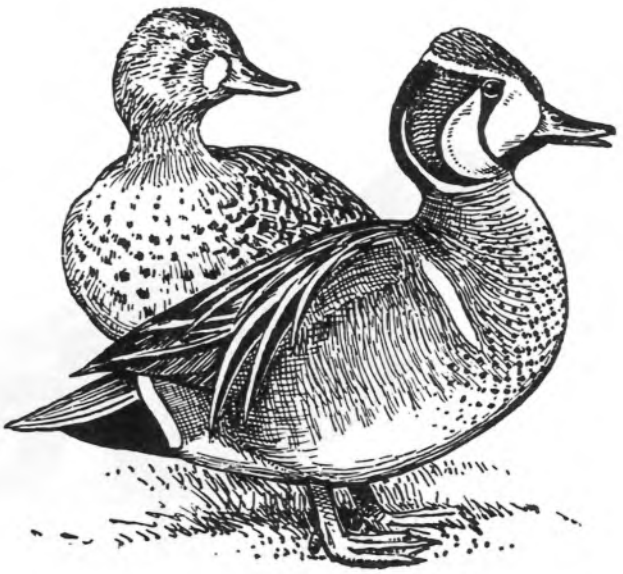

Wildfowl 24

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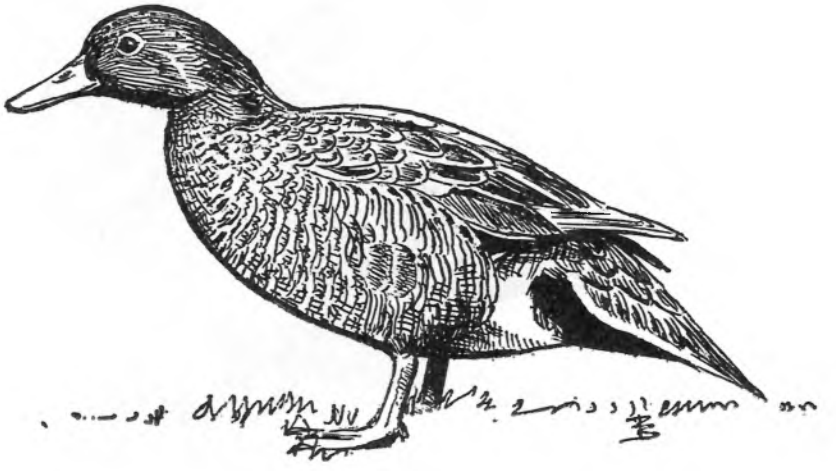

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Contents

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International Swan Symposium at Slimbridge

In association with the annual Executive Board Meeting of the International Waterfowl Research Bureau, which took place at Slimbridge, a 2-day symposium on swans was organized jointly with the Wildfowl Trust on 7 and 8 December 1971. It did not prove possible to publish the proceedings of the symposium in book form, but a number of the major papers are printed in this issue of *Wildfowl*. These are the contributions by William W. H. Gunn (Canada); Professor W. J. L. Sladen (Co-ordinator of the I.W.R.B. Swan Research Group), James G. King, Calvin J. Lensink and Henry A. Hansen (all of the United States); Mrs. Rose Lesser (Japan); Dr Sven Mathiasson (Sweden); Dr Murray Williams (New Zealand). A major part of C. M. Reynolds' (U.K.) contribution was published in *Wildfowl*, 23:111–118, 'Mute Swan weights in relation to breeding performance'. Mary Evans outlined the Bewick's Swan research being carried out by the Wildfowl Trust and Dr Janet Kear introduced 'The Swans', the monograph by Peter Scott and the Wildfowl Trust which was published shortly afterwards. Two papers on particular aspects of the Trust's work on Bewick's Swans complete the presentation in this volume.

Other papers presented to the symposium were those of Dr C. D. T. Minton on 'A study of Mute Swans in Central England'; Dr C. M. Perrins and Malcolm Ogilvie on 'A study of colonially breeding Mute Swans in Dorset'; Dr J. Cadbury on 'Swans on the Ouse Washes, eastern England'; A. Timmermann 'On the occurrence of swans in the Netherlands'; P. Andersen-Harild 'Swan research in Denmark'; Dr A. Haapanen on 'Whooper Swan research in Finland'; and R. F. Ruttledge on 'Distribution of Whooper and Bewick's Swans in Ireland'. Dr Tom W. Barry (Canada) presented a draft 'Bibliography of the Swan' and this has since been extended, in association with Dr Janet Kear, to cover more than a thousand annotated entries. It will shortly be published by the Canadian Wildlife Service.

Other participants were G. L. Atkinson-Willes (U.K.), H. Boyd (Canada), Professor P. Grenquist (Finland), Mr K. Honda (Japan). P. N. Humphreys, Professor G. V. T. Matthews, Dr M. Owen, B. L. Sage, Sir Peter and Lady Scott, Dafila Scott, N. A. Wood (all U.K.) and Mr S. Yoshikawa (Japan).

Figure 1. Feeding time of the wild Bewick's Swans *Cygnus columbianus bewickii* is demonstrated to the symposium participants on a misty morning.

K. Honda

Wildfowl (1973) 24:5–7

Environmental stress on the Whistling Swan

WILLIAM W. H. GUNN

In North America, Whistling Swans *Cygnus c. columbianus* number about 100,000 birds. They breed across the Arctic from Alaska to Baffin Island; on the winter range, they are separated into two fairly-evenly divided populations residing a continent apart, on the Pacific and Atlantic coasts.

My comments in this paper refer to the Atlantic population because it has been studied in more detail, but there is reason to believe that similar circumstances exist for the Pacific population.

On the Atlantic seaboard, the eastern population of about 50,000 Whistling Swans winters largely in Chesapeake Bay but, of late, they have been appearing in increasing numbers as far south as Back Bay, Virginia, and the coastal marshes of North and South Carolina.

Beginning in March, their spring migration takes them northwestward across the continent some 3,000–4,000 miles (5,000–6,500 km) to the breeding range. As one follows them on this long trek, accomplished in 3 months, it becomes more and more evident that they are faced with increasing stress from actual or potential ecological damage of a serious nature at both ends of their range and at every major stopping point in between.

Chesapeake Bay

The heavy traffic of tankers and other shipping in the narrow confines of Chesapeake Bay make oil pollution of the Bay a continuous threat. Neighbouring Delaware Bay, occasionally visited by swans, recently suffered a serious oil pollution incident. Oil slicks of a minor nature are probably a chronic condition on Chesapeake Bay but, in addition, massive industrial and municipal pollution pours into the Bay from the Susquehanna and Potomac Rivers and from the giant Bethlehem Steel plant on the Bay.

Whistling Swans frequent the small inlets and marshy reaches to obtain their basic diet of aquatic and sub-aquatic vegetation. How well this vegetation is standing up to severe water pollution and shoreline development is a problem that is being actively studied.

Lake Erie and Lake St Clair

When the spring migration from Chesapeake Bay begins in March, the first major stop-over is 400–500 miles (650–800 km) to the north-west, in the marshes of Lake Erie and Lake St Clair. Some birds carry on to Shiawassee National Refuge and Saginaw Bay in Michigan.

The extensive pollution of Lake Erie is now a matter of international concern. More and more heavy industry continues to take up space along its shoreline on both sides of the border. Many of its marshes have been destroyed or seriously depleted. As a haven for migrating swans, it can now support only a few thousand at a time.

Lake St Clair still has extensive marshes, particularly along the eastern shore, in Canada. The much publicized discharge of mercury from a chemical plant into the St. Clair River is probably of less concern to swans than the effluent from oil refineries, polymer plants, and municipal sources. To what extent the quality and quantity of swan food has been affected in recent years is not known.

Within the past 5 years, swans have developed the habit of flying from the St Clair marshes daily to glean corn from agricultural land. Between 5 March and 5 April at least half of the eastern population of Whistling Swans visits a 4-mile by 5-mile (6·5 by 8·0 km) area of corn fields east of Lake St Clair. Whether this development is to exploit a newly found food source or whether it has been made necessary by deterioration of the marsh vegetation in Lake St Clair is an important matter we should hasten to investigate.

The sloughs of North Dakota

By late March or early April, the swans are heading for their next major stop-over, on the plains of North Dakota, fully 850 miles (1,370 km) to the west-northwest. There, the countryside used to be dotted with sloughs and potholes. In recent years, the trend towards increasing mechanization and large holdings in wheat-farming operations has brought about accelerated draining of these waters. Even large lakes, such

as Rush Lake, a major swan assembly area, are being drained by diverting the water into the Pembina River, in Canada.

The breeding habitat for ducks has been permanently reduced but, except for Rush Lake, swans are less seriously hit because their spring stop-over lasts only about a month—early April to early May—and at that time of the year the accumulation of snow melt usually lasts until after the swans leave. Most of the marshland is gone, however, and swans are frequenting standing water in the fields, again gleaning for grains, mostly wheat.

The Athabaska Delta

In late April and early May, the Whistling Swans make their next long jump, 900 miles (1,450 km) northwest across the Canadian province of Saskatchewan. The only major stop-over area we have located is in the confluence of waters about the delta of the Athabaska River where it flows into Lake Athabaska. Nearby, the Slave River forms the outlet from the Lake, and the Peace River, descending from British Columbia, flows into the Slave. This was an unusually rich area of wetlands, exceptionally well suited to swans as a staging area. Unfortunately, a few years ago a large power dam was completed far upstream on the Peace River, in British Columbia. With water now held behind the dam, the spring run-off no longer floods the wetlands, and the rich shallow feeding grounds of Lake Claire and other smaller lakes now virtually dry up in years of low run-off. Much concern has been shown in Alberta about the effect of the drastic change in water flow on Indians, muskrats and ducks, but no one has yet considered the plight of the Whistling Swans, which now must largely frequent the open waters of Lake Athabaska, where plant food is relatively scarce.

The Mackenzie Delta

From the Athabaska Delta, the main migration route of the swans continues northwest another 950 miles (1,530 km) to the Mackenzie Delta, which lies within the breeding range. This constitutes the last staging area before dispersal to the breeding territories as soon as weather permits—usually about the end of May and early June.

As yet, the swans are relatively undisturbed, but the Delta is now a centre of exploration for fossil fuels underlying the Delta itself. It is criss-crossed with seismic lines and dotted with drilling rigs—particularly on the outer reaches of the delta which constitute a favoured nesting area. Oil and gas have been discovered there in fairly sizeable quantities, and the start of production appears close at hand. A major oil spill will be a continuous threat for years to come, and what is perhaps more important, human and mechanical disturbance on an unprecedented scale is virtually a certainty.

The Arctic coast

As the snow melts in late May and early June, the swans spread out east and west across the tundra, each pair taking up a sizeable territory, usually centred about a small lake or tarn, and many nesting within sight of the coast. There is safety in this isolation but for one new development—the skidoo or snowmobile. The sale of skidoos is being pushed hard and Eskimos have taken enthusiastically to them. They make extended travel possible through the spring, and I suspect that, as a result, the hunting pressure on wild animals has increased by a factor almost as great as when the rifle was first introduced. The principles of conservation do not come easily to the Eskimo nor, for that matter, to his fellow whites in the Arctic. For the Eskimo, the bird in the hand continues to be better than two on the tundra, and swans are no exception to the rule. The snowmobile makes it possible to cover long distances along the coast, and swans make a large and tempting target.

The melting of the snow and ice at least brings isolation to nesting swans—except for disturbance from low-flying planes and helicopters hurrying back and forth on errands of exploration and research. The swans are left to contend with the more traditional problems of a wilderness existence, but these must not be minimized. The schedule for the breeding season is very tight indeed, and a delayed spring or early winter storm may keep successful reproduction to a low figure. Summer is only too short, and, even in an 'average' year, many young cygnets are overtaken by winter before they have the strength to fly out.

The long return route southeast to Chesapeake Bay closely retraces the spring migration route—a band about 100 miles (160 km) wide drawn diagonally across the continent. Much the same problems have to

be faced, with the added complication of a hunting season now introduced in a few states and under consideration by others.

If we wish to maintain their numbers in the vicinity of present levels, it is essential to begin now to establish the information needed for intelligent management of this resource. The place to start, in my opinion, is with a study of food habits, and a determination of the productivity of relevant plant and animal food sources in the wintering and staging areas.

I think it is true to say that anyone who takes the trouble to become closely acquainted with these birds soon acquires a great respect and admiration for them. They are truly one of the noblest of our birds. They have great adaptability, but they will need all of it in the years to come.

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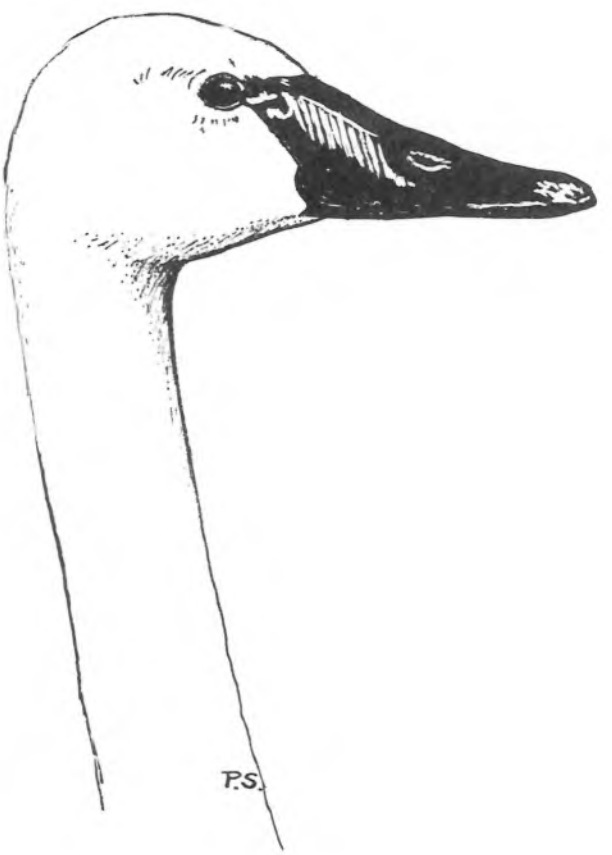

Wildfowl (1973) 24:8–14

A continental study of Whistling Swans using neck collars

WILLIAM J. L. SLADEN

Four species of swan occur in North America. The Trumpeter Swan *Cygnus buccinator* (from Alaska to Wyoming) and the Whistling Swan *C. columbianus columbianus* are native species. The Whooper Swan *C. cygnus* is a regular migrant from Siberia to western Alaska and probably breeds in Alaska (Peter Shepard, personal communication). The Mute Swan *C. olor*, a native of central and western Europe, is introduced and increasing rapidly in central and eastern North America.

There are approximately 100,000 Whistling Swans in North America. More than half migrate across the Continent from their nesting grounds in the tundra regions of Alaska and northern Canada to winter in Maryland, Virginia and North Carolina. This represents an annual round trip of 14,000 to 16,000 km. Other portions of the population winter in western States, mostly California.

A Viscount airliner was lost with all seventeen passengers after striking a flock of migrating *columbianus* at 1,800 m over Maryland in November 1962. This accident coupled with other near swan collisions generated much interest in swan movements among aviation people. In 1968, ecologists at Johns Hopkins University, collaborating with private individuals, Foundations and with biologists from Federal, State and Provincial Agencies in the United States and Canada, initiated a study of the Whistling Swan. The objectives are: how to minimize swan-aircraft hazards; what impact human environmental change has on swan behaviour; what effect the oil industry will have on their breeding grounds and why swans are increasingly feeding in fields instead of in shallow water. Sound management is another objective and whether it be for enjoyment of their aesthetic beauty or related to the controversy of hunting, all must be based on long-term research. The over-all aim is to help sustain the continued well-being of North American swans and learn how we can better live in harmony with these magnificent waterfowl.

To aid these endeavours a number of different methods of study have been used. Methods of capture, dyeing (orange with picric acid and black with nyanzol), radar tracking, and telemetry are described in Sladen & Cochran (1969) and Sladen, Gunn & Cochran (1970). They also describe the early phase of the Continental protocol for colours and coding tarsus bands. This protocol is now completed (Figure 1) and has been used also for neck collars with codes that match the tarsus bands for *columbianus*, *buccinator* and *olor*. These neck-collars were first used for *columbianus* in January 1970, for *olor* in July 1971 and for *buccinator* in August 1972. Data presented in this paper are to support neck collars as a method of study and to compare them with other conventional methods of banding.

Methods

(a) *Metal band protocol*
Following a pattern used in Antarctica (Sladen & LeResche, 1970) the standard metal bands with U.S. Fish & Wildlife addresses are placed on the *LEFT tarsus of known-aged birds* (i.e. cygnets in the arctic or juvenile grey plumage in winter) and on the *RIGHT tarsus for those of unknown age* (i.e. captured for the first time when with all-white plumage). This scheme is especially useful for alerting observers to known-aged swans—important for studying population dynamics—when in social groups or in the far north where close observations are difficult. In other studies the position of the metal band is used as an indication of sex. However, this could generate confusion as swans are often difficult to sex, especially juveniles. Some would be recorded incorrectly or as of unknown sex. With our method, if there is any doubt about the age the metal band is placed on the right tarsus, indicating "age unknown".

(b) *Colour plastic bands (tarsus & collars)*
(i) *The colour protocol* for North America (Figure 1) is very simple, using only five easily recognized colours: blue, red, green, yellow and black. White goes with black and could in the future be interchangeable. This protocol is designed to match with a similar

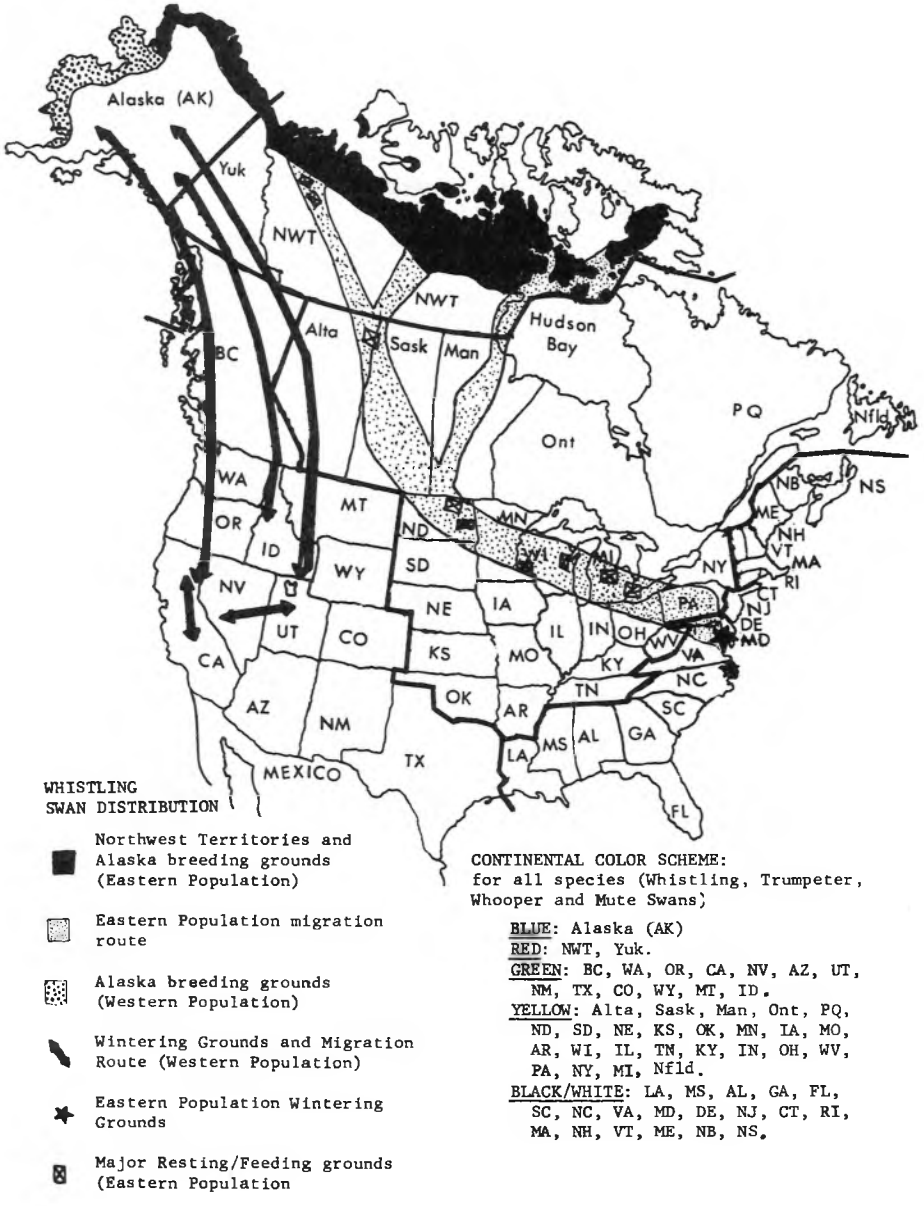

Figure 1. Colour markings (neck collars and/or tarsus bands) for the North American swans.

protocol for Europe and Asia being developed by Sladen for the International Waterfowl Research Bureau's (IWRB) Swan Research Group.

(ii) *Code for colour bands.* The neck collar code matches the band for each swan. We are using four place letter and number combinations, the relative positions of which indicate the species. Thus, for *columbianus* the code is one letter followed by three numbers (e.g. A234); for *buccinator*, two numbers followed by two letters (e.g. 23PA); and for *olor*, two letters followed by two numbers (e.g. CT68). Ogilvie (1973) is using three larger (instead

of our four) digits without letters for Bewick's Swans *Cygnus columbianus bewickii* at Slimbridge in Britain. We believe the advantage of larger numbers is outweighed by the disadvantage of possible confusion in certain numbers when read the wrong way. For example, 169 can be read 691 unless a letter is added (e.g. C169).

We are using only twelve letters (A C E F J K M P R T V Y). The others have been omitted at present because of similarities (B = 8, O = Q, G = C, I = 1, L = 7, W = M, etc.). Others (H N S & X) omitted are the same when read the wrong way (e.g. XH91 *olor* could be read 16HX *buccinator*). The code is engraved four times on a strip of laminated plastic (trade name Lynnply) 216 × 77 mm (i.e. to give 77-mm-tall collar) and shaped, to allow overlap, to diameter 55–60 mm. The letters and numbers are 25·4 mm high. The overlap is fused by quick-drying cement. It is essential that the collar slides freely up and down the neck. Matching tarsus bands are 40 mm tall and diameter 25–30 mm, also with a cemented overlap. Failure to cement will result in band and collar loss or even slipping of the tarsus band over the tarso-metatarsal joint.

The collars can be read through a × 40 power spotting scope in favourable light from a distance of 150 m or more, providing an extremely valuable method of studying large numbers of individually marked swans without disturbance.

Results

Metal bands or metal and colour tarsus bands were used for the first 3 years. Neither could be seen clearly enough to identify swans as had been the case with Bewick's Swan tarsus colour bands at Slimbridge (Ogilvie). The aquatic habits and wide distribution of the Whistling Swan were responsible. Use of neck collars produced dramatic results. Between January and March 1970, the first 300 swans were marked with neck collars in Maryland. In the following winter, 1970–71, over half these collared swans were resighted back in Maryland, Virginia or N. Carolina after a migration of about 11,500 km to and from the arctic.

A more careful analysis (Table 1) of 179 swans neck-collared in three closely watched study areas in Maryland gave us a 60% resighting rate of live birds in the second winter in contrast to only 2% from a sample of 186 swans marked with metal and colour tarsus bands. When all resightings, including dead or retrapped birds, were added in the categories listed in Table 1, it is clear that 84% neck-collared swans were individually identified again during the year since marking. This was in contrast to only 8% of the birds with metal

Table 1. Resightings of Whistling Swans marked by three different methods in wintering grounds in Maryland, 1967–1970*

Method	Total banded	Resightings (alive) after banding (see Key below) I	II	III	IV	Dead or shot	Retrapped after migration to arctic & back	Total resighted (or retrapped or found dead) after banding
Metal (FWS) band only	165	0	0	0	0	3 (2%)	8 (4%)	11 (7%)
Metal + plastic tarsus band	186	0	2 (1%)	0	3 (2%)	1 (0·5%)	8 (4%)	14 (8%)
Metal + plastic color tarsus + NECK COLLAR	179	59 (33%)	63 (35%)	1	108 (60%)	7 (4%)	0	151 (84%)

Resighted and individually recognized: I, in Maryland before spring migration; II, en route on spring migration; III, in arctic breeding grounds; IV, in winter after round trip to and from arctic.
FWS = U.S. Fish & Wildlife metal tarsus band.
*Neck collars were first used Jan. 1970.

plus tarsus colour bands. Moreover, most of these few were not identified at a distance, but retrapped or found dead.

There is a slightly higher incidence of dead or shot swans among those with collars but this is likely to be due to factors other than collars. For example, most of the collared birds were dyed a conspicuous orange, whereas relatively few of the non-collared birds were dyed. Moreover, the collar makes a dead bird more conspicuous and raises more curiosity in the finder than does a metal or colour tarsus band. A further analysis of these factors and band loss will be made after 3 years of data have been gathered.

Some equally spectacular resighting rates have resulted from smaller study samples. Of the first forty-eight swans collared in our closest watched study area in Rhode and West Rivers near Annapolis, Maryland, forty-four (92%) were individually identified during the first year after banding. Two of these (black collars CO22 and CO28) were resighted in summer in their breeding grounds on the Northern Slope of Alaska (Figure 2). Of ten adults collared (blue) in the Arctic National Wildlife Range and near Prudhoe Bay on the Northern Slope, Alaska, in August 1971, eight were resighted in Maryland, Virginia and North Carolina the following winter. Moreover, one of the two not resighted during the first winter after banding was sighted in Maryland in November 1972. This gives 90% resighted since banding in the breeding grounds. All the nine were resighted several times and none have yet been reported dead.

Percentages of resightings are only one aspect of data accumulating from collared swans. A vast amount of data on multiple resightings of individual neck-collared swans throughout the extent of their continental migration is being analysed and cannot yet be presented. However, four case histories of some of our specially interesting swans illustrate the potentials of neck collars.

(a) C030 and C031 (black) were neck-collared in the Rhode River, south of Annapolis, Maryland, in February 1970. Before they left in March we had evidence that they were a pair. Next winter, C030 was seen in the Rhode and Severn Rivers near Annapolis, between November 1970 and 31 January 1971, feeding in the water. Her mate, C031, was resighted between 26 December 1970 and 16 January 1971 at Boardman Lake, Traverse City, Michigan, being fed corn with a large flock of Mute Swans. This pair of Whistling Swans was therefore separated for part of the 1970–71 winter, the male spending some time in Michigan and supplementing his diet with artificial food. We do not know where this pair is in the arctic, but they were back *together* at Boardman Lake, on 4 December 1971 and remained there together all winter until they departed on spring migration on 6 April 1972. They returned to Boardman Lake again on 9 November 1972 with two cygnets. Several interesting biological facts have come from these two neck-collared Whistling Swans. They were separated for at least a part of the 1970–71 winter. Or was it that they had not yet established a permanent pair bond? They were together in Michigan all 1971–72 winter. C031 spent (at least part of) a third consecutive winter, and C030 a second, in Michigan. Thus we must record Michigan as a regular wintering place for some of our eastern Whistling Swans. Moreover, this pair gives us further evidence that neck collars are not deterring *columbianus* from mating or rearing cygnets.

(b) C116 & C119 (black) were banded in February 1970 at East Neck Island National Wildlife Refuge (NWR), Rock Hall, Maryland. Next winter they returned in November and December, 1970, to exactly the same area, and from then on were seen together regularly feeding in the water at the Refuge throughout the 1970–71 winter. They left on spring migration in late March, 1971. For the third consecutive winter, but for 2 days only on 11 and 12 November 1971, they were back together and in the same place at East Neck Island NWR. They were not seen again together until 27 February 1972. Where had they been during the winter? The female, C119, continued feeding in the water at East Neck Island until 17 November, but on 19 November, until 2 December, changed to feeding in a harvested corn field near Grasonville, Maryland, 24 km to the south. Meanwhile we feared that the male, C116, which had not been seen by any of our small team since 12 November had been killed or had lost his neck collar. However, on 12 February 1972 he was resighted feeding in a harvested corn field with 366 other swans 320 km to the south at Jarvisburg, N. Carolina. But the neck collar observations did not end that Spring with a disunited pair. On 27 February they were again side by side feeding in a field near Hope, Maryland, 24 km east of their original banding and wintering site at East Neck Island NWR. Back in Maryland they remained

together in this area until 16 March, after which they apparently took off on spring migration.

(c) The third case history relates to a brood of five cygnets captured by Ray Schweinsburg in August 1971 in the Old Crow Flats, Yukon, arctic Canada. One cygnet had a broken leg so was not banded. The other four were collared (red for arctic Canada) D366, D367, D368 & D369. The entire brood of four red collars and one unmarked (presumably the injured cygnet) reached the Chesapeake Bay safely and were seen regularly from 1 December 1971 to 16 March 1972 in the Ruthsburg, Maryland, area. Throughout the winter they and their unmarked parents fed in harvested corn fields. On 9 April 1972 this same family unit was again resighted intact in the Upper Mississippi NWR near Winona, Minnesota, on their way north during spring migration. Near Winona the marshes boast an abundance of aquatic vegetation and the swans were feeding in their natural aquatic habitat and not in the fields.

(d) Figure 2 illustrates the potentials of resighting Whistling Swans by collars at both ends of their range. C028 (black) banded in the West River, Maryland in February 1970 was resighted on 7 August 1970 in the mouth of the Colville River, Northern Slope, Alaska where its mate was captured and collared A301 (blue). During the second winter they were in company

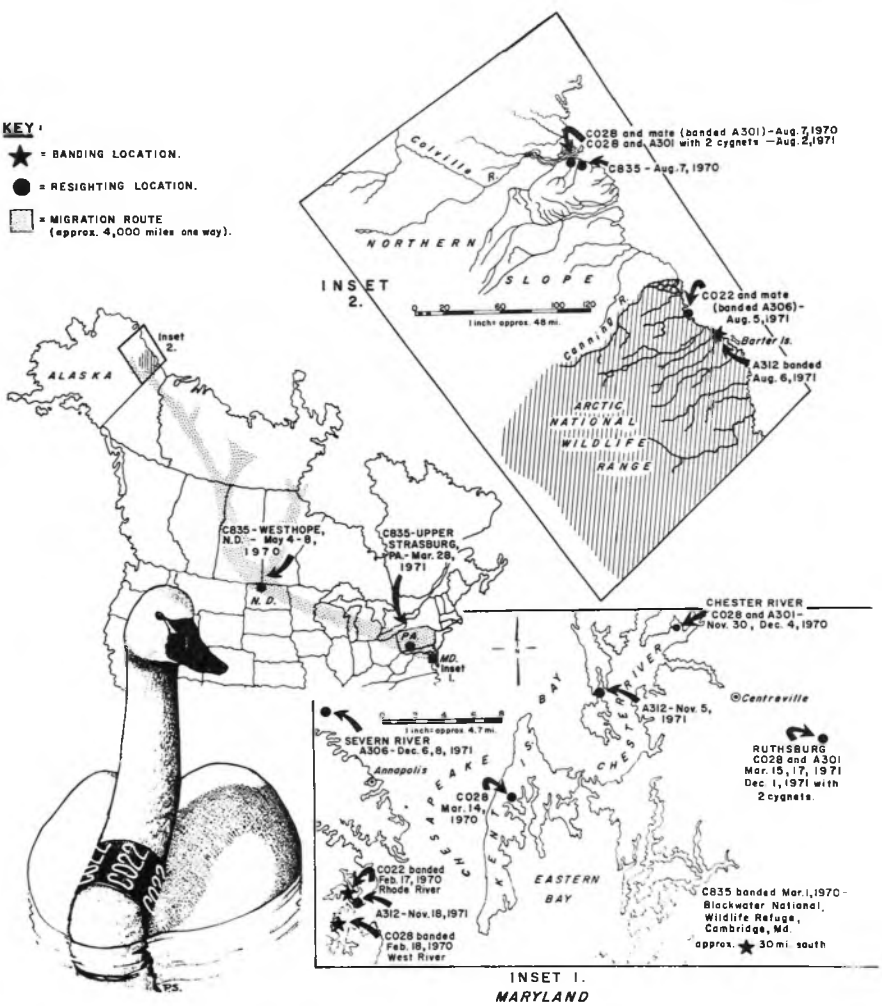

Figure 2. Movements of individually marked Whistling Swans between Maryland wintering grounds and Alaskan breeding grounds.

with two cygnets which had also been seen in Alaska. Like other collared swans, CO28 changed its winter feeding habits from aquatic to harvested corn fields in 1970–71. Swan C022, banded in the Rhode River, Maryland in February 1970 was not seen again until its band was read from a helicopter 18 months later in the Arctic NWR, Alaska. It has not been seen subsequently though its partner, A306, banded in Alaska was seen in Maryland in December 1971.

Swan C835, banded at Blackwater NWR, Maryland in March 1970, was seen at Westhope, N. Dakota 4–8 May on spring migration and on 7 August near Prudhoe Bay, Alaska. It was not resighted the following winter but during spring migration in March 1971 was observed at Upper Strasburg, Pennsylvania.

Discussion

The use of neck collars on swans is not a new technique. Yellow plastic collars were first used on Whistling Swans in U.S.A. by Harvey K. Nelson (personal communication) in 1956 and subsequently by John Frye at Shiawassee National Wildlife Refuge, Saginaw, Michigan from 1960 to 1969, after which they joined the Continental Program. Utah State Fish & Game Department (John Nagel and Clair Jensen) used less than fifty green and red collars between 1964 and 1970 in Utah. A variety of colours were used by Willey (1968) for Mute Swan collars from 1962 in Rhode Island. A few experimental green and red collars were put on Trumpeters at Red Rock Lakes National Wildlife Refuge, Wyoming in 1966. None of these schemes used coded collars, consequently individual swans were not recognized. These early studies, plus 4,500 Black Swans *Cygnus atratus* neck-collared in Australia by Braithwaite (1966), were important in demonstrating, that swans could be neck-collared without adverse publicity and without harm to the birds. Since codes have been engraved on the collars and research workers have agreed to follow a simple continental-wide protocol there has been a widespread increase in public interest. Moreover, the collars have enabled the public to converse on equal terms with the researchers and contribute greatly to the data gathering.

The case histories given above demonstrate that our study method using neck collars is providing us with some remarkable data on pair and family bonds, on winter and breeding site tenacity, and on change of feeding habits (which initially may not be shared by both members of a pair) in relation to environmental deteriorations. Moreover, they are being gathered on a continental scale throughout 16,000 km migration to the arctic and back again. We could not have collected them by any other method.

Acknowledgments

We are deeply indebted to many people from Federal, State and Provincial Wildlife Agencies as well as many private citizens who have helped in banding and resighting swans. Especially we are grateful to James King, Calvin Lensink, Gordon Watson, Tom Barry, Angus Gavin in the arctic; to John Moore, Robert Munro, Ray Schweinsburg, Charles Welling, Steven Blizzard, Jeanette Evans, Bowdy Train, James and Libby Rouse, Robert and Leila Rich, Vern Stotts, William Julian, John Davis, John Fields and many others in the wintering grounds; to landowners Ella Burling, John and Betty Colhoun, Kenneth and Caroline MacKleish, Judith Heintz and to many Department of the Interior National Wildlife Refuges (especially Blackwater, E. Neck Island, Mattamuskeet, Pungo NWR) who have allowed us to freely move on their properties. The first colour tarsus bands were supplied by Malcolm Ogilvie from a design developed by the Wildfowl Trust in England. Financial support has come, in part, from the National Geographic Society, U.S. Air Force, National Science Foundation (Tundra Biome), the Chesapeake Bay Foundation and others. Our headquarters in Maryland have been at the Chesapeake Bay Center for Environmental Studies and our over-all activities a part of the International Waterfowl Research Bureau's Swan Research Group. The U.S. Fish & Wildlife Service and Atlantic Richfield Company have contributed substantially to logistic support in Alaska.

Summary

Using coded colour neck collars increased the resighting rate of Whistling Swans *Cygnus c. columbianus* as individuals to as much as 90%, compared with less than 5% by conventional band methods, even after a migration across N. America. Details of the continental marking protocol for four swan species are given. Much public interest and co-operation has resulted from the use of collars.

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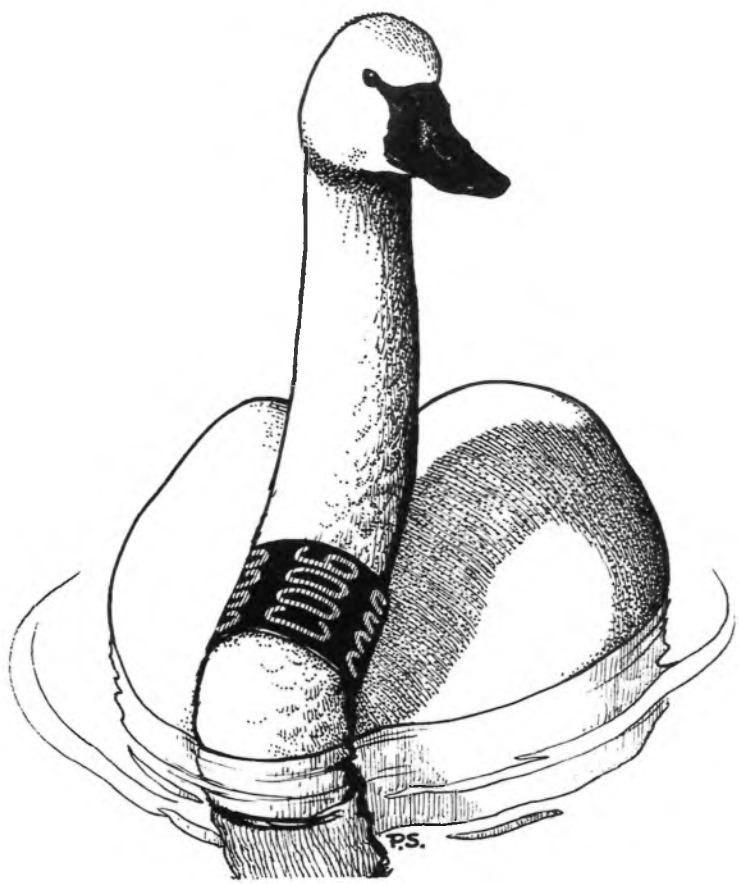

Th planes to gather swan data in A

JAMES

The Publishers regret that the illustrations are not of as high a standard as they should be due to deficiencies in the paper. It was unfortunately not possible to reject this paper as the present shortage in paper supplies would have meant an inordinate delay in publication.

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Whistler habitat. Stragglers from each species are occasionally found within the range of the other but essentially they use well-separated breeding areas (Figure 1).

Down the years, naturalists have re-
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ans and their wide range in the wilderness
was not possible for ground-bound
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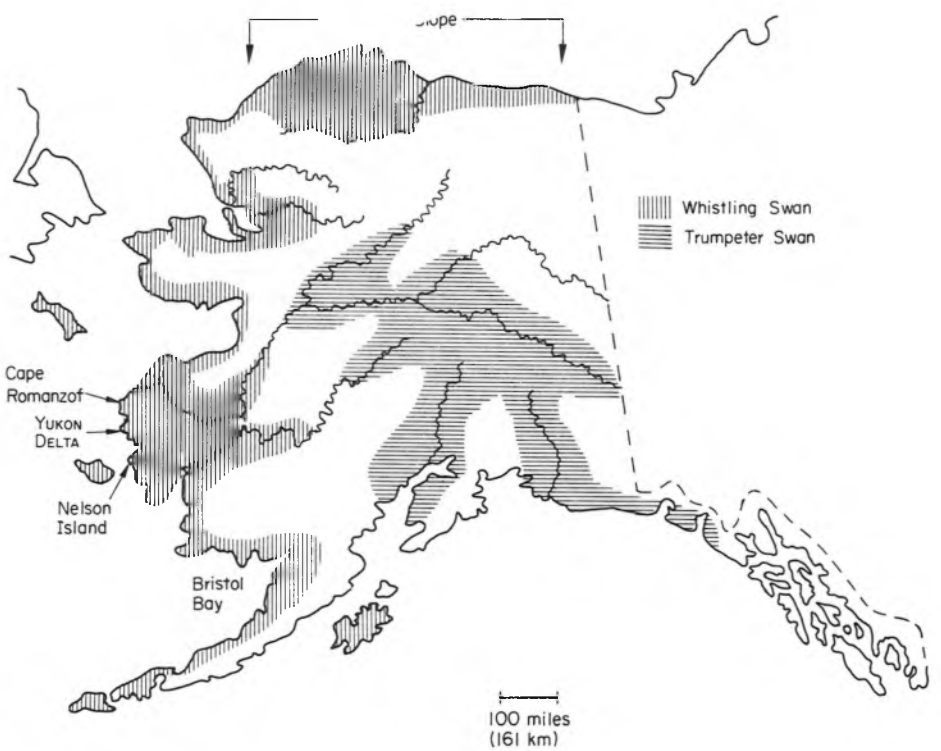

Figure 1. Approximate swan breeding range in Alaska.

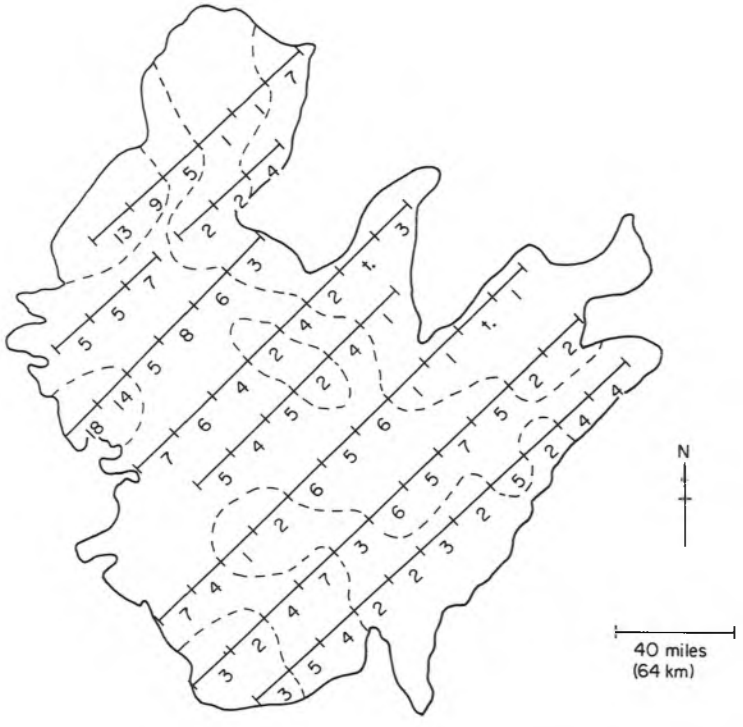

Figure 2. The Yukon Delta showing location of each of the 65, 16-mile line transect survey segments. The number below each segment is the 16-year average number of swans seen there that appear to be on territory. The dotted lines group areas according to density, low averaging from trace (t.)–3, medium 4–8 and high 9–18.

the habitat on the Yukon Delta, providing a good basis for land use and management decisions.

(3) A rough estimate can be made of the swans on territory that are likely to reproduce (breeding population).

Weaknesses include:

(1) The survey was designed to sample ducks, so lacks the precision of a survey specially planned for swans.

(2) The observers must judge the $\frac{1}{8}$-mile observation swath and make accurate observations without benefit of circling or going back to recheck.

(3) At some times the survey is done under cloudy skies and at others bright sun causes water glare that interferes with visibility.

(4) It is difficult to analyse the data without benefit of concurrent ground studies particularly of swan breeding behaviour. We are not sure how many swans are missed. It is not yet known what proportion of single swans actually represent a pair, and which are truly lone birds. Lacking precise data, single birds have been considered a pair in the final analysis (Table 1). This may be more accurate than counting two single sightings as a pair but there is still an unresolved bias.

(5) The survey does not measure clusters of non-breeding birds accurately.

(6) The survey would be improved by being repeated in late August to measure actual production of young.

We must conclude that the line transect method by itself gives a relatively superficial picture of a swan population and that the incubation period is not the best time to do such a survey. When a detailed study of a portion of the swan population is carried through an entire season, the long term transect survey information already gathered will become more valuable.

A line transect survey designed specifically for swans should be planned so some swans occur on every transect. It might be flown somewhat higher than a duck survey permitting a wider survey path.

Table 1. Whistling Swan spring population in Alaska from 1958 to 1971 (excluding the Arctic Slope) as determined from 107 line transects

1958	1959	1960	1961	1962	1963	1964
64,000	59,000	79,000	79,000	56,000	64,000	50,000
1965	1966	1967	1968	1969	1970	1971
62,000	52,000	43,000	50,000	75,000	69,000	61,000

14-year average 62,000; range 43,000–79,000.
(Figures from Chamberlin, Martinson & Clark, 1971).

Random flight method

When making routine flights across swan breeding habitat valuable data can be obtained by recording every swan seen. Nests and clutch sizes can be recorded in this fashion. It is necessary only to fly low enough for swans to be easily seen. The observer need not direct the path of flight, but if he can the quality of brood counts, flock counts, and egg counts are improved. If such flights can be made at least once a week, a good picture of swan productivity and juvenile mortality throughout the nesting season can be obtained.

The best example of this type of survey is from the Yukon Delta where the staff of Clarence Rhode National Wildlife Range have recorded swan data on routine flights since 1963 (Lensink, 1973).

The advantages of this method are that no cost is involved as people are travelling anyway and observations from different areas can be compared if the trips were made at about the same time of year.

Exploratory flight method

An airborne biologist must devote some time to exploring habitat new to him to get the 'feel' of the country before he can set up meaningful surveys. The value of the observations made on such trips can be enhanced if observations are recorded systematically. We have found that over the tundra habitat we can use the techniques of the line transect method to arrive at rough estimates of swans on the breeding grounds. Observations are made in a consistent swath and divided at fixed time intervals. Efforts should be made to reach every part of a given habitat and not to spend too much time in any one area. It is not necessary to fly straight lines. We have used the $\frac{1}{8}$-mile (201 m) observation swath and 10 minute intervals which at 96 mph (155 kph) gives us six samples of 2 sq. miles (5·18 sq. km) for each hour flown. With one observer this permits the recording of all Anatidae and other medium sized birds. If swans only are to be recorded a wider observation swath could be covered from a higher altitude. The coverage is doubled of course if there is an observer on each side of the plane. A figure for the number of birds per sample can be expanded to the total area covered. By this method we estimated there were 800 swans on the 23,000 sq. miles (59,570 sq. km) of waterfowl habitat of the Arctic Slope in 1966 (King, 1970).

Discussion

The foregoing methods can be 'tailored' to time and budgetary limitations. Probably the most important feature of the Alaska work has been consistency in planning and recording so that year can be compared to year and area to area. If we continue accumulating data in this fashion we will eventually piece together a good picture of swan population dynamics on the breeding range.

If airborne biologists working full-time on swans were available, the repeated survey of sample plots would be the most advantageous method. The major effort should be a complete random plot survey conducted in August to determine productivity. Before and after this, portions of the area could be examined at weekly or bi-weekly intervals to determine arrival dates, territory size, onset of nest building, egg laying, clutch sizes, hatching dates, mortality rates, brood movements, fledging dates, fall flocking pattern and exodus from the breeding area. A combination of plot counts and random flights might work best. Air surveys cannot answer all the questions of swan biology and ground work will be essential to learn about feeding habits, general behaviour, and causes of mortality. Some aspects of swan behaviour from year

to year will require marking individual birds as described by Sladen (1973). An aerial team assigned full time to swan work could probably do a lot of ground observation. Swans during their annual moult or prior to fledging can easily be caught for marking by use of a float airplane.

Although this report relates entirely to the use of airplanes we assume that the methods described could be modified to use from a helicopter.

We conclude that the full understanding of swans on the breeding grounds requires the use of light aircraft for surveys as well as ground access.

Acknowledgments

Those who have contributed to swan survey methods in Alaska include: H. Hansen, C. Lensink, W. Sladen, P. Shepherd, D. Spencer, R. Richey, J. Bartonek, A. Thayer, S. Olson, R. Tremblay, J. Branson, L. Johnson. Jack Hodges provided the stratification shown in Figure 2.

Summary

Single engine airplanes have been used in Alaska for swan population counts over the past 17 years. Five different methods have been developed: (1) complete census; (2) random plot census; (3) line transect surveys; (4) random flight method; (5) exploratory flight method. The first two methods are recommended when full time can be devoted to swan work. The last three are used when the flight is primarily for other purposes.

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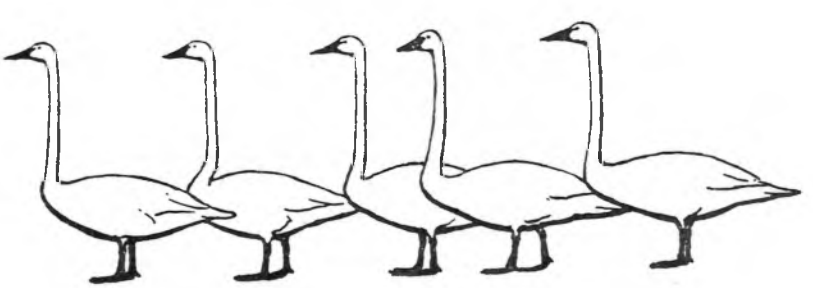

Wildfowl (1973) 24:21–25.

Population structure and productivity of Whistling Swans on the Yukon Delta, Alaska

CALVIN J. LENSINK

Whistling Swans *Cygnus c. columbianus* are the most conspicuous of wildfowl of the Yukon-Kuskokwim Delta, the principal nesting grounds for swans wintering in western states. They are readily visible from low flying aircraft, and local pilots or their passengers frequently remark on their abundance, the occurrence of large flocks, or even of numbers of young in broods, or of eggs in nests.

The occurrence of a large population, and the ease with which swans are viewed from the air, permits detailed observations of many individuals with relatively small effort or cost. Because the various factors which may affect the welfare of Whistling Swans may affect other species similarly, much information on swans should be of significant value in understanding the ecology of species that are more difficult to study.

Methods

Most observations were obtained during routine flights over the Delta for several purposes, including hauling of freight and passengers from point to point, as well as systematic aerial census of wildfowl populations. Flights intended primarily for observing swans include only those conducted for censusing random plots in 1968 and 1971, and occasional flights in late fall to ensure adequate sampling of broods just prior to their migration. The observation and recording techniques used are described by King (1973).

Results are summarized for intervals of 10 days to provide reasonable sample sizes and still permit detection of changes in the structure of population units that may occur over the summer. The basic data are deposited in tabular form at the Wildfowl Trust, Slimbridge, being too extensive to publish with the present paper. The consistency of recording observations and the proportion of swans tallied in the flight path varied with the purpose and altitude of the flight, weather conditions, motivation and ability of observers and many other factors. Consistency has much improved in recent years of the study, as compared to years prior to 1967.

