crested Ibis teeters on the brink of extinction). Hyoko (ko = lake), about 20 acres in area, is a rectangular, three-hundred year old reservoir for the rice paddies which surround it on three sides. A thin row of cherry trees is the only screening. The fourth side abuts on to the houses and gardens of Suibara. There is thus hardly any protection from disturbance, yet a remarkable flock of swans has been persuaded to winter there.

Swans had formerly been abundant in the region but had almost been extirpated from Japan before being protected in 1925. Since then their numbers have slowly increased although there was much poaching during the war and post-war years. Whoopers reappeared at Suibara for the first time in January 1950 when eight visited the lake, increasing to 47 before migrating north. A local farmer, Jusabura Yoshikawa, fell under the spell of the swan's beauty and thereafter dedicated all his efforts to protecting and encouraging them at Hyoko. In 1952 shooting was prohibited on the lake; in 1954 it was declared a Natural Monument, later a National Monument.

In the first years the wintering flock barely maintained its numbers, 27 in 1951, 34 in 1952, 49 in 1953, 33 in 1954, only 15 in 1955. Jusabura Yoshikawa persisted in his efforts, guarding the birds closely, especially when the lake froze and boys or dogs could reach them; diverting a stream into the lake and breaking ice to maintain some open water, and feeding the birds so that they came to know and trust him. His neighbours considered him a swan-obsessed nuisance when he begged them not to hang out washing by the lakeside, lest the birds were frightened. He bullied the town authorities to remove heaps of stones from the roadside, because children used them as ammunition to throw at the swans. Gradually his enthusiasm communicated itself to others, and particularly to his son, Shigeo. But not to his wife, who blames his death at the age of 64 to a complete indifference to his own welfare where that of his swans was concerned. He didn't care whether he ate or not; would stand for hours in deep snow, contemplating his swans, and rush out in his nightgown to drive off poachers. On Christmas Day 1959, although seriously ill, he insisted on going out to tend a sick swan. On returning to the fireside he collapsed and died, murmuring 'one swan more is better . . . . feed the swans'.

In previous winters the swans had arrived in January, but in 1959 they came weeks earlier than usual thus affording Jusabura one last sight of them before he died. That season, also for the first time, the numbers soared into the hundreds. By 1967 there were 687 and in 1970 over a thousand. They come earlier and stay later than did the first nucleus of birds, and the 'season' now stretches from November to April.

Shigeo Yoshikawa has, like his father, dedicated his life to the swans. Likewise, he ignores hardship, sallying forth in the

falling snow, breaking the ice on the lake, to feed his birds. His father had insisted that to understand swans you must become a swan yourself. Together they tasted all the aquatic plants that swans eat. Finding that these had a bitter-sweet taste they introduced tea-grounds (used for cattle feed) into a mixture of unripened rice, wheat, soya beans, bread crumbs and greens. Certainly the swans appear to relish the mixture and will fly to Shigeo when he calls 'Koi, Koi' (come, come) even though he may not be at the usual feeding site. This is in front of the low wooden hut, partly built out over the water and heated by an ancient and fuming stove, which serves as an observatory.

Shigeo can recognise individual swans by their bill markings and by their voice, though it is not clear how many of his thousand guests are thus distinguished. Certainly the few Whoopers that have appeared at Slimbridge have proved much more difficult to differentiate than the hundreds of Bewick's. Incidentally, the 'mirror-image' relationship between Hyoko and Slimbridge is completed by their being a few Hakucho—Bewick's (of the Eastern *jankowski* race)—among the hundreds of Ohakucho—Whooper Swans (Plate VII).

People from all over Japan send Shigeo swans that have suffered accidents. He now has a regular 'hospital' where they can be treated, coaxed back to health with vitamins, or operated on, if necessary, by the local surgeon, Dr. Saburo Iida.

The fame of Hyoko is spreading in Japan. Thousands of human visitors have now come to see the swans. Gift-packages of swan food arrive from friends all over the country, addressed simply to 'The Suibara Swans'. The neighbours are now proud of their Swan Lake and the school children help to clear up litter and patrol the lake shore to prevent disturbance. In March 1970 a 'Society for the Conservation of Wild Swans at Hyoko' was established. The local prefectural government plans a Refuge of some 50 acres and has entrusted the Yamashina Institute for Ornithology with preparing a design.

The Yoshikawas, father and son, have done a wonderful job, not only in providing sanctuary for some lovely birds, but in spreading an interest and love of wildlife amongst their hitherto mainly uninterested compatriots. We look forward to a closer co-operation between the two Swan Lakes.

References

HONDA, K. 1969. Japan's real Swan Lake. *Japan Illustrated* 7 : 2.
LESSER, R. 1970. The miracle of Suibara's ever-increasing wild swans. *Plow* 16 : 1-2, 39-41.
SCOTT, P. 1970. *The Wild Swans at Slimbridge.* Slimbridge, Glos.: Wildfowl Trust.
YAMAGIWA, T. 1955. The Whooper Swan at Lake Hyoko, Suibara, Niigata Prefecture: the story of its taming. *Tori* 14 : 14-23 (summary translation in *Bird Band.* 27 : 196-7).

G.V.T.M.

International Conference on the Conservation of Wetlands and Waterfowl, Ramsar, Iran

This Conference was the outcome and climax of a series of Conferences at governmental level which began at St. Andrews, Scotland, in 1963 and was followed by those at Noordwijk, Holland, in 1966 and at Leningrad, U.S.S.R., in 1968. They were supported by Technical Meetings at Ste. Marie de la Mer, France, in 1962; Jablonna, Poland, in 1965; Ankara in 1967; Vienna in 1969; Espo, Finland, in 1970.

At the invitation of the Imperial Government of Iran, the Conference was convened at Ramsar on the southern coast of the Caspian Sea from 30th January to 3rd February 1971. The organisation was the joint responsibility of the Game and Fish Department of Iran, under its Director, Mr. Eskander Firouz, and of the International Wildfowl Research Bureau under Professor G. V. T. Matthews. Iranian hospitality and efficiency provided an ideal setting for what will surely be an historic Conference. Some seventy delegates and observers from twenty-three countries in Europe, Asia and Africa, together with representatives of eight international organisations, were admirably housed and serviced at one fine hotel. The aims of the Conference were widely publicised by a special issue of three stamps depicting a Greater Flamingo, a Common Shelduck and a Ruddy Shelduck; by an excellent, illustrated booklet *The Wetlands and Waterfowl of Iran;* by a fine new film *Wealth on Wings*; by colourful posters, and by Press, radio and television coverage.

A gracious opening Message from H.I.M. the Shahinshah was read by his brother, H.I.H. Prince Abdorreza. This ended with the statement: 'To emphasise the depth of our convictions that our natural environment must be protected and that all nations are interdependent in the attainment of this goal, we wish to state that Iran is prepared to place one of her wetland ecosystems of special global significance in joint trust with a suitable international agency, such as the United Nations Organisation, to conserve and administer for all mankind.' This brought Iran to the forefront of the nations as the first to undertake to forgo part of her sovereignty for the benefit of the international community. If the lead now given were followed by other countries, the future for wetland conservation in particular and nature conservation in general would suddenly be brighter. The Conference participants were privileged to discuss ways in which this magnificent offer could be implemented, and to visit several of the major Iranian wetlands which could be candidates for selection.

The main task of the Conference, under the able Presidency of Mr. Firouz, was to hammer out a final text of the '*Convention on Wetlands of International Importance, Especially as Waterfowl Habitat*'. This had been in gestation since 1965, and this long, careful preparation paid off, for agreement was reached in the day and a half of formal discussion allotted, somewhat optimistically, by the organisers. Of course, there was much informal discussion, far into several nights, but the international lawyers present were amazed at the quick, friendly solution achieved, which undoubtedly set a new standard for such negotiations. The new Convention establishes another precedent of its own, being the first multilateral agreement to modify national land-use planning. By ratifying the Convention each country will undertake to conserve to the best of its ability certain carefully specified major wetlands within its boundaries. In this way it is hoped that at least the main wetlands of the world will be saved from thoughtless destruction.

The Conference also covered a number of technical themes: the criteria on which the international importance of a wetland should be judged; the status of wetlands and waterfowl, particularly in western Asia; the management of wetlands in arid countries, and the collation of the data necessary for the rational use of waterfowl stocks. This latter is but the first step towards international agreement on shooting seasons and other reasonable limitations to the numbers killed. It was clear that such controls were much more needful in some 'flyways' than in others.

Conference study tours were arranged in Gilan near Ramsar, in the Mian Kaleh/Gorgon Bay area in the south-east corner of the Caspian and in the southern part of Iran, near Shiraz. There the great salt lake complex Tashk/Bakhtegan was visited and also the Dasht-e-Arjan and Lake Parishan area. The participants were privileged to see many wonderful places and birds—pelicans, flamingos, Lesser White-fronted Geese, Ruddy Shelduck, Marbled Teal, White-headed Duck,

Common Cranes, White Storks, White-tailed Eagles, Little Bustards, to mention but a few of the most spectacular. One of the most encouraging observations was that of more than 12,000 Marbled Teal in Khuzestan on the Iraqi border.

The Final Act and Summary Record were published in June and the full Proceedings are expected to be in print before the end of 1971. Both will be obtainable from I.W.R.B. Headquarters, Slimbridge.

CONVENTION ON WETLANDS OF INTERNATIONAL IMPORTANCE ESPECIALLY AS WATERFOWL HABITAT

The Contracting Parties,
Recognising the interdependence of Man and his environment;
Considering the fundamental ecological functions of wetlands as regulators of water regimes and as habitats supporting a characteristic flora and fauna, especially waterfowl;
Being convinced that wetlands constitute a resource of great economic, cultural, scientific and recreational value, the loss of which would be irreparable;
Desiring to stem the progressive encroaching on and loss of wetlands now and in the future;
Recognising that waterfowl in their seasonal migrations may transcend frontiers and so should be regarded as an international resource;
Being confident that the conservation of wetlands and their flora and fauna can be ensured by combining far-sighted national policies with co-ordinated international action;
Have agreed as follows:

Article 1

1 For the purpose of this Convention wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.

2 For the purpose of this Convention waterfowl are birds ecologically dependent on wetlands.

Article 2

1 Each Contracting Party shall designate suitable wetlands within its territory for inclusion in a List of Wetlands of International Importance, hereinafter referred to as "the List", which is maintained by the bureau established under Article 8. The boundaries of each wetland shall be precisely described and also delimited on a map and they may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands, especially where these have importance as waterfowl habitats.

2 Wetlands should be selected for the List on account of their international significance in terms of ecology, botany, zoology, limnology or hydrology. In the first instance wetlands of international importance to waterfowl at any season should be included.

3 The inclusion of a wetland in the List does not prejudice the exclusive sovereign rights of the Contracting Party in whose territory the wetland is situated.

4 Each Contracting Party shall designate at least one wetland to be included in the List when signing this Convention or when depositing its instrument of ratification or accession, as provided in Article 9.

5 Any Contracting Party shall have the right to add to the List further wetlands situated within its territory, to extend the boundaries of those wetlands already included by it in the List, or, because of its urgent national interests, to delete or restrict the boundaries of wetlands already included by it in the List and shall, at the earliest possible time, inform the organization or government responsible for the continuing bureau duties specified in Article 8 of any such changes.

6 Each Contracting Party shall consider its international responsibilities for the conservation, management and wise use of migratory stocks of waterfowl, both when designating entries for the List and when exercising its right to change entries in the List relating to wetlands within its territory.

Article 3

1 The Contracting Parties shall formulate and implement their planning so as to promote the conservation of the wetlands included in the List, and as far as possible the wise use of wetlands in their territory.

2 Each Contracting Party shall arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference. Information on such changes shall be passed without delay to the organization or government responsible for the continuing bureau duties specified in Article 8.

Article 4

1 Each Contracting Party shall promote the conservation of wetlands and waterfowl by establishing nature reserves on wetlands, whether they are included in the List or not, and provide adequately for their wardening.

2 Where a Contracting Party in its urgent national interest, deletes or restricts the boundaries of wetland included in the List, it should as far as possible compensate for any loss of wetland resources, and in particular it should create additional nature reserves for waterfowl and for the protection, either in the same area or elsewhere, of an adequate portion of the original habitat.

3 The Contracting Parties shall encourage research and the exchange of data and publications regarding wetlands and their flora and fauna.

4 The Contracting Parties shall endeavour through management to increase waterfowl populations on appropriate wetlands.

5 The Contracting Parties shall promote the training of personnel competent in the fields of wetland research, management and wardening.

Article 5

The Contracting Parties shall consult with each other about implementing obligations arising from this Convention especially in the case of a wetland extending over the territories of more than one Contracting Party or where a water system is shared by Contracting Parties. They shall at the same time endeavour to co-ordinate and support present and future policies and regulations concerning the conservation of wetlands and their flora and fauna.

Article 6

1 The Contracting Parties shall, as the necessity arises, convene Conferences on the Conservation of Wetlands and Waterfowl.

2 These Conferences shall have an advisory character and shall be competent *inter alia*:

(*a*) to discuss the implementation of this Convention;

(*b*) to discuss additions to and changes in the List;

(*c*) to consider information regarding changes in the ecological character of wetlands included in the List provided in accordance with Paragraph 2 of Article 3;

(*d*) to make general or specific recommendations to the Contracting Parties regarding the conservation, management and wise use of wetlands and their flora and fauna;

(*e*) to request relevant international bodies to prepare reports and statistics on matters which are essentially international in character affecting wetlands.

3 The Contracting Parties shall ensure that those responsible at all levels for wetlands management shall be informed of, and take into consideration, recommendations of such Conferences concerning the conservation, management and wise use of wetlands and their flora and fauna.

Article 7

1 The representatives of the Contracting Parties at such Conferences should include persons who are experts on wetlands or waterfowl by reason of knowledge and experience gained in scientific, administrative or other appropriate capacities.

2 Each of the Contracting Parties represented at a Conference shall have one vote, recommendations being adopted by a simple majority of the votes cast, provided that not less than half the Contracting Parties cast votes.

Article 8

1 The International Union for the Conservation of Nature and Natural Resources shall perform the continuing bureau duties under this Convention until such time as another organization or government is appointed by a majority of two-thirds of all Contracting Parties.

2 The continuing bureau duties shall be, *inter alia*:

(*a*) to assist in the convening and

organizing of Conferences specified in Article 6;

(*b*) to maintain the List of Wetlands of International Importance and to be informed by the Contracting Parties of any additions, extensions, deletions or restrictions concerning wetlands included in the List provided in accordance with Paragraph 5 of Article 2;

(*c*) to be informed by the Contracting Parties of any changes in the ecological character of wetlands included in the List provided in accordance with Paragraph 2 of Article 3;

(*d*) to forward notification of any alterations to the List, or changes in character of wetlands included therein, to all Contracting Parties and to arrange for these matters to be discussed at the next Conference;

(*e*) to make known to the Contracting Party concerned, the recommendations of the Conferences in respect of such alterations to the List or of changes in the character of wetlands included therein.

Article 9

1 This Convention shall remain open for signature indefinitely.

2 Any member of the United Nations or of one of the Specialized Agencies or of the International Atomic Energy Agency or Party to the Statute of the International Court of Justice may become a party to this Convention by:

(*a*) signature without reservation as to ratification;

(*b*) signature subject to ratification followed by ratification;

(*c*) accession.

3 Ratification or accession shall be effected by the deposit of an instrument of ratification or accession with the Director General of the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as 'the Depository").

Article 10

1 This Convention shall enter into force four months after seven States have become Parties to this Convention in accordance with Paragraph 2 of Article 9.

2 Thereafter this Convention shall enter into force for each Contracting Party four months after the day of its signature without reservation as to ratification, or its deposit of an instrument of ratification or accession.

Article 11

1 This Convention shall continue in force for an indefinite period.

2 Any Contracting Party may denounce this Convention after a period of five years from the date on which it entered into force for that Party by giving written notice thereof to the Depository. Denunciation shall take effect four months after the day on which notice thereof is received by the Depository.

Article 12

1 The Depository shall inform all States that have signed and acceded to this Convention as soon as possible of:

(*a*) signatures to this Convention;

(*b*) deposits of instruments of ratification of this Convention;

(*c*) deposits of instruments of accession to this Convention;

(*d*) the date of entry into force of this Convention;

(*e*) notifications of denunciation of this Convention.

2 When this Convention has entered into force, the Depository shall have it registered with the Secretariat of the United Nations in accordance with Article 102 of the Charter.

IN WITNESS WHEREOF, the undersigned, being duly authorized to that effect, have signed this Convention.
DONE at .....
this ..... day
of ..... 19.....,
in a single original in the English, French, German and Russian languages, in any case of divergency the English text prevailing, which shall be deposited with the Depository which shall send true copies thereof to all Contracting Parties.

A Visitor Survey at Slimbridge

It has become a truism that conservation can only succeed when firmly backed by an interested and enlightened public. One of the most effective methods of convincing people that wildfowl are worth saving is to show them the birds, in all their fascinating variety. These should be living in pleasant surroundings bordering a natural wetland, to which wild migrants seasonally come and where resident wildfowl freely breed.