Results

Distribution and behaviour

First swans appear on the Yukon Delta in late April and most have arrived by mid-May. Pairs are soon dispersed widely across the tundra in all suitable habitats, with densities higher in areas near the coast between Nelson Island and Cape Romanzof, an area which, incidentally, is the most productive for several species of geese and ducks as well as swans. Non-territorial swans, presumably mostly subadults, gather in large flocks along coastal estuaries or occasionally on large inland lakes.

Nesting begins almost immediately in normal years, although late springs may delay nesting by 10 days or more. Hatching has begun as early as 20 June, or as late as 6 July—but, in either event, coincides with early growth of green vegetation and maximum activity of insects and other invertebrates.

During nesting incubation, paired swans are frequently separated from their mates and many enter our tally as singles. At hatching, the population structure changes abruptly—members of pairs are less commonly separated and the large non-breeding flocks break up into smaller flocks that begin dispersing over the Delta as they enter the moult.

Although we have not studied individual broods throughout the season, numerous observations suggest that many may remain with their parents near the nesting site (100–400 m) until fledging.

Nonbreeders remain in small flocks of three to fifteen individuals, but as flight is regained in late August they begin congregating in larger premigrant flocks along the coasts or in favourable foraging areas on large inland lakes. Pairs remain scattered until early September when those without broods join the larger flocks, causing a distortion in the apparent proportion of pairs with broods. By late September most swans have left the Delta but some, particularly those with late broods, may remain until freeze-up in October. The number which linger is clearly the direct result of spring conditions—a late spring retarding all events throughout the summer.

Table 1. Survival of cygnets as indicated by changes in size of broods expressed as percentage of the average clutch size for year

	Clutches		Survival (%)					
Year	No.	Average	June	July	Aug.	Sept.	Oct.	Winter
1963	47	4·32	–	(78·6)	(66·1)	66·4	59·1	–
1964	52	3·30	–	(78·5)	(72·1)	–	–	57·0
1965	44	4·34	–	(44·7)	(75·3)	61·5*	–	50·2
1966	21	4·14	–	(73·2)	(57·2)	60·6*	58·9	50·5
1967	42	4·95	(73·3)	(83·2)	60·2	61·4*	58·8	50·5
1968	59	4·80	(85·0)	77·3	75·8*	75·6*	–	53·5
1969	33	4·67	–	75·4	75·8*	75·1*	–	58·0
1970	20	4·45	–	(77·1)	77·5	75·0*	–	53·0
1971	36	3·34	–	(79·6)	78·1*	75·4*	86·5	–

Samples of less than fifty broods are bracketed; *, those with more than 200. The winter observations, in California and Utah during December or January, are summarized in various reports by J. J. Lynch.

Size of clutches and broods

Sizes of clutches have varied from an average of 3·30 in 1964 to 4·95 in 1967 (Table 1). Modal size of clutches has varied from three to five. Average size of broods varies directly with size of clutches. Broods observed in the month following the hatch average only 75% of average clutch size. During the remainder of the summer, attrition to broods is relatively small, and at migration, broods still average between 60 and 75% of clutch size. Both the initial loss of cygnets and attrition to broods during the summer appear to be independent of clutch size.

A second sharp reduction in brood size is indicated by censuses of family groups in California and Utah, where broods observed in December average only a little more than 50% of clutch size (Lynch, 1972). Again, losses appear to be independent of original clutch or brood size.

Number of productive swans

When nesting is completed in late May or early June, the percentage of pairs observed with nests or broods becomes stable and remains relatively constant through August, suggesting that few pairs lose entire clutches or broods (Table 2). An apparent increase in the percentage of pairs with broods in September results from desertion of territories by idle pairs. The numbers of pairs with nests may vary considerably from year to year, and in the 9 years of our study, swans with broods in August ranged from 15·1 to 47·8% and averaged 31·4% of estimated total pairs.

Estimates of the proportion of productive swans in the population are somewhat more tenuous than our analysis of productive pairs, because of the difficulty in sampling the nonbreeding flocks which are not randomly distributed. During July and August, however, when flocks are smaller

Table 2. Percent of pairs with nest or brood

Year	May	June	July	Aug.	Sept.	Oct.
1963	–	–	35·4	(16·1)	52·1	(64·5)
1964	–	29·4	–	15·1	–	–
1965	–	(53·3)	(34·0)	36·6	(62·0)	–
1966	–	(25·4)	(39·5)	34·1	44·7	(60·0)
1967	16·8	47·0	(48·1)	30·1	46·3	(18·3)
1968	(19·5)	50·7	55·9	47·8	61·1	–
1969	(39·2)	48·3	51·6	45·4	71·7	–
1970	(25·4)	36·1	36·2	38·6	65·2	–
1971	–	27·9	24·3	19·2	23·5	(38·4)

Samples of less than 100 pairs are bracketed.

Table 3. Percent of adult or subadult swans identified as singles or pairs

Year	May	June	July	Aug.	Sept.	Oct.
1963	–	–	(57·2)	(22·1)	13·7*	(24·2)
1964	–	(85·6)	–	64·7	–	–
1965	–	(29·8)	(94·0)	(61·6)	(41·0)	–
1966	–	(59·5)	–	(25·8)	44·7	–
1967	(24·2)	56·3	–	(94·6)	49·4	–
1968	(23·9)	61·1	47·1	43·8*	39·2**	–
1969	(25·5)	50·8*	41·7*	52·6*	8·9**	–
1970	12·1	37·4**	62·6	(39·5)	16·2**	–
1971	–	39·1**	44·0	55·2*	44·4*	(13·2)

Samples of less than 1,000 swans are bracketed; *, those larger than 2,000; **, larger than 3,000.

and more dispersed than in other months, our samples seem adequately large, and between 40 and 60% of swans appear to be paired and on territories (Table 3). Occasional pairs are observed in nonbreeding flocks, but these are not considered as potential breeders. Although they may be adult swans, the companion birds may be together by chance, or they may be siblings, as most nonbreeders must be of yearling or other sub-adult age classes.

The proportion of swans occurring in flocks appears relatively stable and does not seem much affected by changes in the number of nesting pairs. We suspect that variation in productivity during preceding years changes the relative sizes of sub-adult age classes.

If we assume that approximately 50% of swans are paired and on territories, estimates of the proportion of productive adults range from about 9% of the total population in 1964 to 25% in 1968. This difference is proportionately much larger than differences in clutch size, hence it is a primary factor in determining annual productivity. As both clutch size and number of productive swans normally vary in the same direction, changes in productivity are larger than either. Thus, estimated production in 1964 was only 0·15 eggs per adult, but in 1968 was 0·62 eggs per adult.

Discussion

Climatic conditions in spring are invariably the most important of factors which affect the productivity of swans. Predators, disease, hunting, or other obvious factors do not cause significant annual variation in production. Hunting may have a controlling influence on the population if Klein's (1966) estimate of an illegal harvest of 5,000 swans on the Delta is correct. A late breakup of ice on rivers and ponds or lakes, caused by low temperatures in April or May, results in a reduction in both the size of clutches and the proportion of swans that nest (Table 4). Differences in survival of cygnets during the summer are comparatively small and seem also to be affected partly by spring conditions, as well as weather during summer months. However, our data is confusing and at present no

Table 4. Comparison of climatic factors and productivity

Year	Ice breakup		Mean temp. (°F at Bethel)				Average clutch	Pairs with broods (%)	Survival	
	Bethel	Chevak	April	May	June	July			Sept.	Winter
1963	5/19	–	19·4	40·6	47·1	54·2	4·32	33·7	66.4	–
1964	6/3	6/16	19·5	31·0	52·5	56·6	3·30	18·3*	72·1	5·0
1965	5/19	6/15	26·5	32·6	48·6	51·6	4·34	39·5	61·5	50·2
1966	5/23	6/15	23·0	33·2	51·8	53·2	4·14	31·5	60·6	50·5
1967	5/11	6/2	30·9	42·5	54·0	53·6	4·95	42·4*	61·4	50·5
1968	5/14	6/5	23·1	41·6	52·3	57·9	4·80	50·9**	75·6	53·5
1969	5/11	5/30	27·1	45·5	52·4	53·7	4·67	48·2**	75·1	58·0
1970	5/14	6/3	22·3	43·3	51·9	51·6	4·45	36·5**	75·0	53·0
1971	5/27	6/15	17·0	35·2	50·0	52·8	3·34	23·4**	75·4	–
Norm.	5/14	?	25·5	40·3	52·1	54·6				

The percentage of pairs with broods is derived from all observations June through August. *, Sample exceeding 500 pairs; **, and exceeding 1,000. Survival is calculated as percentage of average clutch size for year.

conclusion can be drawn. With the exception of 1964, a year when the reliability of our data is doubtful, survival of cygnets during migration was highest in years with early springs. Examination of many cygnets indicates that a few may not be fledged and others are only just fledging at the normal time for migration to begin. At this point in the cygnets' growth they are without fat reserves and muscle development is poor, and it is apparent that many cygnets are unable to survive the excessive demands of long, migration flights. It seems surprising that so many can.

The low productivity and the hazards to survival of cygnets on the Yukon Delta in years with late springs, suggests that swans nesting in more northern areas of Alaska, where shorter seasons are characteristic, are occupying habitat that is marginal for their survival. The relatively large population of swans on the Yukon Delta as compared to these areas (King, 1970), may be due entirely to the difference in length of the summer season.

Comparative data is limited to observations by Sladen (personal communication) in Bristol Bay in August 1969 and on the Arctic Slope in 1971. Swans from Bristol Bay are part of the western population while those from the Arctic Slope migrate to the Atlantic coast (Sladen 1973). In these years spring conditions in Bristol Bay were about normal and comparable to the Yukon Delta, but on the Arctic Slope they were unusually mild, although later than would be normal for the Yukon Delta. In Bristol Bay 31·4% of 156 pairs had broods averaging 3·57 cygnets. On the Arctic Slope 34·5% of 101·5 pairs had broods averaging 2·51 cygnets. Bristol Bay data was well within the normal range for that from the Yukon Delta. Although the season on the Arctic Slope was mild, the percentage of productive pairs were about normal for the Yukon Delta, and average brood size was similar to that observed there in late years.

Productivity appraisals reported by Lynch (1972) for the swans wintering on the Atlantic coast indicate consistently poorer nesting success than western swans, averaging only 11·8% cygnets in wintering populations as compared to 20·6% cygnets for western swans. The number of cygnets in family groups also differs, averaging 2·02 for the Atlantic population and 2·33 for the western. These data confirm our observation on the Delta that the length of the summer season is critical to production among Whistling Swans.

Weather conditions of early spring affect productivity of other wildfowl in Alaska as well as that of Whistling Swans. The deleterious effect of late springs was conclusively demonstrated for ducks of several species during my studies on the Yukon Flats between 1961 and 1964, but on the Yukon Delta our data for most species is too meagre to permit adequate comparison with that of swans. Studies now in progress should meet the necessary data requirements if continued for a sufficient period.

Because of the dominating effect of spring conditions, we can predict production by swans with reasonable accuracy before the first egg is laid. Subsequent observations during the summer essentially confirm and increase the accuracy of earlier predictions. We are satisfied that we can also predict trends in productivity for other species, but cannot at present estimate accurately the magnitude of change that may occur—even after the fact.

Productivity of geese on the Yukon Delta (Black Brant *Branta bernicla orientalis*, Cackling Geese *Branta canadensis minima*, Emperor Geese *Anser canagicus* and White-fronted Geese *Anser albifrons frontalis*) appears generally to be much more stable than that of swans. Perhaps adaptation of these species to changing conditions may not have to be nearly as great as for swans which require a significantly longer period of time between nesting and fledging of young. Among ducks, productivity of late nesting species such as Scaup *Aythya marila* and *A. affinis* seem less affected by late springs than that of earlier nesting dabbling ducks, particularly Mallard *Anas platyrhynchos* and Pintail *Anas acuta*, our earliest migrants and nesters.

Maximum changes in productivity that we have noted for any species occurs among Snow Geese *Anser caerulescens*, which we can observe only during their migration. Bands that we have recovered indicate that the population passing through the Delta nests primarily on Wrangel Island in the Soviet Arctic, and its productivity as indicated by percentage of immatures in the population has ranged from near 0 to 54%. As Wrangel Island has a much shorter season than the Yukon Delta, productivity of Snow Geese there may be analogous to that of swans in northern Alaska.

Acknowledgments

Many persons have contributed observations summarized in this report. James King, former Refuge Manager, initiated the study in 1962 and

1963. In addition, King (1973) has contributed observations made during annual surveys of breeding populations on the Delta and elsewhere in Alaska. All members of the refuge staff, particularly Jerry Hout, and several visitors to the Wildlife Range have participated as observers.

Summary

Observations of Whistling Swans from low flying aircraft on the Yukon Delta, Alaska, provide records which permit analysis of annual variations in productivity. Climatic conditions of early spring are the most important factor affecting production, a late spring resulting in a reduced number of nests and reduced clutch size. The percentage of territorial pairs with broods has varied from about 15 to 50%. The average number of cygnets in broods at time of fledging has varied from 2·52 to 3·63.

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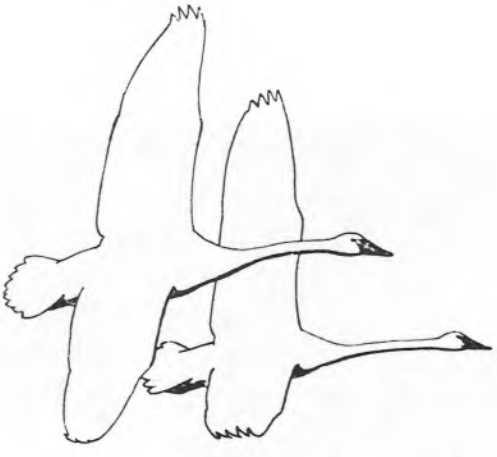


Philippa Scott

Plate I. Above: Trumpeter Swans *Cygnus c. buccinator* and (below) Whooper Swans *Cygnus c. cygnus* were breeding freely at Slimbridge in 1972.

E. E. Jackson

Wildfowl (1973) 24:27–32

Trumpeter Swan management

HENRY A. HANSEN

By 1920, following more than a century of exploitation and intolerable human encroachment, the magnificent Trumpeter Swan *Cygnus cygnus buccinator* was conceded by many to be on the brink of extinction, in all likelihood past the point of no return. Fifty years later this native of the North American continent, the largest waterfowl in the world, had recovered sufficiently for it to be officially declared no longer an endangered species, even though the population is still small by many standards.

This remarkable recovery is, in part, the result of protection from legalized hunting, intensive management of remnant populations, and the beginning of a successful transplanting programme. Entirely independent of man's heroic restoration effort in this area, an undiscovered Trumpeter Swan population in Alaska and along the North Pacific Coast was concurrently thriving. Subsequently, detailed studies of these two major population groups were conducted and reported in detail (Banko, 1960; Hansen *et al.*, 1971). Therefore, this will be a brief summary of the current population status of the Trumpeter Swan in North America and of the attempt to re-establish this species throughout its ancestral range.

In comparison with the Arctic-nesting Whistling Swan *Cygnus c. columbianus*, the Trumpeter, North America's only other native swan, probably never maintained numerically strong populations. Furthermore, its habits and range rendered it far more susceptible to human exploitation. By 1932 there were only sixty-nine Trumpeter Swans known to exist in the United States, south of Canada. These were in the remote high mountain valleys where the States of Montana, Idaho, and Wyoming join. The precarious condition of the Trumpeter led to the acquisition of the Red Rock Lakes National Wildlife Refuge in Montana in 1935 by the U.S. Government. With the protection afforded the Trumpeters there and in the adjacent Yellowstone National Park, the population quickly began to increase and continued to grow until about 1950 when the nesting habitat became too crowded. The population in that area has become stabilized since then at about 300 swans with a very low reproduction rate (Table 1 and Figure 1).

The Trumpeter Swan is notoriously slow to pioneer new areas, particularly where there are long distances between suitable areas of breeding habitat or geographical barriers such as mountain ranges. Thus, by the time the habitat at Red Rock Lakes became saturated, the limited number of suitable nesting areas within a 100-mile radius were also filled. From the outset it was obvious that the Trumpeter needed additional help to come back all the way. It was this knowledge and a desire to accelerate the return of the Trumpeter that led to the transplanting programme. Monnie (1964) and Marshall (1968) have reported the Government's effort to relocate breeding colonies of Trumpeter Swans. The following summary is taken from their accounts.

The first transplant of Trumpeters was made in 1938 when four cygnets from the Red Rock Lakes Refuge were moved to the National Elk Refuge at Jackson, Wyoming, approximately 160 km south. During the next 3 years, six more cygnets were released among these original four. In 1944, 6 years after the initial release, a pair nested successfully and raised one cygnet. From this modest beginning swans quickly filled the available breeding habitat in western Wyoming and adjacent Idaho. The population has been more or less stabilized in this area since about 1950.

Other transplants initiated at about the same time took much longer to bear fruit. Between 1939 and 1955 a total of 137 Trumpeters were translocated from Red Rock Lakes to the Malhuer National Wildlife Refuge in southeastern Oregon, and eighty-four were moved to Ruby Lake National Wildlife Refuge in northeastern Nevada between 1949 and 1955. The first successful nesting in each of these areas occurred in 1958 from 3-year-old swans which had arrived as cygnets in the 1955 transplant. As happened with the earlier transplant on the National Elk Refuge in Wyoming, these swans soon utilized the nesting habitat available to them, not only on the refuges but in surrounding marshes, and have maintained static populations for several years.

The most recent successful transplant in this general area of the continent was at the Turnbull National Wildlife Refuge in eastern Washington. Thirty-six swans from

Table 1. Trumpeter Swan populations south of Canada, 1932–1968

	Red Rock Lakes Refuge			Yellowstone Park			All other areas			Total, all areas		
Year	Adults	Cygnets	Total	Adults	Cygnets	Total	Adults	Cygnets	Total	Adults	Cygnets	Total
1932	19	7	26	29	2	31	9	3	12	57	12	69
1933	15	9	24	27	8	35	7	0	7	49	17	66
1934	16	26	42	16	17	33	16	6	22	48	49	97
1935	30	16	46	16	11	27	No census		—	46	27	73
1936	31	26	57	38	13	51	7	2	9	76	41	117
1937	34	51	85	38	26	64	9	0	9	81	77	158
1938	28	42	70	40	4	44	25	9	34	93	55	148
1939	50	59	109	47	17	64	26	0	26	123	76	199
1940	58	48	106	39	14	53	26	6	32	123	68	191
1941	52	44	96	44	15	59	47	10	57	143	69	212
1942	45	43	88			*	53	10	63	98	53	151
1943	88	25	113			*	49	9	58	137	34	171
1944	106	58	164	41	8	49	60	6	66	207	72	279
1945	113	50	163			*	67	5	72	180	55	235
1946	124	46	170	43	8	51	122	18	140	289	72	361
1947	131	49	180	45	8	53	116	3	119	292	60	352
1948	121	73	194	49	13	62	142	20	162	312	106	418
1949	132	61	193	54	21	75	162	21	183	348	103	451
1950	106	40	146	57	16	73	140	17	157	303	73	376
1951	170	76	246	63	11	74	184	31	215	417	118	535
1952	184	55	239	58	10	68	236	28	264	478	93	571
1953	211	38	249	51	10	61	216	51	267	478	99	577
1954	352	28	380	64	23	87	144	31	175	560	82	642
1955	242	41	283	58	10	68	195	44	239	495	95	590
1956	293	39	332	48	9	57	166	33	199	507	81	588
1957	159	45	204	44	16	60	196	28	224	399	89	488
1958	270	40	310	64	18	82	231	80	311	565	138	703
1959	271	40	311	62	8	70	249	51	300	582	99	681
1960	163	34	197	56	7	63	353	53	406	572	94	666
1961	155	14	169	71	3	74	310	66	376	536	83	619
1962	179	53	232	44	7	51	296	56	352	519	116	635
1963	145	122	275	49	7	56	294	98	392	488	227	715
1964	180	22	202	61	8	69	458	35	493	699	65	764
1965	190	16	206	60	5	65	433	78	511	683	99	782
1966	240	54	294	57	12	69	418	99	517	713	165	878
1967	184	20	204	55	2	57	464	71	535	701	93	794
1968	155	90	245	57	4	61	489,	112	601	701	206	907

*No census

Figure 1. Trumpeter Swan population, south of Canada, 1932–1968. ——, Adults; — — —, cygnets; —•—•—•, total swans.

Red Rock Lakes were released at Turnbull from 1964 through 1966. The first brood was raised from one of these pairs in 1967. Since then, nesting has occurred off the refuge as well, up to 32 km from the original release site. As in the west, limited habitat will not allow for a greatly expanded population in eastern Washington.

Although Nevada and southern Oregon, where Trumpeter Swans are now breeding in limited numbers, are both outside the historical breeding range of this species, and eastern Washington is at the western limit, much was learned from these initial attempts that has facilitated reintroductions elsewhere. Banko (1960) was of the opinion that the chief factor contributing failure in the early transplanting efforts was the practice of pinioning and confining the flock to a single large pool. Intraspecific strife and spatial competition not only created a situation unfavourable for breeding, but it led to significant losses from accident and disease. On the other hand, liberating the transplanted individuals unrestricted into the large open marsh resulted in the liberated birds quickly dispersing and they disappeared.

Consistent success has since been achieved, with transplanted Trumpeters breeding as early as their third year of life. The technique consists of transplanting cygnets prior to flight in September. The birds are wing-clipped to render them flightless throughout the winter and until the following moult, and held semi-captive in spring-fed enclosures. Supplemental feeding is provided as required. This method allows the swan to become familiar with the new environment slowly and to develop a traditional attachment to the area. When they regain flight the following summer, they are then free to explore the surrounding marshes from a home base and complete their maturation under entirely natural conditions.

With little chance for more than limited ultimate success on the western edge of the Trumpeters breeding range, U.S. Fish and Wildlife Service biologists turned their attention eastward to the plains States. The initial reintroduction of Trumpeters into this heartland of their ancestral breeding range was made on the Lacreek National Wildlife Refuge, in south-central South Dakota, which contains about 40 sq. km, over half of which is water and marsh. Despite severe winter weather, fresh water flows through the refuge during the entire year from constant springs in nearby hills. A large winter holding pen was built, with food-hoppers to supplement the natural feed available in the open marsh.

In the 3-year period 1960–1962, a total of fifty-seven cygnets (twenty, seventeen, and twenty respectively) were transplanted from Red Rock Lakes to Lacreek during the month of September each year. Each of the three flocks was wing-clipped upon arrival and released into the holding pen. During the summer of 1963 two pairs from the 1960 release raised young on the refuge. These same two pairs plus another again produced young on the refuge in 1964 and three other pairs nested successfully off the refuge. One nest was located about 96 km north and another 29 km southeast. The third nesting pair was not located but they returned to the refuge in the fall with cygnets. This population has continued to prosper. In the summer of 1969 there were six nests on the Lacreek Refuge and four others located within a radius of 96 km. Eighty swans returned to the refuge that fall, but only seventy survived the winter.

The success at numerous Federal refuges under a wide variety of conditions indicated that the technique of managing transplanted populations into sustained reproduction was sound and warranted wider application. Thus was born the first Trumpeter Swan restoration project in the United States (outside zoological parks) by an agency other than the Federal Government. The Hennepin County Park Reserve District has established a producing flock of Trumpeters from Red Rock Lakes stock in Carver County, Minnesota, about 25 miles from the City of Minneapolis. The first pair was acquired by the Park Reserve in 1966, twenty more in 1967 and ten cygnets in 1968. From this beginning the first known nesting of Trumpeter Swans in Minnesota since the 1880s resulted in the hatching of one cygnet on 21 June, 1969. Although this cygnet disappeared shortly before it was a month old this initial attempt gave reason for optimism. In 1970 a pair again nested on the Park Reserve (presumably the same pair) and hatched five cygnets. Another pair nested on a 12-ha marsh outside the Reserve. Unfortunately, there is an unnecessarily high loss of swans in this area, probably resulting from a large human population oriented toward outdoor recreation both summer and winter.

Inasmuch as several healthy, widely-scattered populations of Trumpeter Swans now exist and the species is no longer threatened, it is desirable, both for the welfare of the birds and for public enjoyment,

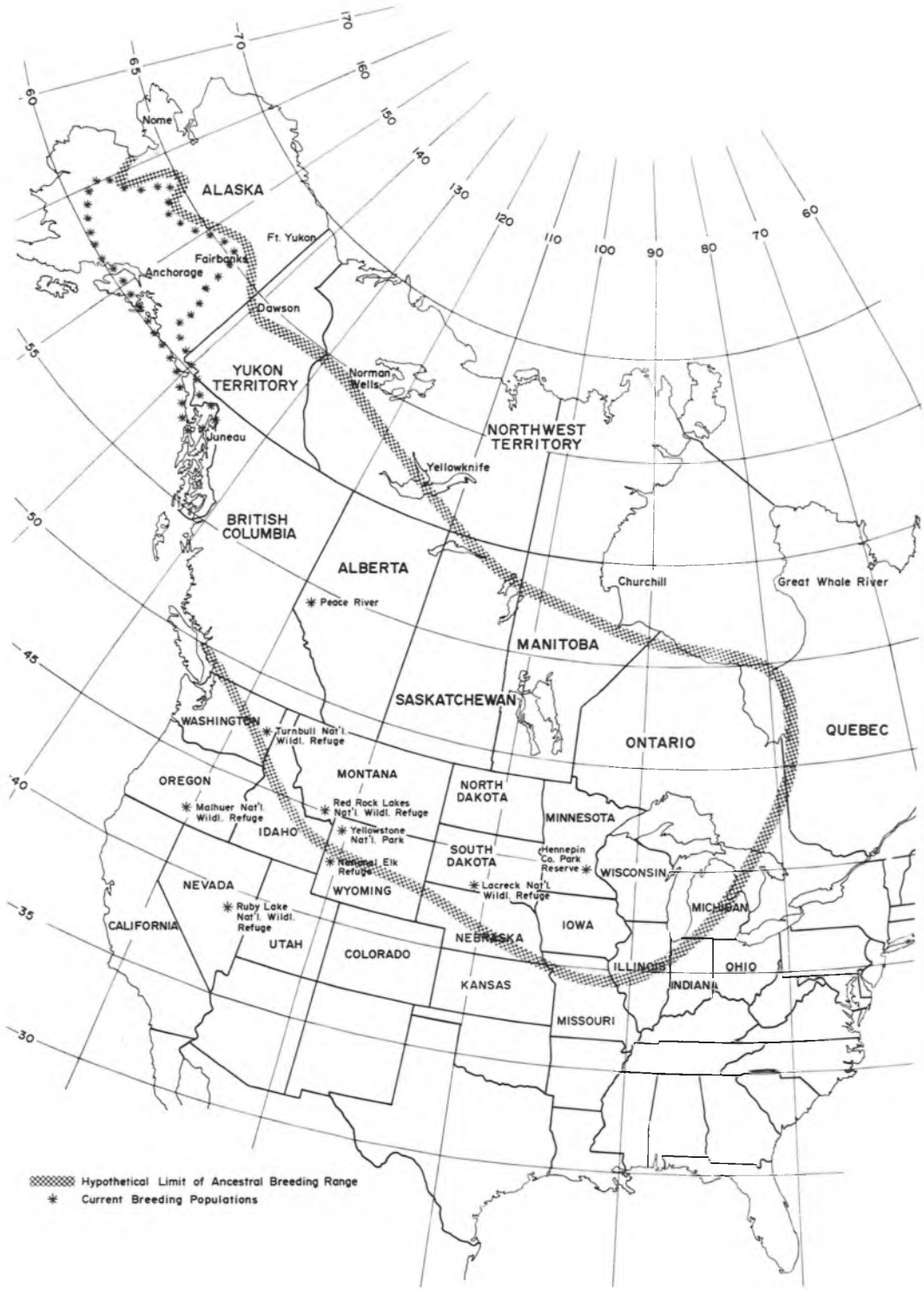


Figure 2. Trumpeter Swan breeding boundaries.

to re-establish swans at other locations within their former breeding range. In order to ensure maximum success and provide adequately for the welfare of the birds, guidelines are being established for all new releases.

Several important factors are limiting the rate at which Trumpeter Swans can be restored throughout their traditional breeding range. Experience has shown that, to achieve reproduction at the earliest possible age, swans should be transplanted as cygnets prior to attaining flight, preferably in September of their natal year.

The Trumpeter Swan has large territorial requirements during the breeding season, free of competition from its own kind and relative isolation from human intrusion. Marsh habitat must be reasonably stable with no marked fluctuations in water level. These basic requirements have been observed in all populations of Trumpeters throughout their range, including Alaska. For example, it has been estimated that the 20 sq. km of marsh habitat on the Lacreek Refuge will successfully accommodate no more than ten Trumpeter nesting territories. Marshall (1968) states that '. . . it appears as though the total number of nesting Trumpeters which can be supported on the 180,000-acre Malhuer Refuge is only about 50. Malhuer Refuge is one of the largest in the 48 contiguous States and contains the largest natural marsh remaining in the west outside Alaska.' In his extensive study at Red Rock Lakes, Banko (1960) found the highest concentration of nests on a shallow lake where the irregular shoreline combined with numerous stable sedge islands to provide the greatest variety and interspersion of water and marsh habitat. This lake of about 200 ha supported seven nesting pairs of Trumpeters in 1957, about 30 ha of territory per pair. On a deeper, less attractive lake of 600 ha on the refuge only ten pairs nested, about 60 ha per pair. Banko noted that 'a certain amount of water space, presumably to meet flight take-off requirements, appears necessary within each territory and the large number of potholes over the refuge which often produce considerable food are not an important segment of the breeding habitat.' We found territorial requirements in Alaska, where crowding has not yet become a serious factor, to be generally larger than at Red Rock Lakes and the other refuges.

Perhaps one of the most serious limiting factors to population growth and a more rapid extension of range is the non-migrant trait of Trumpeter Swans which live south of Canada. It is ironic that this inhibiting trait may well have been the most important single factor that saved the species from extinction. Those swans which were forced by weather to migrate annually from the northern breeding grounds in Canada south into the path of American settlers were soon extirpated, whereas the sedentary birds in the high mountain valleys of southwestern Montana were much less subject to man's relentless pursuit and, thus, survived.

A by-product of the non-migrant trait of Trumpeters, as they are gradually restored farther north across their ancestral range, is the necessity to provide them with adequate food and open water during the winter months. Up to a point, food can be supplied in any quantity that economics and logistics allow. But an adequate supply of open water, in the absence of natural springs, is next to impossible especially from the Canadian border northward east of the Rocky Mountains. A wintering population now numbering about 400 Trumpeters is maintained through an artificial feeding programme on Lonesome Lake in British Columbia (lat. 52° 30′N.). The source of these birds is conjectural at present. It seems likely that they derive from the Alaska breeding grounds, however, inasmuch as there are no known breeding populations of that size in British Columbia. Be that as it may, a wintering flock of 400 swans maintained artificially in the north is cause for concern. Not only is it costly and difficult to supply adequate food at such a remote location, but such a large concentration of birds under artificial conditions with a limited water supply might be conducive to serious outbreaks of disease.

The Trumpeter Swans which nest in Alaska must migrate as their breeding marshes are frozen from late September through April. However, they tend to move down the Pacific Coast only as far as necessary to find adequate wintering conditions. In recent years, as that population has grown to an estimated 3,500–4,000 birds, some Trumpeters move south as far as the mouth of the Columbia River which was part of their traditional wintering ground prior to settlement of the west coast (Hansen *et al.*, 1971)(Figure 2).

If a migrating tradition could be re-established in the Trumpeter Swan and adequate propagating techniques developed, the greatest potential for restoring this species in relatively large numbers lies in the prairie provinces of Canada north of the current agricultural belt. This area appeared to contain the greatest abundance

people lacked food and gathered the roots of water-plants, causing disturbance. However, legally the area remained all the time a non-hunting area and, as times came back to normal, so gradually swans returned to Sagata.

Hyôko, with a circumference of only 1250 m and an area of about 18 ha, seems so tiny that one would think it is of no importance at all. But situated at the centre of Niigata's many fine water systems, it has an ideal position. Within a radius of 7 km lie, to the north the 300 ha Fukushimagata Swamps, to the west the Agano River, coming from the south and making a sharp detour towards the Sea of Japan. Again, 15 km south-west flows the Shinano, Japan's longest river; Sagata with the oldest wildfowl tradition in Niigata lies 30 km south-west. In the east 10 km away rears the mountain chain of Gozuzan and Hishigadake (2,922 ft).

From the time of its creation in the Kanei period (beginning 1624), when it still had its original outline, that of a 'Hyôtan' (Bottle Gourd), Hyôko was used for wildfowl preservation. In winter, big flocks covered the entire surface of the lake which now has dwindled to a mere two thirds of its former size. Whoopers and the Eastern Bean Goose used to be dominant.

However, in the Meiji Age (beginning 1868) reservations like these were abandoned. The reason for this was that many people throughout the nation, which for so long had been secluded, became eager to copy 'Western Culture'. And the most embarrassing and exciting of all the things the Westerners had brought to Japan were firearms. Another strange thing imported was the eating of meat, which heretofore had been despised, for only outcasts ate meat unabashed. The 'up-to-date' hunters would aim at whatsoever things happened to be big (assuring the hit) or of rare beauty (which could be sold as a souvenir from Japan to Westerners) or at anything, bird or beast, that tasted good. And so wildlife disappeared quickly.

Then, in the 28th year of Meiji, in 1895, new hunting laws were issued: now only specified birds could be hunted; those not on the list were protected by the law. But in the Bird Atlas of the Agriculture and Forestry Ministry of that time one can see the swan included in the 'Hunted Bird List'. And thus swans diminished more and more.

Only in the Taisho Era, in 1921, were the swans again declared preserved birds. For the next 10 years little flock of eight to ten Whoopers could be seen on Hyôko every season. In 1931 this law was revoked and, as a consequence, the beautiful swans vanished entirely.

Later, Japanese soldiers were stationed at Shibata and, bored with the dull life in the barracks, found fun in shooting at any wildfowl wherever they were. Again the big swans were the preferred target, probably also because they provided a welcome addition to the monotonous diet. And so swans as well as all other wildfowl no more went to Hyôko.

The build-up of swan preservation at Hyôko

On 28 January 1950, during a heavy snowfall, farmer Jusaburo Yoshikawa and his son Shigeo observed for the first time after the war seven or eight huge white birds circle over Hyôko and disappear in the south. About a week later, on 6 February, eight Whooper Swans *Cygnus cygnus* alighted on the water, all of them adults.

The people of the town rushed to the waterside shouting with excitement, causing the birds to leave after a stay of barely 2 hours. They departed for the south. Three days later, on 9 February, six swans returned. The moment they settled on the water Jusaburo knew only one thing: he must make Hyôko the wintering haven for these beautiful birds. He sacrificed everything, time, money, health, even his family life. The swans became the centre of the life of Yoshikawa's house.

The six swans left on 11 February, but came back two days later. On 17 February a large flock of forty new Whoopers arrived, as before adults only. They stayed until 30 March, when all left. The next morning four cygnets alighted, leaving in the evening.

The Mayor of Suibara, urged on by Jusaburo and Mr. Kazuo Niita, Director of the local Hunters' Friends Society, submitted a request for the preservation of Hyôko to Niigata Prefectural Office. By 14 April, only 60 days after the first Whoopers had set their feet on the water of Hyôko, a law prohibiting shooting there was passed, valid for 10 years.

Two swans arrived on the morning of 16 January 1951 and left in the afternoon; on 26 January, thirteen came to stay. Unluckily, gunshots on 11 February chased them all away; eight returned to the lake. On 8 March they built up to twenty-seven. All left on 30 March, except for one sick

swan. Its mate returned the next day. As the swan was very sick, Jusaburo took it home. At this, the mate left the day after.

Two adults arrived on 7 February 1952, twelve on 10 February and the swans built up to thirty-four with six families on 16 February. Twenty-five left on 25 March, while nine stayed. For the first time Jusaburo thought about the necessity to feed the swans and began feeding experiments. The nine left on 16 March.

On 16 January 1953 two adults with one cygnet arrived. Without special incident, the flock built up to the peak of the first 10 years, forty-nine swans. All left on 15 March. Jusaburo continued his feeding experiments, noting which plants were eaten (Table 1).

Again two adults arrived with one cygnet on 20 January 1954, increasing to twenty-seven on 5 February and on 14 February to thirty-three. Among these were, for the first time, two Bewick's Swans *Cygnus bewickii jankowskii* which showed themselves more inclined to trust man. One of them, whom Jusaburo called 'Cowboy', boldly stepped forward to accept food from him, one Whooper following. After that, the other swans dared to approach Jusaburo and openly received his man-mixed food. From now on he called them to feed. They left on 18 March.

Table 1. Names of plants eaten by swans

Japanese	Latin
Amamo	*Zostera marina*
Gama	*Typha latifolia*
Kawa tsurumo	*Ruppia rostellata*
Fukuro nori	*Gloiopeltis furcata*
Baikamo	*Ranunculus aquatilis*
Watasuge	*Eriophorum gracile*
Ezo ukiyagara	*Scirpus maritimus*
Yoshi	*Phragmites communis*
Inusugina	*Equisetum palustre*
Tokusa	*Equisetum hiemale*
Hiyodori jogo	*Solanum lyratum*
*Makomo	*Zizania latifolia*
*Junsai	*Bradenia schreberi*
*Kawahone	*Nuphar japonicum*
*Hishi	*Trapa natans*
*Onibishi	*Trapa natans*
*Hirumo	*Potamogeton franchetü*
*Hitsujigusa	*Nymphaea tetragona*
*Hasu	*Nelumbo mucifera*
*Onibasu	*Euryale ferox*

Besides these, the swans eat also, when staying in the shallow water of a bay, tiny fish, lobworms and lobsters.

*Plants that grow in Hyôko. Hyôko and Fukushima-gata are the northernmost limit of the Onibasu or Ogre Lotus.

The open acceptance of the swans of Jusaburo's man-mixed food caused another great turn in the preservation work of Jusaburo. Thereafter 'Feeding of the Swans' became an important factor in the swan conservation at Hyôko. Moreover, it founded an entire new relationship between man and bird. It enabled Jusaburo to observe his swans far better. He found many had very easily distinguishable features, so he named a good number of them according to their bill markings.

Because of the enormous cautiousness of wildfowl in general and of the Whoopers in particular, Jusaburo showed himself to them always in the same uniform: black cap, black jacket, brown trousers and boots, the feed basket hanging down from over the shoulder before his chest. Furthermore he applied the conditioned reflex to let the wild birds know beforehand what he was going to do and what they were to expect, calling them whenever they were to get food. Fixing the feeding time at 08.00 hours, 11.00 hours and 15.00 hours was another successful measure to reassure the swans.

By now Suibara had gained quite a lot of fame and on holidays many visitors came to see the swans at Hyôko. It was quite a meaningful year for Jusaburo as well as for Hyôko. On 10 February it was declared a Natural Monument and on 20 March a National Monument and the official name 'Winter Habitat of Wild Swans' was given. On 5 November the government of Niigata through its Department of Social Education and Cultural Affairs bestowed on Jusaburo the unusual title of 'Swanfather'.

Since then the town has paid for most of the food and people from all over the country began to send food packages.

Seven adults and three young swans arrived on 26 January 1955; among these was one Bewick's Swan. This season, however, not more than fifteen swans gathered on their peak day, 10 March. They were all 'old-timers', for, when Jusaburo called them, they at once gathered to get his food. They left, three families and a loner, on 11 March in the afternoon, after a stay of only 44 days. In this year the perimeter of the protected area was enlarged to 1·6 km (Figure 1).

Five adults came on 23 January 1956. Peak day on 13 February had twenty-two swans, five families and a loner. The entire flock left on 13 March. Some high-school boys caused disturbance by snowballing the swans, but were rebuked. A far greater disturbance was caused by a helicopter

coming down like 'a curse from Heaven' with three game-eager GIs, delighted to see so many ducks and mallards below. Instead of a duck, a swan was hit. Jusaburo's protests to higher authorities resulted in the personal appearance of the American Air Force Commander and the Provincial Governor, to apologize and offer reparations.

On 19 January 1957 ten swans, six adults and four young ones, came, and on 20 January two groups arrived separately in the morning. In all they were four families, twenty-two swans, on 13 February, leaving on 13 March.

Two adults and one cygnet alighted on Hyôko in the forenoon of 7 January 1958. By 14 February they had built up to twenty-three, in all six families, of which one was a new one. Fifteen of them returned on 12 March, eight lingered until 15 March. Jusaburo began to study their individual features more intensively. He divided them into two groups, one in which the black went up to the forehead of the swans divided like a 'Y' (not reaching it, though), while the other went up higher, in an 'I' shape. From this, together with their attitude, he believed he was able to distinguish their sex. He tentatively divided his flock into eleven females and ten males but felt that this had to be studied more. He gave them names according to their individual features.

In 1959 the swans again came early, two on 8 January. With thirty-one swans on 19 February they reached their peak, and the last left on 26 March. The numbers and attendances of the swans during their first decade at Hyôko are summarized in Table 2. One of the swans, after an excursion to Fukushimagata, came home with his right eye, side, wing and neck badly wounded. However, it left with the others. One cygnet was bitten by a dog, having become too familiar with man. This seemed to be a warning that too much familiarity on the side of the wild birds might bring new danger to them.

Jusaburo had become ill, so Shigeo, his eldest son, took over the feeding. In February, Suibara town officially celebrated the first decade of its 'Winter Habitat of Wild Swans' at the lakeside with many people present. This turned out to be Jusaburo's farewell to his beloved swans of Hyôko.

Early in the morning of 25 December 1959 eight swans showed up over Hyôko. However, in the afternoon Jusaburo died

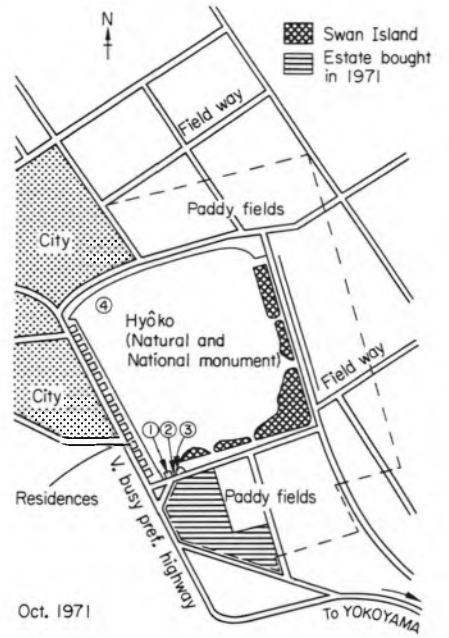


Figure 1. Map of Hyôko showing the winter habitat of wild swans at Suibara Niigata Prefecture, Japan. 1, observation post; 2, feeding dock, 3, water inflow; 4, water outflow; ----, planned purchase of additional estate.

rather suddenly without having been able to see the swans alight. They did not do so until 31 December, when a flock of six swans settled on the water. This was 11 days earlier than the year before.

On 15 January the flock was already fifty-one and grew to seventy-nine at the end of the month. It continued to increase to 3 February, and from then on to mid-March remained constant between 250–300. However, these swans could be divided into two units. One soon accepted the food from Shigeo and followed him like they did Jusaburo. However, the second group of more than 200 swans absolutely would not come near the feeding place.

The first group consisted of established 'old timers' that often had come to Hyôko. But the question remains open whether the second group was not used to man, or whether it could not approach the feeding place because of the domination of the first group.

The further growth of the Hyôko flock, passing the thousand mark in 1970, is shown in Table 2. The security and at-

Table 2. Migrating swans at Hyôko during 23 years, 1950–1972

Season	Number	First swan observed	Last swan departed	Length of stay (days)
1950	46	6 Feb.	31 March	54
1951	27	26 Jan.	24 March	61
1952	34	7 Feb.	16 March	39
1953	49	16 Jan.	15 March	59
1954	33	20 Jan.	18 March	58
1955	15	26 Jan.	10 March	44
1956	22	23 Jan.	13 March	51
1957	18	19 Jan.	13 March	57
1958	23	7 Jan.	15 March	68
1959	32	8 Jan.	26 March	78
1959/60	312	31 Dec.	6 April	96
1960/61	340	8 Nov.	1 April	144
1961/62	138	14 Nov.	31 March	137
1962/63	315	7 Nov.	30 March	143
1963/64	354	29 Nov.	7 April	129
1964/65	253	6 Dec.	6 April	121
1965/66	453	2 Nov.	7 April	156
1966/67	687	2 Nov.	8 April	157
1967/68	583	25 Oct.	26 April	183
1968/69	566	16 Oct.	24 April	191
1969/70	1019	1 Nov.	14 April	164
1070/71	811	28 Oct.	14 April	168
1971/72	543	28 Oct.	12 April	166

mosphere of love Jusaburo built was carried on by his son Shigeo, finding response in the swans. The Whooper and other wildfowl concentrations rapidly grew tenfold. Some 10,000 Mallard and Teal came.

The swans began to reach Hyôko earlier (16 October) and linger longer (26 April). The maximum stay was 191 days. Even the minimum stay of 96 days was longer than that of any season in the first decade. The average length of stay was 146 days.

The swans accepted Shigeo, following him wherever he went, racing towards him at his call. They adapted themselves to the unusual environment, remaining unconcerned about masses of spectators on the embankment and the moving cars. (A slammed door used to chase them away.)

The swans came to know the exact feeding time; many came from the farthest end of the lake aforetime, before Shigeo was visible or called them to line up at the feeding dock.

When the weather permits, Shigeo trains the swans to fly to the opposite side for food to keep them fit and to please visitors. They make a magnificent sight, racing over the water to their Swanfather upon his call.

Pupils of the Elementary School of Suibara voluntarily formed a 'Lake Patrol'. They serve daily after school, taking turns, and on holidays, when visitors throng to see the swans.

In the autumn of 1971 the 'non-shooting' area was expanded to cover the entire hinterland, Fukushimagata 6 km to the north and in other directions.

Origin and migrations

The swans which come to Japan are mostly Whoopers; Bewick's Swans are few. In January 1971 a survey showed an overall total of 7,023 (Table 3).

The nearest breeding place is in Sakhalin at Raichishi Lake. Here are still about twenty nests. Their breeding places spread over the northern Soviet Union, N. Mongolia and the Komandorskiye Islands. The Bewick's Swans breed in the eastern part of Siberia, the Lena Delta and the Kolyma Delta.

The Whoopers that come to Japan most probably come from the east of the Baikal Lake, the Altai Chain and the Amur River which comes from the Yablonovy Chain. They go up the Amur river, their favoured breeding ground, having to cover 4,000 km to Japan. On the way they pick up other flocks, growing in number. From the river mouth they cross over to Sakhalin, where all gather at Raichishi Lake in great num-

Table 3. Survey of swan species, January 1971, (by Tetsuo Kamaoku, Tôkyô, Ueno Zoo, Data Research Station)

Place	Whoopers	Bewick's Swans	Unidentified
Hokkaido			
Nozuke	2,500	–	–
Akkeshi	800	–	–
Aomori Prefecture			
Ominato	–	–	456
Kominato	–	–	449
Akita Prefecture			
Hachirogata	–	–	107
Miyagi Prefecture			
Izunuma	–	–	1,049
Fukushima Prefecture			
Inawashiro	–	–	218
Niigata Prefecture			
Fukushimagata	–	–	174
Sagata	385	53	–
Uwasekigata	192	34	–
Hyôko	191	23	–
Total	4,518	122	2,383

bers. After picking up the last swans, they proceed to Aniva Bay at the south of Sakhalin. The first flock arrives about 10 October. Here they linger until the middle of November, for in the shallow water they find plenty of food.

The Bewick's Swans are said also to go down the Amur River to Khabarovsk and then via Karafuto where they join the Whoopers. The two kinds of swans do not fight each other. In Nemuro, the swans' most favoured winter habitat, one can find about 20,000. There on the Odaito Beach and on Lake Furen they all come together. This lake has a circumference of 52 km, a length from north to south of 20 km and a width of 4 km.

When a severe cold freezes the water of lake and beach, the swans proceed gradually to the south and come finally to Honshu. Here is the bay of Kominato in Aomori Prefecture at the Sea of Japan, the swans' favoured wintering ground. Since olden times the people in this town treated all swans well. They see in the swan a messenger of God and a shrine is dedicated to it, the Raiden-Ji. This beach was declared in 1922 a 'Natural Monument', in 1952 as 'Extraordinary Natural Monument'.

With progessing winter, the swans move on to other parts of Honshu, searching other places where they can find peace and food. And, as in tiny Hyôko Jusaburo Yoshikawa gave them both, Hyôko became their regular winter habitat.

The man and his achievements

Jusaburo had been but a farmer, bringing for his immense task nothing but love for these migrating birds. Their presence was to him the assurance that man had not yet lost his foothold in nature, that man was still trustworthy. And it was this love, not his knowledge, nor the cold reasoning of a scientist, nor was it the skill with which he handled his job that lead to success. There are in Japan many much more magnificent swan concentrations, some even over 10,000. During all the 10 years of Jusaburo's conservation work his swan concentration remained small.

Neither the number of the swans nor the length of their stay were the important factors leading to the fame of Hyôko. It was the unusual, deep inner relationship between bird and man, wonderful harmony radiated by both.

Though the people mocked him so often, yet when he asked them to oblige him in the name of love for the wild creature, in his zeal of his task to give them justice and to readjust man to nature, he spoke with such dynamic force and authority that people in the end could but co-operate. And so he accomplished his aim, laying the foundation for the miracle of the second decade: the ever increasing swans at Hyôko. Through him Hyôko proved to the world that modern man and migrating bird can coexist.

Figure 2. Hyôko Lake.

Kiyoshi Honda

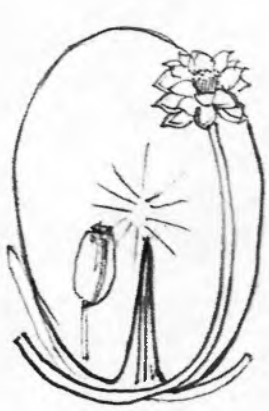
Figure 3. Distribution of wild swans in Japan, January 1970. △, Most known swan concentrations; ●, swan winter habitats; X, places temporarily visited; ○, cities.

Acknowledgments

As I am not a bird expert, only a lover and keen observer of nature, preparing this report was quite a task, though a fascinating one.

Deep gratitude I owe, before all, to Dr Godô Nakanishi who always immediately 'had time' to answer my thousand-and-one questions. Likewise Dr Tetsuo Kamaoku did not tire to further this work. Other people who gave advice and information were Dr Yoshimaro Yamashina, Tôkyô, Dr Saburô Ieda, Suibara, Dr Walther Thiede, Kobe, Mr Kiyoshi Honda, Niigata, who made the excellent photograph and, of course, Mr Shigeo Yoshikawa himself, on whose behalf this paper is written. From him and Toshi Yoshikawa, Jusaburo's widow, I learned many hitherto unpublished facts.