This has been the formula developed at Slimbridge since 1946. In our first fifteen years a million paying visitors had passed through the gates. It took only six more years to raise the second million, and over the last three years the average gate has been just over 200,000. None of these figures include visits by Trust Members, now numbering 9,000, many of whom come several times a year.

Certainly we can claim to have influenced large numbers of people. Moreover the income from gate charges had not only covered the cost of maintaining the grounds and feeding the birds, but had produced a useful surplus. This was used to support the 'non-profitable' activities of the Trust—research, conservation and education in the more academic sense. On both counts, therefore, it would be desirable to increase the numbers of visitors still further.

When this matter was last considered in this publication (*Eleventh Annual Report*, 1960, pp. 16-17), it was pointed out that most visitors came in August, when the birds were not looking their best, and that it would be desirable to spread the incidence of visitors through the year. Although the annual numbers have nearly doubled in the interval, the pattern of visits is still much the same (Figure 1). The average of three years has been used in each period so that influxes due to variable factors such as changeable religious festivals, royal visits or fine weather are smoothed out. The similarity between the two periods is further emphasised if visitor incidence is expressed in terms of percentage of the annual total (Table I).

It is clear that we still are not persuading the uncommitted masses of visitors to come out in the winter half of the year, though getting 40,000 people into the country in those six months is no mean achievement. Nevertheless the people we want to convert to conservation will only be available to us in the summer. The grounds at the peak season are already overcrowded and to squeeze more into the 40 acres would destroy much of the effect we wish to create.

Faced with this dilemma the Trust Council decided that the answer would be to set up more Slimbridges. These would have to be as big or bigger than the present grounds, for experience at our other branch, Peakirk, had shown this to be too small to do more than just cover its upkeep, if that. Laying out and stocking such large areas would be a costly undertaking; mistakes could not be afforded. Moreover, there have in recent years grown up a number of 'wildlife parks', of varying calibre, which would compete with us for visitors.

Therefore it was only wise to examine in detail the successful features—and the shortcomings—of Slimbridge; to find out the type of people who were attracted, where they came from and what they

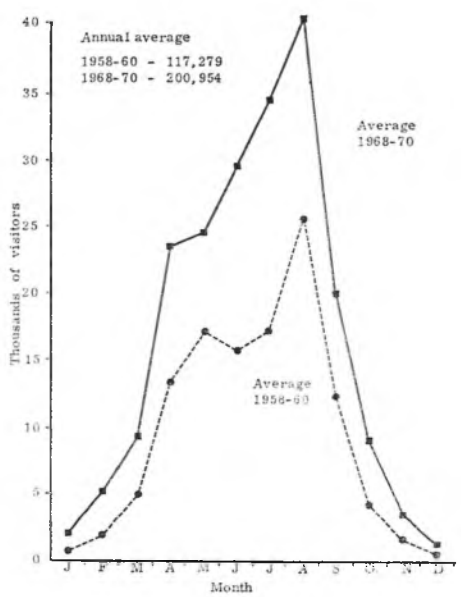


Table I. Percentage of visitors coming to Slimbridge in different months, for two periods ten years apart.

	Jan.	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
1958-60	0.8	1.9	4.3	11.4	14.8	13.7	14.8	21.9	10.6	3.7	1.5	0.6
1968-70	1.2	2.5	4.7	11.7	12.4	14.7	15.5	20.3	10.0	4.5	1.8	0.7

wanted or expected. In the vulgar parlance some 'market research' was required. To have this done professionally is expensive, so it was fortunate that we were able to interest two other bodies in sponsoring a study. The British Travel Association (now the British Tourist Authority) was particularly concerned with those attractions, such as Slimbridge, which lie within reach of important tourist areas. The Countryside Commission wished to ascertain whether the characteristics, activities and opinions of visitors to wildlife parks differed from those of visitors to historic houses. Further, a survey afforded an additional opportunity to test the recreation survey methods developed in previous studies.

The *Slimbridge Visitor Survey—1969*, a booklet of 44 pages, has now (1971) been published by the Countryside Commission, Cambridge Gate, Regent's Park, London, N.W.1, from whom it is available free. The full results, in the form of computer sheet tabulations, are held by the British Tourist Authority and the Countryside Commission, and can be examined on request. It was felt, however, that a summary of the report should be made available in WILDFOWL since the matter is of considerable interest to Trust Members and to others concerned with forwarding conservation through attracting and educating the public. There follows a series of extracts from the *Survey*.

* * * *

Methods used in the survey

Sample selection

Before the main survey, a small pilot study was carried out in May 1969, to test the wording and effectiveness of the questionnaire. In the main survey, interviewing was conducted on 12 days throughout the summer from June to September. Days were phased during the early, middle and late season, as well as on each day of the week.

The method used on both the pilot and the main survey was as follows: on each interviewing day, four interviewers and a supervisor were employed. Interviewers were stationed at various points where the public were likely to pass, and as far as possible in positions where information could be collected from respondents as they were completing rather than beginning their visit. Interviewers were instructed to interview the first person who passed them, and then the next person to pass after an interview had been completed, and so on until the required number of interviews had been obtained. No quotas in terms of sex, age or social class were set. Children under 15 years were excluded from the survey, as were organised school parties.

A total of 1,093 interviews was completed; the average number to an interviewer day was therefore 23. Table II sets out the number of visitors and the number interviewed on each date.

On each day that interviewing was carried out, details were also collected, in the car park, of the number of coach parties. For each coach, information was obtained on the point of departure, the length of stay at Slimbridge, the type of group in the coach party, the number of people in the coach and other places visited on the trip.

Table II. Number of visitors to Slimbridge and number of interviews on each survey day, 1969.

Date	*Number of visitors*	*Number of interviews*
Wednesday 11 June	534	86
Saturday 14 June	864	109
Sunday 6 July	881	98
Thursday 10 July	774	65
Monday 21 July	1176	86
Saturday 26 July	691	86
Sunday 3 August	1429	109
Friday 8 August	940	86
Sunday 31 August	2678	119
Tuesday 2 September	1471	86
Monday 8 September	704	98
Saturday 13 September	368	65
Total	12510	1093

Main findings

What kinds of people visit Slimbridge?

Some 30% of visitors were aged 34 years or less. Compared with the national population, lower proportions of both the younger age groups (16-24) and the older (65 and over) were found among Slimbridge visitors, but those of early and late middle age were highly represented (Table III). Somewhat surprisingly, rather

Table III. Age groups of visitors to Slimbridge.

Ages	*Slimbridge* %	*British Population* %
16-24	11	18
25-34	18	16
35-44	22	16
45-54	21	17
55-64	18	16
65 and over	9	17

fewer than half the visitors (39%) were accompanied by children, 25% were with children under nine years; 20% were accompanied by children aged nine but under 15 years.

Slimbridge results show a proportion in the top two social groups (AB) far above that for the population as a whole (Table IV). There is a corresponding under-representation of the C2, and particularly the DE, groups.

Table IV. Social class of visitors to Slimbridge.

Social Class	*Slimbridge* %	*British Population* %
AB	36	12
C1	29	25
C2	27	30
DE	9	33

How often do people visit Slimbridge? Do they plan their trip in advance?

Although nearly three-quarters (74%) of the interviewed visitors were on their first visit to Slimbridge, 14% had already been once and 12% had been two or more times before. Predictably, these repeat visits were made by people who had travelled less far than those on their first trip; 17% of the visitors who had come from within 30 miles (48 km.) were on their third or subsequent visit, compared with 8% of those who had travelled from more than 75 miles (120 km.) away. There appear to be no significant differences between age groups or social classes in the frequency of visits made to Slimbridge.

Only 6% of the visitors to Slimbridge could be described as 'casual', in that they decided to stop after seeing road signs directing motorists to the Wildfowl Trust. This is probably due to the scarcity of such signs. The proportion of visitors who had done some prior planning of their trip (94%) is higher than the proportions found for historic houses.

What reasons do people give for visiting a wildlife area?

All visitors who had planned their trip in advance were asked to give their reasons 'for coming here today'. The question asked was open-ended, and respondents were not prompted. 30% recorded an interest in birds, but if this figure is combined with other answers relating specifically to wildlife, the proportion rises to 50%, and this interest is found in all age groups and among all social classes. Even so, many people gave reasons related rather more to the attractions of Slimbridge as a pleasant location for a day out; at least 48% were in this category. 20% of the visitors gave no other reason than that they were bringing friends or relatives. Again, the general reasons, as well as the specific ones, were spread among all social classes and all age groups. Even for members of the Wildfowl Trust there was an equal spread of specific and more general reasons (43% and 45%).

The persistence of the general attractions of Slimbridge for a day out, rather than as a focus for a specific interest in wildlife, is shown by a comparison of the views of people on their first visit with those on their second or subsequent trip. More specific than general reasons were given among first-time visitors, while among those on their second or subsequent visit, general reasons were more often quoted. It seems therefore that, perhaps surprisingly, the pleasant surroundings of Slimbridge are an important factor besides the birds themselves in attracting people for a second visit. Also it is apparent that visitors wish to show the attractions of Slimbridge to other people. (33% of repeat visitors said they had come to 'bring others', compared with 15% of those on their first visit.)

How do people travel to Slimbridge? How far do they come?

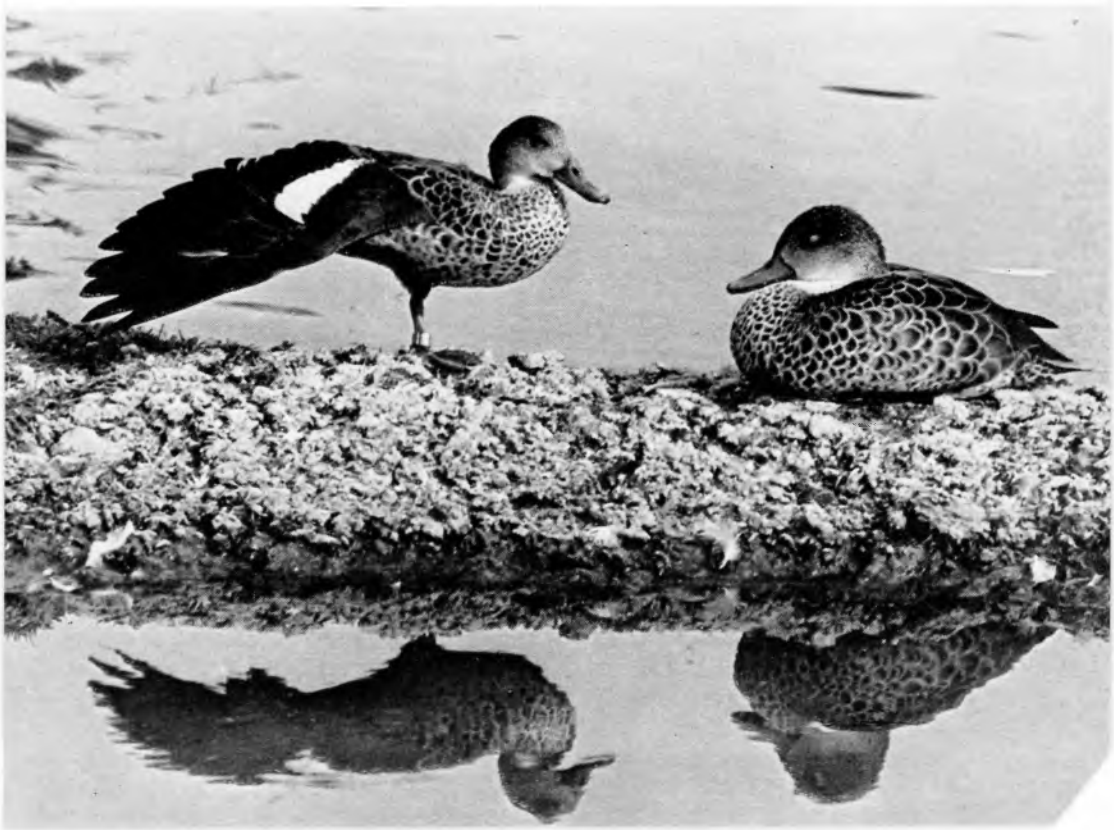
Many studies of outdoor recreation areas have confirmed that the overwhelming majority of visitors arrive by car. At Slimbridge the proportion was 82%. 14% of the visitors to Slimbridge came by coach, and the survey shows that these people were, in general, more likely to be in the lower social class groups and older age categories. Coach travellers also tended to travel further; they were almost equally divided between those in an organised party (for example an amenity society) and those on an advertised tour (such as an excursion from a holiday centre). Weekdays seemed to be more popular than Sundays for coach trips of both kinds, and especially organised outings, and it must be remembered that these are a useful means of spreading the load of visitors from weekends to the relatively slack mid-week periods. Only 2% arrived by public transport.

The survey showed that, of those people who had travelled from home on the day of interview, the majority (57%) had come more than 50 miles (80 km.). The average (one-way) journey for all

Philippa Scott

Plate XIII. (a) A male North American Ruddy Duck *Oxyura j. jamaicensis* in the 'bubbling' phase of its remarkable display.
(b) A pair of Australian Grey Teal *Anas gibberifrons gracilis*, one showing the wing-stretch comfort movement.

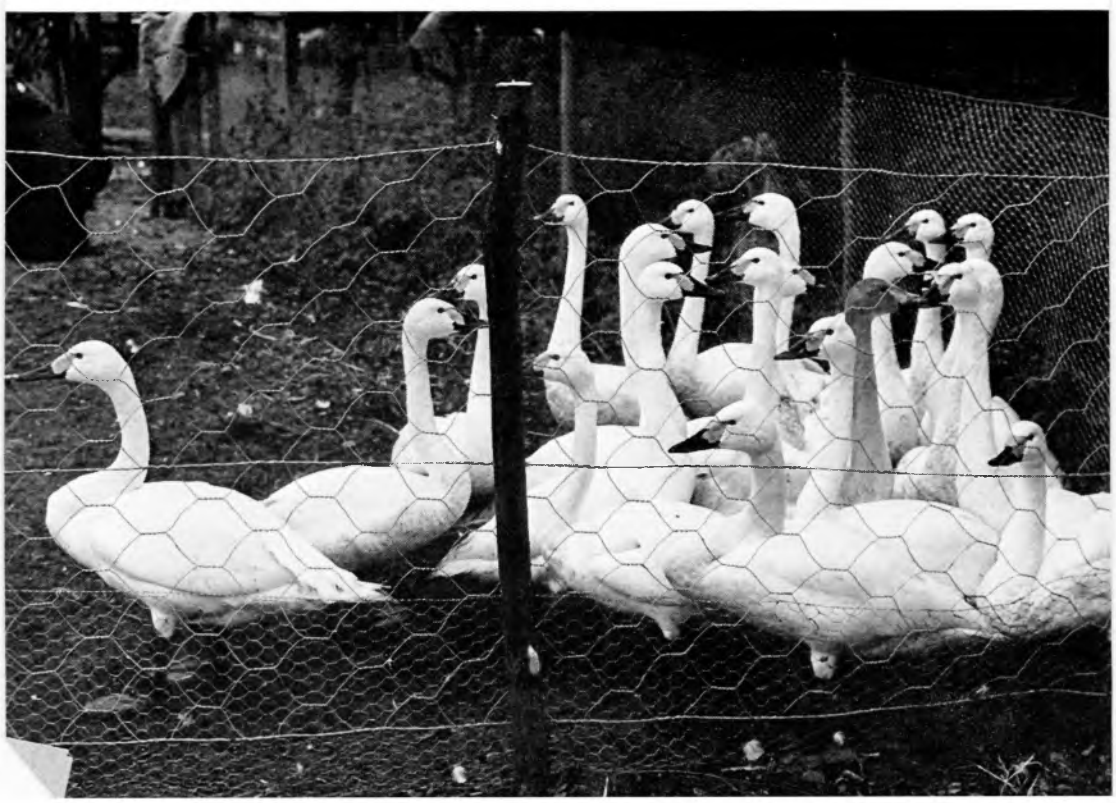
Philippa Scott



Philippa Scott

Plate XIV. Catching Bewick's Swans at Slimbridge. (a) A party of birds is slowly driven up the 'pipe' into which they were decoyed by food. (b) Twenty swans quietly awaiting ringing, measuring and X-raying in the corral at the end of the pipe. From left to right: Shaft, Tahini, Brown, Pingola, Iliad, Coastguard, Beachcomber, Eccles, Nimble, Start, Furze, Partridge, Raquello, a cygnet of Ivy and Mistletoe, Caroline, Rabbit, Xantho, Frobe and Muzzy. Only one bird cannot be identified, having its bill hidden. (See pp. 140-143.)

Philippa Scott



visitors was 58 miles (93 km.)—a distance some 20 to 30 miles (32 to 48 km.) further than the averages recorded for those travelling to historic houses. Indeed, the evidence is that between a fifth and a quarter of all visitors to Slimbridge must have made a round trip of more than 150 miles (240 km.).

When these figures are further analysed, by frequency of visit and mode of travel, it is apparent that those on their first visit were more likely to travel further than those on their second or subsequent visit; 63% of first-time visitors travelled over 50 miles (80 km.), compared with 42% of those on a repeat visit. Coach travellers were prepared to travel longer distances than those travelling by car; 74% came more than 50 miles (80 km.), compared with 54% of motorists. The survey also shows that holiday visitors were far less willing to travel long distances than day visitors. 90% of the visitors who had travelled over 75 miles (120 km.) to Slimbridge had come from home on the day they were interviewed, while only 10% of the people who had travelled that far were on holiday away from home. The average distance travelled by holidaymakers was 33 miles (53 km.), while that of day visitors was 58 miles (93 km.).

All the major towns round Slimbridge contributed day visitors: Bristol (10%), Gloucester (10%) and Cardiff (12%) were especially important; although many came from far afield, even London. The survey shows that visitors who had not come from home, most of whom were holidaymakers, were less widely drawn in terms of distance, but travelled from a variety of local holiday centres (53% from Gloucestershire and Bristol).

What is the proportion of holidaymakers among visitors to Slimbridge?

37% of the visitors had not come from home on the day of interview, including 3% who were visitors from abroad. Nearly nine out of ten of these visitors claimed to be 'on holiday away from home'; in other words 32% of *all* visitors to Slimbridge. A small proportion of visitors were *en route* from home to some other destination when they stopped at Slimbridge, so that the overall total of holidaymakers may have been 34%.

The proportion of visitors to Slimbridge who had both come from, and were returning to, home on the day of interview (that is 'day visitors' in the strict sense) was 61%.

The survey shows that there were relatively more day visitors on Sundays than weekdays, when, although day visitors were in the majority, their proportion was lower.

There is also evidence to suggest that visitors from home travelled further than visitors coming from other destinations—mainly holiday centres. Predictably, day visitors were more likely to make repeat visits to Slimbridge than those on holiday; 76% of the visitors on their second or subsequent visit had come from home, compared with 61% of first-time visitors.

It is surprising that almost all coach travellers had come from home on the day of interview—only 10% had come from some other base, even though it might have been thought that many coach excursions would be operated for holiday makers.

It is interesting to note that the holidaymakers among the visitors to Slimbridge are drawn from a widely distributed area in which no individual place accounts for more than 8% (Bristol). This suggests that many of these holiday visitors are in fact touring the area generally.

What do people do at Slimbridge? What are their reactions to the facilities offered?

At least three-quarters of all visitors walked to both ends of the grounds, the Rushy Pen and the Acrow Tower. People who did not visit the Rushy Pen said that they were short of time (21% of those who did not go), too tired (18%) or could not find it (15%). The tower giving views over the duck decoy was rather less popular; nevertheless 41% had visited it. There being no wild geese on the Dumbles at this season, the Holden Tower and its covered approach were not open.

Over a third of all visitors claimed to

Table V. Activities of visitors to Slimbridge.

	All respondents %
Visited Rushy Pen	85
Climbed Acrow Tower	74
Climbed tower to see duck decoy	41
Visited tropical house	36
Fed birds	28
Looked at conservation exhibition	70
Looked at research exhibition	38
Visited shop	76
Picnicked in car park	20
Picnicked in grounds	12
Visited self-service restaurant	53
Visited waitress service restaurant	8
Bought guide-book	35
Used sound guide	1
Don't know/Not stated	1

have visited the tropical house, but this may well be an overestimate. An extra charge is made for this attraction, and estimates of visitors based on the number of tickets sold indicate a lower overall proportion; some respondents may have answered positively because they 'visited' the tropical house but did not go in (Table V).

Almost a third of all visitors fed the birds, and it is not surprising that in reply to a question asking if any additional facilities were wanted, a number of people (5% of all visitors) would have liked to be able to buy food for the birds. In general, however, few people wanted to see any changes at Slimbridge, and from the 34% who wanted more facilities, the most frequent suggestion was for toilets at the far end of the route (29%), that is, near the Acrow Tower. More shelter and seats in the grounds (21% and 12%) would also have been acceptable.

Visitors were asked about the two permanent exhibitions at Slimbridge: one on conservation, which is passed by everyone going through the entrance hall out to the grounds, and another on research by the Wildfowl Trust, for which a small detour from the main route must be made. The relative location of the exhibitions as well as their subject matter may be accountable for their differences in popularity; 70% of the visitors stopped to look at the conservation exhibition, but only 38% looked at the panels on research. Most of the people who visited the conservation exhibition found it interesting, and more than three-quarters of them thought it had succeeded in its object of making people more aware of the threats of mankind to wildlife. Only a quarter of the people had any suggestions for improvement, and they mentioned the need to make the exhibition larger, more prominent, and simpler—some suggested that this could be achieved by the use of models. Most people who looked at the research exhibition found it interesting, few having any suggestions to make, although again simplification and the need for a guide were mentioned.

The activities of people in the grounds may reflect a lack of information on the position of some features. For example, it might help if the sign on the return route guided visitors to the Rushy Pen and other places of interest. A plan of the grounds, showing the existence and position of the Rushy Pen, is given in the guide-book which costs 12½p; but this was bought by only 35% of respondents. Although this proportion corresponds to a much higher proportion of groups as opposed to individuals (it is to be expected that only one guide-book is bought for each group) it is revealing that two-thirds of all visitors had not read the guide by the end of their visit! Most of those who had read it thought it was good, but it does seem to be kept as a souvenir rather than used for reference at the time of the visit. It may not even be read at home—two-thirds of all those on their second or subsequent visit had not read their copy. Therefore, even if a guide-book is bought, there is no guarantee that it will be read, and even the plan of Slimbridge may be little used for reference. There seems to be some advantage in having further map boards like the one placed at the entrance.

The need for more information is reflected in other findings of the survey. Visitors were asked for their reactions to the notices in the bird pens which give a written description of the species that can be seen. 30% of all visitors considered that the notices did not tell them enough about the birds, and of these people, three-quarters would have liked to see a sketch or photograph of each bird to help them identify the species. One-third wanted a fuller written description, and a further third wanted more information about the habits of birds. It is surprising that only 1% of the visitors hired the tape-recorder sound-guide, and it may be that, like the Rushy Pen, and the opportunities to picnic in the grounds, this facility is not sufficiently well advertised.

Many people visited the shop (76%) but only about half of these made purchases. This may well reflect the fairly high cost of many goods on sale, since half of those who visited the shop felt it was expensive. It is worth noting, however, that souvenir shops normally attract many browsers. A third of those who had visited the shop thought the goods were attractively displayed and the same proportion welcomed the variety; but 9% thought there were rather too few things suitable for children.

32% of visitors picnicked—most in the car park (20%) which is outside and less attractive than the main grounds of Slimbridge, where the rest (12%) picnicked.

A high proportion of visitors used the restaurant, which is divided into two parts. a self-service section, clearly the more popular (visited by 53%), and a waitress section (used by only 8%). 80% of those who had visited one or other

part found the restaurant satisfactory, and people commented on the overall quality (22%), good service (7%), appearance (6%) and view (3%), as well as the quality of the tea (4%)! Even so, 20% thought the restaurant rather too expensive, and the service and choice of food poor.

How long do people spend at Slimbridge? The average length of stay for all visitors to Slimbridge is three hours. There were no differences in different age groups or social classes, but it does seem that those coach travellers on an advertised tour generally spent less time at Slimbridge than those in an organised party; of the coach travellers who stayed less than two hours, 56% were on an advertised tour compared with 31% in an organised party.

Surprisingly, weather seems to have little effect on length of stay. The survey results show no differences in the proportions of visitors who stayed less than one hour, or between one and two hours, on sunny, cloudy or rainy days. Only slight differences can be identified in the proportions who stayed longer on days when the weather was better.

Do people visit other places on their trip? Respondents were asked what other places of interest (if any) they had visited on the day of interview. 22% mentioned other destinations, including 40% of the coach travellers but only 19% of the motorists. The most popular place was Berkeley Castle, some 6 miles (10 km.) from Slimbridge; this accounted for over half of those who had visited another place. The castle was very popular with coach travellers. 15% of those who had visited other attractions, and especially motorists (18% of them), went to the Severn Bridge. The only other important place was Tintern Abbey. For the visitors as a whole, more people tended to see other places on a Sunday than those arriving at Slimbridge during the week. Those who travelled further were rather more likely to combine visits to more than one attraction than those drawn locally.

Are visitors satisfied with their visit to Slimbridge? What interests them most? Visitors were asked to give their reactions to Slimbridge in terms of whether or not the area matched their expectations. 51% said it was 'better than they had expected', 40% considered it the same, while 7% thought it fell somewhat below their expectations. It might be inferred that weather at the time of visit would markedly affect the answers to this question, but a separate analysis showed that it had had almost no effect at all. Even in rainy weather, 47% of the visitors thought their visit was 'better than they had expected'.

Those who found their expectations exceeded gave a variety of reasons for their satisfaction, but most were pleasantly surprised by the open character and extent of the grounds and by the variety of birds.

Flamingos are undoubtedly the most popular birds at Slimbridge (Table VI); 63% of all visitors mentioned these birds. There is perhaps a most important distinction between popularity and the ability to recall a fairly bizarre sight in the English countryside. Members of the Wildfowl Trust, however, expressed a more general interest in other birds, notably geese. The overriding interest in flamingos, compared with other species, applied both to those who had mentioned birds as a specific reason for their visit and to those who gave more general reasons. 19% mentioned the attraction of young birds; but much of the survey was conducted late in the breeding season and after it had ended, and probably the popularity of young birds would be higher in the spring.

Table VI. Features that most interested visitors.

Features	*All respondents* %
Flamingos	63
Young birds	19
Ducks	18
Black Swans	9
Other Swans	13
Geese	9
Tropical house	10
Open atmosphere	6
Gardens	5
Tameness of birds	4
Others	18
Don't know/Not stated	7

Are the prices at Slimbridge acceptable? Visitors were asked to rate specific prices as 'too high, about right or too low'. In answer to this 84% considered the car parking charge to be 'about right'; indeed 5% thought it was too low. Nearly half thought the entrance fee for adults to the Slimbridge grounds was too high.

Visitors reacted even less favourably to the entrance fee for the tropical house. Of those with children, 64% (compared

with 55% of all visitors) considered the tropical house fee to be too high. 63% (compared with 58%) considered the child entrance fee to the grounds to be too high.

Reactions to prices varied not only with the presence or absence of children, but also with the overall distance people had travelled to get to Slimbridge. Visitors who had travelled further tended to react more favourably to prices than those who had come less far; 57% of those who had covered over 75 miles (120 km.) found the entrance charge for adults 'about right', compared with 46% of those who had travelled 30 miles (48 km.) or less. It may be that, after spending a fair amount on travel costs, the difference of 10-20 pence on an entrance fee is relatively unimportant; but that those who spend relatively little on travel costs are more sensitive to entrance charges.

On Mondays at Slimbridge, a cheaper entrance ticket is offered. However, only 12% of the visitors (interviewed on all days except Mondays) knew of such a ticket, and most of these were aware that the reduction applied on Monday. Even when Monday visitors were questioned on this, of those who had planned their visit for that day, only 11% knew that a cheap ticket was available. Again, this suggests a need for greater publicity for the 'cheaper entrance fee' if a policy of spreading the peak weekend load on to a relatively slack day is to be effective.

Is advertising by Slimbridge effective?

Respondents were shown a list of advertising media and asked to say in which of them, if any, they had seen advertisements for the Slimbridge Wildfowl Trust. A third of all visitors claimed to have seen no advertising at all, a proportion that corresponds to that observed for historic houses. Of the 68% who had seen advertisements, television was mentioned by most people (49%), especially those in the lower two social class groups. 61% of the C2DE groups recalled having seen television advertising, compared with 39% of the AB group. The dominance of television among the media recalled reflects the advertising policy followed.

Newspaper and magazine advertising were recalled by 17% and 14% respectively. Guide-books were mentioned by only 5%; this compares unfavourably with the figure for historic houses.

In answer to a supplementary question, 37% of all visitors, and especially those in the younger age groups, replied that they had been recommended to visit Slimbridge by their friends. This was the case for 50% of those aged 15-24 years, compared with 34% of those aged 25-44.

Television and newspapers are undoubtedly effective media for advertising, especially for reaching visitors coming from home. Though the proportions of visitors who had seen television and Press advertisements are large, they are not as large as the proportions of the budget spent on these two media, which suggests that more attention could perhaps be paid to other forms of advertising.

Local Press and television are least effective in reaching visitors on holiday away from home, who are more likely to see coach tour notices, hotel notices and guide-books. The proportions of visitors who recalled seeing these kinds of advertisements, compared with the proportions spent on them, indicate a high return on investment.

* * * *

Conclusions

Many of the results of the survey only serve to confirm what we know already, but of course it is useful to have access to quantitative data when planning. Some of the information about the public and their motives may appear depressing; but, again, it is useful to know the size of the problem we are facing in our attempts to put across the conservation message. We shall not be failing if even a fraction of the summer visitors are impressed enough to become Members (membership also has nearly doubled in the last ten years), or to come again to see the wild birds in winter.

Suffice it to say that our Council and staff are bearing the results of the survey very much in mind when seeking to improve Slimbridge and in setting up new branches.

Summary

To provide a factual basis in planning improvements at Slimbridge and in developing similar sites elsewhere, a visitor-survey was undertaken in the summer of 1969. A thousand interviews provided data on the age groups, social class, reasons for visiting, distance travelled, proportion of holidaymakers amongst the visitors. Their activities at Slimbridge and their reactions to the various features were also investigated, as was the impact of advertising.

G.V.T.M.

Research, Conservation and Education, 1970

The aims of the Wildfowl Trust, and its activities during 1970, may be considered under these three headings, though they do not represent sharp divisions.

Research

Here the aim is to increase the knowledge of wildfowl from any point of view, with emphasis on 'practical' research that will give meaning and direction to conservation measures and management.

Over the past 23 years the populations and distribution of ducks wintering in Britain have been monitored by monthly sample counts carried out by several hundred amateur ornithologists. The most recent data are given on p. 134. In the last five winters international counts, covering much of Eurasia, have also been organised from Slimbridge by Mr. Atkinson-Willes as Co-ordinator of the Duck Working Group of the International Wildfowl Research Bureau (I.W.R.B.). Geese require more intensive counts but these can be less frequent as, in many cases, they amount to near complete population censuses (p. 134). Mr. Ogilvie also collects the international data on the Brent Goose for the I.W.R.B.

Britain is much less important as a breeding area for wildfowl, but nevertheless it was desirable to obtain some quantitative idea of the distribution of the breeding ducks. The data, collected over five years, has now been analysed (p. 63). Useful exchanges of data were made with the British Trust for Ornithology, currently engaged in a presence-or-absence survey of breeding birds. The intensive study of duck breeding biology at Loch Leven, lasting five years, was completed (p. 138). Here ringing of the nesting birds played an important rôle as it did in the joint study, with the Edward Grey Institute, Oxford University, on the colonially breeding Mute Swans at Abbotsbury and Weymouth, Dorset, and with Dr. C. D. T. Minton's Trust-aided study (p. 71). The ringing programme is, however, mainly directed at non-breeding ducks, to monitor changes in migration and mortality patterns. The numbers marked in 1970 are summarised at p. 135, followed by accounts of activities at Borough Fen Decoy and Abberton Reservoir. At Slimbridge the regular small autumn catch was made to maintain a long-term sequence. At Nacton Tom Baker wound up a unique career of 52 years as the decoyman, converted from killing to ringing for the Trust in the last four. He will be succeeded by his son-in-law, Don Revett, in 1971. The 1969-70 season was the last in which Dersingham Decoy, Norfolk, was operated as a ringing station for the Trust. Analysis had shown that its results were not usefully different from our other decoys in East Anglia, and rational economies had been called for by the grant-aiding body. We are most grateful to the owner, Mr. J. E. A. Lambert, and the decoyman, Mr. R. Berry, for their contribution to our studies. Over 4,500 duck had been ringed there since the decoy was rebuilt in 1963.

The future of the long-term monitoring programmes of counting and ringing was assured under a Contract successfully negotiated with the Natural Environment Research Council (N.E.R.C.), coming into effect in April 1971. Under it, arrangements are made for the use of Automatic Data Processing facilities at the Biological Records Centre of the Nature Conservancy at Monks Wood, Huntingdon. Preparations were made for the change over to punched tape and card storage and automatic analysis. The rapid availability of completed analyses will greatly enhance the value of the massive data accumulated. Meanwhile an analysis of part of the ringing data from Borough Fen Decoy is given at p. 89.

Another N.E.R.C.-sponsored research programme, on the feeding ecology and behaviour of geese, drew to a close with the 1970-71 winter. Dr. Owen's three-year study of the White-fronted Geese feeding at Slimbridge is now complete and is being published. It is hoped that further work will be carried out at Caerlaverock, Dumfriesshire, where Mr. Campbell made a basic first year's study (p. 150) of the Barnacle and Pink-footed Geese. He had earlier rounded off a four-year study similarly concerned with the relation between geese and agriculture at Loch Leven. The behavioural aspects of feeding were further studied by Dr. Kear using the unrivalled facilities for rearing wildfowl in the Collection at Slimbridge. She also made growth studies and detailed

analyses of breeding success. Data gathered during her stay in New Zealand were further brought to publication.