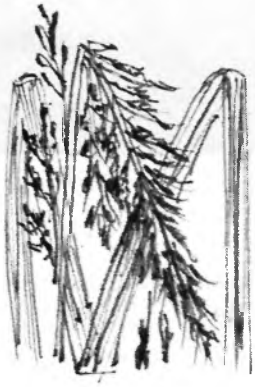
Finally my heart goes out to Paquita Aeschlimann who passed on the writer's article on 'The Miracle of the Ever Increasing Swans at Hyôko' (written August 1970) to Mr Peter Jackson of the World Wildlife Fund in Morges, who then contacted the Wildfowl Trust at



Nymphaea tetragona

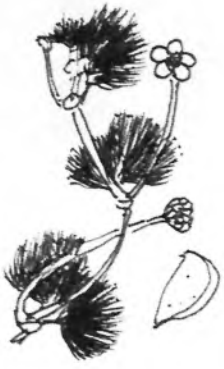
Trapa natans

Typha latifolia
(stem and root)



Zizania latifolia
(root and stem)

Phragmites communis
(seed, stem and root)



Ranunculus aquatil h.
(seed)

Slimbridge. This led to the publication of a brief account of Hyôko in *Wildfowl* 22, and to the presence of Mr Kiyoshi Honda, Mr Shigeo Yoshikawa and myself at the Swan Symposium at Slimbridge. The pen and ink plant drawings were drawn especially for the Wildfowl Trust by Godô Nakanishi, aged 70 years.

Summary

The winter home of up to 1,000 Whooper Swans *Cygnus cygnus* at Hyôko, Japan, is described. The swans are artificially fed and given complete protection on a small (18 ha) reservoir on the outskirts of the town. Details are given of the past history of the area, the build-up in swan numbers, and some of their food plants.

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Rose Lesser, More Joy, P.O. Box Nakahara 5, Kawaseki, Japan.

Brian Crosby

Plate II. Above: the Black Swan *Cygnus atratus* male on the left was loaned to Slimbridge by Sir Winston Churchill in 1953. He died in 1973 having fathered over thirty cygnets and been a foster parent to many more. Below: the Black necked Swan *Cygnus melanocorphus* demonstrates the young carrying behaviour common to the knob-billed group of swans.

A. Middleton

Wildfowl (1973) 24:43–53

A moulting population of non-breeding Mute Swans with special reference to flight-feather moult, feeding ecology and habitat selection

SVEN MATHIASSON

Mute Swans *Cygnus olor* are known to have gathered for moulting purposes in bays of the Swedish west coast during the 1960s (Mathiasson, 1973a,b). In 1971 the situation at the major moulting ground, Kungsbackafjorden (57.25N, 12.04E), was analysed in detail.

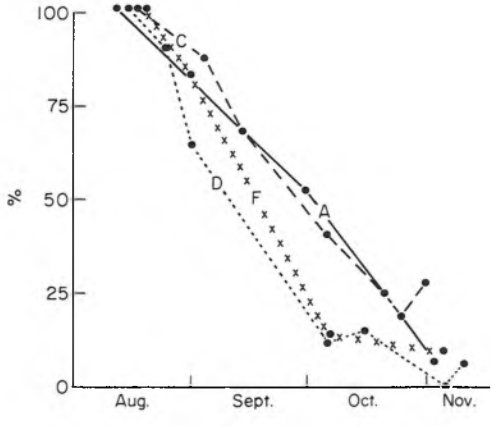
General description of moulting flocks

From previous investigations (Mathiasson, 1963, 1973a,b) we know that the west coast gathering of moulting swans is an annual cyclic event. We also know that the range of these swans covers the coastal areas of the Skagerack-Kattegatt (including southern Norway, Jutland and the Danish Isles), middle and south-western Sweden (but not the eastern part of southern Sweden), and the westernmost part of the Baltic Sea (including the coasts of East and West Germany). The breeding area is restricted to the northern part, but wintering occurs all over the range. The moulting ground consequently forms a centre on which the non-breeding fraction of the geographic population concentrates once a year.

Six moulting grounds were found along the Swedish west coast in 1971 (Figure 1) with in all 1,572 non-breeding moulting swans.

The general build-up and decline of the moulting population at Kungsbackafjorden followed a normal curve (Figure 2). However, it was skewed towards the early part, indicating a rapid disappearance (between 3–9·8) of swans. The decrease in moulting numbers was more rapid in some haunts (Figure 1).

Figure 1. The moulting grounds (A–F) on the Swedish west coast. A, Ödsmals kile, 92; B, Torslanda, 220; C, Kungsbackafjorden, 921; D, Klosterfjorden, 93; E, Balgöfjorden, 63; F, Uteros-Lisereds skär, 183. The graph illustrates the decline from August to November (initial number = 100%).



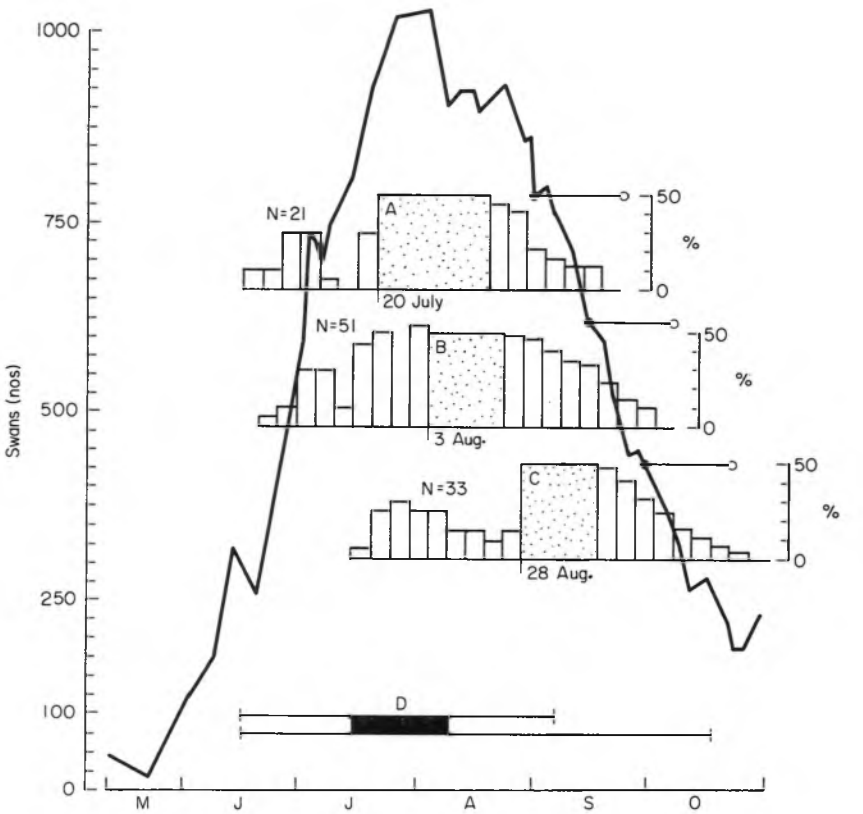


Figure 2. Numerical fluctuations (thick curve) of swans at Kungsbackafjorden. Diagrams A, B, and C illustrate the start of the moult and the regained ability to fly of samples of moulting birds caught on 20 July, 3 August and 28 August. The onset of moult in absolute numbers, in five day intervals is indicated to the left of the dotted central part which shows when the birds were still unable to fly. The right histograms present, in percent and pentads, the fractions of the population with fully grown flight feathers. To the right a ●, indicates all birds had regained their ability to fly; ○, that their flight feathers were full length. Diagram D shows (upper line) when birds started their moult, and the central black section when most did so. The lower line indicates when flightless birds occurred.

At Kungsbackafjorden, 138 swans were caught. All save thirteen (9·4%) were 2 years old or older. Twelve, previously ringed, had the following age distribution: 2 years, 1; over 3 years, 2; 5 years or more, 5; 7 years, 1; 9 years or more, 2; more than 10 years, 1. The percentage of males was: 68% (n = 31) between 5–21·7; 61% (n = 51) on 3·8; 64% (n = 14) on 17·8; 62% (n = 40) between 25–28·8. Calculations based on the sex ratio of birds starting their moult in different periods (Table 1) gave a male proportion of 65·8 for the same population. For later calculations of biomass an average of this value and that on 3·8 has been used, i.e. 63·3% males.

The stabilized July–August concentration had been 1,530 swans in 1970 whereas in 1971 there were only 939. The decrease can be explained in terms of reduced breeding in the summer of 1970 caused by the hard conditions of the preceding winter (Mathiasson, 1973a,b), which had the effect that sexually mature, but underfed swans which failed to breed joined the non-breeding, immature swans at the moulting grounds. The bad breeding success of 1970 is also reflected by the very low percentage of 1-year-old swans among the moulting swans of 1971 (only 9·4% against 29% on an average for the years 1964–1967).

In the early 1960s the Kungsbackafjorden moulting ground had more swans than nowadays (1961: 1,360 individuals;

Table 1. Timing of started moults at Kungsbackafjorden moulting ground, calculated from the moult stage of swans caught

	18–30 June	1–15 July	16–31 July	1–15 Aug.
No. (and %) of started moults	87 (9·8)	209 (23·5)	436 (49·0)	157 (17·6)
No. (and %) of started moults of males	46 (7·8)	154 (26·3)	305 (52·0)	81 (13·8)
No. (and %) of started moults of females	41 (13·6)	52 (17·3)	131 (43·7)	76 (25·3)
Sex ratio (% males) of birds starting their moult	52·9	73·7	70·0	51·8

1962: 1,850 individuals), the recent decrease is most probably explained by a shift of moulting ground (Mathiasson, 1973a,b).

The effect of different flock sizes on the behaviour of the moulting swans in respective years is poorly understood. We do not find any dead swans at the moulting grounds, not even when the moulting numbers reach their peaks. So either the food supply is superabundant or the birds are able to escape the 'moulting trap' (flightlessness for 5–6 weeks). On the other hand, the food supply may vary in abundance and availability and determine the numbers of moulting birds and their behaviour at an early stage.

Moult

The moult is an annual cyclic event, which takes place in May (body feathers)–June–October (body feathers/flight feathers/tail feathers)–November (tail feathers/body feathers). The body feather moult often starts on the pre-moult haunts. The flight feather moult of non-breeding swans is normally performed at certain central moulting grounds, the breeding swans moulting at their breeding sites. The primaries are dropped some days before the secondaries.

The growth rates of the 5th primary and the 5th secondary of four swans (two males, two females) kept in captivity with superabundant food supply (*Zostera marina*, *Ulva lactuca*) were 5·5, 5·7, 5·9, 7·6 mm/day and 3·2, 4·1, 4·3, 5·8 mm/day. The growth rate of the 5th primary of three wild-living females at Kungsbackafjorden was 5·0, 7·4, 8·3 mm/day. The average growth rate of the renewed 5th primary is thus 6·5 mm/day ($n = 7$), the individual variation being rather large.

The longer primaries have a faster growth rate than the shorter secondaries so their replacement is synchronized. The growth rate of secondary 5th is 71·0% and its length is 70·2% of that of primary 4th! However, the 5th primary is full-grown in a day less than the 5th secondary (67 days in an adult male, having a 5th primary length 41·5 cm, against 66 days for the 5th secondary of 29 cm).

The length of the growing flight feathers (primary 4th) of 138 swans of the Kungsbacka-population was measured. Knowing the growth in mm per day, we are able to calculate when the flight feather moult started and when the flight feathers reached their full lengths.

Three diagrams (Figure 2A,B,C) give the essential information on the onset, continuation and termination of the moult in 1971. The flight feather moult started about 18–19 June. Of the swans which were moulting their flight feathers (and therefore unable to fly) on 3 August, 2% started the flight feather moult between 19–21 June (Figure 2B). On 3 August there were 890 unable to fly and an additional 183 flying. Thus, only 1·7% (eighteen birds) of that population started their flight feather moult between 1–21 June. Consequently, only 4·1% (eighteen out of 420 individuals) of the birds present at the moulting ground between 18–21 June were in flight feather moult at that time, against 83% of the swans present on 3 August.

Most birds started their flight feather moult between 14·7 and 7·8 (Figure 2 A,B), quite obviously with the culmination at the turn of the month. The first moulting swans regained their ability to fly around 3 August. But no less than 46% of the swans moulting flight feathers on 28 August had started the flight feather moult later than 3 August (Figure 2C). None of the birds which started their flight feather moult before 15 July (= 33% of the birds unable to fly in 3 August, i.e. 294) were caught on 28 August. That means that those birds had by then regained their ability to fly. The total number of swans present on 28 August was only about 914, which may imply that most (at least 159) of the 294 capable of flight had also left the moulting ground.

Sex distribution in samples of moulting

swans caught, indicate a stronger predominance of males in the moulting flocks at the beginning of the moulting period. More reliable, however, is the sex ratio of swans starting their flight feather moult in different periods, by calculating the start of the moult from the length of the 5th primary (Table 1). Between 18 June–15 July, almost an equal part of the males and females started their moults (34·1% of the males, 30·9% of the females). The culmination in 'started moults' occurred between 16 July–31 July for both males and females. In the period after the culmination, on the other hand, a higher proportion of the females than of the males started.

On 13 June there were 316 swans at Kungsbackafjorden–5 days later the first swan dropped its flight feathers. However, the increase in the number of swans actually unable to fly shows a 30 days' retardation compared to the influx of newcomers (Figure 3). The gap between arrival and

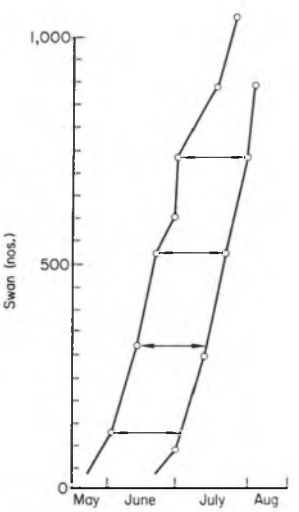


Figure 3. Increase in total numbers of swans at the Kungsbackafjorden moulting ground (left) in relation to numbers of swans having started their flight feather moult (right) at different dates in May–July. The arrowed lines indicate 30 days.

start of flight feather moult seems to be radically reduced (to 16 days) in the beginning of July.

The time required for the flight feathers of an adult male to achieve full length is calculated to be 66–67 days, for an adult female 6–7 days less. At least 55% of the males in a sample of forty swans caught between 25–28 August should have primary 5th 25–32 cm long. Actually there was only 4%. This indicates that the birds regain their ability to fly before the wing feathers are fully grown, when primary 5th reached a length of about 25–27·5 cm, i.e. 35–42 days after the start of the moult.

The number of swans at the moulting ground decreased in a clear relation to the time when the moulting swans regained their ability to fly (Figures 2 and 4). There was a clear tendency for more swans to depart sooner after they have regained their ability to fly in the beginning of the season than later (Figure 4). Thus, on 10

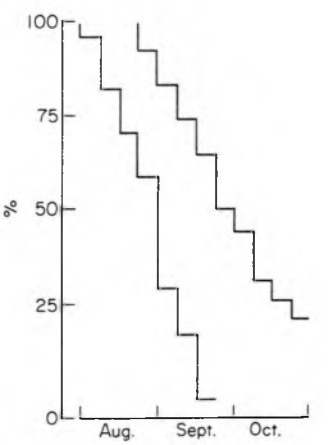


Figure 4. The relation between the decline in swans present at the moulting ground (right) and the fraction unable to fly (left). Expressed as percentages of numbers present in August.

September when all birds moulting on 3 August (890) had regained their ability to fly, 76% of the average August-moulting population was still on the moulting ground. The calculations indicate that all swans should be able to fly by 17 October. On 25 October all the 190 swans still in the haunt were indeed capable of flight.

There was a clear tendency for females to start the moult somewhat later than the males. This seems to be explained by the excess males (average sex ratio = 63·3% males) arriving at the moulting ground earlier in the season (males between 5 and 21 July = 68%). Of birds starting their moult between 1 and 5 July, 73·7% were males (cf. Table 1). However, in breeding swans the female is said to initiate the moult, the male not starting its moult until the female has completed hers, i.e. 6–8 weeks later (Hilprecht, 1970; Heinroth, 1928).

Localization within the moulting ground

The Kungsbackafjorden moulting ground is a sheltered coastal bay of about 53 sq. km. The shallow waters of less than 1·5-m depth provide accessible feeding places for the swans (cf. Figure 6). Under extreme low-water conditions some of the bottoms between 1·5 and 3·0 m are also accessible, extending the total feeding area to 21 sq. km.

We find (Table 2, Figure 5): haunt A was most important in May–June and again in October; haunt B was important all through the season, but especially in August–September; haunt C harboured most swans in July; haunt D was not used during May–August, but lodged comparatively high numbers in September–October; haunt E

Table 2. Monthly and seasonal (22 May–31 Aug. 71) swan-days at different haunts in Kungsbackafjorden (see Figure 5)

Haunts	May	June	July	Aug.	Sept.	Oct.	Season
A	280	3,060	4,538	576	5,157	3,664	17,275
B	220	2,088	2,681	11,044	8,839	2,644	27,506
C	160	2,147	14,501	4,716	1,000	316	22,840
D	0	516	3,983	11,079	1,129	204	16,911
E	0	8	1,004	1,690	1,868	347	4,917
F	30	7	0	0	1,440	1,335	2,812
All	690	7,826	26,707	29,105	19,423	8,510	92,261

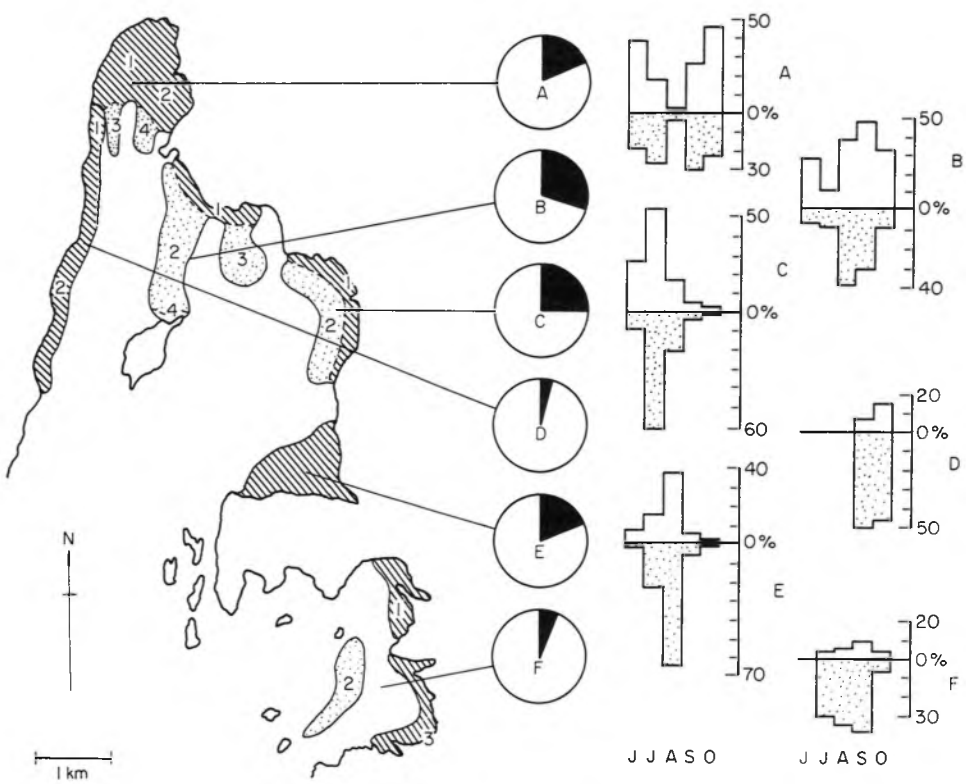


Figure 5. The Kungsbackafjorden moulting ground. The black sectors of the circle diagrams illustrate the proportion of the total annual moulting population (in swan units) which stayed at the different haunts. The histograms show (upper) the fraction of the monthly total of swan units at Kungsbackafjorden present at respective haunt, and (lower) the seasonal distribution of the total sum of swan units at the single haunts. See Table 2.

Table 4. Relative abundance of food organisms at sampling stations in Kungsbackafjorden (see Figure 6)

	Station													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ulva lactuca	+/+ +	+ + + +	—					+			—			
Zostera nana														
Zostera marina					+ + +			—				+ + + +		
Enteromorpha intestinalis	—		+ + + +	+ + +		+ +	+ + +	—	+ +/+ + + +	+ +	+			
Ectocarpus sp.	—							—						
Fucus vesiculosus			—	—	+ +	+ +	—		—	+ + +	+ +	+ +	+ +	
Chorda filum						+ +			—				—	
Mytilus edulis			—		+ +	—				+ + +				
Cardium edule					+ +	—						+ + +		

+ –+ + + +, Degree of abundance;—, present but unimportant.
All stations investigated by complete bottom sample and by raking except 1, 7, 10, 14 (rake only).

Table 5. Combined food preferences of four swans. Columns I-VI refer to sequential choices; the figures indicate how many food units were eaten in fifteen experiments; total of that food offered in one experiment was 100 units

Food	I	II	III	IV	V	VI	Total
Zostera marina	1,180	300	20	—	—	—	1,500
Ulva lactuca	195	840	285	160	—	—	1,480
Zostera nana	—	200	410	400	90	—	1,110
Enteromorpha intestinalis	—	5	140	300	240	—	685
Ruppia maritima	—	—	—	—	70	10	80

for 1 hour at 100° C. The amount of food eaten was calculated by subtracting the weight of the amount left from the weight of the amount offered.

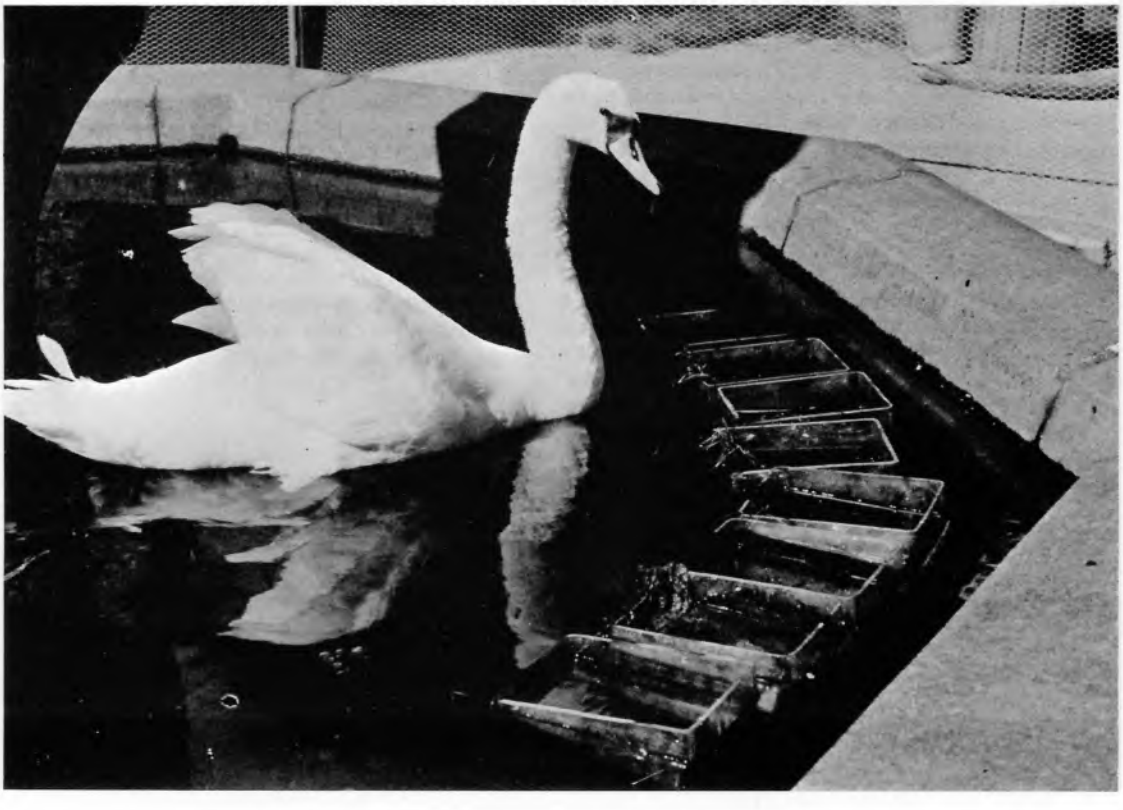
The consumption of the two essential food plants was expressed as kg food/kg body-weight/24 hours. The consumption of *Zostera marina* averaged 0·49 kg fresh weight, or 0·077 kg dry weight. That of *Ulva lactuca* averaged 0·54 kg fresh weight or 0·183 kg dry weight

The average consumption of fresh weight/swan/24 hours was 3·66 kg *Zostera marina* (n = 4), and 4·03 kg *Ulva lactuca* (n = 2).

The information collected tells us that the swans feed nearly exclusively on *Zostera* during May–August, while in September–October they also feed on *Ulva lactuca*. The faeces contain less than 0·5% of *Ulva* in all samples of a mixed composition. Observations, however, show that large flocks may feed exclusively on *Ulva* for some periods, predominantly in haunt F (northern part) and haunt A (inner, northern part).

The weight of moulting males (more than 2 years old) averaged 9·7 kg (n = 10), that of females 8·1 kg (n = 10). The accumulated biomass of the whole period 22 May–25 October was 861,715 kg (= the average biomass of each day × the total number of days), which is equivalent to 94,561 swans. In the period of more active moult, i.e. 15 July–31 August, the daily average swan number was 939, the accumulated number 45,074. Consequently, the accumulated biomass was 417,842 kg. The daily biomass of the stabilized average

Figure 7. Mute Swan and choices of food. *Sven Mathiasson*



August numbers (between 9–24 August) was 8,557 kg. The highest average daily biomass—9,660 kg—was found between 27 July–4 August.

Knowing the biomass of the moulting population and the daily food consumption of *Zostera marina* and *Ulva lactuca* respectively, we are able to calculate the total food need of the moulting flock. Thus, the theoretical food consumption (fresh weight) of the moulting population between 22 May and 25 October was 422,240 kg (based on *Zostera marina*) or 465,326 kg (based on *Ulva lactuca*).

In haunt F1, 1,775 swan-days occurred between 11 September–25 October in a section where nothing but *Ulva lactuca* was available, high water preventing grazing in the *Zostera* areas. Observations showed that the swans were feeding on *Ulva*. With a biomass of 15,990 kg, the total consumption (fresh weight) would be 8,635 kg. In the same period 2,885 swan-days occurred in the adjacent haunt A1 under the same conditions, and the birds were observed feeding on *Ulva*, which might have formed their predominant food (Table 3). Their biomass was 26,290 kg, their total food consumption 14,197 kg.

It seems justified to judge the true total consumption of food of the moulting swans between 22 May and 25 October to be the order of 401,523 kg of *Zostera*, and 22,832 kg of *Ulva lactuca*; 424.355 kg in all.

During June–July *Zostera* totally dominated, during September–October it only answered for 55·4% of the total food intake, the rest being *Ulva*. This means a consumption of 373,123 kg *Zostera* during June–August, against 28,400 kg during September–October, when 22,832 kg of *Ulva* was consumed as well.

Food resources of Kungsbackafjorden

The distribution and relative abundance of different food organisms are shown in Figure 6 and Table 4. Three quantitative studies have also been made. The food item studied was manually collected by a frogman, within a frame of 50 × 50 cm, and put into plastic bags. Fresh weight and dry weight were taken.

Zostera marina

Haunt A3 harboured the richest meadows and the largest plants of the moulting ground. The standing crop (root system, leaves, etc.) was 1,392 g/sq. m (fresh weight), equivalent to 204 g dry weight. The value is the sum of four samples 50 × 50 cm (235, 237, 390, 530 g fresh weight respectively).

Ulva lactuca

Haunt D1 provided the richest supplies of this food. The standing crop was 1,030 g/sq. m (fresh weight), 348 g dry weight. The value is the sum of four samples of 50 × 50 cm (150, 232, 298, 350 g fresh weight).

Zostera nana

The richest supplies of this plant were found in Haunt E. The standing crop was 550 g (fresh weight)/sq. m, which is equivalent to 383 g dry weight. The value is the average of two samples covering 1 sq. m each (525 g and 575 g).

Unfortunately there were no possibilities of making transects for quantitative studies nor to determine the productivity of these plants during this study period.

The total food consumption of swans staying in haunt F1 between 11 September–25 October was calculated to 8,635 kg of *Ulva lactuca*. The standing crop of this plant in the haunt was 1,030 g/sq. m in the middle of September. This means that the amount consumed converted to standing crop covered an area of 8,383 sq. m. This area is similar to the area used by the grazing swans, and the distribution of the *Ulva* supplies of the haunt. An investigation on 25 October showed that the entire *Ulva* crop (except within a narrow zone along the shore, covering about 800–1,000 sq. m) had been eliminated, leaving empty, sandy bottoms. The growth form of *Ulva* (without a root system) facilitates a total elimination of the plant by the feeding swans. The area is protected from heavy waves and strong currents so no other factors but the grazing could have been responsible. After the elimination of their food resources the swans abandoned the locality.

Summary

The build-up of the moulting numbers at the moulting ground and their decline followed a regular, gradual curve. This implies a clear time relation between arrival and departure.

Individual swans started to moult about 30 days after the arrival, this span reducing to half at the later part of the influx period. Govern-

ing factors must include population density, available food supplies and hormonal condition.

Males start their moult somewhat prior to the females. The swans regained the ability to fly 3–4 weeks before the flight feathers achieved full length.

The rate of departure seems to be dependent on population density and available food supplies.

The swans shifted between haunts in relation to changed food supplies. The main food was *Zostera* during summer and early autumn, while *Ulva* was taken later. The swans totally eliminated *Ulva* in certain areas.

The moulting population consumed 425 metric tons, mainly of *Zostera*, but also some *Ulva*.

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Wildfowl (1973) 24:54–55

Mortality of the Black Swan in New Zealand—a progress report

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Black Swans *Cygnus atratus* were first introduced into New Zealand in 1864 and coincidental with this, self-introduction may also have occurred. They found a completely unoccupied niche (the native New Zealand swan *C. sumnerensis* became extinct several centuries earlier) and population growth was spectacular. Today, the species occurs on large water-bodies throughout New Zealand although breeding colonies are restricted to relatively few sites. The largest breeding colony is at Lake Ellesmere, South Island (Cutten, 1966; Miers & Williams, 1969).

Black Swans may be shot during the shooting season (the month of May) in most parts of the country and until recently there was no daily bag limit. At Lake Ellesmere, shooting was allowed for 3 months (May–July) and in response to complaints of pasture damage, special 'swan drives' were conducted there each year. On these occasions, shooters were stationed at intervals across the lake and swans driven toward them. Several hundred to several thousand swans were killed in a single drive.

As a first step towards rationalizing this shooting pressure and the other procedures (such as egg collecting) used to control swan numbers, the New Zealand Wildlife Service commenced banding cygnets at Lake Ellesmere in 1956. Almost 20,000 were banded between 1956 and 1968 and 4,479 of these had been recovered dead by October 1970. Of these recoveries, 91% were made by shooters.

Ellesmere swans appear to be long-lived. In 1968, twenty-three of 1,281 banded in 1956 were recovered, and by 1970 this cohort was still extant. Recoveries of birds up to 20 years old will probably be made. The method of analysing these band returns is therefore a time specific one and I used the method of Seber (1971). Seber's model makes a number of assumptions, the most important of which are: (1) the annual reporting probability is the same for all birds and remains constant from year to year; (2) the probability of a bird's survival depends on age rather than on calendar year. These assumptions may not be completely satisfied by the data.

Mortality rates of males and females were similar (females on average 2% higher than males) and data for both sexes are combined in Table I.

Post-fledging mortality was highest during the first 2 years of life and the relatively constant adult mortality rate was not achieved until the fifth year of life. Mortality after the tenth year increased to 58% in the fifteenth year but these figures may have been influenced by band loss and small samples.

Estimates of the contribution which shooting makes to total mortality depend on knowing how many swans were shot and died but were not recovered and how many bands from shot birds were not reported to the Banding Office. For example, from 19,822 cygnets banded, 31·8% (6,300) died in their first year of life but only 1,519 were reported shot. These correction factors are not known at present.

To achieve a stable population, productivity to breeding age must equate adult mortality. Thus, 0·306 cygnets from each pair's annual production must survive to the fourth–fifth year. To achieve this, each pair of breeding adults must rear 1·02 cygnets to fledging each year. The average number of cygnets hatched per nest in 1960 and 1961 was 3·62 (Miers & Williams, 1969), allowing a maximum hatching to fledging mortality of 72%. Cygnet mortality is currently being studied. However, the decline in Black Swan numbers over the past decade clearly indicates that this modest level of productivity was not achieved.

Table 1. Mortality and life expectancy of Black Swans banded as cygnets at Lake Ellesmere, New Zealand

Years after banding	0–1	1–2	2–3	3–4	Adult*
Mortality rate (%)	31·8	30·9	18·9	20·8	15·3
Life expectancy (years)	2·7	2·7	4·8	4·3	6·0

*The adult figure is the mean of mortality rates for years 4–5 to 9–10 inclusive.

In 1968, the Ellesmere swan population suffered a major setback. A severe storm almost completely destroyed the beds of *Ruppia spiralis* in the lake and swans were short of food (Bucknell, 1969). Few pairs attempted breeding in 1968, 1969 or 1970 and no cygnets fledged in any of those years (Adams, 1971). Despite the total lack of production, shooting continued and the decline of the Ellesmere swan population was accentuated.

Studies on the dispersal, nesting and mortality of Black Swans at Lake Ellesmere continue.

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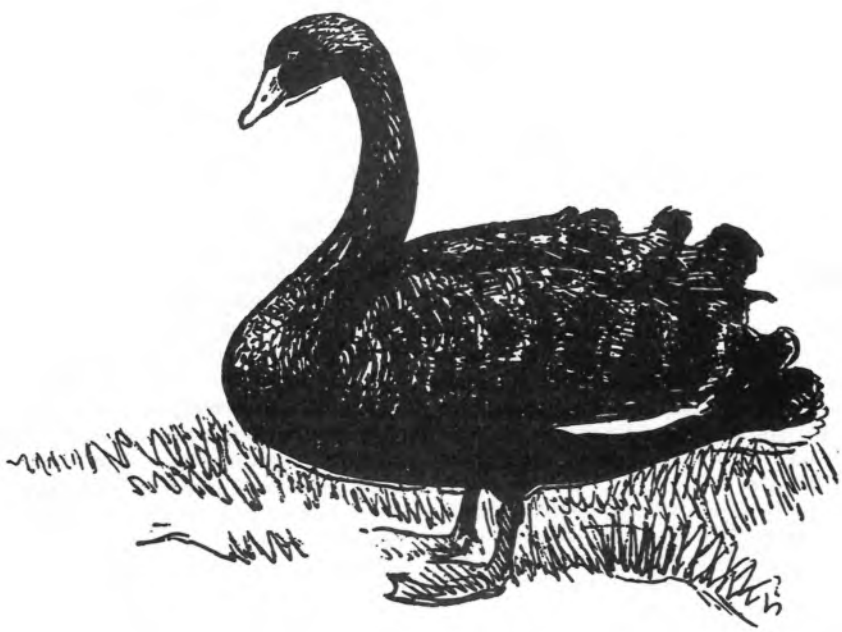


Wildfowl (1973) 24:56–60

Lead shot in Bewick's Swans

MARY E. EVANS, N. A. WOOD AND JANET KEAR

Introduction

The western population of the Bewick's Swan *Cygnus columbianus bewickii* is supposedly protected by legislation and/or custom (Lampio & Michaelis, 1972) in its breeding area (Arctic U.S.S.R.), in the countries bordering the Baltic which it passes through on migration, and in its wintering area (West Germany, Denmark, the Netherlands, Great Britain and Ireland). The flock of 400–600 Bewick's Swans which winters in the Wildfowl Trust's refuge at Slimbridge, Gloucestershire, has been intensively studied (Scott, 1971) and recently it has been found possible, for the first time, to trap substantial numbers. While the birds were being handled for weighing, measuring, ringing and dye-marking, the opportunity has been taken of X-raying them to detect lead shot in their tissues and so determine whether their protection from shooting has been effective. A preliminary account (Evans *et al.*, 1973) was presented to a symposium on hunting rationalization. The present paper contains the results of three winters of investigation, 1970–71, 1971–72 and 1972–73.

Methods

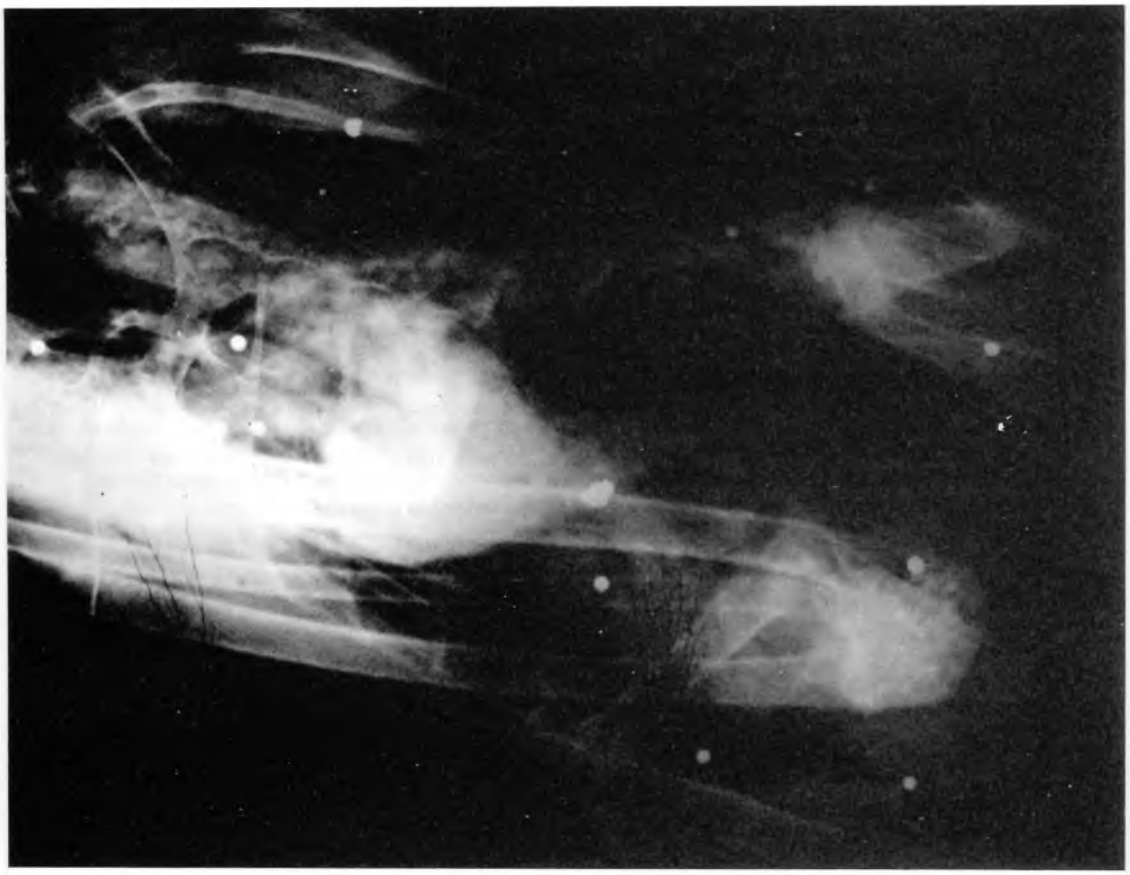
The swans are restrained in a tailored plastic jacket (Evans & Kear, 1972) and radiographed using a Watson MX1 portable machine, at 65 kilovoltage potential and 15 milliamps, at a focal distance of 52·3 cm, and Kodak R.P./D.X-omat radiographic film 30·5 cm × 38·1 cm. The birds are placed belly-down centrally on the screened film cassette. The head and neck are included in the radiograph by tucking the bill into a flap of the jacket, which is barely visible on the X-ray picture.

The use of radiographs rather than fluoroscopic examination was decided upon for two reasons. Firstly, any risk of the operators receiving excessive X-ray dosages was removed. Secondly, we were left with a permanent record that could be examined in detail at leisure, or matched with subsequent records if a bird was recaptured. Although the plates are quite expensive, their cost was largely offset by the prolongation of the life of the X-ray tube because of the short exposure (1·2 sec) needed.

The incidence of lead shot

Of the 272 Bewick's Swans examined after capture at Slimbridge, ninety-two (34%) had lead shot embedded in their body tissues (Figure 1). These shots had been fired at the birds in question without bringing them down (shot too small or fired at too great a range). None of the 272 was found with ingested lead pellets in the gizzard. These would rapidly give rise to lead poisoning. Birds sent in for post-mortem (and not used for the main survey) did indeed include five which had eaten lead shot or fishing weights.

The incidence of shot in the bodies of these protected birds is disconcertingly similar to those reported by the earlier workers in European quarry species, for example, 41% for adult Pink-footed Geese *Anser brachyrhynchus* (Elder, 1955a) and up to 28% for Mallard *Anas platyrhynchos* (Hoffmann, 1965). These studies had demonstrated a relation between body size and pellet incidence, the larger birds presenting more surface area to a burst of pellets and so being more likely to sustain a hit. That this relationship holds good in the present case is indicated by the fact that the adult (3rd winter and older) males were more likely to carry shot than the smaller adult females, i.e. 47% of ninety-seven males, 39% of seventy females. Indeed the difference is greater than would be expected on body size differences (see Scott *et al.*, 1972 and also Table 3 of this paper) and other factors may be involved. However, swans that were freely being treated as hunting quarry would be expected to have a higher proportion carrying pellets than would geese. The really appropriate comparison would be with the western American population of the conspecific Whistling Swan *Cygnus columbianus columbianus* which has recently been put on the shooting list in certain of the United States (Martin, 1970). No X-ray studies are, however, available. It may be noticed in passing that Elder (1955b) advocated such studies to determine the effectiveness of the closed season on this very swan.



N. A. Wood

Figure 1. Radiograph of a Bewick's Swan. This bird (Pie) had no less than twenty-one shot in its body.

The numbers of individual shot found in the birds are shown in Table 1. From this it can be deduced that 37% of the birds carrying shot had only one pellet, and that the average number of pellets per bird was 3·2. This may be compared with the figures Elder (1955b) quotes for the Canada Goose *Branta canadensis*, the nearest quarry species in body size for which we have data, 41% and 2·9.

It is difficult to ascertain the exact size of the shot, since some flatten, distort or shatter on impact. Most of the swans (eighty-five) had the relatively small pellets (No. 4/6) commonly used against duck or pheasants. Goose shot (BB and AAA) were in nine birds, one had an S.S.G. (fox-shot) and one an L.G. (deer). At the other end of the scale six birds (two in the same family) had the small shot (No. 7/9) normally reserved for clay-pigeon targets. Some birds contained more than one size of shot. It is not possible to state that the different shot were received on separate occasions, for shooters sometimes load their own cartridges with different shot sizes. Four birds each contained three different sized shot, and another eleven had two sizes. One bird received for post mortem carried three shot which were probably home-made. They appeared to have been chopped off a length of lead.

Possible causes of variation in the proportion of birds carrying shot

The number of seasons that an individual has been exposed to shooting might be expected to affect its chances of carrying shot. Swans in their first and second winters are easy to age. Thereafter the age classes cannot be distinguished with confidence, even in the hand. Only a small number of adults were of precisely known age, having been ringed in their first two winters. However, the patterns of black and yellow on the bills enable the experts at Slimbridge to recognize individuals as such. Their visits to the pond at Slimbridge having been registered since 1964, it is possible to allocate many of

Table 1. Numbers of pellets carried by ninety-two individual swans

No. of pellets	1	2	3	4	5	6	7	8	9	15	17	...	21
No. of birds	34	22	10	9	5	0	5	2	2	1	1		1

the swans X-rayed to minimal age classes. If they first arrived as adults they were assumed to be then at least in their third winter. How the incidence of pellets varies with age is shown in Table 2.

The young birds travel in the company of their parents to spend their first winter at Slimbridge, and they clearly have not been exposed to much shooting. Some may have been mistaken for geese as Haapanen, Helminen & Suomalainen (1969) suggest in the case of Whooper Swans *Cygnus c. cygnus*. Even the 12% incidence is inflated because three of the seven carrying shot were in one family. Both the parents also had shot in their tissues, so the whole group may have been wounded in the same incident. Further evidence that birds travelling together are likely to be hit at the same time is shown by the X-rays of eighteen pairs known, from their history on the Slimbridge pond, to be well-mated. Both birds in a pair were X-rayed in the same winter. In seven cases both contained shot. In the other pairs, however, only one bird was affected.

The young birds stay with their parents throughout the first winter, barring accidents, and leave with them on the spring migration north-eastwards. At some stage they must separate, for breeding swans do not tolerate last year's offspring in their territory. Probably the young birds amalgamate in flocks of non-breeders in northern U.S.S.R. By the time they arrive back at Slimbridge for their second winter the proportion carrying shot has doubled (to 25%). This is only to be expected in that the relatively inexperienced birds, without parental guidance, are more likely to make the mistake of flying too close to hunters who do not respect the law. There is only a marginal increase in the shot-carrying proportion in their 3rd+ winter, and none in their 4th+ winter.

There is then another over-doubling of the proportion of shot-carrying birds in their 5th+ winter (to 67%). Thereafter there is no indication of further increase with age, so we do not have a steady increment in lead-carrying in relation to the number of migratory journeys completed. Instead there is this great increase at an age when the birds would be expected to have become experienced and wary. Several sojourns in the safety of the Slimbridge refuge might have allayed their suspicion of Man. However, the pond on which they spend much of their time, and are fed, is screened and only one man enters the paddock to scatter grain. If a stranger intrudes they leave in a panic. The swans to be caught are drawn in behind screens by feeding and then driven into a corral. This procedure tends to recapture the most confident swans. Yet of swans which arrived at Slimbridge before 1970–71 (when X-raying commenced), fifteen of thirty-two (47%) were carrying shot when later recaptured, as compared with twenty-three of forty-one (57%) caught for the first time. This at least suggests that Slimbridge-experience was not affecting vulnerability to shooting.

When colour-marking was started in 1970–71 it was also feared that this might selectively expose the birds to the attentions of inquisitive hunters. Yet 79% of the 114 birds which had been dyed returned to Slimbridge the following winter as against 81% of a matched sample of undyed birds of similar age and Slimbridge-experience. Further, of twenty-eight birds X-rayed and dyed and then again X-rayed the following winter, only three had gained shot.

As far as it goes, therefore, the evidence suggests that treatment at Slimbridge does not increase the vulnerability of Bewick's Swans to gunfire. Even on the pond there they become extremely alert if the sounds of shooting are carried into the sanctuary;

Table 2. Variation in lead pellet incidence with age of swan (includes thirty-one birds X-rayed again in subsequent winters)

Winter:	1st	2nd	3rd+	4th+	5th+	6th+	7th+	8th+/ 12th+	All
No. X-rayed	60	55	86	27	21	19	13	22	303
No. with pellets	7	14	27	8	14	11	8	14	103
% with pellets	12	25	31	30	67	58	62	64	34

repeated bangs (even those produced by a carpenter in the buildings) cause them to fly out.

It is permissible therefore to contemplate whether there has been a recent change in the shooting pressure to which the swans are exposed, such that the younger swans are less at risk than had been the older birds in our series. In particular, a ban on spring shooting had been imposed in most of the provinces of the Soviet Union by 1968 (Bogdanov, 1970). The dramatically higher proportion of birds carrying shot in their 5th and later winters may just be coincidental, but it would certainly be interesting to ascertain whether the proportion of swans of that age carrying shot is permanently lowered.

Lest it be thought that the English hosts of the Bewick's Swans are only seeking lawbreakers in other countries, it must be admitted that hooligans with guns exist not far from Slimbridge. One swan, X-rayed on 8 December 1971, carried six pellets; on 2 February 1972 it had eight. Yet its attendance record showed that it had only been away from the pond at Slimbridge for 7 of the intervening 65 days. The same winter a bird picked up close to the refuge had definitely died of gunshot wounds. A pellet had penetrated the optic nerve; yet only 2 days previously it had been seen on the Slimbridge pond in normal condition.

There have been suggestions that the country of origin of the lead shot could be determined by size, weight or chemical analysis. However, there is not only the difficulty of locating and extracting the shot from the living bird, but it is also a fact that there is a good deal of trade in cartridges between countries even as far apart as the Soviet Union and Britain. Identification of origin would therefore be of little use.

Effect of the shooting on the population and individual

A hunter killing a protected bird is unlikely to report its ring number. We are not, therefore, in a position to gauge the effect of unlawful shooting on the small population of Bewick's Swans which winter in N.W. Europe, estimated to be only about 6,000 birds (Atkinson-Willes, 1972). Yet we know that swans are killed by shooting. A case was mentioned above. Another Slimbridge swan was reported shot in Latvia. Mostly, however, the reports are only of 'found dead' or 'injured'. Again we have a case of a blood-stained swan arriving at Slimbridge without its mate (which had presumably fallen to the same burst of shot). Superficially wounded swans have come in to the Wildfowl Trust's other Bewick's Swan refuge at Welney, Norfolk.

Goose shot and ball could be quite lethal to these small swans and we should not assume that shots from careless or indifferent duck- or pheasant-hunters can be discounted as a cause of death. The smallest shot recorded would have been ineffective, but what a sad commentary on the clay-pigeon shooter(s) who could not resist firing at something live chancing to fly overhead.

Those survivors which were examined by X-ray were not apparently much incommoded by the pellets they carried. One bird, containing two pellets, had a healed fracture of the leg and walked with a limp. Another, also with two pellets, had an atrophied and sightless eye.

An ailing swan loses weight, so the weights of shot and pellet-free birds were compared (Table 3). The differences are small, without statistical significance, and, if anything, the birds with pellets are slightly heavier.

Table 3. Weights of swans carrying pellets compared with pellet-free birds in same catches (includes twenty-nine birds weighed again in subsequent winters)

	Without pellets		With pellets	
	No.	Av. weight (g)	No.	Av. weight (g)
Males				
1st winter	30	5,097	2	6,105
2nd winter	23	5,701	8	5,680
Adults	56	5,960	52	6,249
Females				
1st winter	23	4,913	5	4,746
2nd winter	18	5,177	6	5,220
Adults	49	5,306	29	5,525

Conclusions

It is a distressing reflection on the effectiveness of hunting legislation when a totally protected bird is shown to be exposed to a similar level of shooting pressure as are the quarry species. European hunters do not even have the excuse available to their American counterparts who encounter huntable white geese. The adult Bewick's Swan cannot, even in a poor light, be confused with anything other than another swan; and all the species are protected in any case.

The responsible wildfowlers are as horrified as we are by the unhappy situation revealed by the X-ray camera. But it is clear that there are a lot of irresponsible shooters around, even in what we like to think of as the conservationally advanced countries. Hunter education and stringent tests before the issue of a shotgun licence may be a long-term solution. For the moment, legislation based on the selected protection of scarce species of wildfowl does not seem to be as securely based as had been thought.