The health of the Collections was monitored by routine post-mortem examinations. Dr. J. V. Beer, after 16 years at the Trust, left to direct a research unit at Newcastle University. He was succeeded by Mr. N. A. Wood, from the Game Research Association. We were also fortunate to obtain the services, as honorary Veterinary Adviser, of Mr. P. N. Humphreys, M.R.C.V.S. Some useful advances in the treatment of sick birds were made. A small isolation unit was constructed, also a surgery, equipped with an X-ray machine. The control of avian tuberculosis was advanced by the co-operation of Dr. A. McDiarmid of the Agricultural Research Council, Compton. Further additions were made to the museum reference collections and material was supplied to many workers in other institutes.

G.V.T.M.

WILDFOWL CENSUSES AND COUNTS IN BRITAIN, 1970-71

Goose censuses

Pink-footed Goose *Anser brachyrhynchus.* The annual census was held on 7th/8th November, when there were 72,000 Pinkfeet in the country. This total was slightly, but not significantly, fewer than the previous year. Breeding success was about average with 23.1% young birds in the flocks and a mean brood size of 2.2.

European White-fronted Goose *Anser albifrons albifrons.* An early peak of 11,000 was reached in mid-January after which the mild weather led to a drop in numbers. The breeding season was one of the best ever (45.0% young; brood size 3.5).

Greenland White-fronted Goose *Anser albifrons flavirostris.* No complete count of this race was attempted but at its main haunts numbers were about normal. Breeding success was monitored in western Scotland and in Ireland. In both areas there were only about 14% young present.

Greylag Goose *Anser anser.* The census on 7th/8th November showed there to be about 65,000 Greylags in the country, an increase of 3,000 on the previous year. The proportion of young birds (25.1%) was the highest for several years. The mean brood size was 2.4.

Barnacle Goose *Branta leucopsis.* The Spitsbergen population wintering on the Solway had one of their best breeding seasons ever (47.2% young; mean brood size 3.0). However, the maximum count was only 3,200, presumably because the mild winter allowed many birds to stay in Norway.

The Greenland population had an average breeding year (19.4% young; mean brood size 2.5). No census was carried out but the principal wintering haunt of Islay held about 15,000 birds throughout the winter.

Light-bellied Brent Goose *Branta bernicla hrota.* The flock at Lindisfarne, Northumberland, reached a low peak of 650 in early February. Over 12,000 were counted in Ireland in November.

Dark-bellied Brent Goose *Branta bernicla bernicla.* 1970 was the second successive good breeding season with 40% young birds in the flocks. Consequent upon this was a record count of 23,500 in Britain in November.

M.A.O.

Duck counts

Mallard *Anas platyrhynchos.* This was a record season for Mallard, the seasonal index being the highest since counts started. Exceptional numbers were present in England and Wales for most of the winter.

Teal *Anas crecca.* The increase since the cold winter of 1962-63 continued, with the larger flocks being seen in the south-east of England.

Wigeon *Anas penelope.* Another good season. The Ouse Washes again carried large numbers—32,000 in January. Some of these may have been attracted from the Wash, which has never been included in the priority count sample, so the apparent increase of the past two seasons may not be so great as the indices suggest.

Pochard *Aythya ferina.* A poor season. They were especially scarce in Scotland and south-west England and Wales.

Tufted Duck *Aythya fuligula.* A record season, with the highest seasonal index since counts started.

Shelduck *Tadorna tadorna.* A good season. The main influx occurred in December.

Season indices 1970-71 (1969-70 = 100)

Mallard	118	Pochard	136
Teal	68	Tufted Duck	126
Wigeon	130	Shelduck	103

International Wildfowl Census 1970-71

The fifth census in Britain was held in the same manner as last season's census, with counts in mid-November and in mid-January. Considerably more sites were covered this season than in 1969-70 as shown in the table below.

Census	November counts	January counts
1969-70	887	1060
1970-71	1013	1124

G. L. Atkinson-Willes
Barbara Yarker

DUCKS RINGED BY THE WILDFOWL TRUST, 1970

	Abberton	*Nacton*	*Borough Fen*	*Deeping Lake*	*Dersingham*	*Slimbridge*	*Loch Leven*	*Others*	
Shelduck	12							1	13
Pintail	9	292	1						302
Teal	1049	140	228		8	13		3	1441
Mallard	1274	625	1160	268	37	430	44		3838
Gadwall	5	2		3		5	9		24
Wigeon	59	173	1		23	1	4	1	262
Garganey	8								8
Shoveler	23	3	3	6				2	37
Red-crested Pochard	1								1
Pochard	10			4					14
Tufted Duck	133			55			349		537
Scaup							1		1
Red-breasted Merganser							5		5
Totals	2583	1235	1393	336	68	449	412	7	6483

M.A.O.

ABBERTON RESERVOIR, 1970

Low temperatures and snow caused the Top and Middle Sections of the Reservoir to be iced over for the first part of January, thus effectively putting most of the duck traps out of action. After the thaw there were over 6,000 ducks distributed throughout the Reservoir. Nearly a thousand were Wigeon and when some started feeding along the shores of the Middle Section they became of immediate trapping interest. However, as so often happens with this species, they showed a far greater interest in the available natural vegetation, and at first completely ignored the heavily baited traps. With the rapidly rising water reducing the shoreline quickly, the birds moved on to adjoining wet pastures. It was not until the 24th that two were caught. Sporadic catching went on until 9th March, but no good lead was obtained at any time and only 48 were ringed.

Repeated snow cover occurred throughout the rest of the winter, with some severe blizzards, and March was a particularly bleak month. Two large portable wader and passerine traps were constructed to further Mr. Fred Trust's future ringing programme.

The maintenance programme was hindered by April being almost as cold as March, but some progress was made and work completed on several traps. It was not until September that maintenance work could be said to be finished. The boats in particular needed considerable attention in all aspects, painting, structural and mechanical.

The breeding season was a delayed one, and produced only half the normal number of Mallard broods, whereas the diving ducks did rather better. Shelducks were almost a complete failure.

The change in weather conditions from the beginning of May was dramatic. One of the driest and sunniest periods experienced for many years continued almost unbroken until October. By the end of June the daily water demand was 20 million gallons with a further four million gallons lost through evaporation. The level dropped quickly and attracted duck; on 5th August, 4,500. Some 1,250 were feeding over the newly emerged Island, and three traps were subsequently moved out there.

For the following three months traps were operated almost continuously on the Island and Top Section. The depth of mud exposed on the Middle Section shore prevented the use of traps but not before they had made a useful contribution to wader ringing, including ten Curlew Sandpiper out of a flock of 30 at the end of August.

Last year's Shoveler catch could not be repeated in spite of a build-up of 500 on the Reservoir in late summer. In the hope of catching some of the Pochard summer moulting flock, an old small bird trap situated on the Dam had been converted into a duck trap. But the Pochard flock never reached 2,000, compared with over 5,000 the previous year, and due to prevailing adverse winds and other factors they failed to feed in the Dam area. Not one was taken.

From 14th June until 25th September 189 flightless moulting ducks were trapped and ringed, all Mallard apart from a Teal and a Pintail. These were mostly taken on the Top Section where reeds provide the necessary cover.

The highest complete Duck Count of the year, in October, was 7,592 comprising nine different species, mostly on the Main Section. The harvest had been quick and clean and there was little spill left on the fields for ducks as in previous years. In consequence numbers on the smaller Western Section, by the main grain growing area, were unusually small, affecting the catching, particularly of Teal. However, the Island traps compensated for this loss; of 899 ducks ringed from them the majority was Teal.

October and November produced some exceptionally windy days, and this part of the season's work provided many uncomfortable journeys through the turbulent waters round the Island. There were not too many regrets when an unusually wet November quickly refilled the Reservoir and the Island had to be abandoned in early December. There was no severe weather until the Christmas period brought heavy snowfalls. The total number of ducks ringed was 2,583, distributed as shown in the Table.

Monthly catches of duck at Abberton in 1970

January	183	July	217
February	111	August	315
March	32	September	665
April	18	October	454
May	56	November	235
June	99	December	198

Fred Trust and Tony Langstaff continued the passerine ringing and study programme. Between them they were able to man the station on 115 days and were richly rewarded by a total of 3,128 passerines of 51 species which included 986 warblers. Careful selection of the mist netting and trapping sites has enabled a representative selection of passerines to be ringed without disturbing the wildfowl. A small but interesting variety of waders was taken in August.

On 1st May the seven acre Abberton Public Bird Watching Site with its large Hide and other amenities was opened by Mr. A. W. White, Chairman of the Essex Water Company. The Hide gives the public a vista of the Main Section of the Reservoir and the opportunity to view the birds unobserved and in comparative comfort. It was at its most spectacular during the low water of September and October when extensive mud flats spread out in front of the Hide attracted large numbers of waders and duck. A small collection of pinioned duck were introduced on to the pond and these attracted numbers of wild birds.

R. King

BOROUGH FEN DECOY, 1970

Early January was cold, with the Decoy pond and Deeping Lake frozen from the 2nd to the 10th. Snow which settled on the pipes was shaken off daily to avoid tears in the net. Most of the duck left for open waters and the Fenland fields. The best day count was 38 Mallard, 160 Teal and four Shoveler.

A freeze-up between the 10th and 18th February again scattered the roosting birds and despite early morning ice breaking and heavy feeding, only one Teal was trapped during this period. Mallard appeared to be spending much of the day roosting on open fields, especially on wheat following potatoes where it is unnecessary to work the land and they are undisturbed.

A freak snowstorm on 4th March broke down a lot of elder and blackthorn outcrops that are so valuable for cover. Although the nets on the big ends of the pipes sagged alarmingly, none were torn nor did any hoops bend or break. The final Mallard duck of the season was taken in the SE. pipe on the 25th.

Some hundred bundles of reed were cut from our reed bed and at Dersingham (with the kind permission of Mr. J. E. A. Lambert during early April and preparations were made to clear the encroaching Phragmites that threatens to spread over the whole two and a half acre pond. In all ten yards was dug off the northern edge of the reed bed and six feet from the sides. The three big White Poplars that threatened the big end of the NE. pipe were felled. (A fourth had in fact fallen and demolished the pipe in 1969.)

General maintenance and mowing continued into May when a display was prepared for the European Conservation Year exhibition at Peterborough Museum. Preparations were made for the open weekend on 7th and 8th June when 101 visitors were shown trapping and ringing techniques and encouraged to enjoy the peaceful tranquillity of the paths and glades.

After an interval of two years, disused nests were again taken for Dr. M. J. Worms to check for parasites and larvae. Nests of ducks and waders were also taken from the reserve at Welney.

On 15th June two young Mallard not yet flying were taken in the SE. pipe and started the 1970-71 season. A diaphragm type pump was hired to remove some of the glutinous mud accumulating on the north of the pond. The deposit is at its worst on that side as the prevailing S. and SW. winds blow the fallen leaves to the margins before they become saturated, sink and decompose.

Helped by the Spalding and District Wildfowlers' Association, the flock of Canada Geese at Grimsthorpe Park were caught up and 148 plus one Greylag were ringed. The 470 caught included 62 ringed in previous years and only 31 juvenile birds. Later in the month the Whittlesey Wildfowlers released 51 hand-reared Mallard on the Decoy pond.

Problems arose in the first weeks of August in obtaining water from the river Welland to top up the decoy pond. The method used since Cornelious Vermuyden, in the 17th century, built the banks to contain the river, has been to open the sluices between the river and the washland banks and let the water flow down into the decoy pond. Unfortunately, a fall of masonry partially blocked the culvert. Some water invariably soaks into the peaty banks and there were further losses due to leaking slackers at junctions. The final trickle of water was collected in the filler drain and then pumped into the pond. This just maintained a very low level and continued pumping was needed until late October. No doubt this was partly responsible for the lower numbers of duck using the decoy as a roost.

292 completed Nest Record Cards were forwarded to the British Trust for Ornithology, including 12 Great Crested Grebes' on Deeping Lake.

Gale force winds littered the paths with debris on the 9th/10th September and many of the duck left, disturbed by creaking trees and snapping twigs. The year's best midday count was 1,050 Mallard, 80 Teal, 20 Shoveler, three Wigeon and two Pintail, making a total of 1,155 duck.

The first Fieldfare chuckled over the wood on 14th October. Some disturbance was caused by potato pickers but the low water level was probably the main reason for the small catches.

The first frosts of November dislodged the leaves that had withstood the winds and the Poplars stood gaunt and black. The pond had now filled naturally with the autumn rains, but the lead did not reappear. The Mallard still preferred the open fields. In all 1,393 duck were caught in the Decoy in 1970 supplemented by 339 from Deeping Lake.

W. A. Cook

LOCH LEVEN, 1970

The Trust's activities at Loch Leven, begun in 1966, drew to a close this year.

A fourth winter of studying the Greylag and Pink-footed Goose flocks feeding over the fields surrounding the Loch was completed in April. The type of field, the flock position and density, the feeding direction and rate, and the proportion feeding were all noted. A major difference to last year's long slow spring was a very mild spell in April when the cereal fields suddenly turned green. This was reflected in an increased amount of spring cereal grazing. The accumulated data for a varying set of winters will now be analysed and will form a useful basis for comparison and contrast at Caerlaverock.

To help with the duck nesting study, Mr. T. A. Gibson spent six months at Loch Leven, as a temporary assistant. Other help was available from the Nature Conservancy's Warden, Allan Allison, and, for short periods, from Slimbridge. Thus we were tided over a period of staff shortage, following the death last year of Ian Marshall, and the absence in Canada of Dr. Ian Newton of the Nature Conservancy, Scotland.

Monthly counts of the ducks using the Loch were made. St. Serf's Island, the main breeding site, was searched, on a weekly basis, for duck nests and 944 were found. Thus in the five years of the study we have accumulated data on more than four thousand duck nests, mainly Mallard and Tufted Duck. Their final analysis will provide a very real contribution to our knowledge of duck breeding biology.

Using hand-nets, 213 nesting females were captured for ringing. Of these, 64 proved to be recaptures from previous years, yielding valuable data on individual site preference and tenacity (since each nest with a marked female has its position precisely plotted). Some of the recaptures confirmed earlier suspicions that quite a sizeable proportion of Tufted Ducks are laying at the end of their first year of life, like Mallard, instead of having a non-breeding year between.

The eggs hatched in 292 Tufted Duck nests, compared with 164 in 1969. This was due to an increase in the proportion hatching successfully in 1970 since the numbers of nests found was actually seven less. This may well be owing to the intensive control measures applied to the Jackdaw population by the Conservancy. Jackdaws had been shown to be serious predators of duck nests in previous years. To test this further, a comparison was made between the fate of duck nests in the areas of the island searched at weekly intervals and in a control area (100 × 100 m.) which was not entered until after the breeding season. The 99 nests found therein were examined and their species and fate determined from the nest feathers and the condition of the egg shell fragments. It was found that 80% of the Mallard and 86% of the Tufted nests had hatched, as opposed to 50% and 71% elsewhere on the island. However, although the searching disturbance did result in more meals for Jackdaws, the final production of fledged young is not affected because it is in any case very low on the wave-ridden shelterless Loch. This was again confirmed by our regular brood counts. Besides the control zone comb-out for nests, a series of transects across the island were also searched after the nesting season. These provide the basis for estimating the nesting population of St. Serf's by sampling in the coming years when the full nesting study will not be made. This will be especially important in 1971 when the International Biological Programme's research on the total ecology of the Loch is rounded off.

The researches of Mr. K. A. Loughlin into the energy requirements of nesting ducks, for a Ph.D. study at Stirling University, were supported by the provision, under licence, of adult and egg specimens. One Tufted Duck clutch was taken to Slimbridge for rearing, to round off Dr. Janet Kear's study of the development of the ducklings (*Wildfowl* 21, pp. 123-132). One unofficial attempt to remove 80 eggs from St. Serf's was made by a youth who crossed over the half mile of water on an air mattress. He escaped from the fisherman who apprehended him, on the arrival of his large and threatening father!

The writer finally left Loch Leven at the end of July to take up the post of Refuge Manager at the Trust's newly leased Eastpark Farm, Caerlaverock. Sadness at leaving a lovely place, where five wonderful years had been spent with the wildfowl, was thus tempered with anticipation for the future. Mr. Gibson stayed on until mid-September, operating the dive-in traps for the fledged Tufted Ducks. He produced a useful total, together with the unusual bonus of a family of Red-breasted Mergansers.

Colin Campbell

Conservation

The Trust's contribution to conservation is threefold—the application of its research findings; the maintenance of its Refuges at Slimbridge, Welney and Caerlaverock; and the breeding of endangered species in its Collections at Slimbridge and Peakirk.

The application of the monitoring research results is made mainly through the Nature Conservancy in Britain. Its Wildfowl Conservation Committee was chaired in 1970 by Mr. Scott. Through this Committee, and less formally, close liaison was maintained with the Wildfowlers' Association of Great Britain and Ireland (W.A.G.B.I.) and the Royal Society for the Protection of Birds, both closely concerned with wildfowl conservation. Liaison is also maintained with the County Naturalists' Trust, especially of those counties in which our Refuges lie. In the international field, co-operation, essential because of the migratory nature of most wildfowl, is through the I.W.R.B. Professor Matthews serves as its Director, in an honorary capacity, and the headquarters is based at Slimbridge with Mr. E. Carp as Administrator.

An international Technical Meeting was organised at Espoo, near Helsinki, Finland, to thrash out an agreed text for a Convention on "Wetlands of International Importance, Especially as Waterfowl Habitat". This was successfully achieved and preparations then went forward for the next International Conference on the Conservation of Wetlands and Waterfowl, at Ramsar, Iran. Here the acceptance of the Convention was to be one of the main achievements (p. 122).

This was European Conservation Year (E.C.Y.) and two major threats to goose populations in Europe concerned Britain. If the Third London Airport were built at Foulness, a fifth of the population of the Dark-bellied Brent Goose would lose its feeding grounds. Every effort was therefore made to convince the Government-appointed Roskill Commission that the airport should not be sited there. The relief when the Commission rejected Foulness was short-lived, for their conclusions were rejected by the Government. Then, in Iceland plans were announced to flood the great Þjórsárver oasis, breeding grounds of the Pink-footed Goose and scene of the major ringing expeditions of the Trust in 1951 and 1953. To lend credence to the objections which were put forward it was necessary to have an up-to-date assessment of the importance of the area (p. 5).

A major E.C.Y. contribution was the official opening of Welney Wildfowl Refuge with its fine new Observatory (Plate IX). Further purchases of land in the area were made (p. 155). The Trust also took the lease of Eastpark Farm, Caerlaverock, and will be developing it as another Wildfowl Refuge (pp. 150 and 155). The Trust's original Refuge at Slimbridge continued to attract large numbers of White-fronted Geese and Bewick's Swans (pp. 139 and 140).

As usual considerable efforts were made to breed up wildfowl, especially the endangered species, in the Collections at Slimbridge and Peakirk.

G.V.T.M.

SLIMBRIDGE: THE WILD GEESE 1970-71

European White-fronted Goose *Anser albifrons albifrons*

Eleven arrived on 29th September and numbers built up slowly to 128 on 26th November. There were larger influxes in the first half of December to give totals of 500 on the 5th and 1,250 on the 18th. There were 1,700 present on the 23rd and 3,850 on the 29th, when there was a brief cold spell. During early January the total rose to over 5,000 and to a peak of 6,000 on the 18th. This number stayed for a few days before dropping to about 5,000 at the beginning of February. The total fluctuated between 4,400 and 4,800 through most of February until departures began on the 23rd. There were 2,950 counted on the next day, and only 1,600 on the 25th. These remained for over a week before the total fell to 1,320 on 9th March. On the 11th there were 400, and the last two were seen on the 12th.

It was an extremely good breeding season in 1970, one of the best recorded since the Trust started. Age counts in December revealed 47% young in the flocks, with an average brood size of 3.5. Later samples showed that there had been the usual slight drop, but on 5th February there were still 42% young and the brood size was the same as before.

Such a large proportion of young following on a good year in 1969 might have been expected to lead to record numbers of geese. However, the unusually mild

conditions after the New Year cold spell meant that the geese were able to stay in the Netherlands instead of getting pushed over to Britain.

Lesser White-fronted Goose *Anser erythropus*

We have received a belated report that an adult was seen on 1st March 1970, so that winter was not a blank one for the species as stated in WILDFOWL 21 (p. 133).

An adult arrived at Slimbridge on 13th December 1970 (an unusually early date) and was seen frequently until 20th February.

Bean Goose *Anser fabalis*

A family party of two adults and two young was seen on 31st December. A single bird was sighted on 2nd February and last seen on the 18th. All were of the *rossicus* race.

Pink-footed Goose *Anser brachyrhynchus*

Up to nine Pinkfeet were present in January, being seen as a small flock on a number of occasions. From 5th February until the Whitefronts departed only one was seen.

Barnacle Goose *Branta leucopsis*

Four were seen on 4th January and five on the 10th, and subsequently to the 21st. Only one was seen on 4th February, two on the 8th and then one for the rest of the month.

M.A.O.

SLIMBRIDGE: THE WILD SWANS 1970-71

The first Bewick's Swans came to Slimbridge early on 22nd October. They were a pair, Juan and Tobita, well established at Slimbridge in previous years, and their two cygnets. The family slept for most of the day, first feeding at 16.30, but left at 21.15, not to reappear until 26th December. This was the first of an interesting trend which developed later.

Arrivals were, in fact, fairly slow for the first fortnight, and by 6th November only 36 individuals had been recorded. The next day, however, it turned colder, there was a NE. wind, and 53 swans arrived. Pheasant and his mate, Partridge, gave us a rather inconclusive idea of from where they had moved. Pheasant's ring number had been read near Muiderburg in the Netherlands two days before, and in the flock of 430 there were three other ringed swans. Probably one of these was Partridge.

The increase continued fairly steadily for the next ten days, by when 232 swans, including 16 families, had been recorded, although no more than 154 had been on Swan Lake in one day. Of the parents, only two pairs and the females in another two pairs had never been recorded at Slimbridge. Only six families stayed, all of the parents having been to Slimbridge before, except for one of the females. She and her mate, incidentally, lost their only cygnet within three days of arriving. Of the families that left, all returned later in the season except the two in which both mates were new. The other new female never became confident, however, and the family never became satisfactorily established. This confirms the impression gained last season that new pairs with cygnets tend not to stay at Slimbridge. However, previously well-established pairs did not return until between 19th and 27th December, when the weather became very much colder.

During November swans continued to arrive, but the next major influx was not until that cold week at Christmas when the families returned. During the second week in January there were frequently over 400 Bewick's Swans on Swan Lake in a day, and on 16th January a new record of 411 was reached. However, last season's peak was 404, so perhaps we have reached the top level of Bewick's that Swan Lake can hold.

Departures were hardly recognised as such for they began so early. Even before 16th January the weather started to become milder, and there was quite a lot of rain, which gradually began to flood the lower-lying fields. On 20th January 45 fewer swans came, and by the 28th 100 more had disappeared. Another 50 left on 7th February and 120 a week later; after 14th February the day total on the pond was only once over 50, and only one new swan appeared. This is a period when we normally expect a small influx of swans that have wintered further west. Last year 34 came, and the year before that 25. These remaining swans gradually left; the last four on 24th March.

The total number of Bewick's Swans recorded this season was 626, which was

another new record. The proportion of cygnets was 18%, which was an improvement on the past three years. The mean brood size was 2.1. Seven pairs had four cygnets each, although two of these families each lost one during the winter. Of the total, 280 were birds that had been here in previous seasons, which makes the return rate the highest ever (45% of total). The details are in Tables I and II.

This season, for the first time, there were three cases of swans that had missed three winters at Slimbridge reappearing. Their behaviour was interesting to note. Bailey, ringed as a cygnet in 1966-67, had lost all recollection of the place, for his behaviour was no different from that of any new swan. He had to get used to the buildings, the crowded pool and the regular appearance of the feeder. Whistle and Thistle were extraordinarily nervous. When last here, in February 1967, there were never more than 24 other swans present. This year there were 300, rising to over 400 during the month that they stayed. They took a full week to settle at all and still remained 'jumpy', and were one of the earliest departures, on 21st January. When Guy and Letty, here in late winter 1967, returned this January they hung back nervously until most of the swans had fed, before they did so. Conditions can not have been attractive to them, however, for they left that day, dropping in again for a few hours a fortnight later.

This year we had a second example of a pair of swans becoming separated and finding each other again. Stars and Stripes had been coming to Slimbridge for four years, until last season, when, rather late, Stars came alone, from 24th February to 11th March. This winter they returned together on Christmas Day.

It was interesting to note the degree of tolerance that individual families show to their former offspring, and to what extent these offspring 'cling' to their families. This would seem to vary according to the individual pair, and not be dependent on whether or not they currently have cygnets. There were 15 unmated swans this season, whose parents also came, but one of these did not overlap with her parents, while another pair left the day their offspring flew in. Two (siblings) of the remaining 13 paid no attention to their father (perhaps because he had a new mate). The other 11 did associate with their parents; four arrived and left with them; one arrived with and left before them; three arrived alone and left with their parents; three travelled quite independently. But perhaps most interesting is to compare the behaviour of Pepper and Amber to that of Porgy and Bess. This year Pepper and Amber had with them two current cygnets, two

Table I. Numbers of Bewick's Swans at Slimbridge 1963-64 to 1970-71, and annual breeding success.

Season	*Total of different swans seen*	*No. returning from previous years (Adult/2nd yr. only)*	*Cygnets*		*Mean brood size*	*Maximum on Swan Lake on one day*
			No.	*%*		
1963-64	24	—	6	*25*	2.0	24
1964-65	74	13	16	*22*	2.7	56
1965-66	148	31	43	*29*	1.7	125
1966-67	336	68	97	*29*	2.7	224*
1967-68	342	102	31	*9*	1.6	199
1968-69	439	130	34	*9*	1.6	366
1969-70	570	238	41	*7*	2.1	404
1970-71	626	280	113	*18*	2.1	411

* 271 birds were counted on 13th January 1967, mostly on the River Severn and Dumbles.

Table II. Percentages of adult and second year Bewick's Swans returning to Slimbridge in seasons after the first sighting.

Season of first sighting	*Number seen for first time*	*Percentages of original total returning in subsequent seasons*						
		2nd	*3rd*	*4th*	*5th*	*6th*	*7th*	*8th*
1963-64	18	*72*	*61*	*61*	*50*	*39*	*33*	*28*
1964-65	45	*44*	*42*	*31*	*31*	*24*	*22*	
1965-66	74	*51*	*38*	*35*	*32*	*31*		
1966-67	171	*30*	*19*	*18*	*19*			
1967-68	209	*24*	*24*	*20*				
1968-69	275	*42*	*30*					
1969-70	291	*29*						

cygnets of last year (the third died on 25th March 1971 in the River Dove Valley, Staffs.) and a cygnet of 1966. The last did not arrive with the others, but joined up with them. He was readily accepted in the family group, and there was never the slightest sign of discord. Porgy and Bess, on the other hand, had four cygnets this year. Eartha, a cygnet of 1968, met up with them, but as the season progressed her parents tried to discourage the association, and the cygnets began to join in on this. It appeared a reluctant ceremony. The cygnets pecked or made pecking motions in the gentlest manner, while at the same time slightly curving their necks and pointing their bills down at about 45° as in greeting recognition. Eartha stuck with them, despite this, but it will be interesting to see what the situation is next season.

We caught 187 swans and nine were found crash-landed around the grounds. Of these 92 had not been ringed before, which brings the total ringed at Slimbridge to date to 304. There were six catches (Plate XIV). While it was again found that it became more difficult to get the swans up the pipe later in the season, a last catch of 18 was managed on 10th February. As well as taking various measurements, weighing, ringing, and photographing each bird, we also took a blood sample and an X-ray. From the blood samples we hope to find out to what diseases the birds have been exposed, but we have not yet had the results of the analyses.

The results of the X-rays of 100 swans were depressingly interesting—24 carried lead shot. Of 18 cygnets, only one was carrying one pellet. Of four yearlings, two had shot (one pellet and three). The shot in 19 of the 78 adults ranged from one to five pellets (mostly Number 5 size, but one was S.G.). In two pairs both male and female carried shot, while three of the adults have at one time lost their mates (Caesar, now carrying five shot, has lost two wives).

Among swans recovered elsewhere this winter, one cygnet (from the Moors) carried two shot, and one adult (found injured at Welney and subsequently died at Slimbridge) carried four. The most disturbing point is that the International Wildfowl Research Bureau informs us that all swans are totally protected in all countries through which the Bewick's might pass, U.S.S.R., Finland, Poland, East Germany, West Germany, Sweden, Norway, Denmark, the Netherlands, Belgium, France, the U.K. and Ireland. Clearly the law is being disregarded somewhere. As a final bit of gloom, an adult, picked up at Welney, was found to have ingested shot and died of lead poisoning.

This year all swans caught had their tails, scapulars and wing tips dipped in yellow dye, so that more would be learnt about their movements when away from Slimbridge. Being gilt-edged seemed to cause no social difficulties for the birds and certainly brought a touch of colour to Swan Lake. One enthusiastic swan-watcher was heard to inform her companion that it was the males who had yellow tails! We had some interesting reports, but they totalled very few of the 114 birds dyed, especially when some reports may well have been of the same bird. Yellow-tailed swans were seen at Blagdon (2) and Chew (1) reservoirs in Somerset as early as December, and probably were only two individuals. These could even have been daily commuters from Slimbridge, for swans certainly do commute, and it must require little effort. On 1st December 11 Slimbridge swans were identified at Hasfield Ham, 16 miles north. As I left, five took off, including Tim and Sparrow, and were already on Swan Lake when, 40 minutes later, I got back to Slimbridge.

Other sightings were again at Blagdon (2) and Chew (1) reservoirs in January, probably the same two birds; a single bird at Eglwys Nunydd, Glamorgan; and five on our reserve at Welney. They only stayed one day, however, and unfortunately their ring numbers could not be read. During the main exoduses in February we expected a flood of reports, but instead the swans practically vanished. The postal strike didn't help, of course. Birds were seen at two places on the Somerset Levels (one at each), on the Whittlesey Washes, Northants. (4) and the Ouse Washes (2).

In March reports were fewer, indicating, along with the sharply declined numbers at Slimbridge, that the birds had left the country. They were from: Hensal Castle Lake, Glamorgan (1), the Ouse Washes (2), the Haddiscoe Levels, Norfolk (1) and Shingle Street, Suffolk (1). The observer managed to take a photograph at Shingle Street, and Rasco's identity was confirmed by the ring number.

Given that the average wintering population of Bewick's Swans in the British Isles is around 2,500, about one in twenty had a yellow tail and wing-tips. Yet out of 300 seen near Langport on the Somerset Levels on 17th February, only one

Figure 1. Map showing localities of marked Bewick's Swan recoveries (crosses) and sightings (dots).

was dyed, and there were only eight dyed swans left at Slimbridge that day. There was a peak of 420 swans on the Wexford Slobs, Ireland, on 1st March, but none were dyed. A Darvic-ringed swan was seen on the South Slob as late as 15th and 16th March (when only three swans remained at Slimbridge). It was identified by ring number, along with a good drawing of the bill pattern, as Frobe. This swan first came to Slimbridge in 1969-70, but did not return this winter. Another Darvic-ringed swan had been seen in February at the wildfowl refuge at Kilcolman Marsh, Co. Cork, but the ring number is not known. The small number of dyed swans seen among up to 1,250 on the Ouse Washes was also surprising.

During the spring we received reports of dyed swans from various parts of Germany between the end of January and mid-April. Two were seen near Ammersum, close to the Dutch border, in late-January/early February, and eight near Itsehoe, north of Hamburg, in mid-February, and one in the Elbe estuary, west of Hamburg, at the end of March. The greatest congregation, however, was much further up the Elbe, near Dannenburg in West Germany and Dömitz in East Germany. Up to 13 dyed swans were seen by several observers, as well as two ringed in previous seasons. One observer managed to read the complete ring numbers of seven swans, and from his other information we identified another family with one cygnet, and a single bird. Dyed swans were present in this area, flitting infuriatingly between the two banks, from the end of January to the end of March.

Other sightings were one at the Krakower See (unknown date) and one on 3rd April and again ten days later on the west coast of Schleswig-Holstein, near the Danish border. Dafila Scott (p. 144) saw three dyed birds in Denmark and one ringed swan in the Netherlands in late March. Another dyed swan was reported in south Gotland, Sweden, on 11th April.

Finally we had reports from Estonia where two separate groups of flying swans each had one marked bird (on 10th and 23rd April), and another two were seen at Matsalu Bay on 27th April and 2nd May (possibly the same bird). Unfortunately the postal strike had hampered our efforts to circularise foreign ornithological institutes and although quite a start has been made we hope next year to get even more information.

Only two Whooper Swans came to Swan Lake this winter. They arrived on 22nd December and were extremely aggressive. However, despite this, they only stayed until 19th January, leaving with the first departure of the Bewick's.

Mary Evans

SLIMBRIDGE: BEWICK'S SWANS IN THE NETHERLANDS AND DENMARK, MARCH 1971

Itinerary and numbers

On 20th March an excursion was made to the area near Nijkerk, south-east of the Eem Meer in the Netherlands where I had seen swans in March 1970. A total of 111 Bewick's Swans was seen here in three groups. Further north at Strand Nulde, where large numbers of swans occur in autumn, there were none. The usual places along the river Yssel between Kampen and Zwolle were also visited, but due to the complete absence of flooding, there were no swans where there had been more than 300 last spring. At one place just to the east of the Veluwemeer near Kampen, there were four Bewick's in a field with some Mute Swans, but none on the Meer itself. Along the west coast of the south polder a pair of Bewick's were seen and further south near Muiderberg, a small group of 28 swans in a field behind a farm.

On 21st March these areas were re-visited as well as an area near Bunschoten where there was a group of 114 swans.