Acknowledgments

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Summary

The totally protected Bewick's Swan *Cygnus columbianus bewickii* population was found by X-ray to have 34% of its individuals carrying shot in their tissues, a proportion not dissimilar to that in quarry species. A good deal of the shot appeared to have been received between the first and second winters. A higher level still was found in adults at least 5 years old. This may reflect changes in shooting regulations in part of the range. The effect of this illegal shooting is examined. The effectiveness of species by species legislation is questioned.

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Wildfowl (1973) 24:61–62

Leucistic Bewick's Swans

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More than a century ago, one museum specimen of a mysterious swan, *Cygnus davidi*, was seen in Peking by Swinhoe (1870). It was subsequently lost and there was much puzzlement as to its identity, for no other records came in. It had white plumage, a vermilion bill tipped by a black nail, and orange-yellow legs and feet. The fact that the area between the bill and eye was feathered led some workers to suggest it was a Coscoroba Swan *Coscoroba coscoroba*, though they could not explain how it had got from S. America to China. Kear (1972) pointed out that this degree of feathering is found in the juvenile Bewick's Swan *Cygnus columbianus bewickii* (the size was about right), and that the mysterious swan might have been of this species but a leucistic variety, i.e. one genetically deprived of the black pigment melanin. Support for this view has been forthcoming from a number of sightings among wintering Bewick's Swans.

In April 1956 a Bewick's Swan at Gunton, Norfolk, had flesh-pink legs and feet and a bill that was mahogany coloured apart from the normal yellow patch. It was filmed by Mr R. P. Bagnall-Oakeley (Seago, 1957). In January 1962 on Cockerham Moss, Lancashire, an apparently adult Bewick's Swan was seen with bright orange-yellow legs and feet—brighter on the outside of the tarsus. The bill was normal. It was mated to a completely normal black-legged bird, and they were accompanied by a single immature whose appearance seems to have been unremarkable (Sharrock, 1962). In January 1963 there was another report of a Bewick's Swan with flesh-pink feet in Norfolk, at Cley (Seago, 1964).

The suspicion that these swans in Britain and the mysterious 'David's Swan' were only colour variants of the Bewick's Swan has received confirmation by the close attention now being given to that species in Britain and the Netherlands. Until recently the chances to study the legs of Bewick's Swans were distinctly limited; now at Slimbridge, Gloucestershire, and Welney, Norfolk, the observatory facilities set up by the Wildfowl Trust have greatly enhanced the opportunities.

Figure 1. A leucistic Bewick's Swan (Needham) at Welney, February 1972.

During the winter 1971–72 a completely yellow-legged Bewick's Swan was present for several weeks at Welney. About 75% of what would normally have been black on the bill pattern was red. The nail was black. The iris of the eye was pale blue, instead of dark brown, but this is sometimes observed on otherwise normal birds. A detailed record of the identifying bill pattern was made, and it was named 'Needham' (see Figure 1). Sometimes normal second winter birds, with black legs, have a very little red in the centre of the bill. This is, however, quite different, for it occurs approximately where Needham has his only true patch of black, and it disappears by the third winter.

A second, distinct bird with much less red on its bill than Needham, and with grey-yellow legs with a few black spots, was also present at Welney that winter.

On 30 December 1972, Needham re-appeared, not at Welney but at Slimbridge. This time he was accompanied by a normal mate and, most interestingly, a completely white cygnet with flesh/chalky grey legs. Its whole bill was a strong pink tipped with a black nail. Its description almost exactly matches that by Swinhoe. Unfortunately the trio spent only the one evening at Slimbridge, leaving early next morning for fields about 15 kilometres away. There they remained for the whole of January and until 26 February 1973.

Meanwhile another yellow-legged Bewick's Swan, possibly the same as the second bird from the previous season there, was again to be seen at Welney.

Then across the North Sea yet another example was observed, near Ouwrkerk, Schouwen-Duivenland, on 27 January 1973. In this bird all the bill that would normally be black was bright crimson and there was no black nail. The yellow bill patches and the eyes appeared normal, but the legs were flesh coloured.

The leucistic condition is known in the Trumpeter Swan *Cygnus c. buccinator* and even in the Black Swan *Cygnus atratus*; in the Mute Swan *Cygnus olor* the genetic sorting out of the characters has been described in detail (Kear, 1972). It would seem that in Bewick's Swans the leucistic gene is also 'recessive' and perhaps sex-linked. A mating with a normal bird not carrying the gene could then give rise either to white cygnets (as in Needham's mating) or to normal ones (as in the Lancashire report).

It seems possible that there is a change with age from flesh-coloured legs, through grey to yellow. Likewise the pure pink bill may become progressively darker and flecked with black (Needham) until it appears normal (as in the Lancashire and second Norfolk birds). Alternatively the various combinations reported may reflect different genetic mixtures. Clearly it would be desirable to ring a leucistic cygnet and follow its colour changes in detail.

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Censuses of Anatidae in the central delta of the Niger and the Senegal delta—January 1972

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The central delta, or flood plain, of the Niger in Mali, and the Senegal delta within the states of Senegal and Mauritania, are two of the largest wetlands of tropical West Africa and constitute the principal wintering grounds of Palaearctic Anatidae in this part of the Continent.

The interest of the Senegal delta in this respect was recognized as early as 1958 (Roux, 1959); more or less complete waterfowl counts have been carried out quite regularly since the creation of the West Africa Survey within the International Waterfowl Research Bureau (I.W.R.B.) in 1966. However, no quantitative data had been assembled on the duck populations frequenting the central delta of the Niger, despite the fact that their abundance had been emphasized by Guichard (1947) and Duhart & Descamps (1963).

In January 1972 we carried out aerial surveys over these two large marshy complexes to census the Anatidae there. The rapid succession of the two operations, which fell within the period of the international counts of the I.W.R.B., permits a preliminary general view of the waterfowl distribution and their numerical status in their principal winter concentration areas in tropical West Africa.

I Central delta of the Niger

Geographical description

The central delta of the Niger lies between latitudes 13° and 17° North and longitudes 3° and 6° West. It is formed on the central course of the Niger, oriented here in a south-west–north-east direction, by the river overflowing into an immense alluvial plain almost without gradient (0·05 in 1,000). The spreading flood leads to the formation of a marshy area, about 100 km wide, to the south of Lake Debo. This lake, and its adjoining basins, Walado and Korientze, are only vast expansions of the river and act as regulators at the heart of the delta: the water is contained there by a barrage of 'dead' dunes, the Erg de Niafounke. To pass it, the Niger divides into three main arms, connected by multiple secondary branches. It only becomes one river again when it reaches Timbuktu. The region to the north of Lake Debo is characterized by lakes which extend on all sides of the water system in the whole Sahelian zone (dry thornbush savanna). This all constitutes a pseudo-lacustrine complex, 450 km long and over 200 km wide to the north of Lake Debo. Its area is nearly 80,000 sq. km. From south to north, five large areas can be distinguished:

(1) The upper delta. This is the region between the Niger and its right-hand tributary, the Bani, to their confluence at Mopti.
(2) The middle delta or Nigerian Mesopotamia. Bounded in the south by the course of the Niger from Diafarabe to Mopti, to the north by Lake Debo, it corresponds to the sector between the Niger and its left-hand branch, the Diaka. The lateral expansions on the east bank of the Niger below Mopti and on the west bank of the Diaka are included.
(3) The Erg de Niafounke. A mosaic of small and medium water areas between the dunes, drained by the branches of the Niger below Lake Debo.
(4) The series of lakes on the right bank. Depending on the eastern branches of the Niger below Lake Korientze.
(5) The series of lakes on the left bank. Includes the vast water areas fed by the western arm of the Niger, the Issa-Ber.

Hydrological conditions

The rainfall on the Guinea-Liberian massif results in the annual rising of the Niger and the Bani from July, the flood undergoing a considerable delay as a result of the spreading of the water in the plains and its storage in the basin of Lake Debo. The flood peaks at the beginning of October at Ke-Macina, where the river enters its central delta, and only at the end of December at Timbuktu, the exit from the delta area.

At the beginning of January, the southern plains, between the Niger and the Bani, are

Table 1. Numbers of Anatidae counted in the central delta of the Niger, 3–5 January 1972 (rounded totals)

	Upper delta	Middle delta	Erg de Niafounke	Right bank lakes	Left bank lakes	Total
Garganey *Anas querquedula*	4,200	75,000	400	8,500	5,900	94,000
Pintail *Anas acuta*	1,400	9,500	180	2,350	13,300	27,000
Shoveler *Anas clypeata*		10				10
Pochard *Aythya ferina*					400	400
Ferruginous Duck *Aythya nyroca*					42	42
Fulvous Whistling Duck *Dendrocygna bicolor*		300				300
White-faced Whistling Duck *Dendrocygna viduata*	2,250	16,000	140	590	2,100	21,000
Egyptian Goose *Alopochen aegyptiaca*	1		1	800	830	1,600
Spur-winged Goose *Plectropterus gambensis*		1,450		3	49	1,500
Comb Duck *Sarkidiornis melanotos*		2,300		40	110	2,500
African Pygmy Goose *Nettapus auritus*		120	7	2	3	130
African White-backed Duck *Thalassornis leuconotus*		7				7
Totals	7,800	105,000	730	12,300	23,000	150,000

here. In the Senegal delta the species comprises 10–15 times as many female and male first winter birds than adult males. Yet the latter are more distinguishable from a plane than other *Anas* in the mixed flocks. Moreover, it is possible that the Shoveler, without being abundant, is localized in sectors which we did not survey.

Taken as a whole, the results emphasize the overwhelming majority of Palaearctic visitors. Resident species only provide 22% of the total. This enormous imbalance in favour of Eurasian migrants suffices to emphasize the importance of the central delta of the Niger as a wintering zone. It also stresses the impact which the migratory ducks have on the habitat, compared to the endemic species.

Palaearctic Anatidae

The great majority of Palaearctic visitors consisted of only two species, Garganey *Anas querquedula* and Pintail *A. acuta*, in agreement with the literature. These birds winter over the whole delta, from the southern fringe of the flooding to Lake Faguibine. Our counts showed very marked differences in the size of their concentrations according to the zones, differences undoubtedly linked just as much with the nature of the habitats as with the extent of the fall in water level. The most recently drained surfaces, which favour the feeding of granivorous surface-feeding ducks, had the densest concentrations.

This is apparent all along the valley of the Niger, at least up to Niamey: the data collected by B. des Clers from hunters in Gao indicate that the populations move down the water system, following the fall in the water level of the river, until the pre-nuptial migration leads them northwards.

Upper delta. We only explored a small part on the right bank of the Niger between Ke-Macina and Diafarabe, and towards the confluence with the Bani up to 30 km above Mopti. The water had receded from these plains nearly a month before and the remaining pools proved to be nearly all deserted. Only four concentration areas were located, holding 4,200 Garganey and 1,400 Pintail.

Middle delta. This was the main concentra-

tion area: 79% of the Garganey and 35% of the Pintail being counted in this zone. The two species occupied the same sort of habitat, small or medium pools—the largest do not exceed 3 km in diameter—which riddle the immense alluvial plain like the cells of a honeycomb.

Being in the most pronounced depression of the plain, these pools retain water during the greater part of the year, when not permanent. Amid the water sheet which still submerges the surrounding land in January, they are distinguished by being either free from vegetation or choked with *Nymphaea* sp. The *Anas* settle almost exclusively on these pools, avoiding the large flooded meadows where the wild rice *Oryza barthii* dominates, and the floating vegetation of 'bourgou', a very dense association of *Echinochloa stagnina* and *Panicum stagnium* which spreads extensively in the area surrounding Lake Debo.

This region of the delta is sprinkled with mounds which are never submerged—the *toggue*—on which villages are established; the majority are surrounded by rice fields. On the stubble fields there was a thin sheet of water, very favourable conditions for the feeding of the birds.

The profusion of resting grounds causes a very wide dispersal of the populations into flocks of very variable size, from several dozens to several thousands. Of 124 locations of Garganey surveyed, only three held more than 5,000 birds. Pintail were most often associated with flocks of Garganey. We nevertheless found some homogenous flocks, the largest comprised nearly 8,000 birds.

On the right bank of the Niger, between Mopti and Lake Debo, the flood plain is limited by the western spurs of the Bandiagara plateau, and its width does not exceed 15 km. Here, the rice fields are predominant and the semi-permanent pools are less numerous.

Surveyed several times—because it is situated on the direct route from Mopti to the north of the delta—this sector seemed relatively poorer in Palaearctic duck (8,200 Garganey, 350 Pintail). The road from Mopti to Gao which skirts its eastern border permits easy access. It is therefore the only part of the delta which observers of the West Africa Survey had previously been able to visit.

Erg de Niafounke. On the north shore of Lakes Debo and Korientze a vast field of 'dead' dunes begins, pierced by three arms of the Niger: the Issa-Ber to the north-west; the Bara-Issa to the north; the Koli-Koli to the north-east. These dunes lie west-east and at high water the landscape is an alternation of flood corridors and long bands of emergent sand, dotted with *Hyphaene thebaïca*. This arrangement is repeated from Lake Debo to Dire with amazing regularity. Narrow strips of *cuscus* encompass the flooded shallows, the centre of which is often occupied by floating grasses of wild rice and *bourgou*.

There, the aquatic habitats are completely different from the plains of the 'living' delta, and seem much less valuable for Anatidae. Some twenty pools were surveyed in the Bara-Issa and Koli-Koli systems, producing a total of 400 Garganey and 180 Pintail.

Nevertheless, there are in this region more than a hundred water areas of the same type, some, to the north-west of Lake Niangaye, being 15–20 km long. Duhart & Descamps (1963) reported Garganey and Pintail to be extremely abundant there in winter. The populations must vary, here as elsewhere, between sectors, and in relation to the phenomena of flooding and draining in the rest of the delta.

Series of lakes on the right bank. Flowing from Lake Korientze, the Koli-Koli despatches branches to the east which feed several large lakes. These are, from south to north, Lakes Korarou, Aougoundou, Niangaye, Do, Garou and Haribongo. The hydrological regime of these lakes is mixed as is that of certain lakes on the left bank. They are filled partly by their own ground water and partly by the rising of the river. This only reaches the further lakes in years of heavy rainfall. In January 1972, Lake Niangaye was only flooded for two-thirds of its area (about 400 sq. km), Lake Garou one-third; Lake Haribongo was completely dry.

Apart from Lakes Korarou and Aougoundou which hold floating vegetation and reed-beds of *Typha australis*, these water surfaces are practically devoid of marshy vegetation. Their gently-sloping banks let the shallow water expose vast shores of bare mud sprinkled with puddles: the aspect is that of intertidal mud-flats. Old fields of millet, cultivated in the rainy season, occupy the wet fringe; on the circumference extends the Sahelian savanna, greatly degraded by cattle.

The exploration of these lakes proved to be disappointing as regards Palaearctic duck: 7,000 *Anas*, 6,300 of them assembled at the western tip of Lake Niangaye, the

others distributed only on Lakes Korarou and Garou. Pintail account for a third of these figures.

It is doubtful whether the birds can feed on these water areas, but only in the flooded habitats to the west. Moreover, substantial concentrations were noted on the pools which mark the channels joining Lakes Korarou and Aougoundou and which, with their rich carpet of *Nymphaea*, are reminiscent of the basins of the middle delta; for instance, 3,200 Garganey on the Bella Bambi pool. Such ponds, of which only a few were surveyed, could therefore between them hold many more ducks than the large lakes to which they are connected.

Series of lakes on the left bank. The Issa-Ber on its left bank feeds a series of pools and large lakes which are, from south to north, Lakes Kabara and Tanda, Tagadji pool, Lakes Oro, Fati, Tele, Takara, Gouber and Faguibine, the last three being fed through the agency of Lake Tele. Each of these water areas seems to have its own ecological characteristics, varying according to its depth and the nature of the substrate.

The largest, Lake Faguibine, 75 km long, has many points in common with Lake Chad, in particular its water likewise remains fresh. Situated on the outskirts of or outside the plains flooded by the Niger, these lakes are closely surrounded by predesert habitats with thorn-bushes and *Euphorbia* or by palm groves of *Hyphaene thebaïca*. Their value for migratory waterfowl seems to depend above all on the richness of their marsh vegetation and the extent of their drainable fringe.

Of the 19,700 Palaearctic ducks counted over the whole of these lakes (say 16% of the total) there were 15,200 on Lake Oro alone. In contrast, we only saw twenty-five on Lake Fati, 200 on the lakes system of Tele, Takara and Gouber and scarcely 1,200 on the 180 km of shore of Lake Faguibine. The dominant species was the Pintail, with 10,800 at Lake Oro, 950 at Lake Tanda and 1,200 distributed on Lake Kabara and some connected pools. On Lake Tele, partly covered with *Nymphaea*, the majority of the Ferruginous Duck in our Table were counted, and on Lake Faguibine all the Pochard *Aythya ferina*.

Lake Faguibine, in the shape of a square, directs a corner towards the west where the depth of the water falls, allowing the development of a submerged plant similar to *Potamogeton*, which we did not see anywhere else. The Pochard were concentrated here, as well as other Anatidae. It is an uncommon winter visitor but no doubt regular in Chad (Vielliard, 1972b), in the north of Nigeria and in the Senegal delta. Pochard had not been recorded before in Mali. Our observations established that the species does not hesitate to cross the middle of the Sahara.

Ethiopian Anatidae

As was to be expected, the White-faced Whistling Duck *Dendrocygna viduata* proved to be by far the most abundant of the Ethiopian Anatidae of the central delta of the Niger (77% of their total population).

In January 1972, 85% of the birds were in the middle delta, 10% on the lakes on the left bank, mainly at Lake Oro and Tagadji pool, the rest spread on the pools of the lakes of the right bank and in the Erg de Niafounke.

This distribution is very comparable to that of Garganey and the two species are very often seen at the same places. Nevertheless, the *Dendrocygna* like to rest standing in compact groups, which leads them more to frequent the banks of pools, wet rice fields and above all the sand banks and puddles of the lower bed of the river where the Palaearctic Anatidae are hardly found: we counted 1,800 White-faced Whistling Duck on 35 km of the course of the Niger above Mopti, as against seventy Garganey and one Egyptian Goose *Alopochen aegyptiaca*.

As a result of this habit, it is certain that the censuses carried out principally over the flood plains and lake complexes give a poor idea of the quantity of *Dendrocygna* in relation to the other Anatidae in the whole of the delta. A more extensive survey of the lower bed of the river and of its main arms would have raised the number of White-faced Whistling Duck without significantly altering that of the other species.

At the roosts, the flocks did not reach the size of the *Anas* concentrations: at only four of the seventy-three concentration points located were more than 1,000 birds counted, at nine more than 500.

The Fulvous Whistling Duck *D. bicolor* only appeared in the active delta in extremely small contingents (300). Although some undoubtedly escaped our attention among flocks of the White-faced species, it must be admitted that they are very uncommon in the delta at this time of year.

The distribution of Comb Duck *Sarkidiornis melanotos* and Spur-winged Geese

in January is centred even more on the middle delta than that of White-faced Whistling Duck: only 6% of the first species and barely 4% of the second were counted outside this region. These two large Anatidae, however, do not frequent the same localities. The Comb Duck primarily frequents the semi-permanent pools, the wet rice fields and the grassy embankments bordering the secondary rivers, while the domain of the Spur-winged Goose is the floating vegetation of wild rice and *bourgou* which is predominant over the deep flood. The depth of water on this recumbent vegetation also confines the species to places where the birds can move by wading without having to swim. Along the lower course of the Diaka and the south shore of Lake Debo we surveyed nearly 50 km of floating vegetation in deeper water without noticing one Spur-winged Goose (or other Anatidae, except some Pygmy Geese *Nettapus auritus*).

Nevertheless, the population of Spur-winged Geese is largely scattered and its census laborious: the 1,500 observed had to be counted in pairs, or families or small loose groups of several dozen individuals. One still does not have a definite idea of when they breed on the middle Niger. The indications of Duhart and Descamps suggest that eggs are laid from September to February. At the beginning of January one should therefore be able to find families with young at all stages of development. In fact, we did not see any chicks. However, as the 'plane passed, while a number of birds took flight, others were content to open their wings or run without taking flight, as if they were incapable of doing so: non-flying juveniles? adults in moult?—it was irritating not to be able to make sure.

Quite different is the distribution of the Egyptian Goose. They concentrate on the muddy banks of certain large lakes of the north: Tanda, Kabara, Tagadji pool on the left bank, Lake Niangaye on the right bank. Apart from these localities, we only saw seven birds. The area therefore seems distinctly more northern; perhaps it is confined to the Sahelian zone.

With Pygmy Geese the aerial counts are quite deceptive: besides being scattered in pairs or small groups, the birds can only usually be spotted if they take flight as the 'plane reaches them; many must have escaped us. However, 110 of the 132 individuals noted were on the pools of *Nymphaea* and the floating vegetation of the middle delta.

As for the seven White-backed Duck, their observation confirms the presence of this duck in the central delta where it has only been recognized once before (Duhart & Descamps, 1963). In Mali, the distribution is not limited to the Niger valley: B. des Clers found about fifty individuals at the Gossi pool, in the Gourma, on 26 December.

Additional observations

It was not possible to count, in addition to the Anatidae, the populations of all the identifiable waterfowl from a 'plane in flight—only those of a particular faunistic interest.

Pelicans. We think we saw the large majority, if not all, of the population of White Pelicans *Pelecanus onocrotalus* in the delta: 3,500 at Lake Tanda, 700 at Lake Do, plus thirty-two individuals to the south of Lake Debo. Of the Pink-backed Pelicans *P. rufescens*, generally considered more common here, we only observed isolated birds or small groups—sixty in all.

In West Africa the two species breed from October to March. We therefore hoped to find some colonies and thus supply the proof of nesting in the central delta. This is highly probable at least for the Pink-backed Pelican, since young captive birds, presumed to be of this species, were seen in the Bozo fishing encampments (J. M. Thiollay, personal comunication).

The origin of the White Pelicans of the middle Niger would be much more interesting to establish, since no breeding site is known nearer than 1,300 km to the west (Senegal delta and the Banc d'Arguin archipelago, Mauritanian coast) or 1,800 km to the east-south-east (Wase-Rock, East Nigeria, Kapsiki region, North Cameroon) (Naurois, 1969; Dragesco, 1971).

The Long-tailed Cormorant *Phalacrocorax africanus*, the only Cormorant of the central delta, is widespread in tens of thousands. Breeding was taking place in January: two small colonies were located at Tagadji pool and on the left bank of the Issa-Ber. African Darters *Anhinga rufa* were extremely abundant, above all in the middle delta. A hundred birds were sitting on their nests in a colony of Great White Egret *Egretta alba*.

Herons. The Great White Egret is the most evident species, present everywhere in very large numbers except on the bare banks of the large peripheral lakes where Grey Herons *Ardea cinerea* are commoner (hun-

dreds at Lake Korarou, Niangaye, Tele, Faguibine). In the middle delta three large colonies of Great White Egrets were located, one of them of more than 1,500 pairs on a wooded pool near Diaka. Another large mixed heronry is on an island of the Niger below Mopti. Buff-backed Herons *Bubulcus ibis*, Squacco Herons *Ardeola ralloides*, much more numerous that the Little Egret *Egretta garzetta*, each has enormous populations. The same is no doubt true of the Night Heron *Nycticorax nycticorax*; by day its populations, grouped in the shelter of the trees, are impossible to count, but its roosts in the thorny thickets in the middle of the flooded plains, each held hundreds of birds. The Purple Heron *Ardea purpurea* and the Grey Heron are probably the only herons solely represented here by Palaearctic visitors. They are more common in the zones of floating vegetation. The Goliath Heron *A.goliath* seems to be rare; only four were seen, at Lake Niangaye. Other species of Ardeidae were only seen or determined sporadically.

Storks, Ibises, Spoonbills, Flamingos and Cranes. For White Storks *Ciconia ciconia* the central delta of the Niger is an important wintering area, a number ringed in Western Europe and Morocco being recovered. During the cyclical swarming of the African migratory locust *Locusta migratoria*, of which the delta forms the breeding area, massive concentrations of White Storks are attracted by the acridids. However, we only saw 140, beside Lakes Tanda and Oro.

Ignoring the endemic Ciconiidae as well as the Sacred Ibis *Threskiornis aethiopicus*, we counted 1,650 Glossy Ibis *Plegadis falcinellus*, 1,400 of them on the plains and wet rice fields of the middle delta. This must be but a fraction of the actual numbers. Some nests of this ibis were found in the north-west of the delta, near Lake Fati, in March 1960 (Morel & Morel, 1961). The only other known breeding site in Africa north of the Equator is the Nile delta. Nevertheless, the majority of the Glossy Ibis of Mali must be of Palaearctic origin, like those which winter in the Senegal delta and the Chad basin.

Our only observation of spoonbills is that of a group of 140 African Spoonbills *Platalea alba* on a rocky islet in Lake Do.

There are no reports of Flamingos in the central delta of the Niger, nor in the other regions of Mali, and our surveys only confirmed their absence. The Lesser Flamingo *Phoeniconaias minor* might be found there if movements occur between the colonies of Kenya and that in the Mauritania sector of the Senegal delta (Naurois, 1965c). This hypothesis seems better founded since small flocks of Lesser Flamingos were observed to the north of Lake Chad (Vielliard, 1972a).

Crowned Cranes *Balearica pavonina* occur in pairs more often than in flocks and only 245 were counted, 115 of them grouped on a shore of Lake Niangaye.

Waders. To identify these birds from a 'plane is only possible for a minority of species, and all precise counting is deceptive. We tried to census only Black-tailed Godwits *Limosa limosa* and Ruff *Philomachus pugnax*, very gregarious species and easy to recognize. The totals—21,000 Black-tailed Godwits and 110,000 Ruff—indicate at the very most the quantitative relationship between these species. Their populations in the whole of the delta must be hundreds of thousands for the first, and millions for the second.

The muddy shores of the large lakes offer roosts for the Ruffs where there may be imposing flocks (50,000 at Lake Gouber). The sand banks of the Niger at low water played the same role. However, on the pastureland—above all the drained meadows and the stubble of the rice fields—the populations become impossible to ascertain because of their extremely wide dispersal.

The Black-tailed Godwits also depend on the rice fields for their food. In the delta the cultivation of floating rice is practised: this involves endemic varieties which regulate their growth according to the depth of the water cover, just like *Oryza barthii*. The Godwits are mainly on the fields before the harvest when the drainage holds the rice in a few centimetres of water. It is then that they appropriate large parts of the crop: over the 6,000 hectares of the rice growing perimeter of Mopti it is estimated that they take 3 to 6 tons a day. Supposing that the daily requirements of a Black-tailed Godwit were 50 g of seeds (wet weight), the minimum number of birds feeding on the rice fields of Mopti would then amount to 600,000. In fact, it is probable that a large proportion of the loss attributed to the Godwits is due to other avian species, in particular to the Anatidae which must come to feed at night. We only put forward these figures to give a better idea of the abundance of the Godwit.

The Black-winged Stilt *Himantopus himantopus* is equally widespread, scattered

along all the water areas. On the sandy shores of Lake Faguibine we distinguished other Palaearctic waders (Greenshank *Tringa nebularia*, Spotted Redshank *T. erythropus*, *Calidris* sp. and *Charadrius* sp.). On the course of the Niger the Pratincole *Glareola pratincola* was noticeable for the size of its flocks at rest on the sand banks.

Gulls and Terns. There was only one previous mention of the Lesser Black-backed Gull *Larus fuscus* (Guichard, 1947). However, it was not rare on the large lakes of the left bank (Tanda, Faguibine, Gouber, over 150). It goes up the Niger to Bamako, where a juvenile ringed in Great Britain was recovered. On Lake Faguibine we caused the flight of a dozen Black-headed Gulls *L.ridibundus* or Slender-billed Gulls *L. genei*. Black-headed Gulls are more likely, having already been recognized once in the central delta (Paludan, 1936) and recently recorded at Lake Chad (Lévêque, 1969).

The Caspian Tern *Sterna caspia* and Gull-billed Tern *Gelochelidon nilotica* are very common, with imposing flocks on the banks of the river and the shores of the lakes. Ringing has proved the wintering on the middle Niger of a good number of the Caspian Terns originating from the Baltic coasts and it is known that the European populations of Gull-billed Terns regularly cross the Sahara. Nevertheless, it would not be impossible for local-bred birds to be mixed with the migrants. Both species breed on the coast of Mauritania and in the Senegal delta, Caspian Terns also nesting in Gambia, Portuguese Guinea and the maritime mouths of the Niger.

The *Chlidonias* sp. were not further identifiable in their winter plumage and we probably did not always distinguish them from Little Terns *Sterna albifrons* which, according to Paludan, breed here. The numerical dominance of the former is not in question, however, and their wintering population seems quite large.

Birds of prey. Without considering the resident species we noted the frequency of Marsh Harriers *Circus aeruginosus*, widely distributed mainly in the middle delta. The other remarkable Palaearctic bird of prey is the Osprey *Pandion haliaetus*: thirty-four on the shores of Lake Faguibine, plus about ten on other lakes and the course of the Niger. The Ospreys in the whole delta must comprise a large fraction of the nesting population of Europe.

Large mammals. Periodically flooded open habitats, divided by multiple water courses, are scarcely suitable for wild ungulates. However, certain species are adapted to them, such as the Reedbuck. In addition, the thorny Sahelian savanna, which surrounds the large lakes of the two banks of the Delta, is the habitat for Gazelles. We only saw two Reedbuck, one warthog and one hippopotamus in the course of our aerial surveys. Going up the Niger by boat from Gao to Mopti, B. des Clers encountered fifteen hippopotamus in all this stretch of nearly 800 km. In the desert region of the Gourma, which he crossed by car, only two small herds of gazelles were seen. Almost everywhere, on the other hand, mainly by the lakes, excessive numbers of livestock (cattle, goats, sheep) can be seen, the detrimental effect of which on the soil and the vegetation is very marked. In Mali the large animals, hunted without control and driven out by domestic pasturage, have become so depleted that its value for tourism seems inconceivable from now on.

In these conditions, it is the aquatic avifauna of the central delta which would assume a decisive role as a spectacular element for the development of nature tourism in Mali.

II Senegal delta

Geographical description

The Senegal delta lies between 16°40′ and 15°50′N. In contrast to typical deltas with several outlets, the Senegal has only one: a powerful coastal cordon contains the waters of the river in the interior and diverts their outlet towards the south.

The triangle formed by this 'barred' delta has as a base the coastal sector which extends from the Chott Boul, an old outlet blocked by sand for three centuries, 90 km to the present mouth south of Saint-Louis. Its apex is in the region of Richard Toll, 80 km from the coast.

The valley is crossed by a NE-SW depression occupied by two large areas of permanent water: the Lac de Guier in Senegal and Lake Rkiz in Mauritania. These lakes cover 300 and 100 sq. km respectively at maximum, and regulate the river's flow.

Below Richard Toll, a vast system of alluvial plains and decantation basins extends, flooded by the Senegal and by its tributaries on the left bank, the Gorom, Lampsar and Djeuss. On the right bank, in Mauritania, the water system is less complex, the majority of the branches being

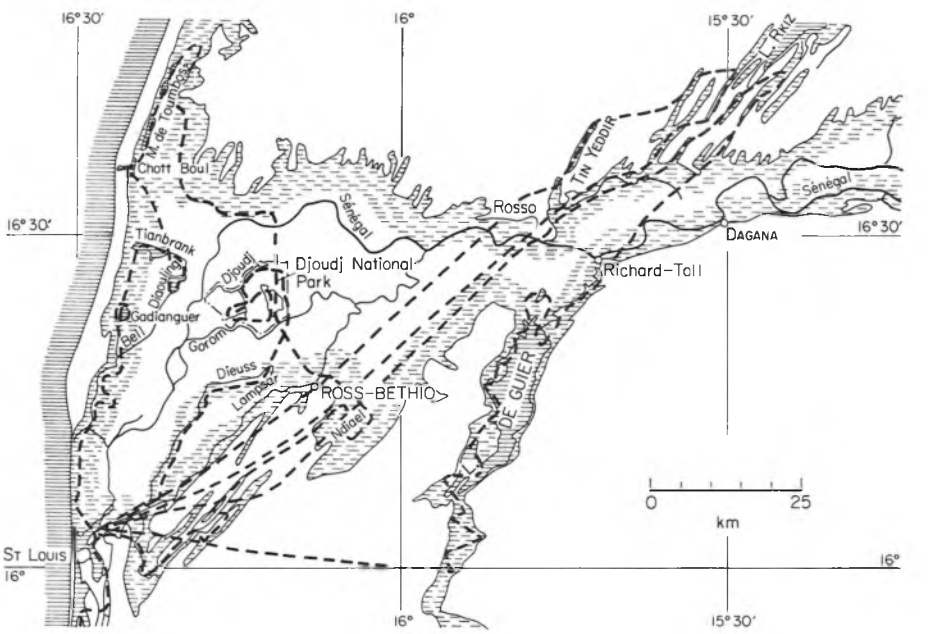


Figure 2. Delta of the Senegal. Shaded area, limits of flood zones; – – –, tracks of observation flights, 14–18 January, 1972.

'fossils'. However, the alluvial plains between the coastal cordon and the river are extended north by a series of depressions and *sebkras* running parallel to the coast for nearly 100 km: this is the Aftout-es-Sahel.

At the height of the flood, the whole of these regions used to be almost entirely under water; only the delta embankments and some outlines of the dunes showed through. Since 1963, rice-growing management works, protected by a network of dykes and barrages have prevented vast areas on the left bank, in the territory of Senegal, from flooding. Among the zones thus drained, the basin of Ndiaël, covering some 15,000 hectares to the west of the Lac de Guier, was one most favourable for the concentration of Palaearctic waterfowl (Roux, 1959). Today, these are essentially concentrated in the Djoudj depression, the largest decantation basin of the delta remaining in its natural state. Eleven thousand hectares of this basin, between the 'bend' of the river and the Gorom, were declared a National Park in April 1971.

Hydrological conditions

The Senegal floods annually as the monsoon rains fall from May to October on the upper basin of the river, over 900 km from its mouth. However, because of the gentle slope, the flood only reaches the delta in September, reaching a maximum at the beginning of November. The Aftout-es-Sahel only floods when there is a strong flow. In 1971 it was very mediocre and by the middle of January 1972 the floods had been re-absorbed over nearly the whole of the delta. Besides the Lac de Guier and permanent water courses, the aquatic habitats in Senegal amounted to the Djoudj basin, some depressions, notably between the Lampsar and Djeuss near their confluence, and the tidal lagoons and mangroves near Saint-Louis.

In Mauritania also, there was only water in the most marked depressions: upstream in the 'dead' dunes between Lake Rkiz and the course of the river; downstream in the pools and Etangs de Gadianguer, de Diaouling, de Tianbrank, linked to the river by its principal right-hand branch. In the Aftout-es-Sahel, the southern basins—Chott Boul, Lagune des Toumbos—still held a little water. The *sebkras* more to the north were dry.

As a result the Anatidae were limited to a small number of well-defined water surfaces where they were concentrated in large flocks: ideal conditions for carrying out a

complete census. We were also served by our knowledge of the lay-out of the delta and the experience of A. Dupuy who, since 1968, had surveyed this region several times to locate and count the waterfowl concentrations there (Dupuy, 1968, 1971).

Dates and itineraries

We used an Alouette I helicopter and then a Piper Tripasser 'plane with high wings. A first reconnaissance on 14 January 1972 surveyed the Djoudj basin and flooded sectors on the left bank of the river, along the rivers Lampsar and Djeuss. On the morning of 17 January we explored the Mauritanian part of the river, on the right bank, downstream to the northern limit of the inundations in the Aftout-es-Sahel, at 16°47'N. In the afternoon we surveyed, on the left bank, the southern system of the delta to the east of Saint-Louis (zone of the three small lakes), the dry depression of the Ndiaël, the Lac de Guier and the region of Richard Toll. Finally, going upstream to the NE, we were unable to reach Lake Rkiz due to lack of fuel. On 18 January after having again tried in vain to reach this lake by direct flight from Saint-Louis, we completed the survey of the basins between the dunes situated in its southwest extension in Mauritania: Sekeirim, Sokam, Tou Kindji, Tin Yeddir and El Hofra. Then recrossing the whole delta by a NE-SW diagonal, we arrived above the brackish lagoons which mark the mouth of the Senegal below Saint-Louis. We inspected the succession of lakes along the coast to Cap Vert, on the way to Dakar.

These various routes covered 1,500 km, 1,100 km of which were effective surveys. In addition, on 15 and 16 January, we carried out counts on foot and by boat in the Djoudj National Park, verifying and complementing our aerial counts in this, the richest, sector of the delta.

Our observations therefore covered all the favourable areas for concentrations of Anatidae in the lower basin of the Senegal with the sole exception of Lake Rkiz.

Results

Table 2 gives the results of our counts for each species of Anatidae in the various sectors of the delta. The reservations expressed in the preceding chapter as to the accuracy of the numbers collected by aerial observation also apply here. However, the figures indicated for the Djoudj National Park combine the results of estimates by helicopter and counts on foot and by boat. It was only during ground observations that Green-winged Teal *Anas crecca*, Wigeon *A.penelope* and Fulvous Whistling Duck were noted. These species, mingled among concentrations of Garganey and White-faced Whistling Duck, completely escaped our attention in the helicopter.

Palaearctic Anatidae

We would emphasize the very great numerical superiority of Palaearctic visitors over the Ethiopian Anatidae. The quantitative relationship between these two categories is the same here as in the central delta of the Niger: 77% being Palaearctic ducks.

The population of January 1972, nearly 200,000, consisted almost exclusively of two species: 70% Garganey and 28% Pintail. The proportional representation of these species is here too the same as that in the central delta of the Niger.

Following our first investigations on the wintering of Palaearctic Anatidae in the Senegal delta, we wrote: 'The November population is not less than 150,000 individuals. At least two-thirds of it is composed of Garganey, the rest mainly comprising Pintail, then Shoveler, and in small numbers, Teal, Pochard and Ferruginous Duck' (Roux, 1959). Subsequent studies were to reveal the presence, rare if not occasional, of two other species, Marbled Teal *Marmaronetta angustirostris* and Tufted Duck *Aythya fuligula* (to which we now add Wigeon). However, in 12 years the contingent of wintering Anatidae has scarcely changed in number or composition, despite the losses of aquatic habitats suffered as a result of agricultural management since 1963.

The third fact which emerges from our results is the very marked localization of the concentrations. Three zones, comprising several water surfaces but each a well-defined entity, hold 95% of the populations. The most important is the Djoudj National Park which held 62% of the total, the large majority of the Garganey (68%), nearly half of the Pintail, virtually all the Shoveler and the whole populations of the three other species. These figures demonstrate the bio-ecological value of this National Park as a refuge for wintering Anatidae.

Djoudj National Park. Nowhere have we seen more spectacular concentrations of

Table 2. Numbers of Anatidae counted in the Senegal delta, 14–18 January 1972 (rounded totals)

	Djoudj National Park	Confluence of Lampsar & Djeuss	Mauritanian delta	Lake Guier	Other areas	
Teal						
Anas crecca	500					500
Garganey						
Anas querquedula	95,000	38,000	240	1,620	1,600	135,000
Wigeon						
Anas penelope	1					1
Pintail						
Anas acuta	26,000	200	28,700	830	320	55,000
Shoveler						
Anas clypeata	2,000	40	215	30	29	2,300
Pochard						
Aythya ferina	420					420
Ferruginous Duck						
Aythya nyroca	230				3	230
Fulvous Whistling Duck						
Dendrocygna bicolor	400					400
White-faced Whistling Duck						
Dendrocygna viduata	35,000	6,300	500	510	680	43,000
Egyptian Goose						
Alopochen aegyptiaca	250					250
Spur-winged Goose						
Plectropterus gambensis	750			410	11	1,170
Comb Duck						
Sarkidiornis melanotos	650				40	690
African Pygmy Goose						
Nettapus auritus	4	4		60	39	110
Totals	160,000	45,000	30,000	3,500	2,700	240,000

ducks. The aquatic habitats are of two kinds. The basin itself, a vast depression on salty soil with brackish water, dries by evaporation from May; in its centre there extends a lake of 4,000 hectares (ha), of uniform depth (less than a metre in January) bordered by meadows of *Vetiveria, Sporobolus, Oriza*, etc. The rivers draining the basin, Djoudj and Tieguel, are permanent fresh water, bordered by *Tamarix* and *Phragmites*. Barrages near their junction with the Senegal prevent the water held in the basin from returning to the river when its level falls. Thus, in January, the water level in the National Park was 70 cm higher than the level of the river. It is clear that such water management is biologically very important in a region where flood water is rapidly reabsorbed because of the dryness of the climate.

The concentrations occurred principally at the edge of the central lake and on one of the adjoining depressions, the Khar, where the depth of the water was lower. This depression, in the process of drying up, served as a refuge for almost 50,000 Garganey and 7,000 Pintail, as well as Teal. In the first warm hours of the day, the birds formed a compact and continuous flock 250-m long on the bank. Other flocks of Garganey, together with Pintail and Whistling Ducks, occupied the side arms of the permanent small lakes. The Shoveler were mainly found along these water courses, while the Pochard and Ferruginous Ducks were all spread over a series of small water areas separated by curtains of *Phragmites* and *Typha* to the north of the central lake.

Confluence of the Lampsar and the Djeuss. In the angle formed by these two rivers near their junction 15 km north-east of Saint-Louis, marshes encompassed by thick formations of *Typha*, are semi-permanent and partly covered with *Nymphaea*. They hold the other most important part (27%) of the population of Garganey of the delta, with a small number of Pintail, Shoveler and a good number of White-faced Tree Duck. An even more considerable population of Garganey has been seen there in January 1971 (Dupuy, 1971).

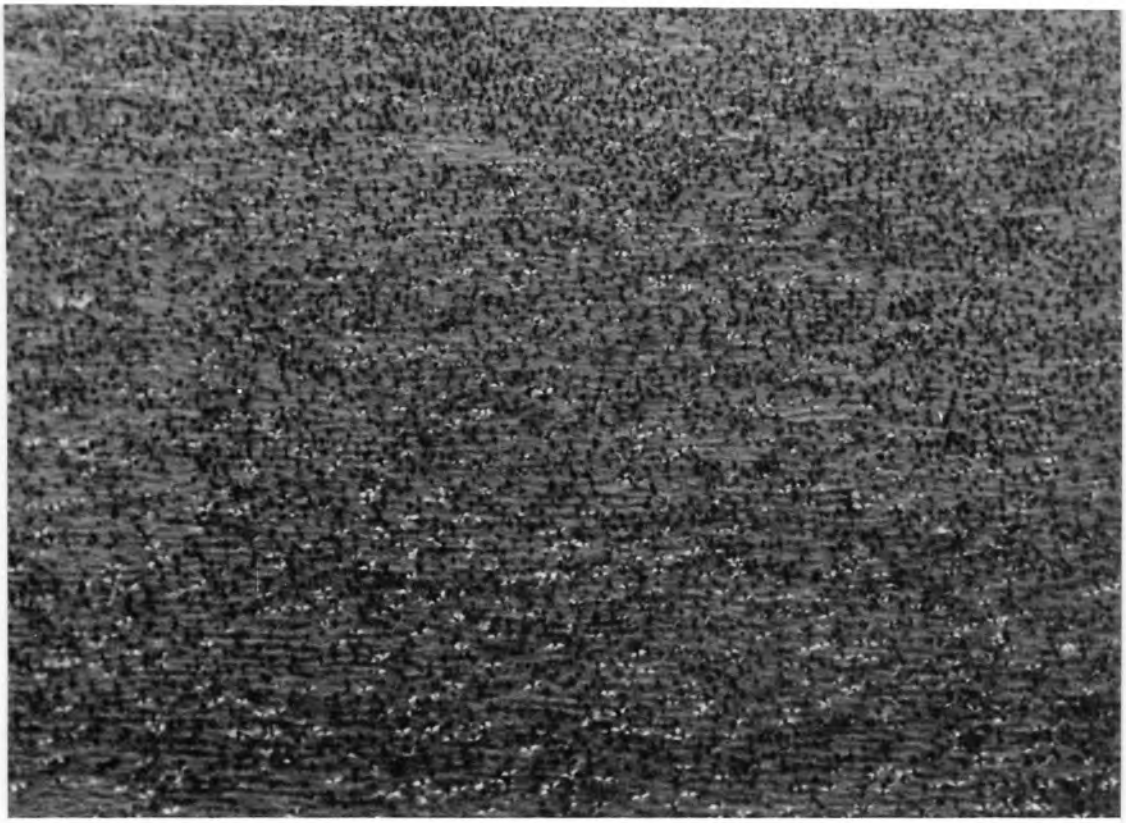


Figure 3. Concentration of Garganey *Anas querquedula* (*c.* 6,500 birds) at Djoudj National Park, Senegal delta, 19 January 1972. *A. R. Dupuy*

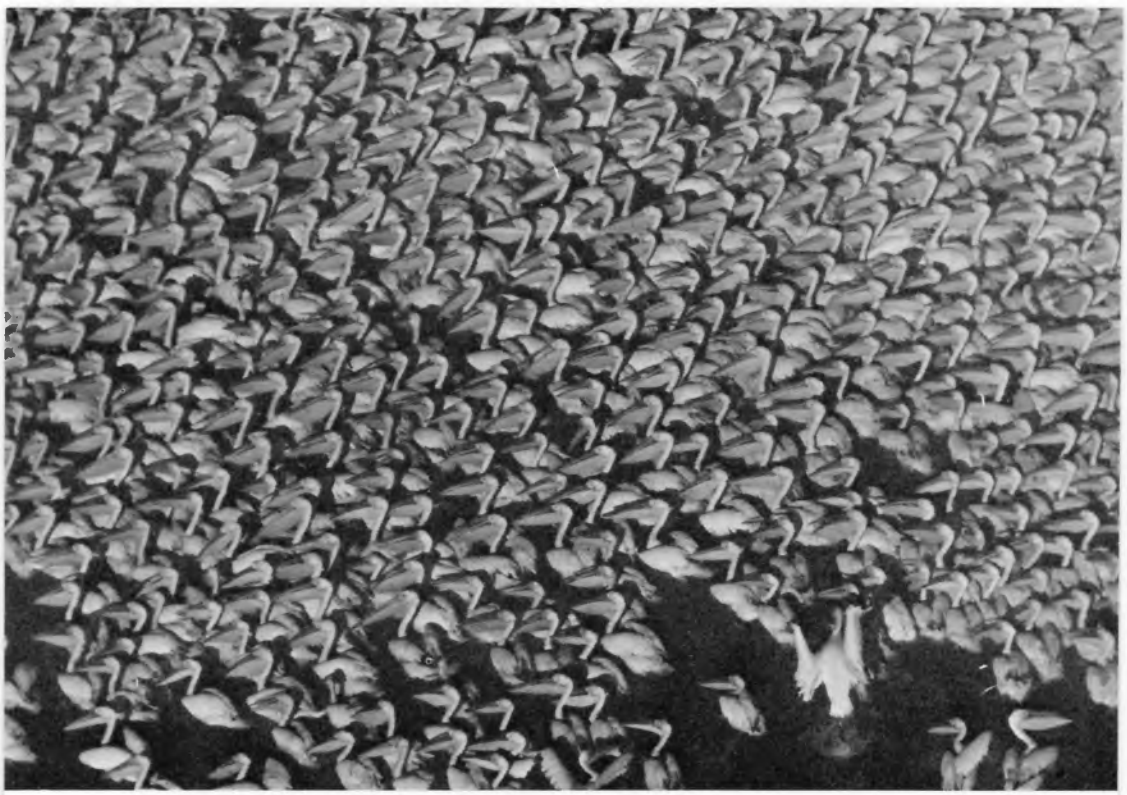
Mauritanian delta. The alluvial plains downstream on the right bank of the Senegal are bounded to the west by the coastal cordon. Here, the proximity of the sea accentuates the salinity. In addition, the tide up the Senegal reaches, via the small rivers Tiallakt and Bell, the ill-defined depressions which spot the plains. As a result, the depressions are totally devoid of vegetation. The majority of these had little water in January, surrounded by vast expanses of bare mud.

These waters were almost exclusively populated by Pintail (52% of the whole population of the delta). However, a very distinct decrease was seen from south to north. Very abundant in the southern depressions, along the Tiallakt, the species was poorly represented on the large central etangs—Diaouling, Tianbrank—and absent to the north, on the Chott Boul and in the Aftout-es-Sahel. This distribution must be related to the habitats favourable to the feeding of the Pintail.

Lac de Guier. The large flocks of wintering Anatidae find refuge by day on this vast permanent lake when the other shallow waters dry up. It is also occupied when the rice fields of Richard Toll and those near Rosso, 15 km north of the lake, in Mauritania, are flooded. The irrigation of these rice fields from February procures new feeding grounds for the ducks just as the natural aquatic habitats are reduced and the feeding requirements of the birds are increasing as their pre-nuptial migration approaches.

On 17 January the lake held less than 2% of the whole population of the delta; but from 29 to 31 January we witnessed large flocks of Garganey—estimated at 15,000 birds—leaving at twilight and returning in the morning. At the same time a large reduction in the contingents at Djoudj occurred; we verified this on a last visit to the National Park on 1 February. This transfer of part of the populations of Djoudj to the Lac de Guier had already been observed in February 1971 (Roux, 1971).

Other zones. On the other aquatic habitats of the delta, Palaearctic Anatidae were few or non-existent. The saline lakes near the mouth of the river below Saint-Louis held none. Nevertheless, two other districts presented a certain interest. The region south-west of Lake Rkiz in Mauritania is an alternation of parallel north-east–south-west 'dead' dunes and inundation corridors bordered by forests of *Acacia nilotica*. The widest depressions—Tou Kindji, Tin Yed-



A. R. Dupuy

Figure 4. More than 450 White Pelicans *Pelecanus onocrotalus* in the National Park of Djoudj, Senegal, January 1972. The nearly unanimous reaction to the passing aircraft is striking.

dir, El Hofra—contain a rich floating vegetation of wild rice and water lilies. Although only holding 1,400 migratory ducks (1,050 of them Garganey), these pools can play a not unimportant role at the end of the season because they dry up late.

To the south of the delta, east of Saint-Louis, three long depressions were connected not long ago to the Ndiaël from which they received surplus water. Now they only receive the outflow of the small river of Ngalam, the last left-hand branch of the Senegal, which is insufficient to fill them completely when the flood is weak. On the only depression holding water we noted 520 Garganey. Some years previously, large concentrations of this species occurred in this zone (A. Dupuy, personal communication).

The coastal areas of the Cap Vert region. Mid-way between the mouth of the Senegal and Cap Vert, along the coast, from north to south, there is first of all a series of freshwater basins in the hollow of the dunes—the Niayes—then a series of more or less extensive lakes, some brackish and temporary, others saturated with salt and permanent, such as Lake Retba, the level of which is 2·40 m lower than that of the sea. The largest is Lake Tanma, a vast level depression filled by the rains from July–August and persisting in dry seasons according to the annual variations in rainfall. It had been dry for some weeks by the time of our survey. These lakes are famed for attracting numerous flamingos and the hunters of Dakar practise their sport there at the expense of the waterfowl.