On 22nd March, in Denmark, the large shallow Lake Tissø, the estuary of the river Halleby at Rersø, and that of the river Tudea, in the west of Sjaelland were visited. The only swans seen were ten on the River Tudea.

On 23rd March, in Jutland, the reserve Vejlerne in the north-west was visited. About 100 Bewick's were seen on Lonnerup Fjord, and about 40 on Osterild Fjord, but none on the other fjords in the neighbourhood.

On 24th March a thick fog cut visibility to about 100 metres until mid-afternoon. Several places down the west coast were visited, and the roads closest to the water were taken, but no swans were seen or heard until the mouth of the Numinde Strom at the southern end of Ringkøbing Fjord. Here there was a group of 67. Further south, on the lake at Filsø, 44 were seen. Returning northwards, 50 swans were seen on West Stadil Fjord.

On 25th March, the area north of Rønde was visited. At the first place, the area round Kolind, four Bewick's were seen on the flooded fields by the river Ryom. On a small unlikely pond close to the main Randers-Grena road, and on the outskirts of the village of Fausing, 18 Bewick's were seen.

On 26th, 27th and 28th all the places north of Lemvig in the west of Jutland were re-visited. The numbers in all the places were unchanged, except at Vejlerne where there were 214 on 26th March (108 on Osterild, 82 on Lonnerup and 24 on Arup Fjord). With good visibility a total of 58 was seen in one area near Harbøør in the extreme west of Limfjorden that day, and on 27th March the 18 at Fausing had gone. The reserve Ulvedybet near Aalborg had no Bewick's.

The numbers seen on my trip appear to have been affected by the spring weather conditions. In the Netherlands it was extremely mild until the beginning of March when there was a brief cold spell. This would have pushed on all swans passing through before the beginning of March, and it is likely that many of the swans did pass through early as it was so mild in England as well. The majority of swans left Slimbridge by the second week of February whereas in the spring of 1970 (also mild) they left at the end of February, and the year before that between 6th and 9th March. Of about 250 swans seen in the Netherlands (compared with about 450 last year) about 200 (80%) were close enough for individual recognition.

In Denmark there had also been a cold spell shortly before, and all inland waters had frozen. But by 22nd March, the weather was quite mild and on several days there was a considerable heat haze to add to the difficulties of identifying swans at a distance. In Sjaelland, six of the ten swans seen at Tudea were close enough for individual recognition. In Jutland, of a total of about 470 swans, only 170 or so were close enough (36%). This is significantly low compared with the Netherlands and is largely due to the different type of habitat in which the swans are found in Denmark.

Recognition of Slimbridge-wintering swans

On this trip the likelihood of picking out Slimbridge swans was greatly increased, since 114 birds caught in the winter of 1970-71 had had their tails, scapulars and wing tips dyed yellow. One bird had been marked pink.

In the Netherlands out of 200 close enough for recognition only one near Bunschoten on 21st March was a Slimbridge swan. It bore a yellow plastic ring (G216) on its left leg, making it a 1969-70 cygnet of Prongy and Square. They, and her brother, Presco, had all returned to

Philippa Scott

Philippa Scott

Plate XV. Greater Flamingos *Phoenicopterus ruber roseus* bred for the first time at Slimbridge in 1970.
(a) A growing youngster in the nest, squatting on its 'hunkers'.
(b) One bird sits peacefully while another bickers with a neighbour.

E. E. Jackson

Plate XVI. A Blue Snow Goose *Anser c. caerulescens* on its nest in a clump of nettles at Slimbridge, very different from the exposed sites available on the wind-swept tundra (pp. 18-28).

Slimbridge this winter, but not her. If she does return, she will now be recognisable by face pattern and she has a mate which will also be recognisable.

In Denmark on 21st and 22nd March, a dyed Slimbridge swan, Muzzy, was seen at Tudea in west Sjaelland, having left Slimbridge on 2nd February. This bird was first reported by an ornithologist as painted purple on the primaries, and since Muzzy was the only swan dyed pink, it was only necessary to confirm her identity. None of the other five birds with her were familiar. Her mate Fuzzy unknown to her was still at Slimbridge having arrived there after her departure, but it is hoped that they may find each other again further north. Also on 22nd March two yellow-dyed swans were reported on Lonnerup Fjord in northwest Jutland. The following day I saw one of these close enough to identify it as Caesar who left Slimbridge on 12th February. (He has been visiting Swan Lake for seven winters.) Caesar was seen almost every day until 27th March when the second reported swan was re-sighted on the neighbouring Osterild Fjord, just too far away for certain identification. It was ringed on the left leg and may have been Ginty who left Slimbridge on 7th February. A third dyed swan was reported by a Danish ornithologist on Lonnerup Fjord on 28th March.

Habitat

In the Netherlands all but ten of the Bewick's Swans seen were in flat fields where the grass appeared very green and shallow water was lying in a few places. Around Nijkerk, westwards towards Bunschoten, and near Kampen, the fields used were not more than a mile from open water and always at a distance from human habitation. Those seen near Nuiderberg were surprisingly close to a built-up area and were feeding in a small wet field behind a farmhouse, the occupants of which were not too pleased about the swans being there. They said 28 eat as much as three cows! The six swans seen along the west coast of the south polder were standing in the shallow water along the edge of the marshy area just inside the dyke. This shore is fringed with phragmites in many places and the swans were feeding in the more open places.

In Denmark, the habitat was in complete contrast. All but 16 of the swans were on shallow water, either on fjords (large or small shallow lakes bordered by flat land) or on river mouths or small pools. The largest concentration of Bewick's was seen at Vejlerne on three shallow lakes. The depth almost all the way across these lakes is not much greater than the length of a swan's neck. The same sort of conditions prevail at Filsø, West Stadil and Stadil Fjords. Some of the other places differ in that they are on the edges of very large fjords such as Ringkøbing, Bøvling and Limfjorden. Along the Aggertange and Harboør Tange there were small numbers of swans on the shallow pools, and in the south of Ringkøbing Fjord swans were seen in the shallow water at the mouth of the Numinde Strom. In all these places the swans were far from human habitation with the exception of the pool at Fausing which was only about 30 metres by 20 and near a village and a main road. At Kolind, and Tudea in Sjaelland, the swans were grazing on wet fields near rivers, much as they do in England.

An interesting point about 'swan places' in Denmark is that few are visited regularly and even there the numbers may vary greatly from year to year. More Bewick's are seen in autumn when the migration appears to be more northerly.

Conclusions

It has become clear from this trip that individual recognition of Bewick's Swans by the bill pattern alone has serious limitations in places such as Denmark where the swans cannot be approached to within 100 metres. So the value of dyeing swans is evident and it is in any case of great help even if swans cannot be identified individually. Rings would also have been extremely difficult to see in Denmark except when the birds were upending, and then they would seldom have been close enough for the number to be read.

Acknowledgements

I would like to thank the following for all their help in making my trip to Holland and Denmark possible: Professor H. M. Thamdrup, Dr. N. O. Preuss, Mag. A. H. Joensen, Dorete Block, Miss Miek Harmsen; and am extremely grateful for the support of the Frank M. Chapman Memorial Fund and the Millfield Society.

Dafila Scott

SLIMBRIDGE: CURATOR'S REPORT FOR 1970

The Collection now has 173 kinds of birds, numbering some 2,000 individuals. A novel addition has been a pair of Musk Ducks *Biziura lobata* presented by Perth Zoo, W.A. (Plate XIa). Unfortunately we have lost the last Blue Mountain Duck *Hymenolaimus malacorhynchos*. This fascinating bird is the only indigenous New Zealand duck that has failed to breed at Slimbridge. Indeed Slimbridge is the only place outside New Zealand where the birds have been kept successfully.

The 1970 breeding season produced nearly 800 fledged wildfowl at Slimbridge, of 88 different kinds. The results with the Ne-ne were the most successful recorded: 51 at Slimbridge, five at Peakirk and 41 in collections to which birds had been loaned. It would be safe to say that the improvements in these breeding results are due to two major factors. Firstly, the four ganders containing wild blood, sent to us from Pohakaloa, two each in 1962 and in 1967, have no doubt increased the virility of our breeding stock inasmuch as most of the young produced in the last two years are related to them. Secondly, we are much indebted to our honorary veterinarian, Patrick Humphreys, whose work in ascertaining the ganders capable of producing a satisfactory amount of semen for pairing with known laying females has been invaluable.

Concerning flamingos, the most successful result was with the Chilean flock, the largest we have—some 70 birds. In 1969 this had produced five birds reared to maturity from 30 eggs laid. In 1970 40 eggs were laid from which 25 chicks were hatched and 21 reared. A number of eggs were rolled out of nests. But it is a significant factor, that might well contribute to their breeding success, that this flock allowed the warden feeding them to walk amongst them and to replace the eggs.

The Andean Flamingos laid four eggs but none was fertile. The Greaters and Lessers both went in for sporadic nest building activities and finally the Greaters laid five eggs and reared three young (Plate XV). The Caribbeans made several concerted nesting efforts during the season but no eggs were laid.

The White-winged Wood Duck have been paired off. One pair has been left full-winged and put into the Guinness Aviary. Here they have been given a variety of nesting sites with the expert advice of Sam Mackenzie who sent them to us from Assam. The other pairs have been pinioned. One pair has been released in the 'Wood', where there are many natural nesting sites. The third pair are in the Rushy Pen Aviary (Plate XIb).

During the summer we were able, albeit some months late, to bring the new Food Store and Preparation Room, Workshop, Incubator Room and Propagation complex into use. We now have indoor accommodation for 40 broods of downies—a tremendous assistance in our English climate.

S. T. Johnstone

PEAKIRK: CURATOR'S REPORT FOR 1970

The breeding season at Peakirk started on 3rd March with snow during the first month. This was followed by rain until the middle of May, when the weather changed to warm and dry for the remainder of the season. June was a particularly hot month, and the heat had an adverse affect on sitting hens.

The construction of the New Service Area Building commenced on 14th March, and work continued on this project until 4th July. During this period numerous upheavals took place in the sitting-hen-box area. Supervision of hens and hatching eggs had to be carried out under most difficult conditions in close proximity to both builders and members of the public in the car park. In view of these conditions, results for the season are considered reasonable.

The first of the six pairs of breeding Ne-ne on the Neaverson Area laid two clutches of eggs and five young were successfully reared Three Trumpeter Swan cygnets were reared for the second time at Peakirk. A further comparatively new species to breed was the Andean Goose.

Other more notable species bred included Fulvous Whistling Duck, Ross's, Cackling Canada and Red-breasted Geese, New Zealand Brown Teal, European Eider, Canvasback, Baer's Pochard and Maned Goose. In all more than 200 wildfowl of 44 kinds were reared.

P. B. Vardy

Slimbridge breeding results, 1970

Species	*Date of 1st egg*	*Eggs set under hens*	*Hatched by hen*	*Hatched in incubator*	*Hatched by parent*	*Reared by parent*	*Total reared*
Magpie Goose	7.7	11	2	5			3
Plumed Whistling Duck	3.6	22	0				—
Fulvous Whistling Duck	1.4			24	14		24
Black-billed Whistling Duck	10.5				15	5	10
White-faced Whistling Duck	5.6			25	10	3	28
N. Red-billed Whistling Duck	30.5			16	12	8	24
S. Red-billed Whistling Duck	24.4			55			36
Black Swan	5.2				2	2	2
Mute Swan	15.4					1	3
Black-necked Swan	11.2			3	5	2	5
Trumpeter Swan	2.4	2	0		1	1	1
Swan Goose	6.4			5			1
Western Bean Goose	1.5	6	0				—
Russian Bean Goose	27.4	10	3				2
Pink-footed Goose	26.4				7	7	7
European White-fronted Goose	12.6	17	5				5
Greenland White-fronted Goose	25.4	23	10		4	3	12
Lesser White-fronted Goose	20.4	22	13				13
Greylag Goose	2.4				20	20	20
Eastern Greylag Goose	2.5	5	0				—
Bar-headed Goose	25.4	22	6		8	7	13
Emperor Goose	1.5	5	0				—
Lesser Snow Goose	26.4				11	10	10
Greater Snow Goose	5.5	11	5		2		6
Ross's Goose	14.5	7	0				—
Giant Canada Goose	20.3				7	7	5
Lesser Canada Goose	19.4	6	5		5	5	10
Great Basin Canada Goose	8.4				1	1	1
Dusky Canada Goose	31.3				8	6	6
Cackling Canada Goose	26.4	25	10				7
Hawaiian Goose	3.2	120	54				51
Barnacle Goose	24.4				26	22	22
Black Brant	1.6	4					—
Red-breasted Goose	3.7	4					—
Ruddy Shelduck	7.4	10	1		10	8	8
Egyptian Goose	15.3			5	6	6	11
Abyssinian Blue-winged Goose	18.4	8	0	5			5
Andean Goose	16.4				5	4	4
Ashy-headed Goose	12.4				2	1	1
Greater Magellan Goose	24.3			3	6	5	8
Cereopsis	13.1				2	1	1
Patagonian Crested Duck	24.3	37	25		4	3	25
Andean Crested Duck	8.3	10	2	3			4
Marbled Teal	—			24			14
Cape Teal	—	6	0				—
Versicolor Teal	19.4	28	9				2
Puna Teal	24.5	5	0				—
Red-billed Pintail	3.5			7			5
Bahama Pintail	17.4	7	4	27	7	3	22
Chilean Pintail	—	10	9	5			13
Kerguelen Pintail	4.7	5	0				—
Northern Pintail	7.4	10	8	17	6	2	27
Chilean Teal	9.3			7	7	4	11
Australian Grey Teal	29.4	19	2				2
Chestnut-breasted Teal	24.4	21	6				6
New Zealand Brown Teal	26.4	12	0				—
Mexican Duck	12.3	5	2		4	2	4
North American Black Duck	11.4	14	6				4

Species	*Date of 1st egg*	*Eggs set under hens*	*Hatched by hen*	*Hatched in incubator*	*Hatched by parent*	*Reared by parent*	*Total reared*
Hawaiian Duck	24.3	35	18	7			25
Laysan Teal	17.4	19	5	4			8
Indian Spotbill	23.5	22	17				17
New Zealand Grey Duck	10.4	15	13				11
Pelew Island Grey Duck	21.4			12			11
Philippine Duck	8.5			18			18
African Yellowbill	20.3	11	8	3			11
Abyssinian Yellowbill	27.3	11	8	11			18
African Black Duck	14.3	9	0				—
Gadwall	18.4				80	60	60
Falcated Duck	24.5	17	4				4
European Wigeon	1.5	4	3	33			35
American Wigeon	26.5	22	5	8			12
Chiloe Wigeon	7.5	19	18	11			18
Blue-winged Teal	12.5	24	7				6
Cinnamon Teal	8.5	21	15				9
Garganey	—	10	0				—
Argentine Red Shoveler	9.5	7	0				—
Cape Shoveler	18.4	9	5				3
Common Shoveler	16.5	8	5	4			6
New Zealand Shoveler	27.5	8	7				6
Ringed Teal	3.4	18	9				8
European Eider	23.4	25	6	5			10
King Eider	8.6	5	0				—
Red-crested Pochard	23.4	22	8	3			9
Rosybill	—	4	4				3
South African Pochard	—	4	0				—
European Pochard	23.4	25	22	4			24
Redhead	—	5	2	7			9
Common White-eye	—	16	13	32			36
Baer's Pochard	13.6	9	7	10			16
Australian White-eye	18.4			15			13
New Zealand Scaup	1.5			15			13
Tufted Duck	—	9	7	16			20
Lesser Scaup	—	8	5	12			14
Muscovy	24.4			15	9	7	22
Greater Scaup	13.6	2	0				—
Brazilian Teal	10.5	2	2				—
Mandarin	28.4	25	12	59			39
North American Wood Duck	25.3	15	7	47			31
European Goldeneye	27.1	8	0				—
Smew	18.5	16	8				1
Red-breasted Merganser	28.5	13	3				1
North American Ruddy Duck	5.5	6	2		50	20	20
Chilean Flamingo	13.5				25	21	21
Greater Flamingo	12.6				3	3	3
Andean Flamingo	30.5				—	—	—
Crested Screamer	8.7				4	2	2

Peakirk breeding results, 1970

Species	*Date of 1st egg*	*Eggs incubated*	*Eggs hatched*	*Young reared*
Fulvous Whistling Duck	18.6	7	7	3
Black Swan	10.3	4	0	—
Black-necked Swan	5.3	4	1	1
Trumpeter Swan	28.4	6	3	3
Swan Goose	12.4	8	1	0
Western Bean Goose	2.5	4	2	2
Pink-footed Goose	8.5	17	5	4
Greenland White-fronted Goose	29.4	16	0	—
Emperor Goose	13.5	11	3	3
Lesser Snow Goose	5.5	10	4	2
Ross's Goose	13.5	8	3	2
Taverner's Canada Goose	4.5	5	0	—
Cackling Canada Goose	13.4	12	6	6
Hawaiian Goose	3.3	9	7	5
Barnacle Goose	11.5	28	12	9
Black Brant	15.5	1	0	—
Red-breasted Goose	8.6	5	4	3
Cape Shelduck	20.3	13	4	2
Common Shelduck	13.5	28	18	18
Andean Goose	31.5	6	4	3
Ruddy-headed Goose	3.5	3	3	2
Lesser Magellan Goose	5.4	5	4	0
Greater Magellan Goose	9.5	4	3	3
Marbled Teal	30.5	6	3	3
Cape Teal	11.5	11	1	0
Red-billed Pintail	3.6	9	0	—
Bahama Pintail	25.5	7	1	1
Chilean Pintail	18.4	2	2	2
Northern Pintail	1.5	30	19	14
Chilean Teal	11.4	11	6	6
European Green-winged Teal	4.6	5	0	—
Chestnut-breasted Teal	17.4	15	0	—
New Zealand Brown Teal	21.4	9	1	1
North American Black Duck	11.5	7	3	2
Hawaiian Duck	1.5	9	2	0
Laysan Teal	24.4	21	10	5
Philippine Duck	14.5	15	7	5
Abyssinian Yellowbill	2.4	15	12	9
Gadwall	5.5	14	3	3
European Wigeon	14.5	28	12	10
American Wigeon	20.6	7	3	2
Chiloe Wigeon	8.5	9	0	—
Cinnamon Teal	30.5	1	0	—
Common Shoveler	11.5	25	17	14
European Eider	20.5	13	7	4
Red-crested Pochard	15.4	30	10	1
Rosybill	15.5	22	12	10
Canvasback	12.5	7	3	3
Redhead	16.5	10	6	4
Ferruginous Duck	28.5	6	6	1
Baer's Pochard	10.6	7	4	2
Australian White-eye	27.5	12	8	6
New Zealand Scaup	9.6	6	5	0
Tufted Duck	6.6	8	3	1
Lesser Scaup	20.6	7	7	0
Maned Goose	3.4	14	7	7
Mandarin Duck	19.4	49	26	24
North American Wood Duck	11.4	43	17	8
North American Ruddy Duck	19.5	15	8	2

WELNEY: WILDFOWL REFUGE, 1970

The undoubted non-ornithological highlight of the year occurred on 7th November when Mrs. Ernest Kleinwort officially opened the Refuge and the new Observatory building, a two-storey breeze-block and wood building, with large plate glass windows sloping inwards from the top to keep the rain off them as much as possible. On the walls inside exhibition panels illustrate the history and wildlife of the Washes, and the significance of the area as prime habitat for wildfowl. The Observatory stands on the inner boundary bank overlooking the Washes and is connected with the road by a covered bridge spanning the Hundred Foot River. It looks out over shallow lagoons, floodlit at night, to the broad sweep of fields and water. It is entered by a box-bridge over the New Bedford River, constructed as a training task by a troop of 3 Field Squadron, Royal Engineers. Near the roadside end of the bridge stand Pintail House, the Warden's home, and Wigeon House, visitors' accommodation. By the end of the year the Trust's holding of Washes was 588 acres, plus a further 31 acres on lease. It also had the shooting rights on another 100 acres. The inner boundary bank, shielding the Washes near the Observatory from disturbance, was extended to 800 yards (Plates IX and X).

Ornithologically the Ouse Washes continue to rate as one of the outstanding areas in Britain. On 22nd January 1970 there was a count of 36,000 Wigeon, of which about 21,000 were on the Welney Refuge. Also present at Welney on the same day were about 2,000 Mallard, 450 Teal, 600 Pintail and 114 Bewick's Swans, truly a magnificent spectacle.

The Wigeon numbers remained high throughout February and much of March with 14,000 on the Trust's land on 8th February and 16,000 on 14th March. Mallard rose to a peak of 3,500 on the latter date. Up to 300 Bewick's Swans were regularly feeding on the Refuge during January and March, part of the much larger flock of up to 900 that wintered on the Washes.

The breeding season on the Refuge was notable for the successful nesting of at least one pair of Ruffs, and other pairs may have tried. Five pairs of Black-tailed Godwits also bred and hatched young, the first time since 1957 that this species has bred successfully north of the Welney Road. This year, however, no Black Terns stayed. Numbers of breeding ducks were good, with up to 25 broods of Shoveler being seen, as well as three of Garganey and two of Pintail.

There was some standing water present on low fields as early as September but the Washes did not flood properly until the beginning of December. Nevertheless, duck numbers built up very satisfactorily in the undisturbed conditions on the Refuge There were 2,000 Mallard and 450 Teal present at the beginning of October and these increased steadily until by the end of the year there were 3,000 Mallard and nearly 2,000 Teal. Wigeon first appeared in force in November with 5,500 on the 21st and 11,000 by 12th December On the latter date there were 15,500 on the whole Washes. Other duck numbers remained fairly low and Bewick's Swans were not much in evidence until the end of December, when the bulk of the 350 present on the Washes moved on to the Refuge, many of them coming for grain put down in the pool in front of the Observatory.

M.A.O.

EASTPARK REFUGE, CAERLAVEROCK, 1970-71

Barnacle Geese (Plate XIIa)

The first 40 Barnacle Geese were observed on 30th September on the merse opposite the Lochar Loup. A gradual increase in numbers took place during October: 7th - 60; 15th - 900; 21st - 1,250; 1st November 2,000.

By the end of November numbers rose to just over 3,000 but this was clearly due to a gathering at Eastpark of all the Solway Barnacles and not as a result of migration at this date. Earlier in November several hundreds were established on Rockcliffe Marsh in Cumberland.

Throughout the winter numbers fluctuated, often on a daily basis. The maxima present at Eastpark in each of the winter months were: 21st October -

1,250; 22nd November - 3,200; 28th December - 2,800; 10th January - 2,250; 7th February - 1,300; 29th March - 2,990; 2nd April - 1,325.

With a great deal of work involved in the taking over of the farm, rehabilitating the buildings and organising the observation facilities, not as much time could be given to goose-observations themselves as desired. However, a start was made on the detailed observation of the feeding distribution and behaviour of the geese which will be one of the main research projects. The results are summarised in the table. It is interesting to note that the Barnacles spent nearly half of their feeding time on arable fields and mostly on Eastpark itself. The Chief Warden of the National Nature Reserve noted 10%, 3% and 7% on arable fields during the past three years.

The disturbance level for the feeding geese on Eastpark in the first winter of the establishment of the Wildfowl Trust Refuge was kept low. With the planned screening of the farm roadways by next winter it should be virtually nil. It would appear that this factor was responsible for the greatly increased use of the arable fields on the Refuge. The past winter was one of exceptional mildness and this might possibly also have influenced the choice of feeding area. During the change over of tenancy at Eastpark the merse was only partially grazed from June 1970 until the end of the growing season. It has been suggested that the longer than usual merse grasses deterred the Barnacle from feeding there and thus increased their use of the farmland. However, this would not explain their return to merse grazing from January onwards.

Future research in the next few years should provide answers to a lot of important questions relating to the winter ecology of the geese as well as providing a basis for a sound combined agricultural and goose management policy.

Apart from Caerlaverock the other most regular area frequented by the Barnacles is Rockcliffe Marsh in Cumberland. Small numbers occur at other places on both sides of the Solway.

On the Scottish side of the Firth Southerness and Arbigland Estate areas are used on and off throughout the winter. The maximum flock recorded there in 1970-71 was in the order of 1,500 geese. Further west the birds frequently appear at Southwick Marsh, up to 650 feeding on the Mersehead Farm fields as well as on the marsh itself. A white Barnacle was with the flocks, having been seen for the first time in 1969-70. Apart from a few light brown-edged feathers on its back it is as white as a Snow Goose and it served as a very useful marker bird when counting the Barnacles in the different areas.

Observations on Barnacle Geese

Month	*Observation days* *Present*	*Absent*	*Goose days*	*% on merse*	*% on Eastpark arable*	*% on other arable*
Oct.	26	0	28418	29.2	65.8	5.0
Nov.	24	1	22956	38.6	54.5	6.9
Dec.	22	0	61531	19.6	50.8	29.6
Jan.	17	4	40352	62.8	34.2	3.0
Feb.	15	11	7503	42.8	23.8	33.4
March	22	5	17392	83.4	16.6	—
April	10	12	5464	91.7	8.3	—
	136	33		52.5	36.3	11.2

Pink-footed Geese

The first 64 Pinkfeet of the winter were observed on 18th September. By the end of the month 1,000 were present and roosting nightly on the Blackshaw Bank. These birds fed well inland away from the foreshore until the close of the wildfowling season at the end of January. There seems little doubt that shooting pressure to the east of the Refuge at Brow Well and Priestside, to the north on Powhillon, and to the west on the N.N.R. shooting zone (although strictly controlled) keeps the Pinkfeet from feeding on the Refuge.

The biggest flock recorded on Eastpark to the end of January was 230 on 14th October. A fortnight after the end of the inland wildfowling season numbers of Pinkfeet feeding on Eastpark had risen to 2,500. A week later 3,080 were recorded two days after the cessation of wildfowling on the foreshore.

During March the minimum daily numbers of Pinkfeet on the Refuge was

1,300 and the maximum 2,780. On the 15th March 3,000 were counted on Rockcliffe in Cumberland and a further 1,000 to 1,200 were present along the Eastriggs to Priestside area. At this time also 3,000 were daily to be seen feeding on Kirkconnel Merse across the Nith from Glencaple. This suggests a total of 10,000 Pinkfeet in the inner Solway at this time.

In April the maximum numbers on Eastpark were 1,000 and on 1st May 500 were still present, the last 47 geese being observed in the grass field next to the Avenue Tower on 6th May.

Greylag Geese

The first eight Greylags were seen on 15th October. Small numbers up to a maximum of 26 were occasionally feeding on the Refuge throughout the winter months. Flocks up to 220 were regularly using the neighbouring farms, Newmains and Midtown. These geese roost further west from Eastpark than the other species and their favourite feeding grounds are on the fields at Lantonside towards Glencaple. The maximum numbers observed there were 415 in February.

Other geese

An adult Light-bellied Brent accompanied the Barnacle flock for most of the winter and an adult Snow Goose was present with the Pinkfeet on 6th and 7th December.

Wild swans

The first four Whoopers were observed on 21st October. From 2nd to 16th November 13 Whoopers were on Nether Locharwoods pond which lies close in to the flood banking along the Lochar water.

Up to 62 swans wintered at Isle Stepps which is six miles flying distance from the Refuge. The flock had 24% young. Two Bewick's were reported at Carsethorn, which lies five miles across the Firth to the west, briefly in December. On 10th January two adult Bewick's took up residence in a grass field near Clarencefield (half a mile east of the Refuge) and remained there for over five weeks. On 8th January 28 Bewick's appeared flying low, east to west along the Refuge Merse. They were calling very loudly and clearly and were viewed from 75 yards. A photograph taken by E. E. Jackson verified the observation. The swans were also seen close in to the Lantonside Merse having turned north, but a thorough search of the local swan areas in Dumfries and Kirkcudbrightshire revealed no Bewick's. The previous maximum numbers observed in Dumfriesshire and SW. Scotland were a party of five during the 1920's.

Ducks

Mallard and Wigeon were commonly seen over the Merses especially at high tide periods. Maximum numbers of duck noted on any one day during the winter were as follows: Shelduck 411; Pintail 38; Teal 75; Mallard 180; Wigeon 750; Shoveler 23; Goldeneye five; Red-breasted Merganser six.

Waders

Golden Plover were observed daily, and odd Black-tailed Godwits and Whimbrel as well as Greenshank during August and September.

On 17th September a higher tide than average coincided with a strong SW. gale which brought the sea water over the Merses and up to the sea wall. A most spectacular gathering of waders took place in the grass field next to the Avenue Tower site: Bar-tailed Godwits 300; Lapwing 75; Golden Plover 50; Dunlin seven (still in summer plumage); Black-tailed Godwits six; Whimbrel two; Curlew 120; Oystercatchers 2-300; Redshank 20-30; Ringed Plover three.

A few of the Black-tailed Godwits remained but most winter further south. Good numbers of Bar-tailed Godwits were seen at high tide periods during the winter, a flock of 1,700 being counted in early December. The commonest small local waders were Knot and Dunlin. Greenshank were seen twice during the winter on the refuge.

Raptors

Male Hen Harriers were seen singly on nine occasions between October and the first week in March. The lack of females is interesting and it would appear that they seek alternative wintering areas. Merlins were seen on eight different occasions during the winter. Kestrels were common throughout the autumn and early winter and Sparrow Hawks were also seen regularly during this period. One Peregrine was noted near Brow Well at the eastern end of the Refuge in January.

Passerines

There is little cover for the less hardy woodland birds since the general Refuge is very flat with only hawthorn hedge cover, and no shelter from winds blowing

straight in from the Irish Sea. The most abundant birds were Linnet and Twite, Chaffinch, Corn Bunting, Reed Bunting, Dunnock, and in small numbers Robin, Goldfinch, House Sparrow and the occasional Wren.

Wheatears were seen regularly during the migration in the early autumn. Fieldfares with a very small number of Redwings appeared at the same period and the species remained during the winter months in small numbers, especially the Redwing. A Great Grey Shrike appeared on the hawthorn hedge on the Saltcot road on 16th December.

Human visitors

Two hundred and ninety-two persons were escorted to see the geese. Facilities to deal with larger numbers will be ready for the coming winter.

C. R. G. Campbell

BOOK REVIEW

The New Wildfowler in the 1970's

Edited by Noel M. Sedgwick, Peter Whitaker and Jeffery Harrison. 350 pages. Photographs and line drawings, coloured frontispiece and eight plates. London: Barrie and Jenkins. £3.50.

This is more than an updating of 'The New Wildfowler' published in 1961. Not only have the chapters been revised, new ones have been added. These have increased the emphasis on conservation, reflecting the attitude of the responsible shooter in this day and age. Of the 32 chapters only 13 are directly concerned with the pursuit and kill. The rest deal with topics of general interest; identification, migration, feeding habits, rearing and ringing, wildfowl counts, the status of geese, conservation in Ireland, North America, wildfowl refuges, local reserves, international co-operation. The close contact maintained between the Wildfowlers' Association of Great Britain and Ireland, under whose auspices the book is published, and the Wildfowl Trust is stressed by the fact that Peter Scott contributes frontispiece and preface, and other Trust officers and staff have written seven of the chapters. Jeffery Harrison, eminent in both bodies and recently the deserving recipient of an O.B.E., contributed four chapters himself. His wife, Pamela, is responsible for the 59 black-and-white plates, whose reproduction does not always do justice to her fine efforts.

All in all a very well-worthwhile volume which should be widely possessed and read.

G.V.T.M.

Education

The wildfowl Collections are central to this third main aim of the Trust. If people are brought into contact with a multitude of varied, beautiful birds an educational process is begun. This can lead to a broad-based popular support for the birds' conservation in particular and Nature's in general. The hope also is that some of the thousands of summer visitors will return to our Refuges during the winter months and get to know and appreciate the migrant wildfowl in their full freedom. The need to attract large numbers of the general public to our Collections and Refuges is clearly of paramount importance. The 'market research' exercise described on p. 126 is thus of much interest.

While the visitors are held as a captive audience the opportunity can be taken of exposing them to further stimulation and education by means of wall exhibitions. Mr. Jackson produced two such permanent displays in 1970. One, in the hall of the new entrance building at Peakirk (Plate XIIb) besides expounding the aims and activities of the Trust, sets out the history and present attractions of nearby Borough Fen Decoy and Welney Refuge. At the latter, the new Observatory (Plate IXb) was similarly equipped with an exhibition explaining how the Ouse Washes were formed and detailing their flora and fauna, in winter and summer. A third large, but temporary exhibition was prepared for the E.C.Y. and mounted at Weston-super-Mare. Another, prepared by Mr. Cook, was mounted in the Museum at Peterborough.

Rather more formal education was provided for organised parties from schools. Some 25,000 children came to

Slimbridge in this way, a considerable increase over last year. The very popular series of work-sheets was extended and will eventually be available in book form. The Field Studies Hostel of the Y.H.A. in Slimbridge continued to be a great success, in close association with our education department.

Links with our neighbouring universities were further strengthened when University College, Cardiff, appointed our Director of Research as honorary Professorial Fellow. Prof. Matthews again gave a course of lectures there, and the Zoology students spent several days at Slimbridge doing special projects. Mr. Humphreys continued his work towards a Ph.D., researching on the fertility of geese and on sperm structure. A second Ph.D. student, Mr. A. C. Gagnon, began a study of the innate differences in adaptability, with regards food and disturbance, among the many species of wildfowl hatched at Slimbridge. At Bristol University, where other courses of lectures were given and student visits arranged, Mr. Whiten continued research for a Ph.D. on the visual acuity of birds, in relation to their navigational abilities. The research that Mr. Mattocks has completed for an M.Sc. at Bath, on goose digestion, is summarised at p. 107. The Loch Leven study provided the material of Mr. K. F. Laughlin's Ph.D. thesis on duck metabolism, at the University of Stirling; and, through birds reared by Dr. Kear, of Mr. A. J. Evans' Ph.D. thesis on fat deposition, at the University of Edinburgh. Other Universities assisted by undergraduate courses, by the examination of Ph.D. theses or by the provision of research material included Aberdeen, Aberystwyth, Bath, Birmingham, Durham, Leicester, Liverpool, London, Monash (Australia) and Oxford.