In the Niayes, nearly all drained and converted for the cultivation of food, we only saw thirty White-faced Whistling Duck. In 1967 White-backed Duck were found there. More to the south, only two of the five existing water areas held Anatidae: the pool of Ndiarhol, with 370 Garganey, some Pintail and Shoveler; Lake Retba, with 200 Pintail and fifteen Shoveler. Black tailed Godwit (940), Ruff (3,000) and Avocet *Recurvirostra avosetta* (890) formed, with numerous Stilt, the majority of the waders present.

In autumn, when these lakes present vast areas of shallow water and when the post-nuptial migration is in full swing, they may be more important.

Ethiopian Anatidae

While the Palaearctic migrants had already been the subject of more or less complete

counts, until now there were no quantitative data available on the endemic Anatidae of the delta. We estimate that we counted virtually all of their population. In the middle of January, this amounted to nearly 46,000 individuals, say three times less than the migratory contingent. White-faced Whistling Ducks constituted 94% of this, the rest being provided mainly by Spur-winged Geese and Comb Ducks, then Fulvous Whistling Duck, Egyptian Geese and Pygmy Geese. The only other Ethiopian Anatidae recorded in Senegal is the White-backed Duck, known through rare observations and recoveries, two of them in the delta in 1963 and 1967 (G. Morel, 1972).

This population is remarkably similar in structure to that of the central delta of the Niger. The only appreciable differences here are the higher percentage of White-faced Tree Ducks and the smaller proportional quantity of Comb Ducks and Egyptian Geese. However, it is possible that, for the Whistling Duck, our figures include some of the birds dispersed at other periods along the valley of the Senegal. The species was incomparably less numerous in the delta during January 1971 (Dupuy, 1971). For the Pygmy Goose, the number only accounts for a fraction of its local population, the smaller water-lily marshes possibly sheltering some.

Table 2 gives the numerical distribution of each species in the different sectors of the delta. It spotlights the unique role of the Djoudj National Park, where 80% of the total was concentrated.

For the majority of these birds, as for the Palaearctic Anatidae, the Djoudj depression is mainly a day roost. It could not in fact satisfy the feeding requirements of such a quantity of ducks for a long time. At night they disperse to seek their food. To explain such a concentration we must mention, in particular, from the tranquillity which they enjoy in this area, free from all human activities; even traffic and grazing are forbidden.

Apart from the Djoudj, principal places of concentration were the marshes at the confluence of the Lampsar and the Djeuss, an important refuge of White-faced Whistling Duck, and the shores of the Lac de Guier, the wild rice fields of which held a third of the population of the Spur-winged Goose.

Additional observations

The Cormorants and the Ardeidae. These were so numerous, they were ignored, as were the Laridae and the majority of the species of waders. Only the results concerning the species of greatest faunistic interest are shown in Table 3.

Pelicans (Figure 4). Perhaps the whole population of White Pelicans in Senegal was assembled in the Djoudj National Park: some 8,000 individuals, a part of which at least must try to breed there. Their colony, abandoned with the eggs destroyed, was discovered at the end of February at the edge of the Djoudj river; the fall in the water level had made the site accessible to the jackals (G. Jarry, personal communication). It was known that the species breeds in the region: during an aerial survey over the Aftout-es-Sahel in November 1958, we had located an islet occupied by a colony (Morel & Roux, 1962), later verified by R. de Naurois. However, nesting in the delta *sensu stricto* had not been established before. Since spring 1972, work has been carried out there to ensure that the breeding site remains continuously isolated by water.

The Pink-backed Pelican, in small numbers, only occupied the water courses of the Djoudj and the lagoons near the mouth of the river. Its nearest known breeding colony in Senegambia is situated near M'Bour, 200 km south of the delta (Naurois, 1965a).

Storks, Ibises, Spoonbills, Flamingos and Cranes. We did not see more than fourteen White Storks. The previous winter, in the same period, A. Dupuy (1971) saw less than a hundred. Twelve years before, the species was observed in considerable numbers in the delta (Morel & Roux, 1966). In the middle of January, those originating in North Africa may already have returned to their native land; we were to encounter dozens of them in the south of Morocco at the beginning of February. However, the contingent from the Rhineland countries, the wintering of which in Senegal is proved by over thirty ringing recoveries, still remains in its winter quarters. There, too, its decline is only too evident.

In contrast, we made a fortunate discovery of sixteen Black Storks *Ciconia nigra*, fourteen of them distributed in two groups to the south of Lake Rkiz. There were only three or four records in the west of tropical Africa, the most recent in 1923. It is the rarity of the species in its European breeding area which makes our discovery interesting—now one of its wintering centres is known—probably that of the Iberian contingent (Roux & Dupuy, 1972).

Table 3. Waterfowl other than Anatidae counted in the Senegal delta, 14–18 January 1972 (rounded totals)

	Djoudj National Park	Confluence of Lampsar & Djeuss	Mauritanian delta	Lake Guier	Other areas	Total
White Pelican *Pelecanus onocrotalus*	8,000		530		10	8,500
Pink-backed Pelican *Pelecanus rufescens*	110				160	270
White Stork *Ciconia ciconia*	7		7			14
Black Stork *Ciconia nigra*	2				14	16
Glossy Ibis *Plegadis falcinellus*	150	900	70	30		1,150
Spoonbill *Platalea leucorodia*	750		100		100	950
Greater Flamingo *Phoenicopterus ruber*	170		4,350		150	4,700
Crowned Crane *Balearica pavonina*	260		3	15		280
Black-tailed Godwit *Limosa limosa*	4,500	1,500	1,500	1,800	1,200	10,500
Ruff *Philomachus pugnax*	500,000	1,600		700	1,400	500,000
Avocet *Recurvirostra avosetta*	1		2,230		850	3,100

The population of Glossy Ibises is very close to that which we found in November 1958, the depression of Ndiaël then held nearly all the population of the delta for the night. It is not impossible that they nest in Senegal—as in the central delta of the Niger—but we do not have any indications despite the very extensive investigations carried out for 15 years on the reproduction of the waterfowl of the lower Senegal (Morel & Morel, 1962; Naurois, 1965b, 1969). We believe these Ibises to be migratory and of Palaearctic origin.

Regarding the Spoonbills *Platalea leucorodia* this is less doubtful: the important colonies of the Banc d'Arguin on the coast of Mauritania are only 400 km away, and young which we ringed in June 1960 were recovered in the delta in the following winter. However, are Spanish and Dutch birds not added here to the Mauritanian ones? At the Banc d'Arguin in 1960, we found a Spoonbill ringed in the Netherlands; in March 1961, we observed two there wearing rings of a different type to ours: clip rings, like those issued by the Rijksmuseum of Leiden. Since they reach the Saharan coast, the Dutch Spoonbills may likewise spread to Senegal. However, our earlier observations and the more recent ones of A. Dupuy (1971) did not allow us to assume the presence of such a number of Spoonbills in winter. In the Djoudj, where they roost, their flocks were mixed with several dozens of African Spoonbills.

The brackish etangs of the Mauritanian delta, from the Gadianguer to the lagune des Toumbos in the Aftout-es-Sahel, held the main part of the population of the Greater Flamingo *Phoenicopterus ruber*. We did not see more in 1958. These birds probably come from the colonies of the Banc d'Arguin, where the species nests erratically, and also from those of the Camargue, as several ringing recoveries have proved. We closely followed by 'plane each flight of Flamingos: we were looking for first-year birds and above all for the Lesser Flamingo. However, the flocks only comprised 'adults' of the large species.

Since the discovery in July 1965 of a breeding colony of Lesser Flamingos in the Aftout-es-Sahel (Naurois, 1965c), they do not seem to have been seen again in this region. They were not there in January 1972, nor on the coastal lakes of Cap Vert. In the middle of the Lagune des Toumbos, we located the site of a colony of Flamingos, no doubt several years old; although very eroded, the nests still formed visible bumps on the surface.

Crowned Cranes are the only cranes

known in Mauritania and Senegambia. At twilight, the birds coming from the north and west converge towards the Djoudj depression where they roost. The order of their population in the delta then must not be very much greater than 300.

Waders. We refer the reader to our earlier publications for all information on the phenology of wintering and the numerical status of the Palaearctic waders in the Senegal delta (Roux, 1959; Morel & Roux, 1966). We will only relate the original data concerning Black-tailed Godwit, Ruff and Avocet.

By day the Black-tailed Godwits disperse over the feeding sites and are difficult to check. They can only be counted at the places where they assemble, either for the night, or for bathing and resting in the day. We cannot therefore conclude that there was a decrease in the wintering population. This, however, would be quite likely, considering the reduction in aquatic habitats of the delta and very active shooting in the rice fields where they are considered harmful.

The Ruffs, on the other hand, remain extraordinarily abundant; on the edges of the depression of the Khar, in the Djoudj National Park, more than 500,000 assembled for the night. At the end of February, the same roost, transferred to the bank of the central lake, held nearly a million birds (G. Jarry, personal communication).

We had already observed Avocets wintering in the delta but always in a limited number. It was therefore a surprise to see such flocks of them on the Mauritanian etangs and the lagoons of the mouth of the river. Nearly 1,000 frequented the coastal lakes of Cap Vert and A. Dupuy (personal communication) was to see several hundreds of them in the delta of the Sine-Saloum in March. The wintering population on the west coast of Africa is therefore greater than was supposed—or than it was 10 years ago. Its increase could be related to the increase in the west European population. On the geographical origin of these wintering birds the only indication is the recovery in Basse Casamance of one ringed as a chick in Belgium.

Acknowledgments

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Summary

The central delta of the Niger was surveyed by air between 3 and 5 January 1972 and the Senegal delta from 14 to 18 January 1972. Details of the hydrological conditions are given. Attention was concentrated on the Anatidae, particularly those of Palaearctic origin. Useful information was also gained on many other types of waterfowl. Detailed lists of the birds counted are provided, together with assessments of their relative importance and the environmental features affecting their distribution.

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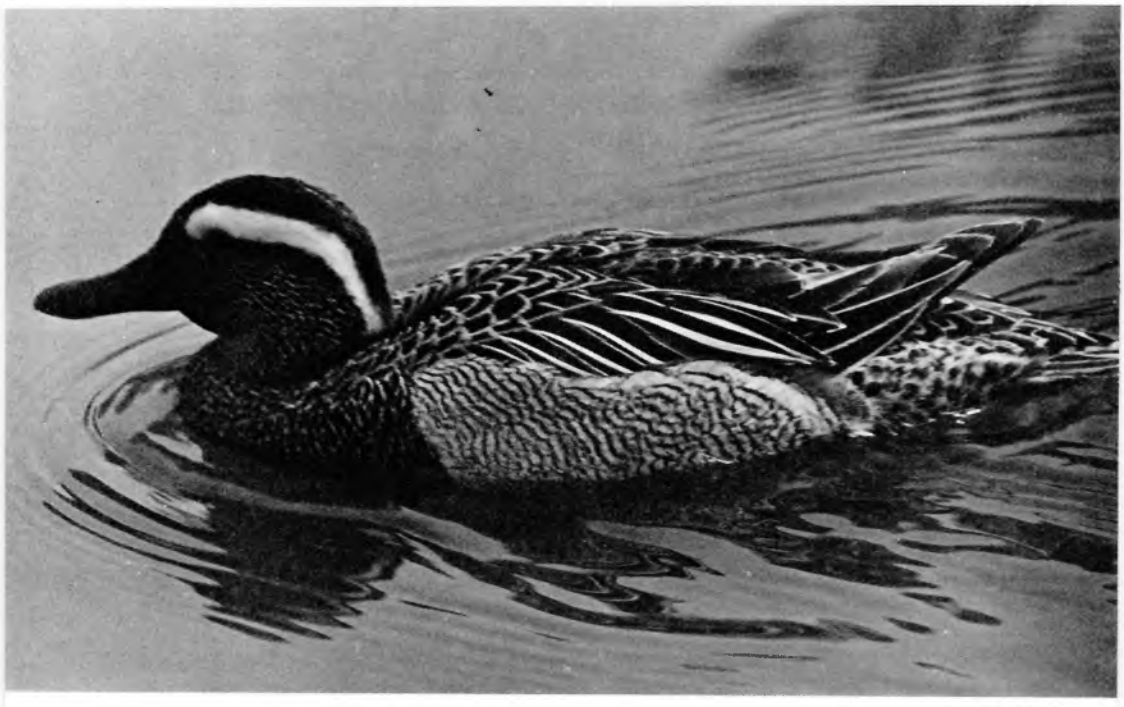


Figure 1. Male Garganey *Anas querquedula* in full breeding plumage at Slimbridge.

E. E. Jackson

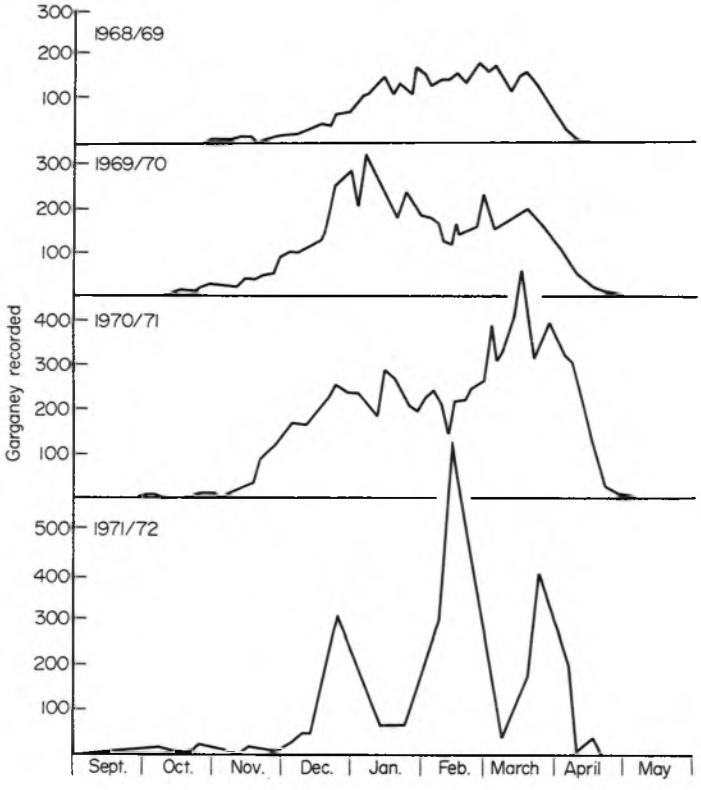


Figure 2. The number of Garganey recorded on each visit to the hippo wallow during the palaearctic winters from 1968 to 1972.

represented waves of passage migrants. Season 1971–72 was very different from the others with three distinct peaks, the first in late December, the second and biggest in the first half of February and the third one in late March.

There is certainly no regular pattern of migration. It is possible that some birds remain all winter, but the pronounced peaks particularly towards the end of the season imply waves of passage migrants. The very large peak in February 1972 is more ambiguous. Its short duration precludes the possibility that the birds were overwintering and they may have been making an early return to their breeding grounds. An alternative explanation is that the Garganey seen are only part of a larger population and that the fluctuations recorded are due to local movements. Counts in other parts of East Africa might throw some light on these. The numbers involved on the hippo wallow are negligible relative to the total number of migrants leaving the palaearctic region.

For most of the time that Garganey are in Africa the males are in eclipse, but by March most have moulted into the breeding plumage and the sexes can readily be distinguished. Table 1 shows that males predominated in all years except 1971 when the sexes were about equal in number. The overall ratio was 1 male: 0·9 females. Possibly the sexes migrate separately.

Table 1. Sex ratios in Garganey on the hippo wallow in March/April

Year	No. of birds sexed	No. of males	No. of females	Sex ratio (male: females)
1969	612	341	271	1:0·79
1970	932	517	415	1:0·80
1971	3,684	1,815	1,869	1:1·03
1972	1,223	803	420	1:0·52
Totals	6,451	3,476	2,975	1:0·86

Northern Pintail *Anas acuta*

No Pintail were recorded during 1968–69. As with Garganey, the pattern of movements in the three succeeding seasons differed markedly (Figure 3). A few were present intermittently throughout November and December 1969 but it was not until January that they arrived in any numbers and rapidly built up to a peak of 111 on 29 January, but were gone a few days later. A second, smaller peak followed in mid-February and possibly a third, even smaller peak in early March after which none was seen. The pattern in the next season was not so very different except that a small but significant number were present during most of November and December. There were again three distinct peaks but the second was the largest and reached a total of 250. The departure of the birds was more prolonged and some were present until the middle of March. The third season 1971–72 showed a radically different pattern. None was seen until 14 December, but thereafter there was a rapid rise to a peak of 213 on 14 January. During the rest of the season there was a progressive decline interrupted in early February and March by irregularities which might perhaps represent the second and third peaks of previous seasons. The departure was delayed as a few Pintail lingered into April.

There is a suggestion of three peaks which, as with the Garganey, may represent passage migrants. No doubt the timing of the migrations varies with the weather on the breeding grounds further north.

The Pintail were much shyer than the other species. They tended to keep to the middle of the wallow in a single large flock, but could be counted satisfactorily through binoculars. However, they readily flew if a tourist vehicle approached too closely.

Other palaearctic migrants

Other species of palaearctic migrants occurred only sporadically and were probably vagrants. Some Green-winged Teal *Anas crecca* were usually present each year. In 1969–70 the first Teal was seen on 16 December and some remained until 27 February. The maximum seen at any one time was four. In 1970–71 one Teal was seen on 4 November but no more were recorded until 10 December. The maximum total was eight. Only one was seen during the 1971–72 season, on 16 October.

Some Common Shoveler *Anas clypeata* appeared in the 1970–71 season. The first was a group of three on 26 October. Numbers reached a maximum of eight, and some birds were present most of the time until 1 February. Both males and females were present. The only other Shovelers seen were three on 14 February 1972.

Other rare palaearctic migrants were seen during the 1970–71 season. Some European Pochard *Aythya ferina*, up to a maximum of four, were present continuously from 10 December until 25 January.

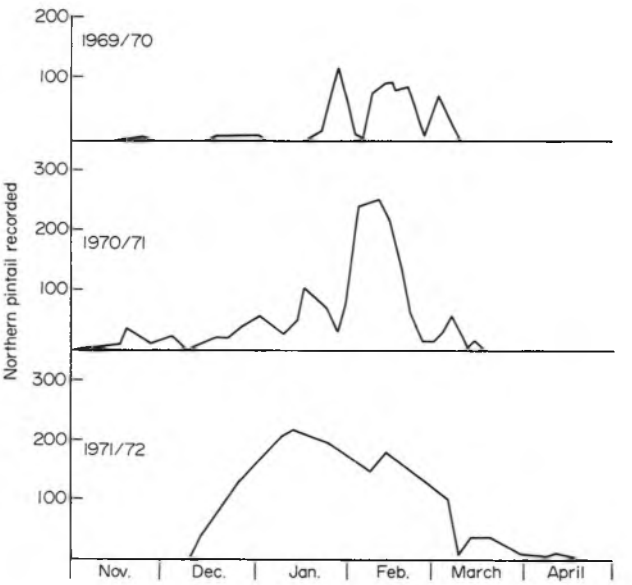


Figure 3. The number of Northern Pintail recorded on each visit to the hippo wallow during the palaearctic winters from 1969 to 1972.

They provide only the second record for the species in East Africa. The first was also from this hippo wallow, seen during the previous season by Dr M. P. L. Fogden.

A single Tufted Duck *Aythya fuligula*, on 11 January 1971, completes the list of palaearctic species.

Resident Ethiopian species

Five species were most frequently seen.

White-faced Whistling Duck *Dendrocygna viduata*

This was usually present each month although it has been seen only once, on 8 October, since June 1971. Possibly it was affected by the near drying-out that year. There is no consistent seasonal pattern in the appearance of the species except that numbers were always high in October. Some large flocks were then present in 1969 with the maximum of 139 on 27 October.

Egyptian Goose *Alopochen aegyptiacus*

The only species present 100% of the time was the Egyptian Goose. This is easy to count since the birds are most reluctant to fly and merely run away if approached too closely. For the most part, however, they are very tame and do not move very far. There was little danger, therefore, of birds being counted twice through flying from part of the wallow to another. The average number recorded was 167 but there were considerable variations from this figure as can be seen from Figure 4. The geese were usually on land and rarely entered the water except to bathe or to feed on algae near the shore. There were always a few, however, using the half submerged hippos as perches. Occasionally, large rafts of birds were found on the water, particularly at the northern end.

The monthly means plotted in Figure 4 show no consistent pattern over the years, though maximum numbers tended to be present between July and October, 1968 being excepted. There was no obvious correlation with rainfall. No doubt the geese using the wallow do not form a distinct population and their home range extends over a wider area of the park.

It is worth recording that the species in the wild, at least in the Ruwenzori Park, is nothing like as aggressive as is suggested by Johnsgard (1965) who says that because of their aggressive disposition they are not gregarious to any extent. This was certainly not true of the birds in the park which often

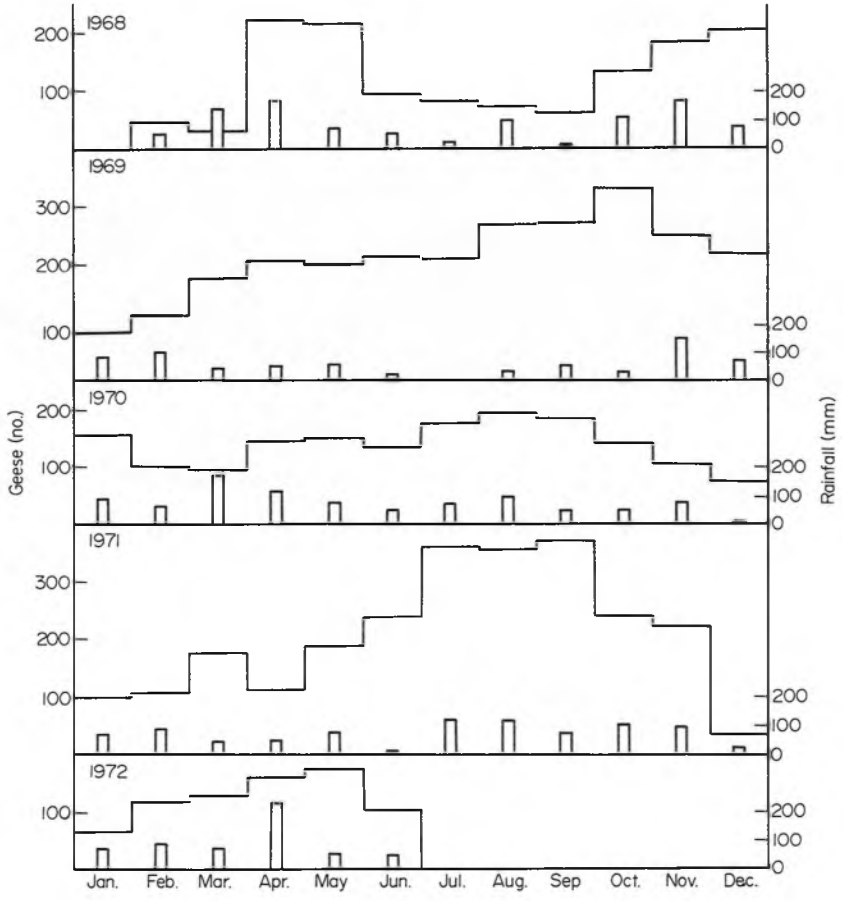


Figure 4. Histograms: the average number of Egyptian Geese present each month on or near the hippo wallow from 1968–1972. Columns: monthly rainfall at Mweya, about 10 km south-west of the wallow.

occurred together in flocks of fifty or more. Pitman (1965) also records exceptional flocks amounting to several hundreds. Mated pairs were sometimes aggressive to other geese, particularly other pairs, but were remarkably tolerant of birds in non-breeding flocks.

Hottentot Teal *Anas punctata*

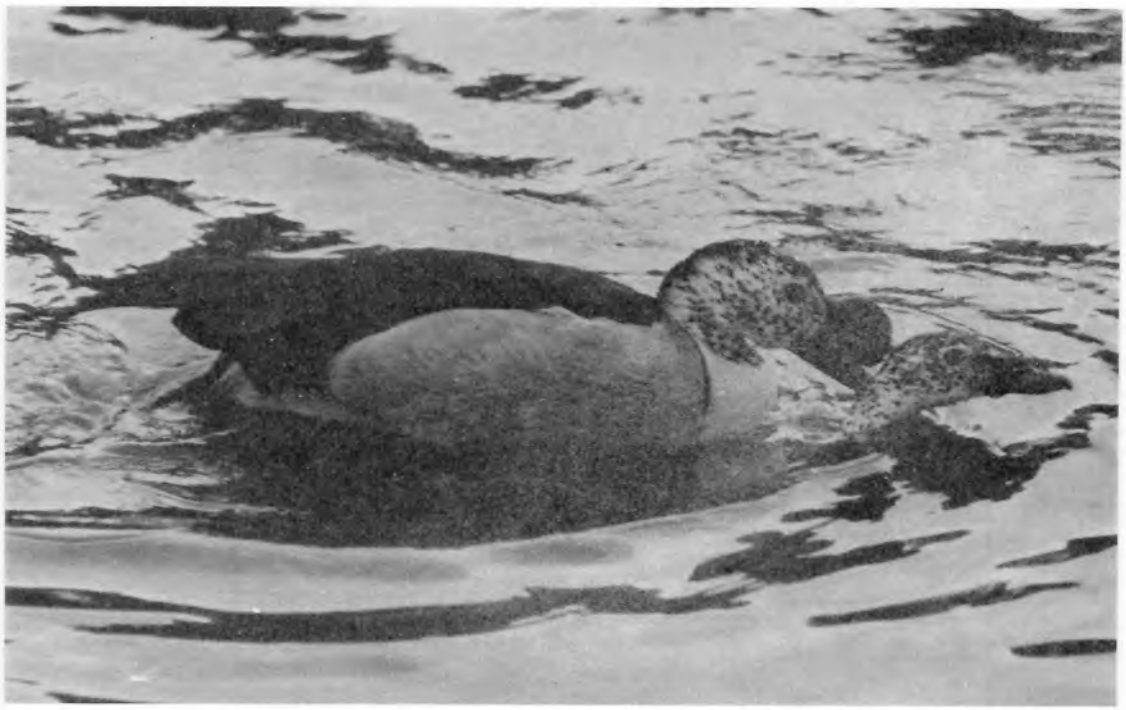
This was only a sporadic visitor and the maximum seen at any one time was only ten.

Red-billed Pintail *Anas erythrorhyncha*

This was one of the most regular visitors although there are some long gaps. Numbers were usually less than a dozen except for a time in the second half of 1970 and early 1971 and again in 1972 when some larger flocks appeared. The maximum seen was forty-eight on 13 March 1971.

Comb Duck *Sarkidiornis melanotos* (Figure 5)

This was very irregular in its appearance and the maximum was no more than eighteen. Pitman (1965) mentions that the Comb Duck is probably polygamous in East Africa. Only one brood was seen during the present counts and that consisted of six young accompanied by a pair, an adult male and female. There were only fifty-seven males out of a total of 407 sexed birds. The distribution by group size is shown in Table 2. In most cases (68%) there



Philippa Scott

Figure 5. Copulation in the Comb Duck *Sarkidiornis m. melanotos* at Slimbridge.

Table 2. Group sizes of Comb Duck seen on the hippo wallow

Group size	Total groups	Single sex		Mixed	Unsexed
		All males	All females		
1	95	14	59	–	22
2	65	–	39	13	13
3	27	–	16	3	8
4	22	1	11	4	6
5	13	–	4	5	4
6	7	–	2	4	1
7	2	–	–	1	1
8	1	–	–	–	1
9	1	–	–	–	1
10	1	–	1	–	–
11	1	–	–	1	–

were either one or two birds. The groups of mixed sexes comprised a high proportion (43%) of pairs. Many of the males in the bigger groups were juveniles or not in breeding condition. Those that were, i.e. with well developed combs on the bill, were mainly solitary. These results are not conclusive and do not preclude the possibility of polygamy but they are more in keeping with a monogamous situation.

The Comb Duck is another species with a reputation for aggressiveness and Johnsgard (1965) says that the sexes do not associate much because the females try to avoid contact with the much larger males. The fact that quite a few of the adult males were solitary tends to support this contention but on the other hand no sign of aggression was noticed between the sexes or between members of the same sex. The situation may have been different if the birds had been breeding. It is possible that the excessive aggression reported in this and some other species of wildfowl is seen only in collection birds and results from the artificial conditions of captivity.

Other Ethiopian species

The Yellow-billed Duck *Anas undulata* was rare. This is surprising since it is not an uncommon bird in Uganda and large numbers frequent a swamp north of the road between Masaka and Mbarara no more than 150 km from the Ruwenzori Park. The species did not occur at the wallow until a single bird arrived on 19 October 1970 and it remained there until 3 May 1971. A second bird appeared in March 1971.

A party of eleven Fulvous Whistling Ducks *Dendrocygna bicolor* visited the wallow on 22 October 1969, but all but one had gone 2 days later. This individual remained until 9 November.

The Ethiopian species show no regular

pattern of movements at the wallow. Not much is known about the local movements of these species but Mackworth-Praed & Grant (1957) say that the Comb Duck is 'definitely migratory in Kenya', the Red-billed Pintail 'somewhat migratory' while the Hottentot Teal is 'subject to considerable seasonal movements'. It is also likely that the other Ethiopian ducks on the wallow show seasonal movements or have large home ranges of which the wallow is only a small part.

Conclusions

Although the area of water studied is relatively small, and the total numbers of wildfowl counted not large, the frequency and regularity of the counts is novel in East Africa. The timing of the influxes of the palaearctic migrants at an equatorial site is of particular interest; indeed any quantitative data on these species in Uganda were hitherto lacking. The causes of the fluctuations would seem to lie outside the immediate neighbourhood of the wallow. The results emphasize the desirability of counts over several seasons before conclusions are drawn regarding the importance of any particular wetland as waterfowl habitat.

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Although most of these counts were made by myself, there were times when I was away on business or on leave when the counts were continued by one or other of the following: G. P. Coleman, N. A. Din, A. H. Harcourt, J. M. Kenyi, K. D. Slotten, P. Stidolph, G. William, M. H. Woodford and J. R. Wyatt. To all these persons I am very grateful. Mr Kenyi also helped in the analysis of the data. I would like to thank Professor G. V. T. Matthews for his critical review of the manuscript.

Summary

Counts of wildfowl were made on an equatorial hippo wallow in Uganda from February 1968 to June 1972 at an average rate of six counts each month. Thirteen species of wildfowl were recorded including six palaearctic migrants. The Egyptian Goose *Alopochen aegyptiacus* was the only species present on all occasions but its numbers varied considerably. No obvious pattern was apparent. Other Ethiopian species appeared erratically. Up to 700 Garganey *Anas querquedula* and 250 Northern Pintail *Anas acuta* occurred during the palaearctic winter. The pattern of movements differed markedly each year and it is suggested that many of these were passage migrants resting on their way to or from wintering areas further south.

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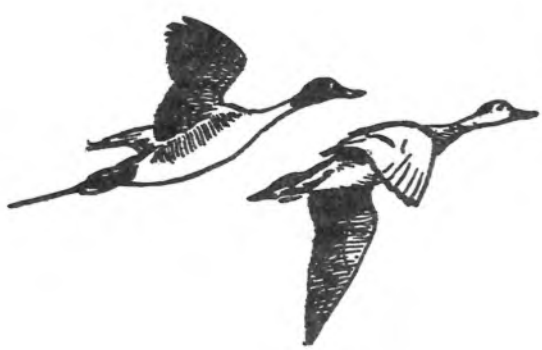

Wildfowl (1973) 24:88–102

Waterfowl in north-east Asia

A. A. KISTCHINSKI

By 'north-east Asia' is meant the territory northwards and eastwards of the middle reaches of the Lena river and of the lower reaches of Amur, including Sakhalin, Kamtchatka, and the Kurile Islands. Most of this huge area is mountainous. Wetlands suitable for breeding waterfowl occupy comparatively small areas in the river valleys and coastal lowlands. In these places waterfowl were abundant, and in some cases still are. Large numbers of water birds moult, migrate and winter in the coastal waters of the East Arctic and Pacific seas.

For several reasons, in the last 20–25 years, waterfowl populations in north-east Asia have greatly decreased. We have almost no quantitative information concerning their status in the past, and some valuable faunistic studies made in previous years can only be used now with essential corrections. Data on the absolute numbers of waterfowl have appeared only recently. The country is poorly studied as yet, and this essay is the first attempt to discuss data obtained to date.

Breeding distribution of waterfowl populations

The general pattern as it is now known is presented in Figure 1. In the arctic tundras of Yakutia and along the northern coasts of the Chukchi Peninsula, waterfowl numbers are still rather high. Long-tailed Duck*, White-fronted Geese and eiders (in some places Pacific Eider and Spectacled Eider) predominate. Attempts have been made to determine waterfowl numbers—generally from aircraft (Table 1). Data on geese are the most reliable. We estimate the total numbers of geese in the Yakutian and Chukchi arctic tundras (excluding Wrangel Island) as 250–300,000. Different species of geese (except Snow Geese) cannot be distinguished from the air, as a rule; however, the White-fronted Goose strongly predominates everywhere in the arctic tundra westwards of Koliuchinskaya Bay. Only in shrub tundras does the Bean Goose replace it. On Wrangel Island, up to 60,000 pairs of Snow Geese breed in normal years (Syroetchkovski, 1972), as well as several thousand Brent Geese. Along the shores of the Chukchi Peninsula westwards to the Amguema lagoon and Anadyr Gulf, the rare Emperor Goose breeds (Kistchinski, 1971; Portenko, 1972).

Breeding populations of Long-tailed Duck in the arctic tundra of East Asia (Table 1) probably number hundreds of thousands; the breeding stock of King Eider is perhaps up to 100,000. The Pacific Eider is very common along the coasts of Chukchi Peninsula westwards to the Tchaunskaya Bay. The Spectacled Eider is most abundant in the delta of the Indigirka river (Table 1; Kistchinski & Flint, in preparation) and in tundra westwards of the Kolyma mouth (Vorobyev, 1963).

In the southern tundra, eiders disappear, and Pintail, Green-winged Teal and Baikal Teal (the teal species are hardly distinguishable from the air), and Scaup appear as common species. Aerial counts at the end of summer of Pintail and teal made by Yegorov (1965; *in litt.*) in 1964–1966 in the southern parts of the Yana-Kolyma tundra (Table 1) were incomplete. Even in the tundra quantitative data are poor, and many areas are not studied yet.

In the forest-tundra and northern thinly-forested areas Pintail, Green-winged Teal, Baikal Teal, Wigeon, White-winged Scoter, Black Scoter, Scaup, Long-tailed Duck and Bean Geese predominate (Figure 1). Table 2 summarizes some data on the population density of ducks. One should realize that dabbling ducks (especially teal) are decidedly underestimated from aircraft (see figures for 1966–1970). In 1972, our total results are probably too high, because most of the counts were made in favourable habitats; however, data on Baikal Teal are too low. The results are thus not too accurate, but they show the general pattern. We can see that the productivity of lowlands between Yana and Kolyma rivers is somewhere still high enough. However, numbers of Bean Geese have strongly decreased here.

Unfortunately, we have no quantitative data on the breeding waterfowl populations of Anadyr and Koryak lowlands, nor on the lowlands of Central Yakutia where waterfowl numbers have recently greatly diminished. Waterfowl are abundant on the Parapolski Dol (V. D. Yakhontov, personal communication). In the mountains of the Kolyma Highlands there are few water birds; Green-winged Teal, Harlequin Duck,

*Scientific names are listed in Appendix A.

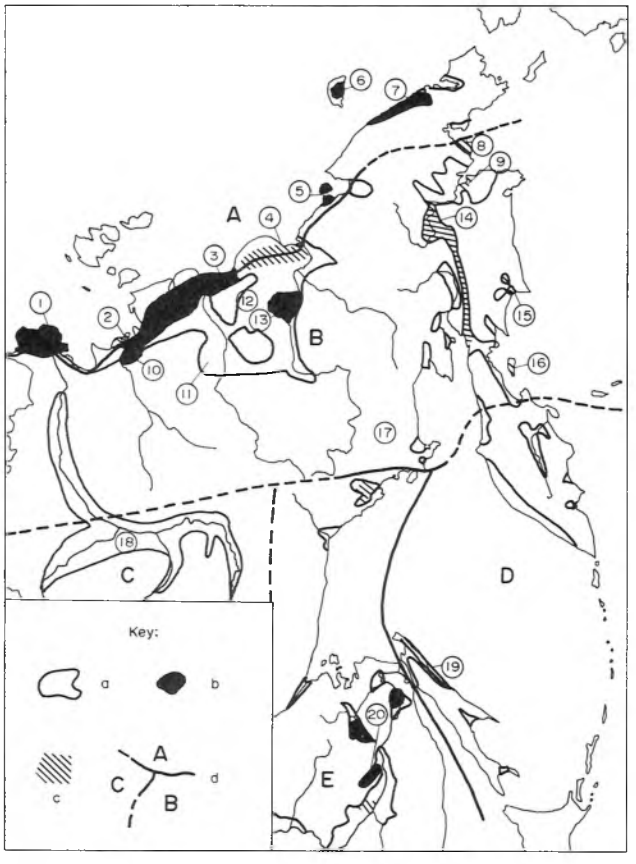

Figure 1. Waterfowl breeding distribution in north-east Asia. Key: a—lowlands and flats rather rich in wetlands; these areas are potentially productive in waterfowl; b—known areas of high concentration of waterfowl; for most of them quantitative data are available; c—known areas of relative abundance of waterfowl; usually, quantitative data are absent; d—boundaries between the provisional zones with the different waterfowl situations. Localities, time of survey, main species, and source: 1—delta of the Lena (see Table 1:1); 2—tundras of the Yana delta (see Table 1:2); 3—lowlands between Yana and Sundrun rivers (see Table 1:3–4); 4—tundras between Alazeya and Kolyma rivers, 1966 (see Table 1:5); 5—northwestern shores of Tchaunskaya Bay and Ayon Island, 1958; White-fronted Goose, Long-tailed Duck, Pacific Eider, King Eider (Lebedev & Filin, 1959); 6—Wrangel Island, Snow Goose (120,000—Syroetchkovski, 1972), Pacific Eider, Brent Goose; 7—northern coasts of the Chukotski Peninsula (see Table 1:6); 8—Uelkal area, 1961; Pintail, Long-tailed Duck, Common Eider (Portenko, 1972); 9—Anadyr mouth area, 1957; Pintail (Kuzyakin, 1965); 10—forest-tundras of the Yana delta (see Table 2, left column); 11—middle reaches of the Indigirka, old data, White-winged Scoter, Pintail, Baikal Teal, Bean Goose (Mikhel, 1935); 12—southern tundra and forest-tundra along the Alazeya river, 1963; Long-tailed Duck, Pintail, Scaup, Lesser White-fronted Goose, White-fronted Goose, Bean Goose, Baikal Teal, White-winged Scoter (Vorobyev, 1967); 13—middle reaches of Kolyma river (see Table 2, three right columns); 14—middle reaches of the Anadyr river, old data; Wigeon, Pintail, Green-winged Teal, Bean Goose, Scaup, Black Scoter, White-winged Scoter, Long-tailed Duck (Portenko, 1939); 15—valleys of the Koryak Highlands, 1959–1961; Pintail, Green-winged Teal, Black Scoter, White-winged Scoter, Scaup, Bean Goose (our observations); 16—Karaginski Island; Harlequin Duck (up to 4,000), Pacific Eider (hundreds) (Gerasimov, 1972a); 17—Kolyma Highlands sea slope, 1963–1964; Green-winged Teal, Harlequin Duck, Goosander (Kistchinski, 1968); 18—central Yakutia, 1950s; Pintail, Green-winged Teal, Tufted Duck (Vorobyev, 1963); 19—lagoons of north-east Sakhalin; Green-winged Teal, Baikal Teal, Garganey, Mallard, Wigeon, Gadwall, Long-tailed Duck, Harlequin Duck, mergansers (Vshivtsev & Tchernyshev, 1965); 20—large lakes of the lower Amur region; Mallard, Falcated Duck, Green-winged Teal, Garganey (see Table 3).

Table 1. Results of waterfowl censuses in the tundras of Yakutia and Chukotski Peninsula: (a) birds per 10 sq. km; (b) total numbers, in thousands

No. Territory	Bewick's Swan		Geese (mostly White-fronted)		Long-tailed Duck		King Eider		Spectacled Eider		Pintail		Teal (Green-winged and Baikal)	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
1. Delta of the Lena, arctic tundras, aerial counts, 1963, estimated (Yegorov, 1965)	1·7	4·2	27·2*	68*	No count		2·4	6	No count		1·2	3	1·6	4
2. Eastern parts of the delta of the Yana, shrub- and moss-lichen tundras, ground counts (original, 1972)	Very rare		Very rare		15·2	No estimate	Very rare		Not observed		Common (no count)		Rare (no count)	
3. Lowlands between Yana and Indigirka, all subzones of the tundra, aerial counts, 1964, estimated (Yegorov, 1965)	1·5	10·5	15·5	108·5	No count		1·6	11·2	No count		7·5	52·5	10·3	72
4. Tundras (all subzones) between Khroma and Sundrun rivers, 1971 (Kistchinski & Flint, 1972)**	?	1–2	20–25	40–70	1–19	40–60	Very rare in 1971 (usually common)		2–100	30–40	0–6	No estimate	Very rare	
5. Tundras between Kolyma and Alazeya rivers, all subzones, aerial census, 1966 (Yegorov, in litt.)			16·6	No count			6·2		No count		26·5			36
6. Northern shores of the Chukotscki Peninsula (Vankaremskaya lowland) arctic tundras, ground counts, 1970 (Kistchinski, 1972 and unpublished.)	Not observed		10–15	30–50	65	200	10	30	Accidental		Only moulting flocks		Accidental	

*Since the census year geese numbers have essentially diminished here (Nagretski 1972).

**This territory partly intergrades with the foregoing one. Total numbers of swans, geese and Long-tailed Duck are estimated by means of aerial counts; all the other data—by means of ground counts.

Table 2. Results of waterfowl counts in the forest-tundra and northern taiga of north-east Asia (birds per 10 sq. km)

Species	Forest tundra, southern parts of the delta of Yana river, ground census, June 1972 (total studied area 1,500 ha.: our data)*	Northern taiga, middle reaches of Kolyma river (near Sredne-Kolymsk), aerial counts, total area censused 10,000 ha.** (Yegorov & Perfilyev, 1970; Perfilyev, 1972)		
		August 1966	August 1967	August 1970
White-winged Scoter	16·0	52·8	10·4	
Scaup and Tufted Duck	5·4	52·8	23·1	28·0
Long-tailed Duck	5·4	22·5	5·6	
Pintail	45·4	16·1	25·7	
Wigeon	10·6	12·1	15·0	32·0
Green-winged and Baikal Teal	18·6	2·6	1·0	
Total	101·4	161·3	81·8	60·0

*Counts were made in optimum habitats, and cannot be extrapolated to the total area of the delta.
**Counts were made in the lowlands rich in lakes, and can hardly be extrapolated to the whole Yana—Indigirka forested lowlands; these are probably optimum figures.

and mergansers are more common (Kistchinski, 1968).

There are almost no quantitative data on the breeding waterfowl of Sakhalin and Kamtchatka. In Sakhalin, most of the birds breed on the coastal lowlands in the north-east of the island (Figure 1); in Kamtchatka—on coastal lowlands, river valleys, and near thermal lakes in volcanic areas. In general, we do not know any great concentrations of breeding waterfowl here. On Karaginski Island, up to 4,000 Harlequins and hundreds of Pacific Eiders breed (Gerasimov, 1972a); on the Commander Islands, several hundreds of pairs of Pacific Eiders as well as few other ducks—in total not more than 2,000 pairs (Marakov, 1965).

The number of breeding waterfowl in the lower Amur region has recently greatly decreased. Most of the ducks rear young in the lowlands near large lakes—Bolon', Udyl', and in the Evoron-Tugur depression. No large-scale counts were made there; ground censuses carried out on some of these optimal wetlands (Table 3) show that their productivity is still rather high. In the Evoron Game Management area, before the hunting season it can reach 12,000–

Table 3 Waterfowl productivity of the optimum wetlands in the Amur basin

Territory	Birds per 1,000 ha. of wetlands	Birds per 10 km of census route	Source
Game management area "Utinoye" near Khabarovsk	84 broods (1963)	—	Yakhontov, 1965
Game management area "Utinoye" near Khabarovsk	—	3–47 (1965–1967)	Stcherbakov, 1968
Game management area "Utinoye" near Khabarovsk	73–100 broods (1963–1969)	—	Sapaev, 1971
Lake Bolon'	—	6–48·5 (1965–1967)	Stcherbakov, 1968
Lake Bolon'	70 broods	—	Sapaev, 1971
Lake Udyl' and adjacent area	152 broods	—	Yakhontov, 1965
Lake Evoron	100–2,500 birds	—	Roslyakov & Koltchin, 1972
Lake Tchukchagirskoye and adjacent area	—	113–116	Stcherbakov, 1965
Valleys of Nai, Ulike and Amir rivers which are not flooded in summer	—	27–63	Stcherbakov, 1965
Valleys of Amur, Amgun' river, and their tributaries which are flooded in summer	—	3–15	Stcherbakov, 1965

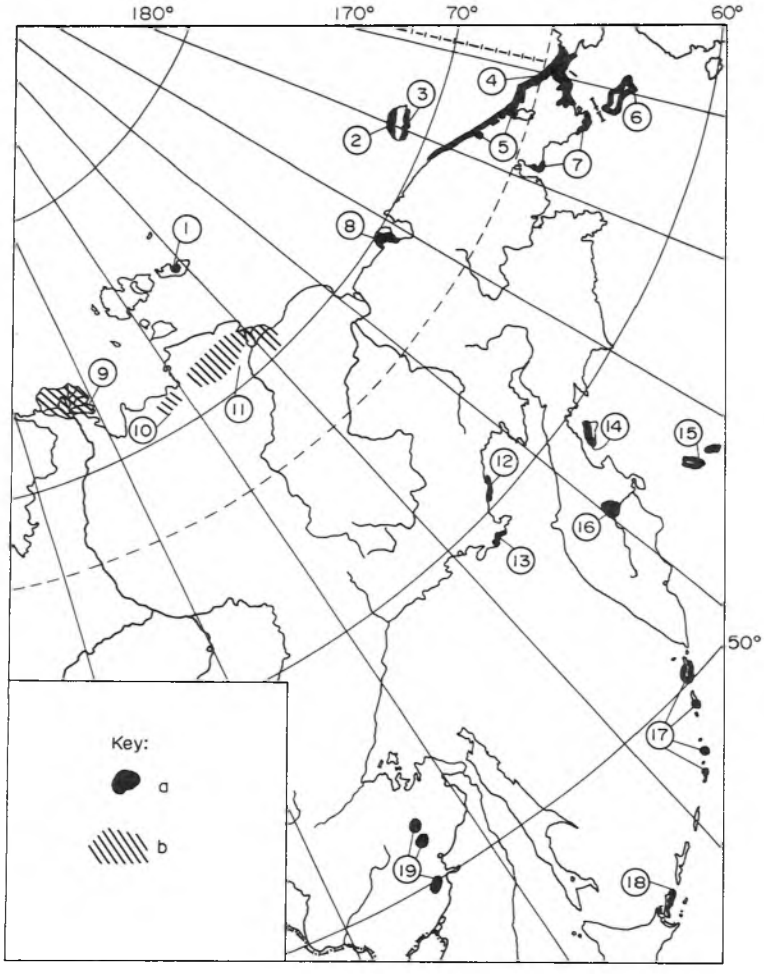

Figure 2. Moulting areas of waterfowl in north-east Asia. Key: a—known moulting concentrations; b—moulting areas where birds are more scattered. Localities, time of survey, main species, and source: 1—Novaya Sibir Island, 1950s, Brent Goose, thousands (Shevareva, 1959; our enquiry); 2—Wrangel Island, Snow Goose (hundreds of thousands), Brent Goose; 3—southern coast of Wrangel Island, Long-tailed Duck (Portenko, 1972); 4—northern coasts of the Chukotski Peninsula and Bering Strait area; Long-tailed Duck, Pacific Eider, King Eider, Steller's Eider, Spectacled Eider, very large amount (Portenko, 1972; our data); 5—Ukouge lagoon and Koliuchinskaya Bay, Emperor Geese, 2,000 and more (Kistchinski, 1971; M. E. Shumakov, personal communication); 6—St. Lawrence Island; Long-tailed Duck, Harlequin Duck, King Eider, Pacific Eider, Steller's Eider (Fay, 1961); 7—southern coasts of the Chukotski Peninsula, old data, Steller's Eider, Harlequin Duck, Pacific Eider (Portenko, 1972); 8—shores of Tchaunskaya Bay and Ayon Island, 1958; Long-tailed Duck, King Eider, Pacific Eider (Lebedev & Filin, 1959); 9—delta of the Lena, geese; 10—eastern part of the Yana delta; Pintail, Baikal Teal (Kistchinski & Uspenski, unpublished); 11—tundras between the Yana and Sundrun rivers; White-fronted Goose, Bean Goose, Long-tailed Duck, Pintail (Uspenski *et al.*, 1962; Kistchinski & Flint, unpublished) 12—coasts of the Shelikhov Gulf, 1963; mergansers, Pacific Eider (Kistchinski, 1968); 13—Babushkin Bay, 1964; Harlequin Duck, thousands (Kistchinski, 1968); 14—Karaginski Island and Litke Strait; Harlequin Duck, mergansers (2,500–3,000), White-winged Scoter (4,000–4,500), Steller's Eider (5,000), Pacific Eider (2,500–3,000) (Gerasimov, 1972a); 15—coastal waters of the Commander Islands; Harlequin Duck (10,000—Marakov, 1965); 16—middle parts of the valley of the Kamtchatka river, old data; Tufted Duck, Scaup, Pochard (Vershinin, 1965); 17—northern and middle Kuriles, 1963; Harlequin Duck (11,000—Velizhanin, 1965); 18—Kunashir Island, sea coasts, 1963; White-winged Scoter (1,200—Velizhanin, 1965); 19—Lake systems in the lower Amur basin, dabbling ducks (Sapaev, 1971, etc.).

25,000 ducks (Roslyakov & Kolchin, 1972). But their total area is comparatively very small. Mallard, Falcated Duck, teal and Garganey are the most common (Figure 1).

Population distribution during moulting, migration and wintering

The most important moulting areas known to date are shown on Figure 2. Hundreds of thousands of Long-tailed Duck and eiders (all four species) moult along the northern and eastern coasts of the Chukchi Peninsula and in the Bering Strait area. Snow Geese moult on the northern lowlands of the Wrangel Island; Brents moult on the same area, as well as on the northern shores of the Chukchi Peninsula and on the Novaya Sibir Island (the most recent information from this island was in 1960).