G.V.T.M.

Publications in 1970

ATKINSON, K. Dispersal of phytoplankton by ducks. *Wildfowl* 21 : 110-11.

ATKINSON-WILLES, G. L. National Wildfowl Counts. Pages 237-48 in: *The New Wildfowler in the 1970's*. Ed. N. M. Sedgwick *et al.* London: Barrie and Jenkins.

BLACKWELL, F. and E. W. HOUGHTON. Radar tracking and identification of wild duck during the autumn migration. *Proc. World Conf. Bird Hazards to Aircraft, Ottawa*: 359-76.

BULSTRODE, C. J. K. and D. E. HARDY. Distribution and numbers of the Pink-footed Goose in Central Iceland, 1966-69. *Wildfowl* 21 : 18-21.

KEAR, J. Studies on the development of young Tufted Duck. *Wildfowl* 21 : 123-32.

KEAR, J. The adaptive radiation of parental care in wildfowl. Pages 357-92 in: *Social Behaviour in Birds and Mammals*. Ed. J. H. Crook. London: Academic Press.

KEAR, J. The experimental assessment of goose damage to agricultural crops. *Biol. Conservation* 2 : 206-12.

KEAR, J. and R. G. SCARLETT. The Auckland Islands Merganser. *Wildfowl* 21 : 78-86.

LEACH, B. A. A Slimbridge on the Pacific. *Wildfowl* 21 : 112-14.

MATTHEWS, G. V. T. The use of amateur workers in British studies of bird populations. *Finnish Game Res.* 30 : 197-201.

MATTHEWS, G. V. T. Bird navigation: reply to Keeton. *Nature* 227 : 627.

MATTHEWS, G. V. T. Dark-bellied Brent Geese in relation to the Essex estuaries and particularly Foulness. *Comm. Third London Airport. Papers & Proc.* 3 : 235-6, 239-41, 485-90.

NEWTON, I. and C. R. G. CAMPBELL. Goose studies at Loch Leven in 1967/68. *Scot. Birds* 6 : 5-18.

OGILVIE, M. A. The status of wild geese in Britain and Ireland. Pages 249-57 in: *The New Wildfowler in the 1970's*. Ed. N. M. Sedgwick *et al.* London: Barrie and Jenkins.

OGILVIE, M. A. Bewick's Swans in Britain 1956-69. *Brit. Birds* 62 : 505-22..

OGILVIE, M. A. The Pink-footed Goose in danger. *Scot. Birds* 6 : 183-5.

OGILVIE, M. A. and C. G. BOOTH. An oil spillage on Islay in October 1969. *Scot. Birds* 6 : 149-53.

OWEN, M. and D. J. HARBERD. Vegetational pattern in a stable grassland community. *J. Ecol.* 58 : 399-408.

PENGELLY, W. J. and J. KEAR. The hand-rearing of young Blue Duck. *Wildfowl* 21 : 115-21.

ROCHARD, J. B. A. and J. KEAR. Field trials of the reactions of sheep to goose droppings on pasture. *Wildfowl* 21 : 108-11.

SCOTT, P. Survival values. *J. Roy. Soc. Arts* (1970) : 621-33.

SCOTT, P. Redbreasts in Rumania. *Wildfowl* 21 : 37-41.

SMITH, F. V. and K. H. NOTT. The "critical period" in relation to the strength of the stimulus. *Z. f. Tierpsychol.* 27 : 108-15.

VIELLIARD, J. La distribution du Casarca Roux *Tadorna ferruginea* (Pallas). *Alauda* 38 : 87-125.

WALKER, A. F. G. The moult migration of Yorkshire Canada Geese. *Wildfowl* 21 : 99-104.

WÜRDINGER, I. Erzeugung, Ontogenie und Funktion der Lautäusserungen bei vier Gänsearten. *Z. f. Tierpsychol.* 27 : 257-302.

The Wildfowl Trust, Annual Report, 1970

Royal visit

H.R.H. The Prince of Wales paid an informal visit to Slimbridge on 7th and 8th March.

Meetings

The Officers, Council and Committees of the Trust as at 31st December 1970 are set out on page 160.

The Council met on 13th February at Slimbridge and on 15th April, 18th June, 21st July and 13th October in London. The Finance Committee met in London on 18th March, 17th June, 23rd September and 11th November. The Scientific Advisory Committee met at Slimbridge on 5th March.

The 23rd Annual General Meeting was held at The Royal Society of Arts, London, on 18th June. The President referred to the loss the Trust had suffered by the deaths of its Hon. Treasurer, Mr. Michael Crichton, and of Mr. Gerald Askew, a Council Member, both enthusiastic friends and supporters. The Hon. Vincent Weir was elected Honorary Treasurer and Dr. Jean Delacour, Sir Julian Huxley, F.R.S., and Mr. E. G. Kleinwort, were elected Vice-Presidents. After the meeting the Hon. Director gave an illustrated talk about his recent visit to Zambia.

The Annual Dinner took place at the Hyde Park Hotel, the same day. His Grace The Duke of Northumberland presided, and the speakers were Lord Ritchie Calder, Sir Bernard Lovell, Mr. David Attenborough and Mr. Peter Scott.

Development

Slimbridge

The Propagation and Service Building was taken over from the builders in February and the Trust staff carried out the internal work to provide arrangements for the indoor duckery, for food storage and preparation and for workshops. This has greatly enhanced the arrangements for breeding and for servicing the collection. A three phase electricity supply was installed. A second well point system to give an auxiliary water supply was put in near the Tropical House; but was not fully developed by the end of the year.

Peakirk

The new Entrance Building incorporating a hall with educational displays, a shop and a Curator's office was completed and was officially opened on 21st April by H.R.H. The Duchess of Gloucester. The new building has been greatly admired and in 1970 there was a notable increase in sales (Plate XIIb). The old gate hut was re-erected as a tea room.

Welney

A generous donation, by Mrs. Ernest Kleinwort, enabled us to buy a further 96 acres of washland, bringing the acreage owned by the Trust to 588. The screen bank with Presco hides was extended to 800 yards and the main observatory and the access bridge to it over the Hundred Foot River were constructed. These developments were made possible by the generosity of Condor International Ltd., who designed the 300 ft. bridge and fabricated and donated the steel work for it, of Guest, Keen and Nettlefolds Ltd., who donated the piled foundations for the bridge and the observatory, and by donations from the Carnegie (U.K.) Trust, the Sir J. Knott Settlement and the World Wildlife Fund Youth Service. The bridge was erected as a training task by a troop of 3 Field Squadron, R.E.

Caerlaverock

In June the Trust took over the lease of Eastpark Farm, to which belong the 600 acres of merse, included in the sanctuary area of the Caerlaverock National Nature Reserve, and 235 acres of arable land alongside, which the Trust is managing as an extension to the reserve. The farm was taken over with the help of an interest-free loan from the Ernest Kleinwort Charitable Trust, and generous donations by Major Sir Reginald Macdonald-Buchanan, the Dulverton Trust, and the McRobert Trust enabled us to make a start on development. A reserve manager was installed, a pond was dug in an eight-acre paddock which was enclosed with a fox-proof fence to accommodate a small collection of British wildfowl, a screened approach between earth banks to the Saltcot Tower was constructed, plans were prepared for a system of observation hides on the farmland with covered approaches, and arrangements were made for the operation of the farm without detriment to the primary aim of creating both a sanctuary and study area. Studies are being initiated with the particular object of research into the better integration of wild geese and farming.

Arundel

Outline planning permission for the proposed Wildfowl Refuge at Arundel was received in July and plans were made for its development in 1971.

Membership

The increase in the rates of subscription slowed down the growth of membership in 1970. Comparative figures for 31st December are:

	1969	*1970*
Life Members	356	369
Full Members	5794	5891
Associates	1573	1468
Parish Members	224	239
Junior Compounded Members	11	8
Goslings	710	797
Corporate Members	85	80
Contributors	37	35
	8790	8887

Swan Supporters increased during the year from 197 to 270.

Attendances

For the third year running there was an increase in the numbers visiting Peakirk, and Slimbridge was once again visited by over 200,000 people. Comparative figures:

	1967	*1968*	*1969*	*1970*
Slimbridge	209,243	206,903	194,512	201,446
Peakirk	46,181	53,602	55,217	58,294
Totals	255,424	260,505	249,729	259,740

Finance

The increased income from visitors was offset by increased advertising and other higher costs resulting in an excess of expenditure over income in the Current Account of £2,709, of which £427 went to increasing the valuation of Trust property.

The net income from the Fund Raising Campaign during the year totalled £10,022 of which £9,574 came in earmarked donations for Welney, Arundel, Caerlaverock, and Martin Mere. The balance of £448 was transferred to the General Development Fund.

The General Development Fund began the year with a credit of £14,468 and received £13,389 in donations and legacies: £2,533 was transferred to the Accumulated Fund to cover over-expenditure in 1969, £7,625 was transferred to the Welney Fund and £9,088 was spent at Slimbridge and Peakirk, leaving a carry-forward of £8,611. Of this £2,709 will have to be transferred to the Accumulated Fund to make up the over-expenditure in the current account in 1970.

In addition to the transfer of £7,625 from the General Development Fund, the Welney Capital Fund benefited by donations totalling £24,381: £13,000 was spent on land purchase and £14,636 on development and £4,647 was carried forward to 1971.

£11,731 was spent at Caerlaverock on taking over Eastpark Farm and on initial developments: this was £4,420 more than the £7,311 of donations received; but the debit balance was more than covered by the £6,000 loan from the Ernest Kleinwort Charitable Trust.

An anonymous benefactor undertook to match donations to the Trust's Arundel Fund pound for pound up to £20,000. With the help of this very generous arrangement £6,459 was raised in the last three months of the year and the credit balance on 31st December was £11,216.

Aviculture

Wandering Whistling Ducks, White-winged Wood Ducks and a pair of Musk Ducks were added to the collection at Slimbridge and a flock of Chilean Flamingos was established at Peakirk. 1,200 young birds were raised during the season.

Twenty Chilean Flamingos were reared at Slimbridge plus three Greater Flamingos, these last being the fourth species of flamingo bred for the first time in Britain by the Trust, since it started to keep flamingos in 1962.

It was the most successful breeding season so far for Ne-nes: 52 were raised and 56 flown to Hawaii bringing the total repatriated to 200.

Full details of the breeding results are given at p. 147.

Research, Conservation and Education

Record numbers of White-fronted Geese were present at Slimbridge and the intensive study of their feeding ecology continued. The Bewick's Swans also came in greater numbers than ever before. Many were caught, ringed, X-rayed and had their tails dyed so that their subsequent migration could be tracked. The ringing of ducks continued at Slimbridge, Borough Fen, Abberton and Nacton.

The international mid-winter counts over Europe and Asia were organised from Slimbridge, as well as the long-established monthly duck counts in Britain.

The health of the Collection was guarded by improved veterinary and pathological facilities.

Every effort was made to ensure that the Roskill Commission fully appreciated the disastrous consequences to the Brent Geese of siting the Third London Airport at Foulness. Besides making protests at the proposed flooding of þjórsárver, Iceland, breeding ground of most of our Pink-footed Geese, their numbers and distribution of nests were established by a helicopter survey.

The link with the neighbouring University College, Cardiff, was strengthened by the appointment there of the Director of Research as Honorary Professorial Fellow.

Two substantial permanent wall exhibitions were prepared for the new buildings at Peakirk and at Welney.

Numbers of school and other educational parties increased further, and the facilities at the new Youth Hostel were extensively used.

Full details of these activities will be found between pp. 132-154.

TERMS OF MEMBERSHIP

(as from May 1971)

LIFE FELLOWS	A single payment of £100.00. Entitled to all the privileges of Full Membership (see below) but with free entry with one free guest to any refuge which is open for visiting.
FELLOWS	£5.00 a year. Privileges as for Life Fellows.
FULL MEMBERS	£3.00 a year. Entitled to free entry to Slimbridge and to Peakirk with one free guest but may opt for free entry to any one other refuge which is open for visiting instead of Peakirk. Entitled to entry at half price to other establishments which are open for visiting. Receive a free copy of WILDFOWL and bulletins, and may vote at the A.G.M.
ASSOCIATE MEMBERS	£1.50 a year. Entitled to free entry to Slimbridge and to Peakirk (but may opt for free entry to any one other refuge which is open for visiting instead of Peakirk). Entitled to entry at half price to other establishments which are open for visiting. Receive a free copy of bulletins.
GOSLING MEMBERS (under 18)	£0.63 a year. Privileges as for Associates. A leaflet obtainable at all refuges gives details of a scheme of grading of Goslings, with appropriate distinguishing marks, and promotion and recognition tests.
CORPORATE MEMBERS	£1.00 a year. Limited to educational establishments, youth clubs and bodies which are members of the Council for Nature. Entitled to a free copy of WILDFOWL and bulletins. Free entry for one adult per each ten members of a party. Details for party visiting may be obtained from each refuge.
CONTRIBUTORS	Organisations which do not qualify for Corporate Membership may become Contributors by subscribing not less than £1.05 a year. Receive a free copy of WILDFOWL and bulletins.

THE WILDFOWL TRUST, SLIMBRIDGE, GLOUCESTER

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER 1970

1969 £	EXPENDITURE	£	£
	To **General Expenses:—**		
12107	Salaries and Superannuation, Administrative Staff	13390	
2143	Rent, Rates, Water Rates and Insurance	2218	
5609	General Administration Expenses	6930	
3828	Maintenance	3926	
3108	Printing and Stationery including Bulletins	3451	
145	Bank Charges	141	
10040	Advertising	15377	
36980			45433
	New Grounds and Peakirk:—		
23279	Salaries, Wages and Superannuation	25214	
6236	Purchases of Wildfowl	3117	
9332	Food for Wildfowl	9417	
5767	Maintenance, Fuel, etc.	6546	
1736	Transport, Mechanical Equipment and Travel	2079	
1017	Miscellaneous	779	
47367			47152
	Shops:—		
8393	Salaries, Wages and Superannuation	9288	
2086	Miscellaneous	1754	
10479			11042
	Research and Conservation:—		
19094	Salaries and Superannuation	18950	
5325	Miscellaneous Research Expenditure	4451	
3253	Printing *WILDFOWL*	3001	
9078	Management and Upkeep of Refuges and Ringing Stations	11501	
36750			37903
	Education:—		
3329	Salaries and Superannuation	3611	
440	Miscellaneous	796	
3769			4407
	Capital Expenditure:—		
188	Equipment		—
100	Written off Buildings		100
£135633			£146037
£3788	To Deficit for year, brought down		£2282

1969 £	INCOME	£	£
	By **General Income:—**		
14555	Subscriptions	17966	
568	Donations	660	
227	Film Royalties	—	
3479	Income Tax repaid on Covenants	2139	
1750	Interest received	3168	
20579			23933
	New Grounds and Peakirk:—		
68854	Takings	70661	
4048	Sale of Surplus Wildfowl	5118	
2486	Restaurants	2640	
75388			78419
	Shops:—		
38321	Sales	43817	
29096	*Less:* Purchases (with Stocks adjusted)	30368	
9225			13449
	Research and Conservation:—		
18933	The Natural Environment Research Council Grant	20719	
683	Donations	1283	
4229	Other Receipts	5050	
23845			27052
	Education:—		
275	County Council Grants		475
2533	Increase in Valuation, 31st December 1970		427
3788	Deficit for year, carried down		2282
£135633			£146037
£3788	By Transfer Accumulated Fund		£2282

THE WILDFOWL TRUST, SLIMBRIDGE, GLOUCESTER

BALANCE SHEET AS AT 31st DECEMBER 1970

1969	LIABILITIES	£	£
47100	**Accumulated Fund**		56147
	Special Funds:—		
19564	Specific Projects	14275	
2169	Life Membership	3472	
7500	Special Reserve	7500	
14468	General Development	8611	
43701		33858	
13239	*Less:* Net Cost of Fund Raising Campaign	—	
30462			33858
1332	**Mortgage on Freehold Property**		1312
	Current Liabilities:—		
20421	Sundry Creditors and Accrued Charges	20677	
4024	Unsecured Loans	12656	
24445			33333
£103339			£124650

1969	ASSETS	£	£
	Fixed Assets:—		
13079	Freehold and Leasehold Properties, at Cost or Valuation (less depreciation)		12979
	Assets, at Valuation, 31st December 1970		
9428	Transport and other equipment	9235	
13280	Wildfowl	13900	
35787			23135
			36114
	Special Funds represented by:—		
30462	Investment at Cost and Cash on Deposit		33859
	Current Assets:—		
11964	Gate House and Other Stocks	20920	
8010	Sundry Debtors and Payments in Advance	10906	
17116	Cash	22851	
37090			54677
£103339			£124650

We have examined the above Balance Sheet of The Wildfowl Trust dated 31st December 1970, together with the accompanying Income and Expenditure Account and find them to be in accordance with the Books and Vouchers produced to us and the information and explanations given to us.

STROUD, Gloucestershire.
26th April 1971.

S. J. DUDBRIDGE & SONS,
Chartered Accountants.

The Wildfowl Trust

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