Geese, Pintail, Baikal Teal and diving ducks moult on almost inaccessible lakes and rivers in the tundra and forest-tundra. Many goose-moulting areas between the Yana and Kolyma rivers where, in former times, thousands of geese could be taken in one catch, are now of no importance. Many thousands of diving ducks moulted on the Sen-Koel lake near Sredne-Kolymsk; it was recently drained, and the ducks have disappeared (Perfilyev, 1972). In the 1940s, many diving ducks moulted in the system of shallow lakes in the valley of Kamtchatka river near the mouth of Yelovka river (Figure 2:16), but the present situation is unknown. Many Harlequins, mergansers, and Pacific Eiders spend the moulting period along the northern coasts of the Okhotsk Sea (Kistchinski, 1968). The same species as well as White-winged Scoter and Steller's Eider, moult in thousands near Karaginski Island (Gerasimov, 1972a). Harlequins also moult near the North Kuriles and the Commander Islands (see Figure 2). Many dabbling ducks moult on the large lakes in the lower Amur basin (Sapaev, 1971).

Large numbers of waterfowl migrate along the sea coasts, and along the valleys of the Lena, Kolyma, and Anadyr, through interior valleys of Sakhalin and along the Evoron-Tugur depression, the Ussuri and Amur rivers. Important 'ecological routes' of migration are sketched on Figure 3. However, detailed patterns of migrations of different species and populations vary and in most cases are not well known because of the scarcity of ringing data. Therefore, these 'ecological routes' cannot be treated as real flyways; sometimes they are probably only resting grounds on flyways of unknown direction. Routes along the arctic coast (Snow Goose, eiders, Brent), Lena, Kolyma, Kuriles, east Sakhalin, Amur, Anadyr seem to be true 'flyways'. Much study is needed to solve the problem. Some birds (Bean Goose, White-fronted Goose, dabbling ducks) move in a dispersed way across the mountains as well.

In recent years (especially in 1970–1971) winter waterfowl counts were made in north-east Asia. Professional zoologists have participated in this work as well as game, forestry and fishery officers, and hunters. Data for the U.S.S.R. are presented in Table 4 and Figure 4 (Figure includes also St. Lawrence Island as a geographical unit close to Chukchi Peninsula). Figures in Table 4 regarding marine wintering grounds are certainly not complete nor accurate, due to the difficulties of census techniques (especially in the waters adjacent to the Kuriles and Sakhalin). Besides, areas of waterfowl winter concentrations are not constant from year to year.

From January 1970, regular winter counts are being carried out in Japan—at more than 1,000 points. Professor Y. Yamashina has kindly informed us that the numbers of waterfowl counted in January were approximately:

Whooper Swan (1970–1972)	9,800–11,400
Bewick's Swan (1970–1972)	540– 930
White-fronted Goose (1970–1972)	3,400– 3,700
Bean Goose (1970–1972)	1,500– 1,900
Brent Goose (1970–1972)	2– 340
Ducks (1970–1971)—about 1,000,000, among them:	
Mallard	200,000
Green-winged Teal	160,000–220,000
Spotbill	140,000–160,000
Tufted Duck	130,000
Scaup	16,000– 50,000
Pochard	37,000– 43,000
Pintail	37,000– 44,000
Wigeon	38,000– 43,000
Baikal Teal	11,000– 37,000
Shoveler	10,000– 12,000
Falcated Duck	12,000– 15,000
White-winged Scoter	5,700– 12,000
Mandarin	9,500– 10,000
Long-tailed Duck	2,600– 8,600
Goldeneye	1,600– 2,300
Red-breasted Merganser	2,400– 3,200
Goosander	1,200– 1,600

The number of birds varied little between the years. Geese and swan counts are highly accurate; counts of dabbling ducks fairly accurate; numbers of sea-wintering diving ducks are certainly underestimated.

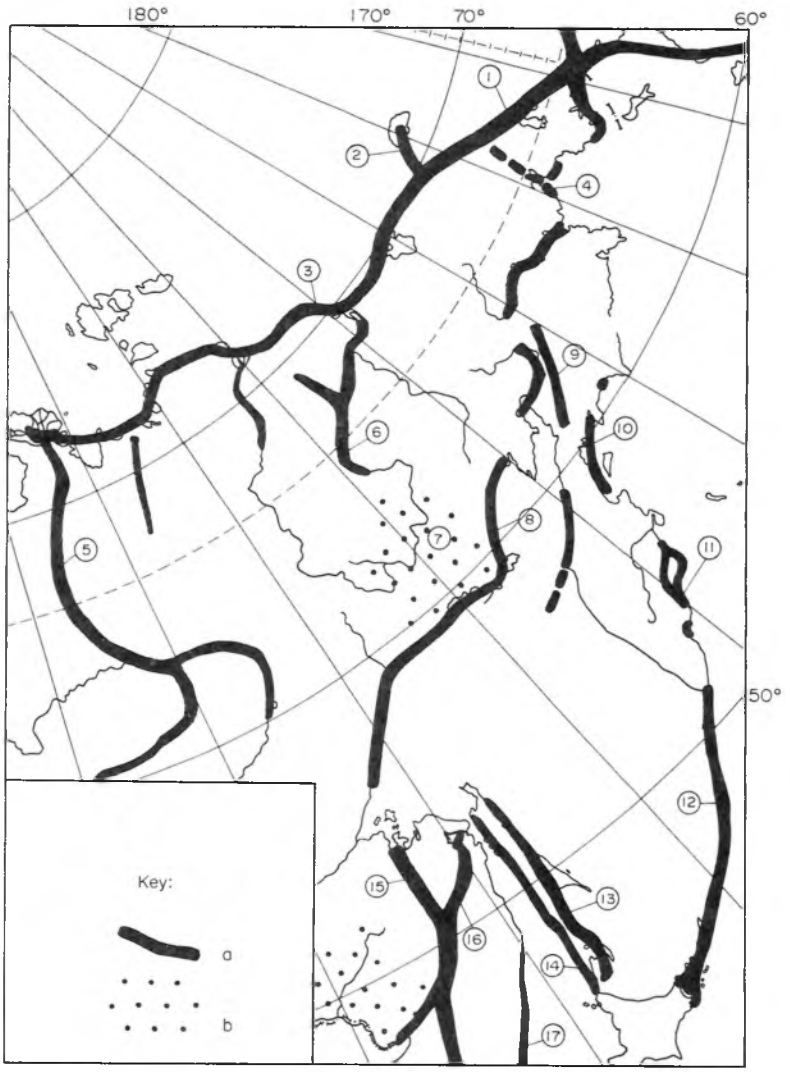

Figure 3. Important 'ecological routes' of waterfowl migration in north-east Asia. Key: a—important ecological routes; b—some areas where migration goes by a dispersed pattern. Localities, and main species: 1—arctic coasts of Chukchi Peninsula: Snow Goose, Brent, Eiders, Long-tailed Duck; 2—across the De-Long Strait: Snow Goose, Brent; 3—arctic coasts of the Yakutia: eiders, Long-tailed Duck; 4—Uelkal: Long-tailed Duck; 5—Lena river: Long-tailed Duck, Bean Goose, White-fronted Goose, White-winged Scoter, Pintail; 6—Kolyma river; Pintail, Baikal Teal, White-winged Scoter, Long-tailed Duck, Scaup, Tufted Duck, White-fronted Goose, Bean Goose; 7—Kolyma Highlands: Green-winged Teal, White-fronted Goose, Bean Goose, Pintail; 8—northern coast of the Okhotsk Sea: Long-tailed Duck, Harlequin Duck, Black Scoter, White-winged Scoter, Scaup, Tufted Duck, geese; 9—Parapolski Dol; geese; 10—shores of the Litke Strait: Long-tailed Duck, Scoters, Harlequin Duck, Scaup, Tufted; 11—Kronotski State reserve, sea coasts and inland thermal lakes; Scaup, Pintail, Wigeon, Green-winged Teal, Long-tailed Duck; 12—Kuriles; all the diving ducks, Mallard, Pintail, Green-winged Teal, mergansers; 13—east Sakhalin ways; many diving and dabbling ducks, geese, swans; 14—west coast of the Sakhalin; Goldeneye, mergansers, Scaup, Harlequin Duck, Mallard, Wigeon, Green-winged Teal, swans; 15—Evoron-Tugur depression; Pintail, Gadwall, Mallard, Falcated Duck, Tufted Duck, Goosander; 16—Amur valley; Pintail, Green-winged Teal, Falcated Duck, geese; 17—coasts of the Primorye Territory; Goldeneye, mergansers, Harlequin Duck, Scaup, Tufted Duck, Mallard, Wigeon, teal, swans.

Table 4. Results of waterfowl winter counts and estimated numbers of wintering waterfowl in north-east Asia

No. Territory	Year of count	Number of counted birds	Total number of birds estimated (thousands)	Main species and their estimated numbers (thousands)
1. Korf Bay (Yakhontov, 1972)	1971	500	12–15	Long-tailed Duck (12–15), Pacific Eider
2. Coastal waters of the Commander Islands (Marakov, 1965 etc.)	Many years		25–30	Steller's Eider (10), Harlequin Duck (3), Long-tailed Duck (3), Mallard (3), Black Scoter, White-winged Scoter, Goldeneye, mergansers, Pacific Eider (hundreds), Emperor Goose (0·2)
3. Coastal waters of eastern Kamtchatka, Kronotski State Reserve (Markov, 1963)	1960–61		Several thousands	Black Scoter, White-winged Scoter, Harlequin Duck, Long-tailed Duck
4. Rivers and lakes of Kamtchatka (Gerasimov, 1972b)	1966–68		24·5–25	Mallard (14·5), mergansers (2·5), Goldeneye (2·5), Whooper Swan (5–5·5)
5. First and Second Kurile Straits (Marakov, 1968; Voronov, 1972; and *in litt.*)	Different years		200–400	Pacific Eider, Steller's Eider, Long-tailed Duck, Harlequin Duck, White-winged Scoter, Black Scoter
6. Coastal waters of the Kuriles southwards of the Second Kurile Strait (Voronov, 1972; and *in litt.*); mainly Pacific side	Different years		Many thousands	Long-tailed Duck, Harlequin Duck (numerous), Black Scoter, White-winged Scoter, Scaup (common)
7. Non-frozen rivers and thermal lakes of Southern Kuriles (Marakov, 1968, new counts 1971)	Different years		2–3	Mallard, mergansers (more than 1), Whooper Swan (hundreds)
8. Waters near Cape Terpenyia and Tiulenyi Island (Voronov, 1972 and *in litt.*)	1970		400–500	Long-tailed Duck
9. Waters near Moneron Island (Voronov 1972 and *in litt.*)	1970	150–200	0·15–0·2	Harlequin Duck
10. Waters near Cape Krilyon (Vshivtsev & Skurtchayev, 1972).	1966–67		8	Long-tailed Duck, Harlequin Duck, Scaup

11. Coasts of Sakhalin (new counts)	1970	2,000	10–15	Long-tailed Duck (4–5), White-winged Scoter (1·5–3), Eiders (1), Scaup (1)
12. Interior waters of Sakhalin (new counts)	1970	47	8–10	mergansers
13. Rivers of the 'sea slope' of the Primorye Territory (new counts)	1970	117	1·5–3	Mallard (0·5–1), mergansers (0·4–0·7), Green-winged Teal, Goldeneye
14. Coasts of the Primorye Territory, from Cape Povorotny to Adimi river (new counts)	1970	168	Several thousands	mergansers (3–3·5), Goldeneye (2), White-winged Scoter (1), Pochard (1)
15. Gulf of the Peter the Great and adjacent waters (Nechayev, 1972 etc.)	1970	Up to 13,000	20	Long-tailed Duck (more than 11) White-winged Scoter (1), Scaup, Harlequin Duck
Total, approximately			700–1,050	

Table 5. The waterfowl productivity of the tundra, forest-tundra and northern taiga (1963–1972)

Territory	Time of census	Birds per 10 sq. km.	Main species	Source
Northern coasts of the Chukotski Peninsula, arctic tundras, ground counts	June 1970	96·7	Long-tailed Duck, King Eider, White-fronted Goose	Kistchinski, unpublished
Delta of the Lena river, arctic tundras, aerial counts	August 1963	34·1	White-fronted Goose	Yegorov, 1965
Tundra (all subzones) between Yana and Indigirka rivers, aerial counts	August 1964	36·4	Geese, teal	Yegorov, 1965
Delta of the Indigirka river, arctic tundras, ground counts	June–July 1971	111·0	Spectacled Eider, White-fronted Goose	Kistchinski, unpublished
Delta of the Indigirka river, hilly dwarf-shrub-moss-sedge tundras, ground counts	June 1971	56·8	Long-tailed Duck, Bean Goose, White-fronted Goose, Pintail	Kistchinski, unpublished
Lower reaches of the Yana river, forest-tundra, ground counts*	June 1972	101·4	Pintail, White-winged Scoter, Wigeon, Green-winged Teal, Baikal Teal, Scaup, Long-tailed Duck	Kistchinski, unpublished
Northern thin-forested taiga, lake-land near Sredne-Kolymsk, aerial counts*	August 1966 August 1967 August 1970	161·3 81·8 60·0	White-winged Scoter, Scaup, Tufted Duck, Long-tailed Duck, Pintail, Wigeon	Yegorov & Perfilyev, 1970

*Counts were made in good waterfowl habitats; so the data cannot be extrapolated on the whole subzone.

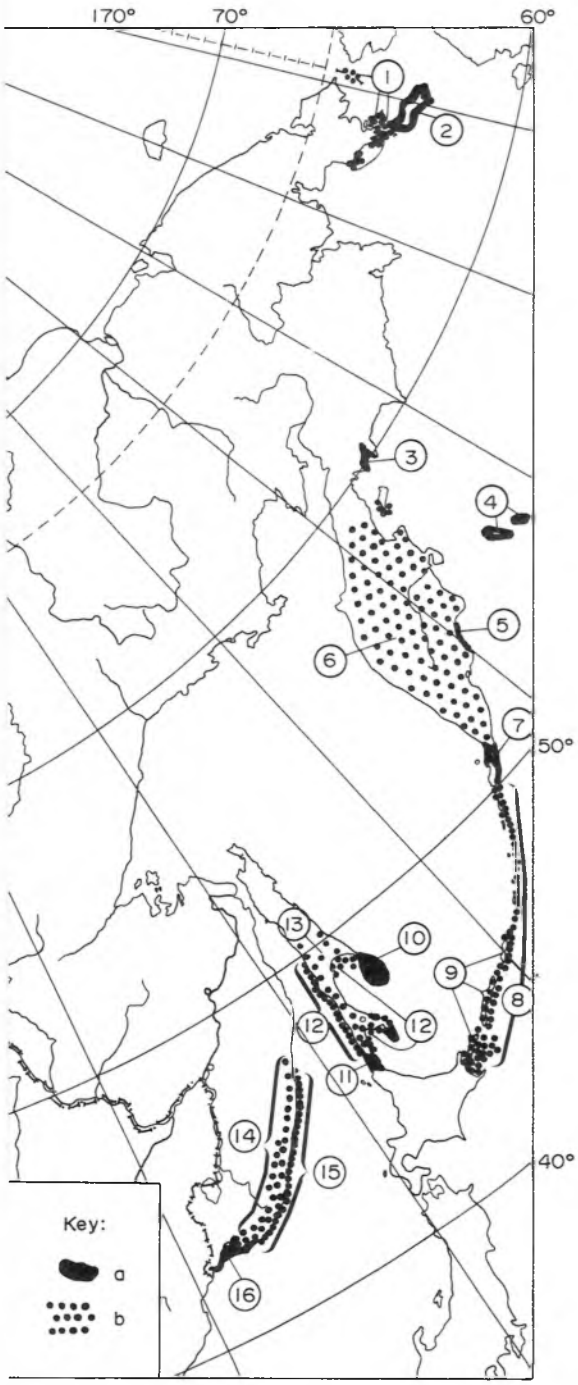

Figure 4. Main wintering grounds of waterfowl in north-east Asia (U.S.S.R.). Key: a—dense winter waterfowl concentrations; b—areas where wintering waterfowl are more scattered. Localities: 1—eastern and southern coasts of the Chukotsk Peninsula; Long-tailed Duck, Pacific Eider, King Eider (Portenko, 1972); 2—coastal waters of the St. Lawrence Island; Long-tailed Duck (up to 500,000), Pacific Eider, King Eider (dozens of thousands) (Fay, 1961); 3—Korf Bay (see Table 4:1); 4—coasts of the Commander Islands (see Table 4:2); 5—coasts of eastern Kamtchatka (see Table 4:3); 6—inland waters of Kamtchatka (see Table 4:4); 7—First and Second Kurile Straits (see Table 4:5); 8—coastal waters of the Kuriles (see Table 4:6); 9—inland waters of Southern Kuriles (see Table 4:7); 10—waters near Cape Terpenya and Tiulenyi Island; (see Table 4:8); 11—waters near Cape Krilyon (see Table 4:10); 12—coasts of Sakhalin (see Table 4:11); 13—interior waters of Sakhalin (see Table 4:12); 14—mountain rivers of the 'sea slope' of the Primorye Territory (see Table 4:13); 15—coasts of the Primorye Territory (see Table 4:14); 16—Gulf of the Peter the Great and adjacent waters (see Table 4:15).

Unfortunately, we know almost nothing about the present-day status of wintering waterfowl in the Chinese People's Republic and South Korea. In the countries southwards, Palaearctic ducks winter in very small numbers.

Main trends in waterfowl populations in north-east Asia

The majority of waterfowl which breed in the arctic tundra (Figure 1, zone A) of eastern Asia, migrate eastwards along the arctic coast and winter either in America (Snow Geese) or in the coastal waters of the north Pacific—mainly on the American side (Emperor Geese, Brent Geese) or on both sides (Long-tailed Duck, eiders). Part of the Long-tailed Ducks probably migrate from the arctic tundra to the Far East wintering grounds overland; their situation is different and will be discussed later (zone B). The Snow Goose is hardly harvested in the U.S.S.R. but it is a popular sporting game species in North America. At present, the Asian population has probably stabilised at a level determined by the carrying capacity of the wintering grounds; numbers fluctuate in accordance with annual breeding success. 'Sea-wintering' species, as a rule, are hardly accessible for hunting during winter; their spring, summer and autumn kill does not seem to be excessive. We have now no information about any essential changes in their year-through habitats. However, prospects for oil drilling on the shelves of Izembek and Bristol Bays—the main wintering or spring resting grounds of Emperor Geese and Brent—are cause for serious alarm. Populations of sea-wintering arctic species also seem to fluctuate according to breeding success in different years but no overall decrease is probable.

Another group consists of arctic birds which migrate across the continent and winter in south-eastern Asia—White-fronted Geese and Brent breeding in Yakutia. In the last 20–25 years, their numbers have sharply decreased over the whole of north-eastern Asia (Vorobyev, 1965; Perfilyev, 1972; our data). Yakutian populations of Brent are evidently close to extinction. In the areas where they were formerly abundant when breeding (e.g. in the deltas of Lena and Indigirka rivers) or on migration, they can hardly be found now. Several hundred Brent winter near the shores of Hondo (Y. Yamashina, personal communication) but we do not know where they come from. The winter status of the species in China is unknown. The breeding habitats of neither of these geese species are seriously disturbed. Hunting has decreased there, and traditional ways of mass harvesting (catching of moulting birds, egg-collecting) have ceased. We believe the main reason for the strong population decrease of these birds to be over-harvesting and degradation of habitats on the migration and wintering grounds.

On the whole, the area of arctic tundra (Figure 1, zone A) is not large, but productivity is rather high (Table 5). However, the main part of this production consists of eiders and Long-tailed Duck which are not very important as game. The most valuable game species—geese—are in a rather unsatisfactory state.

In the southern parts of the tundra zone, in forest-tundra and in northern taiga (Figure 1, zone B), numbers of almost all waterfowl species have strongly diminished in the last 20–25 years. Productivity of the territory, in general, does not exceed that of the arctic tundra (Table 5). This seems to be unnatural and probably indicates a strong decline in the primary (initial) productivity. Breeding habitats have deteriorated locally, but on the vast areas of southern tundra, forest-tundra and northern taiga, disturbance is not serious. However, grazing of domestic reindeer exerts a very unfavourable influence in summer and spring: deer, dogs and men often destroy waterfowl nests. The consequences of unwise wetland 'melioration' play their role too. Nevertheless, the main reasons of waterfowl decline lie, as far as we understand, in the worsening conditions of migration and wintering. The majority of waterfowl breeding in the area winter either in the coastal sea waters (Tufted Duck, Scaup, White-winged Scoter, Black Scoter, Long-tailed Duck, Harlequin Duck, mergansers) or on the fresh-water bodies of south-east Asia (Green-winged Teal, Baikal Teal, Wigeon, Bean Geese and in part Pintail). Only Pintail from the extreme north-east (southwards to central Kamtchatka and westwards up to the lower reaches of Kolyma and Magadan) migrate in part to America (Shevareva, 1968). Diving ducks are essentially safe when wintering on the sea, but they are subjected to a strong hunting pressure during migration, except probably in the case of Harlequin Duck. The numbers of all ducks on migration along the Lena and Kolyma rivers, among them the formerly numerous White-winged Scoter and Long-tailed Duck, have sharply decreased (Yakhontov, 1969; Perfilyev, 1972). We can assume that our 'sea ducks' spend the winter

mainly in the U.S.S.R.'s waters; only our Tufted Duck winter in Japan in considerable numbers. On the contrary, the dabbling ducks (except for part of the Mallard) and geese winter outside the U.S.S.R. The latter undoubtedly go mainly to the Chinese People's Republic; wintering numbers in Japan and in eastern India are negligible. No one country can succeed in stopping the decline of their populations. The numbers of Bean Geese and Baikal Teal have especially diminished; it can be seen both on their breeding grounds in Yakutia and on migration in the lower Amur basin. This process will continue if active measures (including international ones) are not put into force.

The situation in central Yakutia (Figure 1, zone C) has not been studied in detail but waterfowl numbers are decreasing both on breeding and migrations. Habitat deterioration as well as over-hunting and disturbance are involved. Areas of migration and wintering are poorly known, although several ducks ringed in winter in the Ganges basin (India) and in Japan, were recovered from the Central Yakutia and upper reaches of the Lena river.

On Sakhalin Island (especially in the south) breeding waterfowl habitats have seriously deteriorated due to wetland draining, cutting of coastal vegetation, disturbance, and overharvesting. Ducks are rare as breeders but abundant on migration; no overall decrease of migratory stocks have been proved. On the whole, the status and trends of the Sakhalin and Kamtchatkan (Figure 1, zone D) waterfowl populations are hardly known. Ringing data show that birds moving through these areas winter mainly in Japan.

In the lower Amur region (Figure 1, zone E), numbers of waterfowl (especially dabbling ducks and geese) are decreasing both on the breeding grounds and on migration. Migratory stocks of Baikal Teal have strongly diminished, and Greylag Geese, Swan Geese, Mandarin, and Chinese Merganser are endangered. The number of harvested ducks as well as the success of hunters have decreased. Nevertheless, evident overharvesting and strong human disturbance occur. In the south of the Amur basin, great habitat deterioration is due to cutting and trampling of coastal and meadow vegetation, cattle grazing, meadow fires in spring and early summer, and water pollution. A strongly unfavourable influence is the flooding of nesting and feeding grounds during summer high waters in the Amur basin (Table 3). Many former places of waterfowl concentrations have lost their role. At present, waterfowl reproduction seems to occur mainly in the valleys of the vast, unfrequented mountain areas, where population density of waterfowl is rather low but the total area is large. Conditions on migration have essentially worsened (hunting pressure, loss of good resting grounds, disturbance). Waterfowl which breed and migrate in the Amur basin winter probably in the Chinese People's Republic, and to some extent (ringing data) in Japan. Winter conditions in Japan are satisfactory. The situation on the migration and wintering grounds in China is not studied but we have no reason to believe it to be favourable. In most recent years (from 1969) when spring hunting in the Amur region was not allowed, duck numbers on spring passage and breeding in some areas seem to have increased (Roslyakov & Kolchin, 1972). However, we think that if further measures, including continental-wide ones, are not taken the total population decline will not be arrested.

The situation described above is based on the present level of our knowledge, which leaves much to be desired. In order to improve it, some steps are necessary, among them: (1) To gather more quantitative information on the population distribution of waterfowl, and to make essential progress in waterfowl ringing. In future, we should know the seasonal distribution of the different geographical populations of each species, and we should work out overall schemes of management and conservation for the whole area of each population—with corresponding hunting quotas for various parts of its area. (2) To enforce protection of wildfowl habitats; to create reserves in the important concentration areas and to improve feeding conditions (perhaps through planting food species); to reach effective agreement on land-use practices between game management, agriculture, and forestry.

Populations of migratory birds, among them waterfowl, have continental-wide ranges. Therefore, their management and conservation should also be planned and carried out on a continent-wide basis—not within administrative boundaries. Only international agreement will provide effective conservation and secure an increase of waterfowl populations.

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Summary

The distribution of waterfowl on breeding, moulting, migration, and wintering grounds in north-east Asia is described and the main areas of concentration indicated. Trends in the waterfowl populations are outlined. The situation in the arctic tundra is quite satisfactory for the 'sea-wintering' Long-tailed Duck *Clangula hyemalis* and eiders which migrate along arctic coasts, as well as probably for the Snow Goose *Anser caerulescens*, Emperor Goose *Anser canagicus* and the eastern populations of Brent *Branta bernicla*. The status of the White-fronted Goose *Anser albifrons* and especially of Yakutian populations of Brent is unfavourable. Waterfowl populations breeding in southern tundras, forest-tundras and northern thin-forest taiga, are still highly productive in places, but their total numbers have strongly decreased in the last 20–25 years. The main cause seems to be overhunting and habitat deterioration on migration and wintering grounds. On Sakhalin and Kamtchatka breeding waterfowl are no longer numerous, but birds are abundant on migration. In the lower Amur basin, waterfowl stocks have strongly diminished due to habitat degradation, overharvesting and disturbance on breeding grounds, migration routes and probably on winter ranges as well. Brent Geese, Baikal Teal *Anas formosa* and some rare species have suffered especially. More studies are necessary, as well as urgent protective measures (including international ones) directed to the protection of habitats and creation of reserves.

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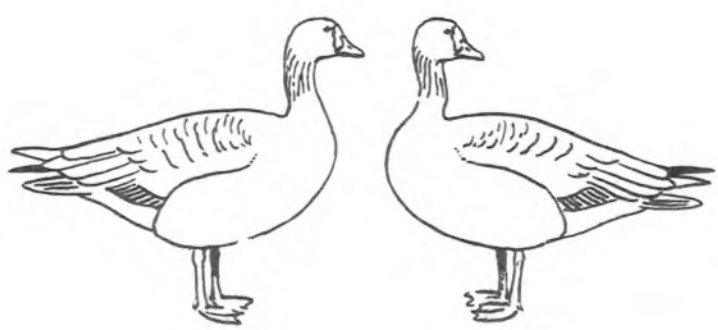
Appendix A. Scientific names of species mentioned in the text, tables and captions.

Whooper Swan	*Cygnus cygnus*
Bewick's Swan	*C. columbianus bewickii* (*jankowskii*)
Swan Goose	*Anser cygnoides*
Bean Goose	*A. fabalis*
White-fronted Goose	*A. albifrons*
Lesser White-fronted Goose	*A. erythropus*
Greylag Goose	*A. anser*
Emperor Goose	*A. canagicus*
Snow Goose	*A. caerulescens*
Brent Goose	*Branta bernicla*
Pintail	*Anas acuta*
Green-winged Teal	*A. crecca*
Baikal Teal	*A. formosa*
Falcated Duck	*A. falcata*
Mallard	*A. platyrhynchos*
Spotbill	*A. poecilorhyncha*
Wigeon	*A. penelope*
Garganey	*A. querquedula*
Shoveler	*A. clypeata*
Pacific Eider	*Somateria mollissima v-nigra*
King Eider	*S. spectabilis*
Spectacled Eider	*S. fischeri*
Steller's Eider	*S. stelleri*
Pochard	*Aythya ferina*
Tufted Duck	*A. fuligula*
Scaup	*A. marila*
Mandarin Duck	*Aix galericulata*
Black Scoter	*Melanitta nigra americana*
White-winged Scoter	*M. fusca deglandi*
Harlequin Duck	*Histrionicus histrionicus pacificus*
Long-tailed Duck	*Clangula hyemalis*
Goldeneye	*Bucephala clangula*
Red-breasted Merganser	*Mergus serrator*
Chinese Merganser	*M. squamatus*
Goosander	*M. merganser*



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A cosmopolitan duck moulting resort; Takslesluk Lake Alaska

JAMES G. KING

Description of the Area

Takslesluk Lake lies about 40 miles (64 km) northwest of Bethel, Alaska at 61°0 N and 16°35 W. It is near the centre of the 26,000 sq. miles (67,340 sq. km) of waterfowl habitat on the Pleistocene Delta of the Yukon River. Although most of the boreal forest of Interior Alaska lies to the northeast of Takslesluk Lake and it is nearly 400 miles (640 km) south of the Arctic Circle, the climate and vegetation are considered truly Arctic by most authorities. (Stonehouse, 1971; Freuchen & Salomonsen, 1958).

The entire Delta area is characterized by low tundra dotted with thousands of lakes. The coastal areas within the Clarence Rhode National Wildlife Range have large goose nesting populations described by several observers (Spencer, Nelson & Elkins, 1951; Hansen & Nelson, 1957; Nelson & Hansen, 1959). Inland around Takslesluk Lake the habitat is dryer and the climate less marine resulting in slight vegetative changes (Walkinshaw & Stophlet, 1949; Williamson, 1957; Burns, 1964). Ducks rather than geese become the most abundant form of waterfowl in the central part of the Delta. A few miles east of the banding site scattered spruce *Picea* spp. and birch *Betula* spp. appear as pioneers on the tundra but the nearest real forest in 100 miles (160 km) east.

The Delta is known for its large duck breeding population. Table 1 shows the estimated average fall population of ducks on the Delta. These figures were compiled from 14 years of air survey data, 1957–1970 (King & Lensink, 1971).

Takslesluk Lake is characteristic of the central Delta. It is a rather large lake for this pothole area, being 12 × 3½ miles (19 × 6 km) in extent. It has a shallow mud bottom and is probably not over 15 ft (4·5 m) deep anywhere. Some 10,000 ducks normally moult their flight feathers here. Summer storms from the southwest with winds of 20–40 knots (32–64 kph) make this a difficult area in which to work.

There are two Eskimo villages, Kasigluk and Nunapitchuk within 15 miles (24 km) of Takslesluk Lake on a connecting waterway. These people, over 600 of them, are a long way from the coast and the major rivers where most Eskimos live. They rely heavily on the resources of lakes and marshes and have traditionally made much use of the waterfowl of the area. These tundra citizens use boats to drive the flightless birds to one end of the lake where they can club, shoot, net or otherwise take possession of some hundreds of them in a single day.

Methods

During each of the 3 years of banding, large drive traps of the style used at Ohtig Lake (King, 1963) were constructed at the east end of the lake. These traps consisted

Table 1. Breeding populations in Alaska of species banded at Takslesluk Lake, and numbers banded there in 1963, 1964, 1965 and recovered by the end of 1972
(Goldeneyes not separated by species in air surveys)

	All Alaska	Yukon Delta	Percent on Yukon Delta	Number banded	Number recovered
Pintail	813,000	288,000	35%	6	0
Canvasback	38,000	1,200	3%	50	7
Greater Scaup	449,000	326,000	73%	2,294	176
Lesser Scaup	547,000	10,000	2%	31	2
Common Goldeneye				108	3
	108,000	21,000	19%		
Barrows Goldeneye				6	1
Bufflehead	64,000	2,500	4%	204	7
Old Squaw	470,000	292,000	62%	1,784	34
Total	2,489,000	940,700		4,483	230

Figure 1. The large corral-type duck-trap at Taksleshuk Lake, Alaska. At the back of the banding crew's camp, the typical Yukon Delta habitat extends 100 miles to the sea. Tent at the water's edge was used to protect the band-record keeper from the weather.

of a 100-yard (19-m) net lead, a 3,000-sq. yard (2,500-sq. m) holding pen of chicken wire, and a small catching pen at the end. The whole trap was in water 2–3 ft (0·6–0·9 m) deep on a relatively flat mud bottom. Two float equipped airplanes and three or four motor-powered boats were used for the drives. It took 12–14 hours to move the ducks the 12 miles (19 km) up the lake.

Duck drives were scheduled each year for early August but as a wind greater than 5 knots (9 kph) make the lake too rough to navigate there was usually a wait for a calm day. In 1963, several thousand ducks were caught on 1 August. As it was dark when the ducks were finally in the large pen, they were left overnight. The next day high winds were putting 2-ft (0·6-m) waves

Figure 2. Ducks in the trap are driven to a small pen in the corner where they can be caught with a dip net and placed in a burlap sack for transportation to the shore.

through the trap, and removing the ducks proved nearly impossible. The high winds continued unabated and on the fourth day those ducks that had not escaped through breaks in the trap were released. Only 201 birds were banded. In 1964 the same method produced a catch of nearly 4,000 ducks in one drive, 3,699 of which were banded. In 1965 continuous high winds, rain and fog again hampered the project and only 583 ducks were banded during a 2 week effort.

The next-to-last column of Table 1 lists the total number of ducks by species banded during the 3-year period. The species composition of the catch bears little relation to the population composition because of the trapping method which was primarily designed for the diving ducks. All birds in the catches were at least 1 year old. This was the first time that Greater Scaup and Old Squaw had been banded in Alaska in any substantial numbers.

It was concluded that the size of the lake plus the quality of the weather made banding at Takslesluk Lake a chancy thing and the project has not been repeated.

Results

By 1972 there were 230 recoveries from the Takslesluk banding. More recoveries of course will continue to come in small numbers but it is appropriate to summarize the data now.

Pintail *Anas acuta*

Only six Pintail were caught, all in 1964, and these gave no recoveries.

Canvasback *Aythya vallisineria*

Canvasbacks are regularly seen on the big lakes near Takslesluk but make up a very small percentage of Yukon Delta ducks. They are more common in the forested valleys to the east. We do not know if Canvasbacks actually nest on the tundra or are present merely as a non-breeding segment of the population. Of the birds banded, thirty-nine were males and eleven females. The seven recoveries are shown in Figure 3. They gave a 2% direct (i.e. same season) and a 14% total recovery rate. The distribution is interesting, with three going to the Pacific Flyway, two to the Mississippi and one each to the Central and Atlantic Flyways. Banding in the Interior indicates this to be typical distribution for Alaskan Canvasbacks.

Figure 3. Approximate location of recoveries away from banding site (all species except Greater Scaup and Old Squaw). X, Banding site; ●, Canvasback; ○, Lesser Scaup; ▲, Common Goldeneye; △ Barrow's Goldeneye; ■ Bufflehead.

Figure 4. Approximate location of Greater Scaup and Old Squaw recoveries. Banding site recoveries in large symbol at site. X, Banding site; △, Greater Scaup; ○, Old Squaw. Number of recoveries indicated if more than one per State or Province.

Greater Scaup *Aythya marila*

Greater Scaups are the most common duck throughout the Delta area. They are found in substantial numbers in all the western and northern tundra areas of Alaska and make up more than 90% of the scaup population of the tundra, with Lesser Scaup contributing less than 10%. In the forested valleys inland the reverse is true with Greater Scaup making up something less than 10% of the scaup population, although they have been found in small numbers wherever banding has been done. More than half the ducks caught at Takslesluk Lake were Greater Scaup (2,294) and of these 96% were males and only 4% were females. We assume the low number of females caught indicates most of them were still occupied with broods on smaller ponds.

Distribution of the 176 recoveries is shown in Figure 4. The twenty-five recoveries at the banding site indicate a special situation not faced by most scaup populations. There is intensive spring shooting by Eskimos in this area and they have continued to drive ducks at the banding site. Bands recovered by Eskimos in this area are normally kept but not reported. During the summer of 1970 an Eskimo was hired by the Alaska Department of Fish and Game to pay one dollar each for fish tags received in the villages. Through a misunderstanding he also bought some 45 bird bands, eighteen of which were from Greater Scaup recovered at Takslesluk Lake in July 1969. An additional seven recoveries have been reported from the vicinity over the years. Thus, of the thirty Alaskan recoveries only five were from birds that had left the breeding grounds.

Greater Scaup are common in eastern Siberia and have been heavily hunted there (Dement'ev & Gladkov, 1967) so the lack of recoveries indicates Alaskan birds do not normally go there.

The birds appear to be using wintering areas along the Atlantic and Pacific coasts in about equal numbers, with just a few going to the Gulf of Mexico. The Great Lakes area seems to be an important staging point for the eastern population and they may linger in this area for some time. The recoveries (apart from those at the banding site) split between the Flyways: Pacific seventy-one, Central five, Mississippi twenty-six, Atlantic forty-nine (Figure 2). Four birds banded in New York state and one from Vermont were recovered at the banding trap. The direct recovery rate was 1·3% and total recovery rate to date 7·7%. As only birds that had completed one full migration were banded, the low recovery rate is not surprising.

Table 2 Greater Scaup recoveries by years from banding data (recoveries away from banding site)

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	Total recoveries
West	16	16	11	11	8	5	4	–	–	71
East	15	12	7	5	7	18	8	6	2	80
Both	31	28	18	16	15	23	12	6	2	151
Total %	20·5	18·5	11·9	10·6	9·9	15·2	8·0	4·0	1·4	100

In Table 2, the seventy-one recoveries from Pacific Coast states are compared with the eighty east of the Continental Divide to determine if survival characteristics are similar for birds going either way. For the western birds the recovery rate was greatest the first two seasons and then tapered off consistently. The eastern recoveries were slightly less than the western during the first 5 years, then peaked the sixth year and remained higher than the western rate from then on. This unusual pattern may result from peculiarities of the hunting season or merely from too small a sample. It does appear that the eastern population is more heavily hunted during migration and the western population after they reach the wintering areas. In spite of different mortality patterns the net result is nearly equal with the total recovery rate 6·6% away from the banding site being split 3·5% from the east and 3·1% from the west.

Lesser Scaup *Aythya affinis*

Lesser Scaup are on the edge of their breeding range at Takslesluk Lake, being much more typical of the forest habitat inland. Of thirty-one banded, only a direct recovery from Michigan and an indirect recovery from North Carolina were made. We know from banding in the Interior that Alaskan Lesser Scaup use all four flyways. Recoveries from over 33,000 Lesser Scaup banded in Alaska show a distribution of 20% to the Pacific Flyway, 12% Central Flyway, 40% Mississippi Flyway, 9% Atlantic Flyway, 10% Canada and 9% Latin America (King & Lensink, 1971).

One recovery was made at Takslesluk Lake in 1964 of a male Lesser Scaup banded from a huge congregation of moulting scaup on Ohtig Lake, Alaska, 700 miles (1,120 km) northeast, in July 1963.

Common Goldeneye *Bucephala clangula*

The status of Common Goldeneyes in Alaska is not well understood. They can not be reliably separated from Barrow's Goldeneyes on air surveys and the females of the two species are almost identical, making them difficult to identify unless in hand. Apart from the 108 birds banded at Takslesluk Lake only thirty-one Common Goldeneyes have been banded in Alaska. One recovery from Takslesluk was in January 1967 at Chignik Lagoon on the south side of the Alaska Peninsula and another in the same month from Salton Sea, California (Figure 3). This does not tell us much because either could have been an accidental wanderer and both are within the published winter range for the species (Gabrielson & Lincoln, 1959).

Of the birds caught, forty-three were males and sixty-five were females. As Common Goldeneyes normally nest in trees and there are no trees in the banding area one can only assume that there is a moult migration of a non-breeding portion of the population to tundra areas. Goldeneyes in small numbers are regularly noted in various parts of the Yukon Delta.

Barrow's Goldeneye *Bucephala islandica*

Only six males were caught and one was recovered in November 1965 on Kodiak Island (Figure 3). Recoveries from birds banded in the Interior indicate this is within the expected winter distribution of the species

Bufflehead *Bucephala albeola*

Buffleheads are another common forest breeding species of the Interior that would seem to be out of place on the treeless tundra. They are not known to nest except in holes in trees and although recorded in summer occasionally in the treeless Aleutians probably do not nest there. Of the 204 birds banded only six were females and none of them were recovered. Of the seven male recoveries, four were at the banding site in subsequent years, one was in Interior

Alaska near McGrath in May, one was near Kodiak in December and the only direct recovery was from 20 km northwest of Petropavlovsk, Kamchatka U.S.S.R. in December (Figure 3).

Buffleheads are common winter birds in the Aleutians and other Bering Sea Islands including the Soviet Commander Islands where they are considered stragglers (Gabrielson & Lincoln, 1959; Dement'ev & Gladkov, 1967). The Siberian recovery, the first from mainland Asia, extends the edge of the known Bufflehead range by about 500 miles (800 km).

Long-tailed Duck *Clangula hyemalis*

Old Squaw are typically a tundra nesting species, however, they are regular spring migrants throughout the northern forested portions of the Yukon drainage. Irving (1960) reports them moving eastward in May at Old Crow in the Northern Yukon Territory of Canada and points out they are unknown in the southern Yukon. A few remain in forest lakes through the summer. Apart from the 1,784 Old Squaw captured at Takslesluk Lake, only fifty-six have been banded elsewhere in Alaska. One of the ten Old Squaw banded at Tetlin in 1961 was recovered on the Kamchatka Peninsula in 1969. Of the Takslesluk birds only one was recovered away from the banding site in North America, a male shot in September near Coronation Gulf on the Arctic Coast of Central Canada. Of the sixteen other recoveries from the Bering Sea and U.S.S.R. as shown in Figure 2, five were in May, four in June, one in July and six, August–March. The indications are that Alaskan Old Squaw winter in Bering Sea and the Sea of Ohotsk. Pairing evidently takes place on the wintering area and males follow females to nesting areas throughout Eastern Siberia and Arctic portions of Western Canada and Alaska. There may be an important migration route up the Yukon River valley for birds headed for Western Canada. No wintering in North American waters except the Bering Sea is indicated for Alaskan Old Squaw.

Even including the seventeen recoveries at the banding site the recovery rate, at 1·9%, is low by American standards for a hunted species. The low rate of foreign recoveries after the fourth season could reflect a rather heavy unreported or natural mortality rate. The high recovery rate at the banding site in the fifth year reflects the purchase of bands as described for Greater Scaup.

The sex ratio of the catch is rather interesting with 61% being females. Males appear to be more apt to be recovered by hunters. However, recoveries at the banding site are nearly equal indicating females may suffer natural mortality that compensates for reduced hunting mortality (Table 3).

Discussion

The Takslesluk banding produced some firm new information on the waterfowl that moult on the Yukon Delta. The Greater Scaup distribution to two coasts of the American Continent seems rather well defined for the first time. A brand new concept of Old Squaw distribution from a major North American breeding area is outlined. Interesting recoveries of Common Goldeneye and Bufflehead indicate migration of these species may be more extensive than previously supposed.

Although the sample is small, some in-

Table 3. Long-tailed Duck recoveries by years from banding date

	Number banded	1st	2nd	3rd	4th	5th	6th	7th	8th	All
Recovered away from banding site										
Male		5	1	2	4	–	1	–	1	14
Female		–	1	1	1	–	–	–	–	3
Recovered at banding area in summer										
Male		–	–	–	2	5	2	–	–	9
Female		–	–	–	1	6	1	–	–	8
Total male	689	5	1	2	6	5	3	1	–	23
Total female	1,095	–	1	1	2	6	1	–	–	11
Grand total	1,784	5	2	3	8	11	4	1	–	34

formation on mortality rates for Greater Scaup and Old Squaw indicate these species are not harvested heavily enough to cause concern for their welfare.

We have known for some time that Siberian nesting grounds provide birds for American hunters such as Snow Geese *Anser c. caerulescens*, Black Brant *Branta bernicla orientalis*, Pintail and others, but this project gives the first evidence that North America is producing game birds for Soviet use. This is a significant new illustration of the ultimate need for bird management co-operation and treaties with the Soviet Union. The 10% recovery rate by Canadians of birds from this American lake somewhat reverses the usual concept of Canada one-sidedly raising birds for American consumption. We also learn for the first time what sort of kill results from Eskimo drives of moulting ducks. Obviously the bulk of this harvest is of adult male Greater Scaup, and Old Squaw of both sexes. There would appear to be no significant conflict between this Eskimo take and the hunters to the south. There are no indications of destructive over-harvest or interference with the breeding population and perhaps this may be a good resource utilization for this area. It is unfortunate that it is contrary to the terms of the Migratory Bird treaties between the United States, Canada and Mexico.

Several interesting questions emerge from the project. Why is this region, and, particularly, Takslesluk Lake so popular with species which obviously have such different habitat preferences the rest of the year? Why are specific sex ratios' so different, with both sexes of Old Squaw and Goldeneye well represented but only males of Scaup and Bufflehead? Do these moulting birds represent a portion of a local breeding population or have some of them made long moult migrations from other areas where they were raised? What is the appeal of the tundra for the tree-nesting Goldeneyes and Buffleheads? Why do birds of one species that moult together on the same lake disperse to opposite sides of the Continent for the winter, as do the Canvasbacks and Greater Scaups? How do some Greater Scaup and Canvasbacks manage the problems and hazards of a migration nearly twice the length of the others of their kind? How does such diverse migration develop?

We can only conclude that a great deal more research is needed on these tundra ducks, which are of obvious value to such a widespread human population.

Acknowledgments

The three banding crew leaders, W. Smith 1963, M. Zahn 1964, and R. Tremblay 1965 deserve much credit for the success of this unusual project. I am indebted to D. Pospahola of the Migratory Bird Populations Station for help in compiling fall duck population figures in Table 1.

Summary

In the years (1963–65) Fish and Wildlife Service personnel caught and banded 4,483 ducks of eight species at Takslesluk Lake, Alaska. Recovery of 230 of these bands show a surprising dispersion through 40 degrees of latitude and 180 degrees of longitude or from North Carolina to Central Siberia.

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Plate III. Above: the elegant wild Bewick's Swans *Cygnus columbianus bewickii* fight it out on Swan Lake. Below: the savage looking Black Spur-winged Goose *Plectopterus gambensis niger* is a peaceful inhabitant of the African Pen at Slimbridge.

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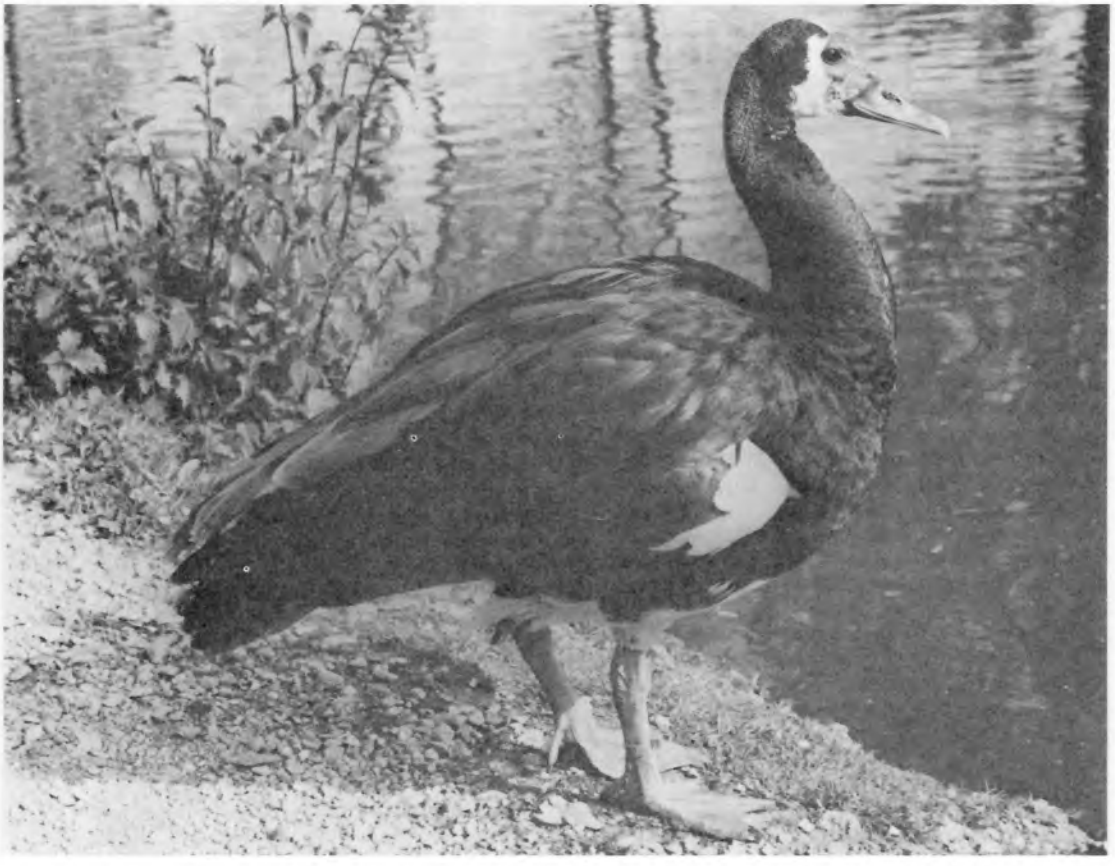

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Behaviour and distribution of wild geese in south-east Scotland

I. NEWTON, V. M. THOM AND W. BROTHERSTON

The distribution of wintering Greylag *Anser anser* and Pink-footed Geese *A. brachyrhynchus* in Britain is governed by the presence of suitable roosting sites, such as estuaries and lakes, from which the birds fly to nearby farmland to feed. The same roosts and associated feeding areas are used year after year. This paper examines the dispersal of geese in south-east Scotland and, in particular, their choice of roosting and feeding sites. It forms part of a general study, more of which has been published elsewhere (Newton & Campbell, 1970, and 1973; Newton, Campbell & Allison, in press). The area involved, covering 24,000 km², extended from Pitlochry in the north to beyond Biggar and Kelso in the south, and from the east coast to beyond Stirling in the west (Figure 1). It included a representative selection of roosting and feeding sites, and held the bulk of the immigrant population of both species. In recent autumns, Icelandic Greylag in Britain have numbered about 60,000 individuals, and Pinkfeet about 70,000 (Boyd & Ogilvie, 1969, 1972).

Methods

The first detailed information on goose distribution in Scotland was built up over several years from extensive ground searches and aerial surveys by Wildfowl Trust staff, helped by local observers. This information, summarized by Atkinson-Willes (1963), formed the starting-point for our survey. From 1960, V.M.T. studied goose distribution around Perth. This was done partly at weekends, but also on other days, because her job took her to many farms in the study area, and provided further opportunity to find geese and question farmers (Thom & Murray, 1964). In 1952, W.B. (in Edinburgh) began watches at certain roosts, which came to

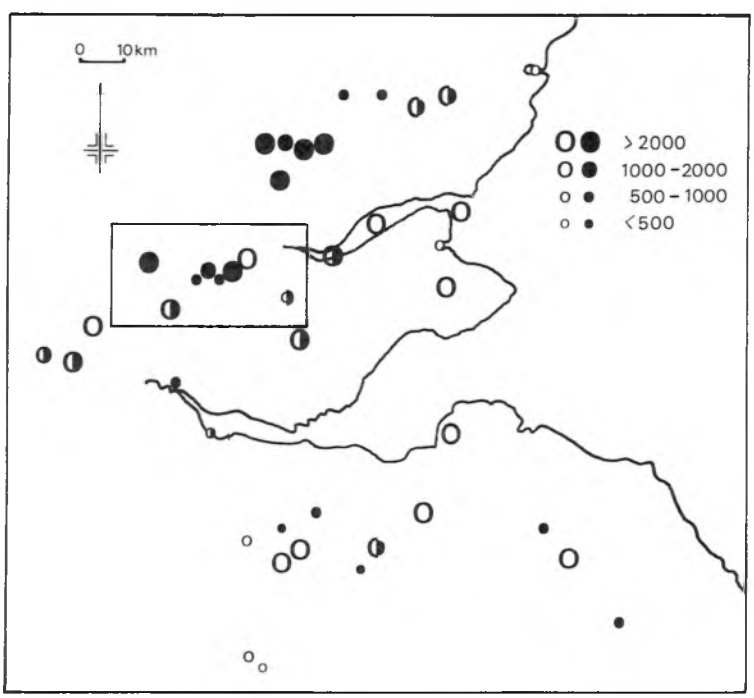

Figure 1. Map showing position of study area, and main roosting sites. Filled circles = Greylag; open circles = Pinkfoot; split circles = both species. Inset shows area covered by Figure 2.

more time than normal resting during snow periods and less in trying to feed. When a roost froze over, but food remained available locally, geese usually rested on the ice, either on their feet or bellies. It was often possible to see how many had spent the previous night on a site from the castles of droppings left behind.

Roosting sites

Several factors combined to make a site safe and acceptable to geese for roosting. These included not only the degree of actual disturbance, but also various intrinsic features which conferred safety, like situation, area, openness, distance from centres of human activity, and so on. The extent to which any particular roost was used seemed to depend mainly on the balance between its intrinsic attractiveness and the level of actual disturbance. The extensive mud flats of Montrose Basin, for example, were highly attractive to geese, yet little used because of great disturbance by wildfowlers. On the other hand, Dupplin Loch was basically unattractive because of its small size and woodland setting, but was so undisturbed that at times it held more geese than any other site in Britain. To judge from the reactions of geese, the most important disturbances were, in order of importance, low flying aircraft, shooting, human presence, and unfamiliar and prominent objects like oil drums and scarecrows. Geese soon learned to associate danger with particular places, and the same birds were more wary at one place than at another. The main roosts of the two species in the study area are given in Table 2, and all the sites at which geese were seen to roost in Appendix 1.

(a) *Coastal and estuarine sites*

Some favoured roosting sites were on estuaries and coastal mud and sand flats, which were flooded for a minimum period each day, yet where no enemy could approach undetected. A total of nine large mud or sand flats was available in the area, in or near estuaries; at seven, Pinkfeet predominated, and at two Greylag (Table 3). The smallest mud flat used by geese for roosting covered about 3 km^2, but the area of a site was less important than the distance it spread from shore. Greylag, in their favourite sites, could get up to 1 km off shore, but Pinkfeet liked to get even further out, and on Abertay Sands and Dog Bank in the Tay regularly stood up to 3 km off shore. The only smaller areas of coastal mud which geese frequently used were cut off on all side by water. Both species roosted

Table 2. Main roosts of Greylag and Pink-footed Geese in the study area

	Greylag	Pinkfoot
Strathmore	Lochs Rescobie, Balgavies, Forfar Kinnordy, Lintrathen, Clunie, Marlee and Stormont, Monks Myre, 'Bloody Inches'.	Montrose Basin, Lochs Forfar and Rescobie
Firth of Tay	Mugdrum island	Three sites in the estuary
Strathearn	Drummond Pond, Pitcairnie Loch, three sites on river	Dupplin Loch
Strathallan	Carsebreck	Carsebreck, Loch Mahaick
Ochil Hills	Glenfarg Reservoir	Glenfarg Reservoir
Kinross Plain	Loch Leven	Loch Leven
Eden area	—	Edenmouth, Cameron Reservoir
Forth Valley	Flanders Moss, Lake of Menteith, Inches near Alloa, Grangemouth	Flanders Moss, Lake of Menteith, Grangemouth, Aberlady
Pentland Hills	Harperig and Threipmuir Reservoirs	Cobbinshaw, Baddinsgill and Westwater Reservoirs
Moorfoot Hills	Gladhouse Reservoir, Portmore Loch	Gladhouse Reservoir, Fala Moor
Lammermuir Hills	Watch Reservoir	Hule Moss
Lanark Hills	—	Upper Cowgill and Culter Reservoirs
Lower Tweed Valley	Hoselaw Loch	

Table 3. Use of coastal and estuarine sites for roosting by geese in the study area

	Approximate area (km²) exposed at low tide	Used by
Montrose basin*	7	Pinkfeet, rarely Greylag
Tay (1) Abertay sands	3	Pinkfeet
(2) Dog/Carthegina banks	26	Pinkfeet, some Greylag
(3) Mugdrum and nearby banks	1·5	Greylag, some Pinkfeet
Edenmouth*	6	Pinkfeet
Forth (1) Tyninghame*	3·5	Pinkfeet
(2) Aberlady Bay	4	Pinkfeet, rarely Greylag
(3) Grangemouth Flats*	10	Pinkfeet, some Greylag
(4) Inches at Alloa*	0·7	Greylag, some Pinkfeet

*Those thus marked are much disturbed by wildfowlers, are now used less than at the turn of the century, and mainly after the end of the shooting season. Edenmouth is also disturbed by low-flying aircraft.

on Mugdrum Island and its associated sand banks in the Tay, and on certain islands in the Forth near Alloa.

In both Tay and Forth, several sites were used, but Pinkfeet predominated at the safer seaward ones, and Greylag further inland. Thus Abertay Sands near Taymouth were used only by Pinkfeet, Dog and Carthagina Banks further upstream mainly by Pinkfeet, and Mugdrum and its associated sand banks yet further up mainly by Greylag. Likewise in the Forth, Tyninghame Sands and Aberlady Bay were regularly used only by Pinkfeet, Grangemouth mainly by Pinkfeet, and the upstream sites around Alloa mainly by Greylag. Furthermore, at Grangemouth, where a harbour divided the flats, Pinkfeet mostly used the larger eastern sector, and Greylag the smaller western one. The only suitable site on the Eden (at the mouth) was used almost exclusively by Pinkfeet, as was Montrose Basin on the Angus coast.

(b) *Rivers*

Further up river, Greylag occasionally roosted on bare islands or on shingle banks in mid-stream, or on wet ground and flood pools at the edge. The river at such points was also fairly wide, with low banks devoid of trees. All three rivers in the area which offered these facilities were used. Favoured roosts on the Earn included the flood pools at Innerdunning, Dalreoch, and Netherfordun; on the Tay the Inches near Meikleour and the islets south of Pitlochry; and on the Clyde the Haughs near Quothquan (Lanark). Pinkfeet were seen at no such sites, but used the extensive sheets of water which occasionally resulted from flooding on the Clyde south of Libberton. This was especially true when nearby still waters were frozen.

(c) *Lakes and reservoirs*

Ordnance Survey Maps (scale 1/63,360) show a total of 165 ponds, lochs and reservoirs in the study area, excluding pools on mosses discussed below. Many such sites were too disturbed, in too narrow and steep-sided valleys, surrounded by trees, too far from feeding areas, so high that they were often frozen, or otherwise unsuitable as roosts. For the remainder, the surface area of water had an obvious influence on whether a site was used. Only 22% of

Table 4. Use of ponds, lakes and reservoirs for roosting by geese in the study area (mossland pools excluded—See Appendix 2)

Area of water (km²)	Total available	Used by Greylag	Used by Pinkfeet	Used by both species	Used by neither species
< 0·1	99	20	2	0	77
0·11–0·20	29	18	4	2	9
0·21–1·00	31	23	13	8	3
> 1·0	6	5	5	4	0
Totals	165	66	24	14	89

ninety-nine waters less than 10 ha in area were used by geese, but this proportion increased with increasing area, and all waters extending over more than 100 ha were used. The two species differed in the water areas they accepted. Greylag used the largest number, including both small and large waters, but Pinkfeet used mainly waters more than 20 ha in surface area (Table 4). Thus, of 128 waters of less than 20 ha in area, thirty-eight were used by Greylag and only six by Pinkfeet, but of thirty-seven larger waters, twenty-eight were used by Greylag and eighteen by Pinkfeet ($P < 0{\cdot}01$). Further, only twelve of the thirty-seven large waters in the area were used by both species together, the remaining twenty-five by one or other, so here again the species tended to separate.

(d) *Moorland pools*

Many roosts were centred on small pools on remote, damp, moors (or mosses). Because of the nature of the ground, such sites were seldom disturbed and all provided a wide view. Geese roosted on the pools themselves or on ground nearby. The map showed nineteen such mosses, with suitable pools, in our area. One of these was used by Greylag alone for roosting, four by Pinkfeet alone, and another two by both species (Appendix 2). Three of the most important Pinkfoot roosts in the area were on east Flanders Moss (Perthshire), Fala Flow (Midlothian) and Hule Moss (Berwickshire). For daytime resting, Greylag used at least another two such sites, and Pinkfeet another four. Also, Pinkfeet rested by day on at least eight other mosses, which lacked permanent water, and Greylag roosted on Cranley Moss (Lanark) when flooding created pools.

In conclusion, the two species differed in their favourite roosting places. Pinkfeet preferred extensive estuarine mud flats, large lochs and reservoirs, and remote mosses; Greylag used these sites to some extent, but also used smaller waters and rivers. In general, sites used by Pinkfeet offered greater security and freedom from disturbance than did many of the sites used by Greylag. This does not explain why Greylag avoided many of the safer sites, unless to avoid Pinkfeet already there. On shared roosts, the two species normally kept to different areas, and flighted independently.

The extent to which any particular roost was used seemed to depend partly on the number of alternatives available, on the relative degrees of security they offered, and the extent of recent disturbance at each. In practice, the numbers of geese at many sites fluctuated greatly from night to night, especially during the shooting season. Appendix 1 gives some idea of the maxima for the different sites recorded during our study, but adding them together would give a figure far in excess of the total geese in the area at any one time.

Rest stations

When feeding several kilometres from a roost, or when the roost offered only a small sheet of water, geese usually adopted areas of moor or rough grass as 'rest stations' from which they commuted to feeding areas nearby. These rest stations were constant from year to year, but not necessarily used throughout a season. Their siting appeared to result partly from the need to be near feeding areas and partly from the need for safety. Sites were often centred on a wide stretch of damp moorland or near the summit of a rounded hill in farmland, but always provided a wide view over surrounding land. The farmland ones were usually as far as possible from a road. One could not approach geese on such sites without being seen. Of twenty-three regular Pinkfoot rest stations found, twelve were on mosses, six on large grassy fields on hillsides, four on offshore sand banks or islands, and one in a damp field. Of twelve Greylag rest stations found, three were on mosses, two on islands, and seven on damp riverside fields (Appendix 3).

Rest stations were used much more by Pinkfeet than by Greylag and possibly helped Pinkfeet to exploit successfully feeding areas distant from roosts. After leaving a roost in the morning, Pinkfeet sometimes flew to a rest station and then, using it as a base, flew to and from the fields throughout the day. At evening, too, Pinkfeet often assembled on a rest station before going to roost. They then approached the roost in much poorer (and possibly safer) light than if they had flown there direct. This behaviour was especially prevalent when the roost offered only a small expanse of water, like the pond on Fala Moor. As a rule each Pinkfoot roost had one or more rest stations associated with it.

Feeding areas

Geese fed on only a small part of the farmland in the study area. Usually each roost

had several associated feeding areas, which varied from a single field to tracts of several square kilometres (Figure 2). (A feeding area was considered separate when it was more than 0·5 km from the next, otherwise the two were classed as one.) Adjacent unsuitable terrain limited the extent of most feeding areas. In general, geese fed most in extensive flat or slightly undulating country, with few trees and hedges, and avoided hummocky or well timbered terrain, with small fields and tall hedges, which restricted their view. They also avoided areas which, though topographically suitable, were much disturbed. Pinkfeet were more extreme in their preferences than Greylag, and often flew further from their roost to feed. We have tried to quantify this last difference in the study area by calculating the proportion of the total feeding area of the two species which lay at various distances from the nearest roost (Table 5). Analysis was restricted to the area north of the Forth where feeding areas were best known. In this area 90% of the Greylag's total feeding ground was within 5 km of a roost, and only 2% more than 10 km away compared with 66% and 15% for the Pinkfoot. About 1% of the Pinkfoot's feeding areas were more than 20 km from a roost. (The difference between the species is significant at the 0·1% level.) No account was taken of the extent to which the two species used feeding areas at different distances, nor the fact that geese did not invariably fly to the nearest roost from a particular feeding area.

Spatial separation of the two species

Differences in roosting sites and flighting distance tended to separate the two species and reduced the extent to which they fed on the same ground. Also Greylag generally preferred to be near rivers and Pinkfeet on extensive open areas, however far from water. North of the Forth, geese of one species or the other fed over about 351 km² of land, Greylag alone over 151 km², Pinkfeet alone over 153 km², and the two species together over only 47 km². Hence only 13% of the total goose country was used by both species.

Changes this century in the distribution of geese in the study area

Because of the sporting value of geese, their distribution over the years was well documented (Baxter & Rintoul, 1953; Harvey-Brown, 1906; Millais, 1901; Muirhead, 1895; Nash, 1935). Both species seem to have been increasing in Britain at least since 1880. The evidence up to 1930, mostly based on memory records, was given by Berry (1939), but since 1950 counts organized by the Wildfowl Trust have confirmed the trend (Boyd & Ogilvie, 1969, 1972). Throughout, moreover, the increase has been most marked in Scotland.

Not only did numbers rise at established roosts, but new sites were also occupied, mainly inland. The spread inland was probably encouraged by: (1) increased disturbance at coastal sites resulting from greater public wildfowling, aircraft and military activities (Berry, 1939); (2) construction of reservoirs (= roosts) in areas lacking natural lakes; (3) removal of trees and hedges, creating open spaces attractive to geese in inland areas formerly unsuitable; and (4) more autumn ploughing near the coast rendering much ground useless to geese thereafter, and improved management of grass in the uplands providing better feeding there than formerly (Brotherston, 1964).

The main coastal sites occupied in 1875–1900 were Montrose Basin (Pinkfeet), Inner and Outer Tay (both species), Edenmouth (both species), Grangemouth Flats (Pinkfeet), Aberlady Bay (both species) and Tyninghame (Pinkfeet). The main inland sites were Loch Leven (both species), Cobbinshaw Reservoir (Pinkfeet), Hule Moss (Pinkfeet), Coldingham Moss (Pinkfeet), Flanders Moss (both species), two unspecified mosses in Lanarkshire (Pinkfeet), and Fala Flow (Pinkfeet). The Pinkfoot was thus most widespread, roosting at fourteen sites (eight inland), compared with the Greylag's five (two inland). At that time, the Greylag shared all its roosts with the Pinkfoot, which always outnumbered it. Today the Pinkfoot has twenty-five major roosts (nineteen inland) in the same area, and the Greylag twenty-nine (twenty-eight inland); north of the Forth, both species are about equally numerous, but to the south the Pinkfoot still predominates, less so than in 1950. Now the Greylag shares only nine of its twenty-nine main roosts with the Pinkfoot, so the two species are also more segregated than formerly. The disappearance this century of Pinkfeet from Coldingham can be attributed to the destruction of the moss by ploughing, but Greylag have recently adopted the ponds remaining.

Several roosts in the study area have

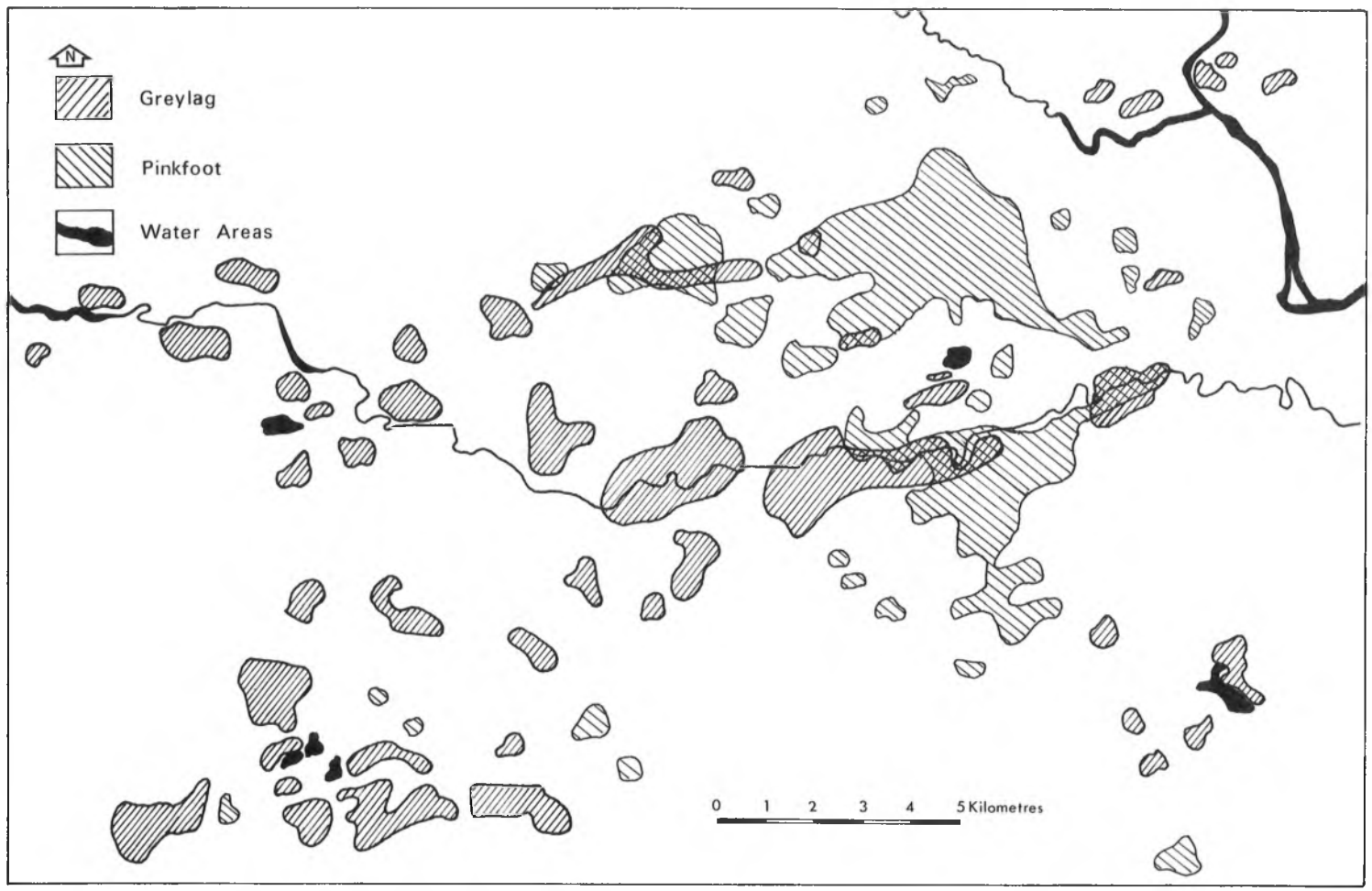

Figure 2. Part of the study area, showing the separation of feeding areas of Greylag and Pink-footed Geese.

Table 5. Extent of total feeding area of geese lying at different distances from roosts

	Distance from nearest roost (km)				
	0–2	2–5	5–10	10–20	20–30
% Greylag feeding area	49	41	8	2	0
% Pinkfeet feeding area	24	42	19	14	1

*Greylag alone fed over 151 km² of the study area north of the Forth, Pinkfeet alone over 153 km², and both species together over 47 km².

experienced fluctuating usage by geese over the years associated with changes in disturbance. Coastal sites, being public, were generally more disturbed than inland ones, the more so in recent years because of increased mobility of wildfowlers. At the Tay and Forth Estuaries military operations were also involved (Berry, 1939; Brotherston, 1964). Some coastal sites, with public access, such as Montrose, Eden, Grangemouth and Tyninghame, which were formerly important, are now little used until after the shooting season each year. Likewise the use of Cobbinshaw by Pinkfeet has declined since shooting increased there, while Harperig was largely deserted by Greylag for a time in favour of Threipmuir under the same conditions. On the other hand, the use of Aberlady Bay increased again after it became a nature reserve in 1952 (Brotherston, 1964). These changes provide circumstantial evidence for the importance of disturbance in influencing goose-distribution.

One last point worthy of comment is the increased importance to both species of reservoirs and other artificial lakes. Nowadays eight of the twenty-nine main Greylag roosts in the study area, and nine of the twenty-five Pinkfoot ones, were on man-made waters.

Conclusions

Potential limits to the distribution of geese in the study area were set by the location of suitable roosting sites in or near farmland, where all feeding was done. Within this framework, the distribution of the birds was then influenced mainly by disturbance, which banished or reduced them in certain areas and led to their increase in others. The degree of safety offered by an area was influenced by two types of factors. First were those imposed by the environment. For roosting, coastal and estuarine sites were intrinsically the most attractive to geese because they were the most extensive and open, while inland, large waters were more attractive than small ones. For feeding, open, flat or slightly undulating country, with a minimum of trees and hedges, was preferred to hummocky, well timbered country, with small fields. Second, actual disturbance, caused by shooting, human presence and other factors, superimposed its own pattern on that set by topography. The extent to which a particular roost or feeding area was used seemed to depend on the balance between its intrinsic attractiveness and the degree of actual disturbance. Lastly, while geese clearly linked disturbance with particular sites, the degree of overall shooting probably also affected the minimum requirements for roosting and resting areas, a heavily shot population using only the safer of a range of sites and a lightly shot population accepting others.

Differences in roosting, feeding and flighting habits between the species could be attributed largely to the greater wariness of the Pinkfoot and its stronger reaction to disturbance. For roosting, it used places which were especially safe, either because of their intrinsic characteristics, or because they were remote and otherwise free from disturbance. The avoidance of some of these sites by Greylag is puzzling, unless to avoid Pinkfeet. On shared roosts, the two species normally kept apart, and several times this century Greylag segregated completely from Pinkfeet when an alternative roost in an area became available (Brotherston, 1964). Last century all the Greylag roosts were shared by Pinkfeet, but now that more waters are occupied, less than one-third of the Greylag roosts are shared (Appendix 1).

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Summary

In southeast Scotland immigrant Greylag and Pink-footed Geese fed entirely on farmland (including grassland), where their distribution was governed by the location of suitable roosts, from which they flew to restricted feeding areas nearby. Continual movement took place between different roosts, and peak numbers occurred in different months in different districts.

Pinkfeet preferred the safer of a range of sites for roosting, including estuaries, large lakes and reservoirs, and remote moorland pools, while Greylag also used less safe sites, including small ponds and rivers. Of forty-five major goose roosts in the study area, only nine were used regularly by both species, the rest by one or other. On shared roosts the two species kept apart.

Pinkfeet were also more particular in their choice of feeding areas, and often foraged further from their roosts than did Greylag. Greylag rarely flew more than 5 km to feed, but Pinkfeet regularly more than 10 km, and occasionally more than 20 km.

Differences in roosting and flighting habits led to spatial separation of the two species on farmland and, of the total goose country in the study area, only 13% was occupied by both species together, the rest by one or other.

Within limits set by the location of suitable roosting and feeding areas, the distribution of geese, was influenced mainly by disturbance, especially shooting.

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Appendix 1. Sites on which geese were known to roost in the study area, 1966–70. A: usual maximum number more than 2,000; B: 1,000–2,000; C: 500–1,000; D: less than 500.

Greylag

O.S. map 49: Haughs of Tay south of Pitlochry (D), Dowally Loch (D), Craiglush Loch (D), Loch of the Lowes (D), Butterstone Loch (D), Loch Benachally (D), Loch Clunie (A), Kings Myre (D), Broomhill Pond (A), Bloody Inches (A), Marlee Loch (B), Dykeside Moss (D), Fingask Pond (D), Stormont Loch (A), Hare Myre (D), Monks Myre (A), Lintrathen Loch (C), Long Loch (D), Redmyre (D), Airntully Pools (D).

O.S. map 50: Kinnordy (C), Forfar Loch (B), Rescobie/Balgavies Loch (B), Monikie Reservoir (D), Duns Dish (C).

O.S. map 54: Lake of Menteith (B), Loch Rusky (D), Flanders Moss (A), Muir Dam (D), Airthrey Loch (formerly D), Braco Pond (D), Loch Monzievaird (D), Loch of Balloch (D), Cowden Loch (D).

O.S. map 55: Drummond Pond (A), Carsebreck Ponds (A), Glendevon Reservoirs (D), Meallbroden Loch (D), Gartmorn Dam (D), Peppermill Dam (D), Pitcairnie Pond (A), Craigluscar Reservoir (D), Bertha Loch (C), Loch Glow (D), Glenfarg (B), Loch Leven (A), Loch Fitty (D), Loch Ore (D), Earn-Nether Fordun (C), Earn-Dalreoch (B), Earn-Inverdunning (C), Tay-Mugdrum Island (A), Tay-Dog/Carthegina Banks (C) Harperleas Reservoir (D), Ballo Reservoir (D), Holl Reservoir (D), Forth-Alloa Inches (C)j

O.S. map 56: Loch Lindores (C), Dunshelt Moss (C), Carriston Reservoir (D), Clatto Reservoir (D), Kilconquhar Loch (D), Carabee Pond (D).

O.S. map 61: Springfield Reservoir (D), Grangemouth Flats (C), Crosswood Reservoir (D), Crane Loch (D).

O.S. map 62: Harperig Reservoir (D), Threipmuir (C), Portmore Loch (D), Gladhouse Reservoir (B), Allanshaws Reservoir (D).

O.S. map 63: Stobsheil Reservoir (D), Watch Reservoir (C), Coldingham Ponds (D), Hirsel Lake (D).

O.S. map 64: Hoselaw Loch (C).

O.S. map 68: Cranley Moss (D).

O.S. map 70: Yetholm Loch (D).

Pinkfoot

O.S. map 49: Redmyre Moss (D).

O.S. map 50: Forfar Loch (A), Rescobie Loch (A), Montrose Basin (C).

O.S. map 54: Lake of Menteith (B), Flanders Moss (A), Loch Mahaick (A).

O.S. map 55: Carsebreck Ponds (A), Glendevon Reservoirs (D), Peppermill Dam (D), Dupplin Loch (A), Clevage Moor (D), Glenfarg (C), Loch Leven (A), Loch Fitty (D), Loch Ore (D), Tay-Mugdrum Island (A), Tay-Dog/Carthegina Banks (A), Tay-Abertay Sands (A), Harperleas Reservoir (D), Ballo Reservoir (D), Forth-Inches near Alloa (D).

O.S. map 56: Edenmouth (C), Cameron Reservoir (A).

O.S. map 61: Springfield Reservoir (D), Grangemouth Flats (C), Cobbinshaw Reservoir (C), Crane Loch (D), Bowmuir (D).

O.S. map 62: Westwater Reservoir (A), Baddinsgill Reservoir (A), Gladhouse Reservoir (A), Fala Flow (A), Aberlady Bay (A).

O.S. map 63: Hopes Reservoir (D), Tyninghame (D), Hule Moss (A).

O.S. map 68: Loch Lyock (D), Floods on Clyde, Quothquharn (B), Upper Cowgill Reservoir (C), Culter Reservoir (D).

Appendix 2. Mosses and moors used for roosting and resting by geese. G: Greylag; P: Pinkfoot.

Areas with ponds used for roosting: Bowmuir (P), Crane Loch (P), Dunshelt (G) Fala Flow (P), Flanders Moss (PG), Hule Moss (P), Redmyre (PG).

Areas with ponds used for resting: Auchterhead Muir (P), Clevage (P), Cranley Moss (G) Dykeside (G), Kippen Muir (P), Rossie Moor (P).

Areas without ponds used for resting: Auchencorth Moss (P), Esperson Moss (P), Toxside Hill Moss (P), Cocksmuir (P), Middleton Muir (P), Methven Moss (P), Muir of Orchill (P), Sherriffmuir (P).

Appendix 3. Rest stations of geese in study area. G: Greylag; P: Pinkfeet.

Strathmore: Rossie Moor (P), Redmyre (GP), Wester Essendy Farm (G).

Strathtay: Tentsmuir Point (P), Abertay Sands (P), Mugdrum Island (GP).

Strathearn: Methven Moss (P), Bachilton Farm (P), Pow Water (G), East Fordun Farm (G), Bogtonley Farm (P), Denmarkfield River Shingle (G), Milton of Forteviot Farm (G), Lauchie Farm (P), Kilspindie Farm (GP), East Forden Farm (G).

Kinross Plain: St Serfs Island, Loch Leven (P).

Eden Area: Dykeside Moss (G).

Forth Valley: Kippen Muir (P), Flanders Moss (GP), Sherriffmuir (P), Muir of Orchill (P).

Moorfoot Hills: Toxsidehill (P), Esperton Moss (P), Middleton Moss (P), Cakemuir Hill (P), Auchencorth Moss (P), Halflow Kiln Farm (P), Cocksmuir (P).

Lanark Hills: Cranley Moss (G).

E. E. Jackson

Plate IV. Diving ducks on land. Above: a male Canvasback *Aythya vallisneria* shows that it can maintain a horizontal posture despite its far-back legs. Below: a pair of Ring-necked *Aythya collaris* unusually have erected crests (part of the courtship) while ashore.

Philippa Scott

Wildfowl (1973) 24:123–130

The management of grassland areas for wintering geese

MYRFYN OWEN

Introduction

Grass is an essential part of the food of most British wintering geese. There is no shortage of pasture in Britain, but much is unavailable to geese.

Most of the areas now used by wintering geese are managed solely for agriculture and in many cases the requirements of the birds conflict with those of the farmer. There is a decline in the area of semi-natural grassland, much being claimed for intensive agriculture or, particularly near estuaries, for industrial development. The creation and efficient management of refuges, albeit quite small, in areas of high goose concentrations can help to safeguard those populations and lessen conflicts with agricultural interests on surrounding land.

Research into the feeding behaviour and food requirements of geese on grassland has been carried out at the Wildfowl Trust for the past 5 years. The main study has been on White-fronted Geese *Anser a.albifrons* (Figure 1) at the New Grounds, Slimbridge, and the detailed results have been published (Owen, 1971, 1972a,b). This paper summarizes that work, current studies on the Barnacle Geese *Branta leucopsis* (Figure 2) at Eastpark, Caerlaverock, Dumfriesshire, and recent work by other authors, to suggest management procedures. The main aims of management are to increase the carrying capacity of refuge areas to a maximum and ensure that geese are provided with easily available food of good quality so that they can withstand adverse weather and attain optimal body condition for migration and breeding; it is also necessary to ensure that geese are available for observation as leisure time and interest in nature conservation increases.

It is essential to have suitable feeding grounds reasonably close to a safe roosting place. This has been discussed in detail for Greylag *Anser anser* and Pink-footed Geese *Anser brachyrhynchus*, two species normally associated with arable agriculture, by Newton, Thom & Brotherston (1973), and their conclusions apply to other goose species. The effect of disturbance or of a change in land use often overrides a traditional attachment to certain areas (Ogilvie, 1968). Barnacle and Brent Geese *Branta bernicla* are generally more sensitive in this respect than British grey geese.

Within this broad pattern, factors affecting the availability, quantity and quality of food are important influences on the attractiveness of goose haunts.

Figure 1. A group of White-fronted Geese *Anser a. albifrons* in the Tack Piece at Slimbridge, in the alert, head-up posture.

Philippa Scott

Philippa Scott

Figure 2. Barnacle Geese *Branta leucopsis* feeding on arable land at Caerlaverock and drinking from the shallow scrapes left when excavating the screen banks. (Two birds have leg rings put on at least 10 years previously.)

Disturbance

Most British geese have long been quarry species and even those that are now protected are still occasionally shot. Thus, geese have a reinforced fear of human beings and the sights and sounds associated with shooting. Disturbance is the most important factor controlling the availability of feeding areas. White-fronted Geese used the least disturbed areas of the Slimbridge refuge early in the season and subsequently moved to other smaller fields closer to human activity. Newton & Campbell (1970) came to similar conclusions working on Greylag and Pink-footed Geese at Loch Leven, Kinross, Greylags being the less sensitive.

Disturbances can be separated into several types which elicit different reactions.

(a) *Shooting*

Occasional and limited shooting only causes local movements of the geese. At Slimbridge, when Whitefronts are shot on the refuge, they move to fields outside it, but soon return. Heavy shooting pressure does keep geese away from otherwise favourable habitat, and such areas are sometimes heavily used when the shooting season ends.

(b) *Other ground disturbances*

In agricultural areas these are usually related to stock management, but may also be due to recreational activities. Riders are less disturbing than men on foot and are sometimes able to approach to within 50 yards of a flock of wild geese. Geese also quickly become used to vehicles.

Stock on fields are no deterrent to most goose species. Greylag Geese walk among sheep while feeding on turnip fields and also take swedes scattered for outwintered stock (Kear, 1963). However, Barnacle Geese are frequently put to flight by advancing cattle and keep away from fields where stock is present.

Ground predators, such as foxes and stoats are usually kept under observation but do not often put the birds to flight.

(c) *Aerial disturbance*

Large birds or birds of prey may cause some disturbance. Barnacles are put to flight by Kestrels and Sparrowhawks as well as Herons, whereas Pinkfeet in the same situation are relatively unconcerned.

Helicopters are extremely disturbing to all geese on their wintering grounds. Low flying small 'planes usually put geese to flight and in some cases cause them to seek the safety of the roost or refuge areas. Barnacle Geese at Caerlaverock are sometimes raised by small aircraft at a distance of 1–2 miles. Larger planes are usually less disturbing, and even Brent Geese can become indifferent to their taking off and landing.

(d) *Noise*

Noise is less important than visual disturbance, but sudden sounds such as the starting of an engine, and especially shots or bangs usually have an effect. The birds habituate to regular noises, and to be lastingly effective, scaring devices relying on banging must have their timing and position varied frequently.

Geese also keep away from unfamiliar objects, and from cover such as hedges, apparently because they are regarded as potential sources of danger. In undisturbed situations Whitefronts spend about 3% of their time in alert behaviour, but much more in relatively 'disturbed' situations. This increased vigilance takes place at the expense of feeding.

An attempt was made to quantify the effects of potential and actual disturbing influences on forty-seven fields at Slimbridge. 'Avoidance values' were calculated for each field, by allocating arbitrary points according to distance from roost (0–2), size of field (0–20), extent of hedges or banks (0–5), shepherding frequency (0–15), distance from roads or canals (0–10), distance of bordering roads or canals from field centre (0–30). The sum of the avoidance values for each field is the 'avoidance index', and this varied from 1 for the Dumbles, a large, open, undisturbed field, to 62 for a small field bordered on one side by a canal, on another by a farm track and on another by farm buildings. Plotted against the mean goose usage for the four seasons, 1968–69 to 1972–73 (Figure 3), the correlation coefficient is—0·809, which is significant at the 0·1% level. This is remarkably strong considering that there were

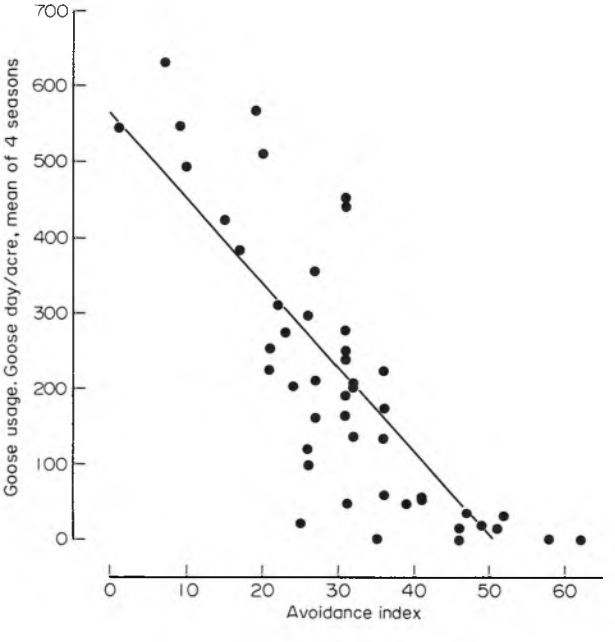

Figure 3. Regression of goose usage of forty-seven fields at the New Grounds refuge, Slimbridge, on the 'avoidance index' (see text).

considerable vegetational differences between the fields. It was calculated that disturbance at the New Grounds resulted in only half the potential usage of the refuge (700 goose days per acre on most favoured fields) being realized.

Feeding requirements

1. *Broad ecological characteristics*

It has often been stated (e.g. Markgren, 1963; Philippona & Mulder, 1960) that geese prefer the vegetation of marshy areas, because geese are associated with such habitats. However, many species, when given the choice, prefer to feed on the higher quality grasses usually found in better-drained situations. For example, Newton & Campbell (1970) found that both Greylag and Pink-footed Geese preferred recently sown, nutritious grasses, and no relationship was found between the wetness of fields and their use by White-fronted Geese at Slimbridge.

However, there is still an advantage to the birds in having standing water on fields. Geese require to drink during the day, and in situations where water is constantly available, White-fronted Geese spend more than 2% of their daytime drinking (up to 25% of non-feeding activity). In situations where water is not freely available, the birds have to fly, usually to the roost, in order to drink and bathe. This may mean travelling long distances (Pink-footed Geese at Loch Leven travelled several miles to the roost at midday). Geese which rely on grass in mid-winter and spend up to 95% of their daytime feeding can ill afford such expenditure of time and energy. In general, however, the occurrence of geese in marshy situations is probably due to the fact that farm stock is not outwintered in such areas, and there is thus little disturbance.

Geese like to feed in open fields with a clear view on all sides. Vegetation more than 30 cm in height discourages usage, and fields with tall rushes are generally avoided by White-fronted Geese at Slimbridge. Similar areas, where the rushes have been cut in late summer, are visited.

2. *The quantity of food*

Most geese when on pastureland feed mainly on grass. Other items are important, especially the stolons of white clover *Trifolium repens*, and, exceptionally, other items such as seeds (Owen & Kerbes, 1971). 'Grass' includes other low herbs whose leaves or shoots are obtained by the goose's normal rapid pecking.

(a) *Grass*. The quantity of grass available on fields in winter is affected by the amount of grazing by farm stock in autumn and by the amount of grass growth during winter. Other grazing animals (such as hares) are usually at too low a density to have much effect on goose foods.

The agricultural management of the New Grounds at Slimbridge was monitored in 1969–70 and 1970–71. There were no obvious differences between grazing and hay cutting as forms of summer management, but stock grazing intensity in early winter was very important. The effect of different grazing regimes on goose usage of five favoured fields in shown in Figure 4. These fields are close to observation facilities and goose usage was accurately determined. The goose usage figures were weighted to take account of different disturbance pressures. It was then calculated that if farm stock were removed from the New Grounds during winter then the goose-carrying capacity could be increased by 30%. This took into account disturbance from shepherding activities as well as quantity of food.

In 1971 the farming tenant died and in April 1972 the management of some 380 acres (154 hectares (ha)) of the New Grounds was taken over by the Wildfowl Trust. About 300 acres (120 ha) of this, the inner refuge, was now managed primarily for the benefit of the geese. Table 1 shows the goose usage of the whole refuge and of the inner refuge area over five seasons, in terms of 'goose days'. This figure is based on a daily count of the geese through most of the season. The table shows that the proportion of goose time spent on the inner refuge is much higher in the last two seasons and especially in 1972–73 when management for geese was fully effective; the usage per acre has almost doubled. The main management change was the withdrawal of stock from the fields most favoured by geese (Dumbles) at the end of September and from nearby fields (those shown in Figure 2) at the end of October. No stock were allowed on any fields after the end of November. Goose usage of both the previously undisturbed areas and disturbed areas has been greater, indicating that increase in food supply and decrease in disturbance were jointly responsible.

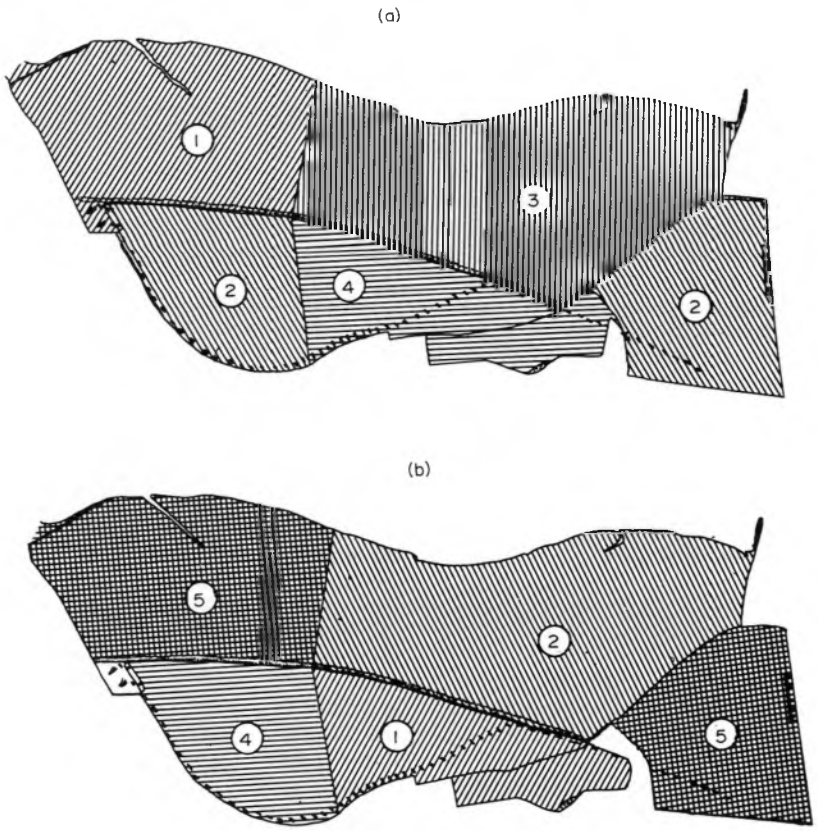

Figure 4. Stock grazing pressure and goose usage of the favoured fields at the New Grounds, Slimbridge. Usage increases with increasing field number. Goose usage values are corrected for disturbance (see text). Data adapted from Owen 1972b. (a) Stock grazing pressure, Oct.–Dec. 1969; (b) total goose usage 1969–70.

Table I. Goose usage of the whole of the New Grounds and of the 'inner refuge' in five seasons

Season	New Grounds		Inner Refuge		
	Total goose days (thousands)	Approximate goose days/acre	Goose days (thousands)	Approximate goose days/acre	Proportion of total of inner refuge
1968–69	397	310*	133	470	34
1969–70	417	300*	104	370	25
1970–71	321	260	139	490	43
1971–72	211	170	143	510	68
1972–73	324	260	238	780	74

* Some of the total usage was outside the main refuge area.

(b) *Clover stolons.* White clover stolons in grassland can be very important goose food. For example, they constitute up to 60% of the food of Barnacle Geese during their stay at Caerlaverock. Pink-footed Geese feeding on the same salting pasture also feed on stolons. White-fronted Geese take substantial quantities of stolons especially during wet weather.

The quantity of stolons in pasture depends on several factors, but on the Caerlaverock saltings the height of the vegeta-

ference can be attributed solely to the difference in vegetation composition and probably in its nutritive value.

Not much is known about the quality of clover stolons. This certainly varies as starch is laid down in autumn and used up for leaf growth in spring. The weight per unit length, which varies with clover varieties, has an important bearing on intake rate. Barnacle Geese at Caerlaverock do not usually eat stolons when on reseeded grassland, although stolon density there may be higher than on saltings. This suggests some difference in stolon quality.

Acknowledgments

I am indebted to Mr G. B. Cross who collected information on goose movements during the 5 years of the Slimbridge study. Messrs J. S. Adams, T. A. Gibson and A. B. Rylands also assisted. Most of the field work at Caerlaverock was carried out by Mr C. R. G. Campbell. I am grateful to Mr S. E. Allen for nutritional analysis of vegetation and to Dr J. Kear for a critical reading of the manuscript.

Summary

Basic management policies for semi-natural and agricultural grassland to improve them as goose habitats are set out.

Disturbance is the most important single factor, and various types are listed and their relative importance considered. A relatively objective 'avoidance index' was computed, which showed a negative correlation coefficient greater than 0·8 with actual goose usage over four seasons.

The presence of standing water, at which they can drink, preen and bathe, on the feeding grounds is beneficial to grazing geese in midwinter when up to 95% of their daytime must be spent feeding.

The quantity of grass in winter is affected by farm stock grazing pressure in autumn and early winter. The quantity of clover stolons, another important goose food, on salting pasture increases as summer stock grazing pressure, which affects vegetation height, increases.

The selection of feeding sites and food by Whitefronts was shown to be in part determined by the nutritional quality of that food. Quality can be increased by proper summer grazing management, cutting, fertilizing and reseeding.

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The manurial effect of Cape Barren Goose droppings

RICHARD W. MARRIOTT

Introduction

There are many ways in which geese interact with agriculture. One of these is the effect of their droppings (the term 'droppings' is used rather than 'faeces' because they include the product of the kidneys, which is largely uric acid). The droppings are often alleged to 'foul' the pasture. This 'fouling' is said to include the burning of the pasture plants, presumably due to ammonia (Kear, 1963) and making the grass unpalatable to sheep (Rochard & Kear, 1968, 1970). Cape Barren Geese *Cereopsis novaehollandiae* feeding on managed pastures in Australia are similarly accused of 'fouling' pasture.

Methods

Attempts were made to crop pasture following applications of goose droppings, but these failed in 2 consecutive years due to the effect of drought. Weed species came up to such an extent that the effect of the droppings on the pasture species was blurred. In the third year a rye grass and clover mixture was grown in boxes (25 cm × 25 cm) outdoors and droppings applied to the growing plants. The fresh droppings were crumbled and scattered evenly over the grass. Three levels of application, 10, 20 and 30 g wet weight of fresh droppings, were used plus a control to which no droppings were added. There were nine replicates of each application and control.

The droppings were applied three times at monthly intervals, beginning after 1 month's growth of the grass, making totals of 30, 60 and 90 g. The droppings were collected fresh from geese in the A. J. Marshall Reserve, Monash University.

A dropping's wet weight is approximately 4 g so the applications are equal to approximately 128, 256 and 384 droppings per sq. m. The maximum density ever recorded at one time on managed pasture at Yanakie (S. E. Victoria) was eighty-one droppings in a sq. m, and over 40 per sq. m were recorded commonly in the dry summer of 1967 around a stock dam (Figure 1). The rate of disintegration of droppings is not known

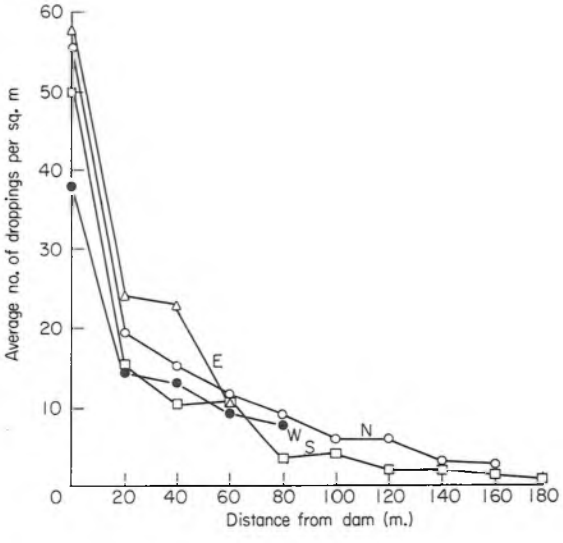

Figure 1. The distribution of Cape Barren Goose droppings in a paddock at Yanakie, S. E. Victoria in March 1967. The numbers of droppings per sq. m are the averages of ten 1-sq.-m quadrats placed at right angles to a transect line running from a stock dam to the paddock fence. The letters indicate the approximate compass bearings of the four transect lines. The transects show a marked concentration of droppings immediately around the dam.

and probably varies with the weather, but a figure of one month is assumed. The geese spend about 3 months in the paddocks in large numbers. Therefore the maximum number of droppings likely to be produced in a sq. m of paddock is probably $3 \times 81 = 243$, and the applications used in this trial span the likely maximum manuring to be expected. After 4 months' growth the grass was cropped with shears. The clover had scarcely grown by the time it was cut and contributed a negligible proportion of the final crop.

Results

There is a clear increase in the production of grass following the three applications of goose droppings (Table 1). The differences

Table 1. The manurial effects of Cape Barren Goose droppings (mean weight (g) of grass cropped per 25 × 25 cm box)

Treatment	Wet weight	Dry weight	p*
Control	33·8	5·3	–
+ 30 g Droppings	44·3	6·6	1·10
+ 60 g Droppings	63·7	8·9	0·001
+ 90 g Droppings	66·6	9·5	0·001

*P = the probability that the differences from the control are due to chance (student t-test). The probabilities were the same for wet and dry weights.

between the applications and the control were significant at the $P = 0{\cdot}001$ level for the two denser applications but not the + 30 g one ($P = 0{\cdot}1$). The differences between the applications were significant for the 30 versus 60 g application ($P = 0{\cdot}001$) but not for the 60 versus 90 g application (P = greater than 0·1).

Discussion

It is clear that the overall effect of Cape Barren Goose droppings on grass was to increase growth. The increase at the lowest rate of application was not significant but the final crop at the maximum rate of application was nearly twice that of the control. This suggests that on managed pastures only the highest densities of droppings close to stock dams (Figure 1) will have a significant effect on the pasture growth. It is interesting in this connection that the farmer at Yanakie (S. E. Victoria) who complained about the geese in one of his paddocks admitted that the pasture came up very lush and green where the geese had been, following harrowing and rain. There was no appearance of a burning effect of the droppings on the grass even at the maximum application, and any undetected effect is clearly outweighed by an enriching effect. No attempt was made to determine whether the droppings had an effect on the nutrient content of the grass.

The other effects of goose droppings were not investigated. Sheep were never seen obviously to avoid areas 'fouled' by goose droppings, and they often fed close to geese. Marshall (1966) claimed that preliminary experiments showed that sheep did not avoid areas where Cape Barren Geese had been, but he gave no data at all. Rochard & Kear (1968) showed that sheep did dislike goose droppings, but in field trials (1970) found this effect to be short-lived and thus unlikely to be the cause of real loss to the farmer. Such a dislike could still be locally important where goose droppings are markedly concentrated around stock dams (Figure 1).

Rochard & Kear (1968) cited observations of sheep and cattle eating goose droppings presumed to contain minerals from other areas where the geese had fed or gritted. In view of this ability of stock to overcome their distaste of goose droppings it may be worthwhile to speculate about what happens on some of the Bass Strait islands in the dry summer period. On Big Green Island (Furneaux group, Tasmania) fresh droppings were sometimes harder to find than expected. The suspicion that sheep were eating the droppings was purely subjective and unfortunately could not be tested. The question arises as to what they would gain if they did. The geese were resident and could not have been bringing in minerals from elsewhere. As the pasture at this time of year is largely dried-off grass with a very low nitrogen content (Marriott, 1970) the nitrogen in the goose droppings—particularly that in the uric acid—would be beneficial if the sheep could utilize it. Coombe & Tribe (1963) found that sheep fed low quality roughage diets could utilize supplementary urea and improve their nitrogen balance, and reduce weight loss. In a preliminary report Lawes & Kenwood (1970) refer to experiments being set up where sheep and beef cattle were being fed diets containing $12\frac{1}{2}$ and 25% poultry manure. They comment that poultry waste may be a better additive than urea because the uric acid is less soluble, and being slower acting is less likely to release too much toxic ammonia. If sheep on Bass

Figure 2. A pair of Cape Barren Geese *Cereopsis novaehollandiae* on Big Green Island, Furneaux Group, Tasmania.

Strait islands could overcome their distaste of goose droppings (as other sheep apparently can in some circumstances) and utilize the uric acid, the presence of Cape Barren Geese on the islands in summer could be beneficial. This idea might repay further investigation.

Acknowledgments

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Summary

Fresh droppings from Cape Barren Geese *Cereopsis novaehollandiae* applied to grass produced an increase in the weight of grass cropped after 4 months. No 'burning' effect on the grass was observed.

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Plate V. Close ups of the two forms linking Anatidae to other groups. Above: a Caribbean Flamingo *Phoenicopterus ruber ruber* demonstrates its suction/filter feeding. Below: a pair of Black-necked Screamers *Chauna chavaria* indulge in mutual preening.

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Studies of shorebirds at Lindisfarne, Northumberland. 1. Feeding ecology and behaviour of the Bar-tailed Godwit

P. C. SMITH AND P. R. EVANS

Introduction

The Lindisfarne National Nature Reserve in north Northumberland (Figure 1) covers about 3,000 ha (12 sq. miles), chiefly tidal mud- and sand-flats, saltmarsh and dunes. It is famous chiefly for its wildfowl and shorebirds, as described in the vivid writings of Abel Chapman (1907). Lindisfarne is an important wintering area for Wigeon *Anas penelope*, Pale-bellied Brent Geese *Branta bernicla hrota* and Whooper Swans *Cygnus cygnus* among the wildfowl; maximum counts of these species in the winter of 1970–71 were 27,000, 1,000 and 430 respectively (Prater, 1971). In that same winter the total sum of the maximum counts of all shorebird species was 33,320, which placed the area eleventh in importance amongst British estuaries. The nearest estuaries which hold appreciable numbers of waders are the Forth (80 km north) and Teesmouth (130 km south), both of which are threatened by reclamation and further industrialization, and by oil pollution. Their loss would displace at least 60,000 shorebirds and several thousand Shelduck *Tadorna tadorna*. In these circumstances, it seemed imperative to investigate the potential 'carrying capacity' of the Lindisfarne Reserve for different species of waders and wildfowl. Studies were begun in January 1970, with the full co-operation of the Nature Conservancy and under the general

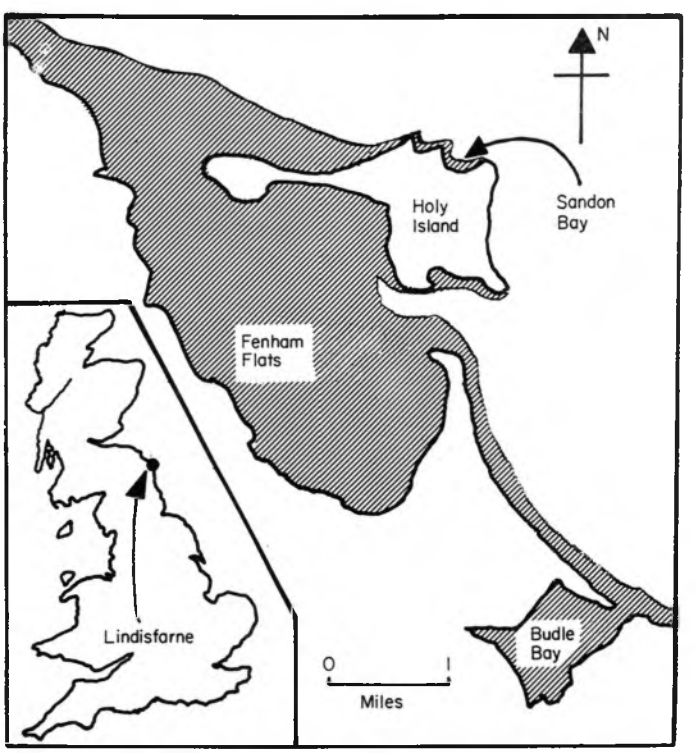

Figure 1. Lindisfarne, Northumberland. The intertidal sand and mud-flats lying within the National Nature Reserve are shown cross-hatched.

direction of P.R.E. This paper summarizes part of the findings of 3 years' research by P.C.S., particularly on the relationship of sexual dimorphism to feeding ecology and behaviour of Bar-tailed Godwits *Limosa lapponica*. While data were collected on this species, which both feeds and roosts on the Reserve, observations were also made on the use of the mudflats by several other wader species, notably Curlew *Numenius arquata*. These observations will be reported later.

The British Isles hold an important fraction of the populations of Bar-tailed Godwits which winter in western Europe. A total of just over 37,000 were recorded on British estuaries in January 1971 (Prater, 1971). Lindisfarne holds about 10% of that number in most winters. The majority of the birds arrive in late August and September, young preceding adults, and peak numbers are usually reached in December and January. In the recent mild winters, numbers have dropped below 1,000 as early as mid-February, but some wintering birds normally stay until April. Migrants pass through later, in May.

Remarkably little has been published on the feeding ecology of Bar-tailed Godwits, probably because the large flocks are found only on extensive sand- and mud-flats during the non-roosting period. Thus, while feeding, they remain beyond convenient observational range from the shore, except where small flocks and individuals occur, scattered in sandy bays along the coast. As will be mentioned later, the feeding behaviour of these solitary birds is not typical of the behaviour shown by birds in flocks.

Godwits feed chiefly at the tide edge or in water up to about 15 cm (6 in) deep. They return from high tide roosts as their feeding areas are uncovered by the ebbing tide, usually 2–3 hours after high water. They then follow the tide in its ebb and flow, feeding for 4–6 hours (depending on daylength and weather). Some birds also feed by night during periods of full moon and on dark nights in mid-winter, but as yet we have insufficient data to indicate how important such feeding is to satisfy the birds' daily energy requirements.

In terms of biomass, the most important food of the Bar-tailed Godwit at Lindisfarne is the lugworm *Arenicola marina*. (Intensive bait-digging by fishermen in the major wintering areas may thus seriously affect the future of this wading bird.) Other important prey are the ragworm *Nereis diversicolor* and a variety of small oligochaetes, polychaetes and molluscs, which often dominate the diet in numbers taken but are less important in terms of weight. Female Godwits take slightly larger size-classes of prey than do males. The importance of the different worm species in the diet was assessed mainly by direct observation of prey taken. The gut and gizzard contents of birds shot while feeding gave information chiefly on size-classes and on 'hard-shelled' items of diet.

The species shows sexual dimorphism, females larger than males, as in all British wader species except Ruff *Philomachus pugnax*. This dimorphism is greatest in bill-length; that of females averaging about 30% more than that of males (Table 1). It is probable that adults of each sex have slightly longer bills than the corresponding juveniles. Females are also slightly longer in the leg, and can thus wade in deeper water than males.

With a little practice the two sexes can be separated quite reliably in the field by comparing the length of the bill against that of the head (which varies very little between the sexes).

Table 1. Bill and tarsus lengths of Bar-tailed Godwits at Lindisfarne, Northumberland

	Bill	Tarsus
Males	77·0±3·1 mm	48·5±1·0 mm
Females	97·7±3·5	54·3±1·1

Figures quoted are mean ± standard error for sample sizes of twenty of each sex. Bill length was measured from feathers to the tip of the upper mandible, tarsus from the proximal end of the tibio-tarsus to the hallux.

Methods

Observations were made by telescope from the dunes at Sandon Bay, Holy Island and from simple hides, constructed from straw bales, set near low water mark out on the mudflats. Data were recorded on tape and transcribed later. When birds were feeding in flocks, observational periods of 60–100 minutes were used, divided into alternate periods of 10 minutes in which the locations of feeding birds were noted every 30 seconds, and 10 minutes in which probing and success rates of individual birds were measured. When birds were feeding solitarily, probing and success rates were measured for periods of 4–10 minutes immediately before or after observations on a nearby flock. The data were collected chiefly in the winters of 1970–71 and 1971–72.

Results

The data analysed below were collected from fifteen flocks at Sandon Bay, each containing between seven and sixteen birds. (It was difficult to make comprehensive observations on birds in flocks of greater numbers.) The fifteen flocks comprised five each of males only and females only, and five containing approximately equal numbers of the two sexes. All observations were made at the same stage of the tidal cycle (about an hour after low water) and under similar weather conditions. Data on feeding behaviour of single birds were collected from fifteen individuals of each sex.

This information has been analysed with respect to feeding situation, probing rate and success rate, and is summarized in Tables 2 and 3. Two feeding situations are recognized: 'at the tide-line' and 'beyond the tide-line'. Birds wading in water up to 'knee'-depth were in the former category, over 'knee'-level in the latter.

In both single- and mixed-sex flocks, males fed chiefly at the tide-line, but females beyond the tide-line. These preferences were more marked in mixed flocks: significantly fewer females fed at the tide-line in mixed-sex than in all-female flocks (*t*-test, $P < 0.001$), while significantly fewer males fed in deeper water in mixed-sex than in all-male flocks (*t*-test, $P < 0.01$) (Table 2).

Table 2. Feeding situations of male and female Bar-tailed Godwits feeding in flocks of different sex ratio

	Single-sex flock		Mixed-sex flock	
Males				
At tide-line	72%	(360)	81%	(380)
Beyond tide-line	28%		19%	
Females				
At tide-line	45%	(420)	26%	(380)
Beyond tide-line	55%		74%	

Figures in parentheses are the numbers of observations made (for details, see text).

The feeding situation markedly affected the feeding performance of males, but not of females (Table 3). When males fed beyond the tide-line they probed significantly less often and were less successful than when they fed at the tide-line (*t*-test, $P < 0.001$, < 0.05 respectively), no matter whether they were feeding in flocks with other males or with females. Females also probed slightly less often when feeding in deep water (though the differences are of doubtful statistical significance), but were equally successful in obtaining prey in both locations. Data obtained on the main mudflats support the above conclusions. The feeding performance of solitary birds showed high variability in both probing and success rates. To reduce the standard errors, data for all fifteen males and fifteen females have been pooled. Their average feeding rate was 50.3 ± 11.5 probes per minute and success rate 0.7 ± 0.3 items swallowed per minute. These observations refer to single birds feeding in the vicinity of, but not within, the flocks whose behaviour was detailed in Tables 2 and 3. Their feeding performance can therefore be compared directly with the means of the pooled data for all birds feeding in flocks, viz. 76.4 ± 3.1 probes per minute and 1.9 ± 0.2 items swallowed per minute. Thus solitary birds are clearly less successful than birds feeding in flocks, and often spend more time standing in an upright alert posture.

Discussion

In view of the poor feeding performances of solitary godwits, it is perhaps surprising that birds are so regularly seen feeding

Table 3. Feeding rates (F.R.) and success rates (S.R.) of male and female Bar-tailed Godwits in single-sex and mixed-sex flocks in two feeding situations

	Single-sex flock		Mixed-sex flock	
	F.R.	S.R.	F.R.	S.R.
Males				
At tide-line	78·5±1·4	2·1±0·4	83·6±1·5	2·3±0·2
Beyond tide-line	55·2±1·1	1·3±0·2	54·1±2·7	1·4±0·2
Females				
At tide-line	80·3±1·8	2·3±0·4	83·1±2·0	2·4±0·3
Beyond tide-line	72·2±1·3	2·2±0·4	76·3±1·7	2·4±0·4

Feeding and success rates are the number of probes and items swallowed per minute. Values given are means ± standard errors.

alone at Lindisfarne. Although they might merely be satiated, there is no evidence of an increase in the number of solitary feeders towards the end of the low tide period. Possibly they may be physically unfit. Whatever the reason for their behaviour, solitary individuals form a very small proportion of the total godwit population. Hence, for calculations of the impact of godwits on their prey during a winter, the feeding success rates of flocking birds must be used, even though these are more difficult to obtain. From observations of other species, we believe that greater feeding success in groups of birds is widespread in those shorebirds which flock regularly. We therefore urge caution in using measurements of feeding performance of solitary birds to estimate food consumption of whole wintering populations.

A feeding flock of godwits maintains an approximately oval shape, elongated parallel to the tide edge. Since flocking birds feed more successfully than solitary individuals, which spend more time on the alert, there may well be a selective advantage in flocking. (This can be confirmed only when the reasons for solitary behaviour are identified conclusively.) If a flock contains only males, some will be forced into deep water where their feeding performance drops (Table 3). Hence, it is of advantage to males to feed in mixed flocks, in which the females can utilize feeding situations beyond the tide-line without a reduction in their success rate. As expected, most flocks (about 90%) at Lindisfarne contain both sexes.

The division of feeding situations between males and females, the latter in deeper water, may help to reduce competition between the sexes when numbers are high in relation to the areas available for feeding. Sexual dimorphism in bill- and body-size has often been suggested as a means of reducing intraspecific competition for food, by for example, Selander (1966), Newton (1967) and Reynolds (1972). The long-billed female godwits may be at an advantage in some hard weather conditions. Although no prolonged cold spells have occurred in the last two winters at Lindisfarne, during brief cold periods two important prey species, *Arenicola marina* and *Nereis diversicolor*, were found deeper in the mud and sand than usual. At such times, female godwits took more of these prey than did the short-billed males. They by contrast took more of the small oligochaetes and polychaetes, which do not burrow so deeply. Males may therefore have found it more difficult to satisfy their daily energy requirements than females, in the short term. In prolonged or severe cold spells, however, females are at a potential disadvantage in that they require about 11% more food per day than males (This figure is derived from comparison of metabolic rates, calculated from Lasiewski & Dawson's (1967) equation, of birds of mean weight 340 g (females) and 300 g (males)).

In no other wader species occurring in Britain is the dimorphism in bill-size so great as in the Bar-tailed Godwit. It is not known whether selection for size occurs on the breeding or wintering grounds or both, though Salomonsen (1955) has argued that selection in the Ringed Plover *Charadius hiaticula* acts primarily in winter. At this time of year, different races are distributed in accordance with Bergmann's Rule, with the larger birds furthest north. In summer, the reverse is true; the largest birds breed furthest south, in contravention of Bergmann's Rule. Hence, Salomonsen argued, selection acts in winter. However, in arctic breeding species such as the Bar-tailed Godwit, selection might also occur on the breeding grounds, where long-billed females might be at an advantage over short-billed females in being able to feed in a greater diversity of sites upon first arrival, when food for egg-formation is needed. This does not wholly explain why males have much shorter bills. Sexual selection, as described for two North American sandpipers (Jehl, 1970), may also be involved. Jehl found that pairs formed between the smallest males and the largest females were among the earliest to breed in each season. The explanation proposed for the origin of sexual dimorphism in raptors by Cade (1960)—that the female must dominate the male to keep him in his role as food provider during incubation and care of the young—cannot apply in waders as the young are precocial. The problem will remain unresolved at least until we are able to study the godwits at Lindisfarne through a severe winter.

Acknowledgments

We are grateful to Professor D. Barker for allowing P.C.S. to use the facilities of the Zoology Department, Durham University; to the Nature Conservancy and the Lindisfarne Wildfowl Advisory Committee for allowing us to work on the Lindsfarne N. N. R., and to M. J. Hudson (Deputy Regional Officer) and E. F. Pithers and D. O'Connor (Chief Warden and Warden at Lindisfarne) for practical help. Financial support

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Summary

An outline is given of the status and feeding ecology of the Bar-tailed Godwit *Limosa lapponica* at Lindisfarne, Northumberland. Sexual dimorphism in bill-length is pronounced, those of females averaging 30% longer than those of males. Birds feed close to the tide edge, but females tend to feed in deeper water than males. Males feeding in deep water are less successful in capturing prey than males feeding at the tide line, but females are equally successful in both locations. Godwits feed more successfully in flocks than solitarily. Selective advantages of long- and short-billed birds are discussed speculatively.

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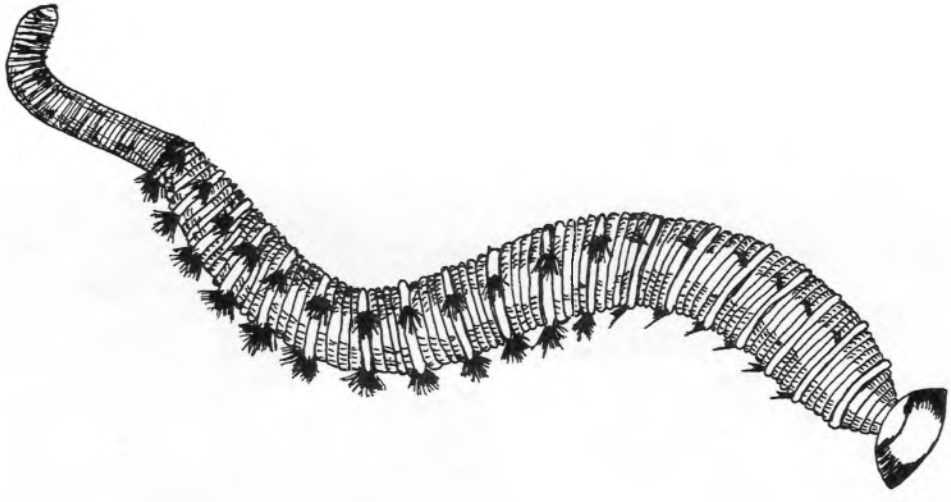


Lugworm *Arenicola marina*

Philippa Scott

Plate VI. Above: this unusually marked wild male Shoveler *Anas clypeata* has been coming to Slimbridge for four winters. Below: something of an identification problem. It is actually a Falkland Island Flightless Steamer Duck *Tachyeres brachypterus*.

Philippa Scott

Wildfowl (1973) 24:141–143

The systematic status of the Cape Barren Goose as judged by its photo-responses

J. KEAR AND R. K. MURTON

The Cape Barren Goose *Cereopsis novaehollandiae* has a possibly relict distribution, breeding on scattered islands off the southern coast of Australia from the Recherche Archipalago in the west to the Furneaux Group in the east (Frith, 1967). In the past, it perhaps ranged further, but is now confined between longitudes 122°–148°E and latitudes 32°–40°S. Ecologically the bird was probably always restricted to the coast, as suggested by the immense development of its salt-extracting glands, a feature it shares with its relative, the extinct and flightless *Cnemiornis* of New Zealand.

The species is considered by Delacour (1954) to be an aberrant member of the tribe Tadornini of the sub-family Anatinae (ducks) and by Johnsgard (1965) to be of the Anserini (swans and geese). Indeed, when first described it was labelled *Cygnus cendré* (Delacour, 1954). No true geese (*Anser* and *Branta*) occur in the southern hemisphere nor have any been certainly identified as fossils, so it is unlikely that *Cereopsis* is at all closely related to these genera. However, it has a typically goose-like triumph-ceremony which is performed by the mated pair after an enemy has been repulsed (Johnsgard, 1965); and in the reticulated tarsus, absence of a syrinx and in the structure of bones and muscles (including the number of cervical vertebrae), *Cereopsis* resembles the Anserini rather than the Tadornini (Verheyen, 1953; Woolfenden, 1961).

In anserine geese, tadornine sheldgeese, and *Cereopsis* the young are grazers of grass and other low vegetation, so in body proportions, the goslings are rather similar. However, young shelducks and sheldgeese (except the Kelp Goose *Chloëphaga hybrida*) are strongly patterned in black-and-white, while anserine goslings and cygnets tend to be unicoloured, white, grey, yellow or brown. On this basis, the pied *Cereopsis* gosling closely resembles the tadornines. In two other features, *Cereopsis* shows similarities to the sheldgeese rather than to the true geese: opponents are attacked with the 'wrists' of the wings, which have bony carpal knobs; and erect, chest-puffing displays are given as a greeting to the mate (Veselovsky, 1970).

Resemblance of *Cereopsis* to the swans (genera *Cygnus* and *Coscoroba*) is noted in the fact that the gander undertakes a prime share of nest-building, a task predominantly left to the female in *Anser, Branta* and all tadornines (Kear, 1970); and in an incubation period of 35 days, 5 days longer than any anserine goose, but similar to many swans. The species has two other 'primitive' features: goslings are occasionally oiled by their parents (Scott, 1972), as are screamer (Anhimidae) chicks, and copulation occurs on land with no indication that this is a secondary feature.

No taxonomic clues can be obtained from hybrids, simply because *Cereopsis* has never hybridized. To some extent this is not surprising as it breeds in the winter while most of its supposed relatives are in reproductive condition only in spring or summer. But one goose, the Nene *Branta sandvicensis*, also breeds on short days and copulates (secondarily) on land. In 1968, a young hand-reared *Cereopsis* female mated with a Nene gander at the Wildfowl Trust, Slimbridge, England. The pair were encouraged with a spacious pen of their own where they copulated, apparently successfully, and nested during the following 3 years. The eggs were always infertile. This might suggest a degree of genetic incompatibility between the two genera, although further investigation is clearly needed.

Recently we have examined the photo-responses of various wildfowl species by relating the median date of first egg-laying in the Slimbridge collection (and the day length on that date) to the mid-latitude of their natural breeding range (Kear, 1966; Murton & Kear, 1973a,b). The plots of egg-laying date against latitude can be described by regression lines for groups of closely related species and these are summarized in Figure 1. It can be seen that swans emanating from any particular latitude lay earlier in the year, that is, respond to shorter daylengths, than do goose species from the same latitude. But this is only true above latitude 50°N. Further south, true geese must breed later, because at low latitudes they need a longer photoperiod than swans, and it is significant that only *Branta sandvicensis* occurs further south than latitude 40°N as a breeding species. We have argued that closely related species

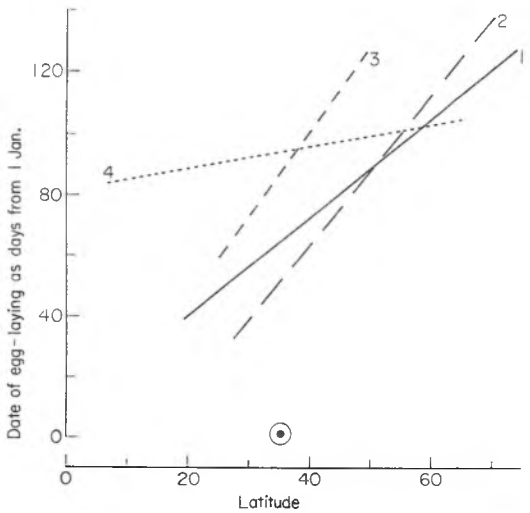


Figure 1. Regression lines relating date of egg-laying (represented as number of days from 1 January = 1) of various wildfowl species at Slimbridge to the mid-latitude of their natural breeding range.
(1) *Anser* and *Branta* geese (25 species)
$y = 6{\cdot}9 + 1{\cdot}6x$; $r_{23} = 0{\cdot}871$, $P < 0{\cdot}001$
(2) Swans (8 species)
$y = -35{\cdot}4 + 2{\cdot}47x$; $r_6 = 0{\cdot}882$, $P < 0.01$
(3) Shelducks (6 species)
$y = -12{\cdot}3 + 2{\cdot}8x$; $r_4 = 0{\cdot}941$, $P < 0{\cdot}01$
(4) Sheldgeese (5 species)
$y = 81{\cdot}6 + 0{\cdot}4x$; $r_3 = 0{\cdot}786$, not significant.
The isolated point with co-ordinates $y = 1$; $x = 36$ represents *Cereopsis* and its relationship to the regression lines depicted is examined statistically in the text.

share common regression lines because the physiological mechanisms controlling their photo-responses and breeding behaviour have not evolved significant divergences from the ancestral pattern (Murton & Kear, 1973a). On this basis, we can enquire whether the breeding of the Cape Barren Goose at Slimbridge shows any resemblance to the response patterns of the groups featured in Figure 1.

The median date for first eggs of *Cereopsis* at Slimbridge over 23 years has been 1 January, designated day 1, and the mid-latitude of its natural breeding range is 36°S. The regression lines in Figure 1 relate to eight swan, *Cygnus* and *Coscoroba*, species, twenty-five *Anser* and *Branta* species, six shelducks *Tadorna* species and five sheldgeese *Neochen* and *Chloephaga*. Regression equations, correlation coefficients together with their significance levels are given in the caption to the figure. Statistically we wish to determine to which of the regression lines in Figure 1 the isolated point y_0x_0 is closest and whether it might be regarded as belonging to one of the four groups whose taxonomic relationships are reasonably certain.

If y_0 can be defined by the regression equation which describes the swan data we predict that:

$$\begin{aligned}\hat{y}_{01} &= a_1 + b_1 x_0 \\ &= -35{\cdot}44 + 2{\cdot}47(36) \\ &= 53{\cdot}48\end{aligned}$$

and the divergence from expectation is given by

$$d_1 = y_0 - y_{01} = 1 - 53{\cdot}48 = -52{\cdot}48$$

The standard deviation of the predicted value y_{01} is:

$$s_1' = s_1\sqrt{\left[1 + \frac{1}{n_1} + \frac{(x_0 - \bar{x}_1)^2}{n_1\,(\mathrm{var}\,x_1)}\right]}$$

$$= 12{\cdot}68\sqrt{\left[1 + \frac{1}{8} + \frac{(36 - 51{\cdot}5)^2}{8(160{\cdot}78)}\right]}$$

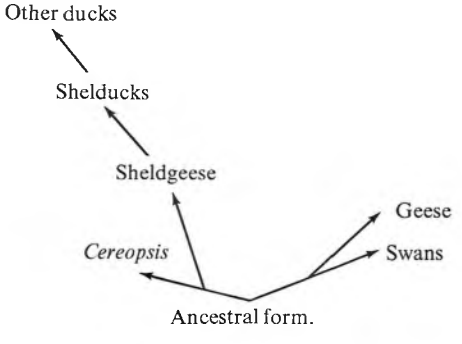
$$= 12{\cdot}68\sqrt{1{\cdot}312} = 14{\cdot}524$$

We calculate $t_1 = d_1/s_1' = -52{\cdot}48/14{\cdot}524 = 3{\cdot}613$ with $n_1 - 2 = 6$ degrees of freedom. The two-tailed probability that this differs from zero is between $P = 0{\cdot}02 - 0{\cdot}01$. Similarly, if y_0 can be defined by the regression line for true geese we obtain a t_2 value $= d_2/s_2' = -63{\cdot}5/13{\cdot}145 = 4{\cdot}831$ with 23 degrees of freedom (d.f.). This is very significantly different from a value of zero

($P \ll 0.001$). Considering the shelduck regression in the same way we obtain $t_3 = 39{\cdot}954$ which with 4 d.f. gives $P \ll 0.001$.

Perusal of Figure 1 shows that the regression line (correlation coefficient not significantly different from zero) describing the photoresponse of the South American sheldgeese cannot be nearer to the *Cereopsis* point than the regression line for the shelducks just considered.

Thus the statistical analysis confirms the visual impression from Figure 1 that the photo-response of *Cereopsis* is totally unrelated to the pattern shown by the true geese or sheldgeese, rather different from the shelducks and that it is closer to the swan group than to any of the above. This suggests that *Cereopsis* might be close to the ancestral stock which led on the one hand to the shelducks and on the other to a line that has terminated with *Cereopsis*. We propose an evolutionary tree in which the swans and *Cereopsis* are closer to each other than to any living goose or sheldgoose species and perhaps closer to the ancestral stock from which the Anatidae arose. These relationships might be illustrated as follows:



Summary

The median date of egg-laying of various wildfowl species in the Wildfowl Trust's collection at Slimbridge, England, is plotted against the mid-latitude of their natural breeding range. The result for the Cape Barren Goose *Cereopsis novaehollandiae* is closer to the pattern for the swans than to that of the true geese or the sheldgeese. An evolutionary tree placing *Cereopsis* closer to the swans than to any living goose or sheldgoose species and perhaps closer to the ancestral Anatidae stock is proposed.

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Wildfowl (1973) 24:144–149

Proximate and ultimate determinants of clutch size in Anatidae

PAUL A. JOHNSGARD

In a stimulating analysis, Lack (1967, 1968a) reviewed waterfowl clutch size and egg size data, and concluded that interspecific variations in average clutch size are generally inversely related to those of relative egg size. Thus, he suggested that the average clutch size of each waterfowl species has evolved in relation to the average availability of food to the female around the time of nesting. He hypothesized that in waterfowl, relatively large eggs have probably evolved to provide the newly-hatched young with a large food supply (an idea he subsequently (1968b) questioned) or with an adequate insulating layer of fat. He also suggested that, since annual, seasonal, and local variations in clutch size exist, proximate factors, such as the food supply of individual females, may be more likely to influence a bird's date of laying than either its egg size or clutch size. Since the publication of Lack's study, several additional reviews of avian clutch sizes have appeared, notably those of Klomp (1970), von Haartman (1971) and Cody (1971). Klomp considered the problems posed by the Anatidae in some detail, and generally agreed that the food supplies available to the female are probably the ultimate factor influencing clutch size in this group.

Because of the large amount of information available for waterfowl, and since Lack did not concern himself with proximate influences on clutch sizes of individuals, I have given these matters some attention and have reached somewhat different conclusions. No simple single explanation for inter- and intraspecific variations in clutch sizes seems possible at present, but a summary of the evidence relating to these phenomena nevertheless appears worthwhile.

Proximate factors influencing clutch sizes of individual birds

It is well established that intrapopulation variations in clutch size of waterfowl do exist, which probably reflect proximate environmental influences that vary with time. Klomp (1970) listed thirteen species of Anatidae that have been reported to exhibit declines in average clutch size during a single breeding season, and Bengtson (1972) reported this trend in all of ten species of ducks in his study. Except for Koskimies' (1957) suggestion that such individual clutch size variations might be the result of genetic polymorphism having adaptive value, it has been generally believed that these seasonal differences are mainly the result of proximate influences. The lowered hormonal levels after the reporductive peak (Hilden, 1964), or the reduced stimulating by temperature or photoperiod effects (Dane, 1966), might reduce the clutch size of late-nesting birds. Their smaller clutch sizes might also simply reflect renesting, since repeat clutches are generally smaller than the original ones (Sowls, 1959). This, in turn, may result from exhaustion of the female's reserves (Wagner, 1960). Again, the smaller, later clutches may be produced by younger females nesting for the first time and thus not in peak reproductive condition (Lemieux, 1959). Kossack (1950) provided some data for the Canada Goose *Branta canadensis* favouring this view.

Variations in average clutch of a single population in different years also occur in the Anatidae, and clearly must be controlled by proximate factors. The possibility that these might be related to annual variations in food availability has recently been supported by Bengtson (1971) who observed that during a year of relative food scarcity, four species of diving ducks and the European Wigeon *Anas penelope* produced significantly smaller clutches than normal. This finding clearly runs counter to Lack's suggestion that annual variations in food supply influence laying date rather than clutch size, but does support his view that the average clutch size may be basically attuned to normal food availability.

Annual variations in clutch size and nonbreeding, related to weather conditions during the egg-laying period, have also been established for the Anatidae, particularly among arctic breeders. Evidence on this point has been provided for the Atlantic Brent Goose *Branta bernicla hrota*, the White-fronted Goose *Anser albifrons*, Black Brant *Branta bernicla orientalis*

and Lesser Snow Goose *Anser caerulescens caerulescens* by Barry (1962), for the Lesser Snow and 'Blue' Geese by Cooch (1961), and for the Ross' Goose *Anser rossii* by Ryder (1970b).

If females breeding for the first time tend to have smaller clutches than experienced breeders, then variations in the percentage of young females in a population might result in between year variations in average clutch size. Mendall (1958) suggested this possibility for the Ring-necked Duck *Aythya collaris*, when he found a limited correletion between poor hatching success in one year and large average clutches of Ring-necked Duck. Hilden (1964) provided supporting evidence among Tufted Ducks *Aythya fuligula* and Greater Scaups *Aythya marila.*

Population density is, theoretically, another factor controlling clutch size. Hilden (1964) found no evidence for this among the two *Aythya* species just mentioned. The only example I have encountered is that of Marshall (1967), who reported that increased clutch size (but reduced nesting success) was associated with increased nesting densities in the European Eider *Somateria m. mollissima*. Ryder (1970b) found that Ross' Geese nested earlier in high-density concentrations, but that clutch size was not influenced by the breeding density.

Interpopulation variations in clutch size might, of course, be a reflection of either proximate or ultimate factors. If the populations are geographically well isolated, the probability of genetic control for these differences would seem to be higher, and indeed Lack (1967) provided some examples among various races of certain ducks. However, continuous clines in clutch size might well be geared to such proximate factors as photoperiod or temperature gradients. Weller (1964) was unable to find any evidence for such geographic variation in the clutch size of the Canada Goose. The suggestion of Paynter (1951) that the American Eider *S.m.dresseri* has intraspecific clinal variation was based on data from various investigators and, as Weller indicated, is therefore of questionable value as well as being only over a range of less than ten degrees of latitude. A more general comparison of average clutch size of this species (Table 1) is not indicative of increased clutch size with increasing latitude; if anything, the average clutch size is largest at intermediate latitudes.

To summarize, it would appear that proximate factors are as likely to influence anatid clutch size as to account for variations in laying dates, at least in temperate or arctic species.

Ultimate factors influencing average clutch sizes of anatid species

Lack (1967) advanced the view that the average clutch size of each anatid species has evolved in relation to average available food supplies for the female, as influenced by the size of the species' eggs. He and, earlier, Heinroth (1922) have also pointed out that larger-bodied birds channel relatively less food material into the production of individual eggs, resulting in a negative correlation between average adult female weight and the weight of the species' eggs. An even clearer negative correlation

Table 1. Breeding latitude and reported clutch sizes of the Common Eider *S. mollisima*

Latitude (°N)	Average Clutch-size	Total nests	Locality	Authority
79	2·95	2,993	Kongsfjord, Spitzbergen	Ahlen & Andersson 1970
65	2·74	42	Iceland	Gudmundsson, 1932
64	3·44	1,598	Cape Dorset, NWT	Cooch, 1965
63	4·6*	193	Valassaaret, Finland	Hildén, 1964
62	4·89	89	Yukon-Kuskokwim Delta	Lensink (personal communication)
61	4·32	734	Green Is., Que.	Lemieux (cited in Cooch, 1965)
60	3·13	73	Payne, Bay, Que.	Edwards (cited in Cooch, 1965)
56	4·47	120	Belcher Is., NWT.	Freeman, 1970
51	3·6	60	Amchitka Is., Alaska	Kenyon, 1961
48	4·04	1,131	Saquénay Co., Que.	Lewis, 1939
45	3·53	134	Kent Is., Me.	Gross, 1938
44	3·25	44	Penobscot Bay, Me.	Paynter, 1951

*Excludes clutches of less than three eggs.

may be seen between the average adult female weight and the proportional weight of the average total clutch. This ratio provides a useful index to the relative energy drain on the female during laying. Lack's (1968a) tabular data indicate that in eight taxa (species or subspecies) of swans, the equivalent of from 16 to 34% (average 24%) of their adult weight is deposited in an average clutch of eggs. For sixteen taxa of true geese the calculated range is from 20 to 40% (average 28%), for forty-seven surface-feeding ducks from 35 to 106% (average 60%), and for sixteen sea ducks from 20 to 109% (average 63%). The larger species, geese and swans, which have the greatest available energy reserves of body fat, thus actually experience the smallest relative energy drain from egg-laying. Their generally small clutch size is therefore unlikely to be attributable to limited food supplies during laying.

Several hypotheses have been proposed to explain this problem. Ryder (1970a) has suggested that, at least in the Ross' Goose, the total pre-breeding food reserves needed by the female for both egg-laying and during incubation might limit the average clutch size of this unusually small goose, which usually lays only four eggs. Thus, for this and perhaps other arctic nesting geese, the female's energy supplies must allow the female to provide maximum protection to the clutch during incubation and ensure the survival of the young until they can forage. This theory is essentially an extension of Lack's basic views on clutch size controls.

A second hypothesis is that egg predation during the egg-laying period may limit effective clutch size. Thus the dangers of leaving the nest exposed prior to incubation may outweigh the advantages of adding additional eggs. The probability of this occurring increases with increasing clutch size, especially in species vulnerable to pre-incubation predation of the entire clutch. Lack has rejected predation as an ultimate control of avian clutch size, on the grounds that natural predation levels are normally too low to be effective and in general this would seem to be true. Bengtson (1972) provided data for ten Icelandic duck species, showing that pre-incubation nest predation caused 55% of the nest failures in 2,889 nests, or a total of about 19% of the nests under study. This would suggest a daily predation rate of little more than 2% per day during a 10-day egg-laying period, too low effectively to limit clutch size. However, Choate's (1967) study of American Eiders indicated that 66% of the entire nest predation in 1 year (totalling 58% of 448 nests) occurred on incompleted nests, implying a 12–15% daily nest loss during the 3- or 4-day period required to complete a clutch. If they are at all typical, such predation rates might easily account for the low average clutch size of this species.

Thirdly, it is possible that average clutch size may be limited by decreasing parental effectiveness. Mendall (1958) reported decreased hatching success among large clutches of Ring-necked Duck. Hilden (1964) had similar results for Tufted Ducks and Greater Scaups, and Bengtson (1972) for Greater Scaups. Ryder (1970a) has cited some additional examples. Likewise, larger than normal broods may suffer relatively higher mortality rates than normal sized ones, as indicated by Eygenraam (1957) for Mallard *Anas platyrhynchos*. Cooch (1961) noted that Lesser Snow Goose goslings hatched from eggs laid late in large clutches survived less well. Similarly, Parsons (1970) reported that Herring Gulls *Larus argentatus* hatched from smaller eggs, usually the third-laid ones, exhibited the poorest survival. If this trend is general, it might well be a source of increasing selective disadvantage for enlarging the clutch size.

Fourthly, a restricted optimum breeding period, or the need to synchronize hatching with an optimum hatching date, may limit average clutch size. Koskimies (1957) found laying date and clutch size to be individually constant among female Velvet Scoters *Melanitta fusca*, and believed this ensured uniform hatching times of different-sized clutches. Cooch (1961) similarly pointed out that, in the Lesser Snow Goose, smaller clutches are 'necessary' in retarded breeding seasons or towards the end of normal ones if reproduction is to be efficient. Hilden (1964) mentioned that, since the period of both egg-laying and hatching are undesirably prolonged in large clutches, and since late-hatched broods generally survive poorly, selection may limit clutch size below the female's physiological limits or her incubation abilities. Dane (1966) similarly pointed out that each egg added to a duck's clutch delays hatching another day, both increasing the problems of egg and chick survival and shortening the available time for maturation prior to migration. There is considerable evidence from a variety of waterfowl species that broods hatching relatively late usually survive more poorly than those hatched fairly early in the season (Grice & Rogers, 1965; Bengtson, 1972).

This influence of a restricted optimum

breeding period is most likely to be exerted in arctic or subarctic areas. If one compares the average clutch size of a number of northern hemisphere waterfowl as given by Lack with average July isotherms (°F) representing the northern limit of these species' breeding ranges primarily as reported by Voous (1960), an interesting relationship may be seen (Figure 1). Species having small average clutches nearly all are arctic or subarctic breeding, while those with large average clutches tend to be more temperate or subtropical. If one calculates clutch weight as a percentage of adult female weight for such species and again plots the results against July isotherms at the northern limits of distribution, a greater taxonomic spread may be seen (Figure 2). Although collectively there is a strong tendency to reduce the relative amount of energy put into the clutch the further north they breed, the trend is clearer in some groups than in others. This may be due to restricted breeding periods, possibly to increased egg-predation dangers, to other demands on energy reserves associated with breeding in arctic environments, or to other factors.

In general, those anatid species having the smallest average clutch size (swans, geese, eiders) are not likely to encounter food shortages at the time of laying. Nor are their clutch sizes likely to be limited by ecological needs for relatively large eggs. Increased average food availability seem to play little part in the evolution of increased average clutch size in waterfowl. Instead, I would suggest that, where food supplies are not a limiting factor, clutch size is likely to be limited by decreasing parental effectiveness, decreased available optimum breeding time, and increased probability of nest predation. These four selective factors are in turn further obscured by proximate factors which produce the individual, seasonal and local variations in clutch size encountered by field biologists.

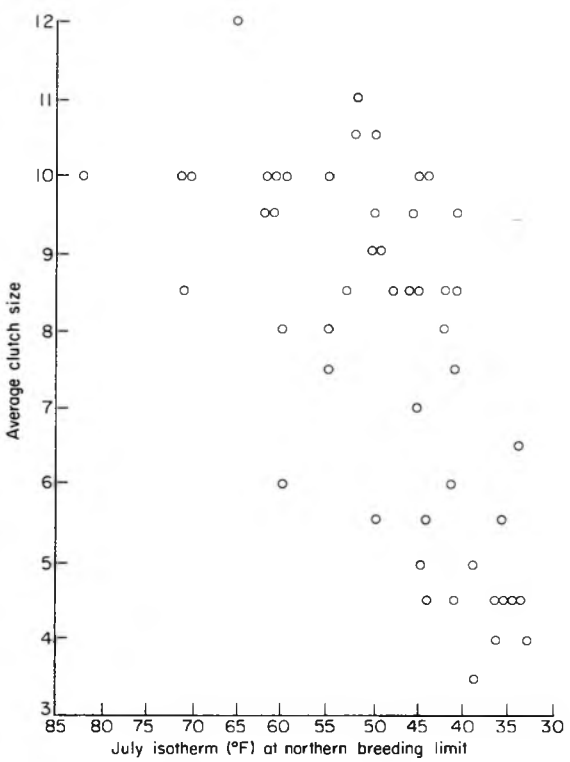

Figure 1. The relationship between average clutch size and northern breeding limits in fifty northern hemisphere Anatidae.

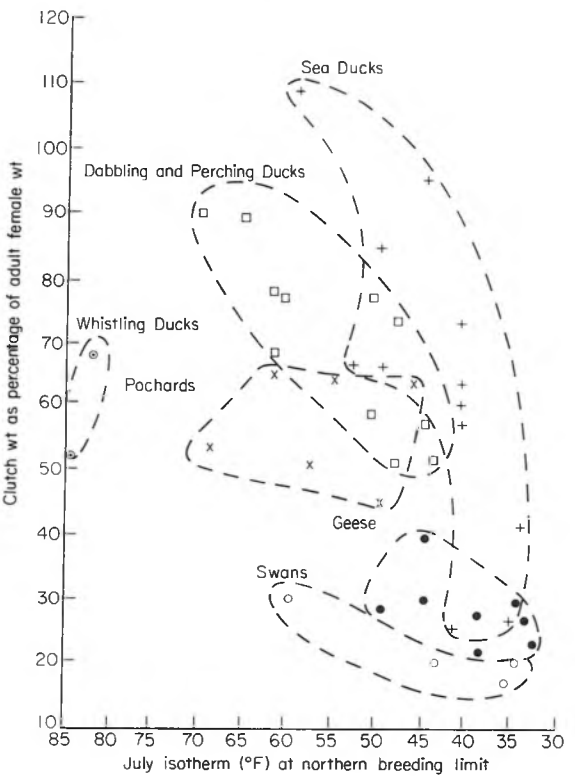

Figure 2. The relationship between the total average clutch weight relative to adult female weight in the northern breeding limits in forty-three northern hemisphere Anatidae.

Summary

A review of Anatidae clutch-size data and an analysis of David Lack's hypothesis that food availability to the female around the time of her nesting can account for the evolution of average waterfowl clutch-sizes suggest several additions to or modifications of his theory. First, in contrast to Lack's suggestion, proximate factors do influence anatid clutch-sizes and result in measureable seasonal, yearly and perhaps also interpopulational variations in these. Secondly, indirect evidence suggests that several factors in addition to average food supplies may have influenced clutch-size evolution. These include needs for efficient partitioning of energy reserves between the incubating female and her eggs, dangers of pre-incubation clutch losses in those species that are unusually susceptible to nest predation, and decreasing parental effectiveness as well as possible decreased available optimum breeding periods associated with increases in clutch-sizes. Several or all of these may have placed upper limits on anatid clutch-sizes independently of or in conjunction with food supply effects.

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Wildfowl (1973) 24:150–153

Platform-building by male and female Ruddy Ducks

W. ROY SIEGFRIED

In the Anatidae the interval between the start of nest-building and laying of the first egg is characteristically short–usually no more than 2 or 3 days (Weller, 1964). In ducks of the sub-family Anatinae, the nest is constructed entirely by the female. Males are, however, capable of performing the motor patterns appropriate to nest-building, and the behaviour is quite widespread (McKinney, 1968). McKinney considered this behaviour to be non-functional and 'vestigial', and Kear (1970) suggested that it might be triggered by the sight of a nest or of a female building.

This paper reports nest-building behaviour as relatively common in both male and female Ruddy Ducks *Oxyura jamaicensis*, 3–4 weeks preceding onset of the egg-laying season. A possible adaptive value is suggested for this unexpected behaviour which I call 'platform-building'.

The observations were made while I studied wild Ruddy Ducks in the Minnedosa pothole country and at the Delta marsh, Manitoba, Canada, during May–August 1971. I noted a total of seventy-eight separate instances of platform-building, of which sixty-eight involved females, and ten males. With one exception, these records were restricted to the period 3 May (when I first went into the field) to 4 June, with most of the records falling between 3 and 25 May. The single exception was provided by a male observed performing 'sideways' building movements on 30 June. The observations were made over all hours of the day, and there appeared to be no bias in favour of building activity in the early morning—a time when anatids generally are most active in prospecting nest-sites and building nests.

All the usual motor patterns associated with normal nest-building were performed by both males and females constructing platforms. Platforms were built over water mainly in stands of emergent dead stems of hardstem bullrush *Scirpus acutus*, though other vegetation (e.g. cattail *Typha latifolia*) was also used. Typically, platforms were more or less circular, measuring about 55 cm in diameter, and raised some 10 cm above water-level (Figure 1). A shallow bowl-like depression, formed by the bird using its beak, feet and breast, occupied the centre of the platform. In short, the platforms essentially resembled normal nests in early stages of construction. Many of the platforms were quite substantial, and capable of supporting weights of 5 kg and more. Hence, considerable effort had gone into their construction, and at least certain birds displayed a degree of tenacity in returning to them. This last statement is based on individually marked birds, of which one male and two females were observed building. One of the females was captured by a cage-trap set on a platform.

I timed platform-building bouts and the number of sideways-passing movements performed by individual birds. Female bouts averaged 6·4 min. (range 1–15 min, number of bouts, $n = 11$) with nineteen passing movements per minute, and those for males 2·0 min (1–3 min, $n = 3$) with seventeen movements per minute. Information on frequency of building bouts was harder to obtain, primarily because of the small sample of marked birds. However, platform-building featured commonly in the females' programme of activities. The general cycle was expressed as: feeding (by diving); bathing and preening; building; sleeping (loafing on platform); building; bathing and preening; feeding. The cycle's major components of feeding and sleeping alternated regularly. The bathing-preening and building phases were less regular. Nevertheless, building followed preening and preceded sleeping on nine out of sixteen separate complete cycles, and on ten out of twenty cycles it was observed to follow sleeping. On four occasions, birds were noted interrupting their sleeping bouts to build. Thus, platform-building formed a fairly regular phase in the females' cycle and the incidence of platform-building was similar to that of normal nest-building as found in incubating Ruddy Ducks (W. R. Siegfried, unpublished). Table 1 summarizes data on the amount of time birds spent on the different phases of the cycle.

Some of the platforms were found in open exposed sites and the birds did not attempt to hide themselves or their building actions. This contrasts with normal nest-building behaviour during which the female Ruddy is shy and secretive, choosing a well-

Figure 1. Platform built by Ruddy Duck *Oxyura j. jamaicensis* in *Scirpus acutus*.

Table 1. Time (in min) spent by Ruddy Ducks on bouts of sleeping, feeding, and preening and bathing

	Sleep	Feed	Preen and bathe
Females			
Average:	73	37	7
Range:	20–180	10–80	1–30
Number:	32	31	22
Males			
Average:	111	38	9
Range:	25–225	20–75	1–25
Number:	5	5	6

hidden site for the nest. Platforms were found in small 'colonies' (maximum of eight recorded in one group with an average 3-m distance between neighbouring platforms), or as isolated singletons. I doubt whether the 'colonies' were the result of social situations. A more plausible explanation would be that 'colonies' reflected a tendency by the birds to aggregate at favourable sites. Also, single birds (males as well as females) were observed building where other platforms or birds were out of sight. Individually marked birds (males as well as females) were observed to build more than one platform and also to add to the construction of platforms built by others. Some birds were observed to break off building operations at one platform, swim to another, and add to its construction. Thus, individual birds did not 'own' platforms in the same way as they would nests.

In my opinion, platform-building should not be regarded as non-functional or vestigal—at least in females it was of too general occurrence and involved too much effort and time. It is pertinent that platform-building, and loafing on platforms, was rarely observed after the end of May. During early and mid-May, Ruddy Ducks spent most of their time resting or sleeping (estimated at 65% of a normal 24-hour day); they slept on platforms, or generally tended to keep to dead emergent plant cover in which they could haul out of the water. The birds spent relatively little time in the water

itself, and then only for feeding or indulging in brief bouts of courtship. This applied especially to females; males spent relatively more time swimming around. However, both sexes rarely slept on the water. Towards the end of May the birds were often observed sleeping and resting on the water and males generally spent more time out in the open. At the beginning of June the platforms disappeared (no longer being maintained by the birds), and by the second week of June females generally became very secretive, concomitant with the onset of proper nest-construction and egg-laying. Nests were not built on the platforms.

Of all the waterfowl which breed in southern Manitoba, the Ruddy Duck is one of the last to arrive on the pothole breeding grounds; normally in the first week of May, immediately or soon after the ponds and sloughs have become free of ice. Like all other *Oxyura* spp., the Ruddy Duck is essentially warm temperate in its area of geographical distribution, and I have unpublished data (W. R. Siegfried) that lead me to believe that the species has only recently extended its breeding range beyond 50°N. I suggest that the platforms were used by the Ruddy Duck as a means of enhancing the efficiency of its thermoregulation. In short, the birds temporarily escaped the effects of cold water by hauling out and loafing on the platforms.

In possible support of this supposition, Ruddy Ducks were commonly observed rapidly to vibrate their folded wings, usually immediately following on or during the preening phase, after having hauled out on platforms. Such 'wing-shivering' was observed rarely after 1 June, and then usually on days of cold, overcast weather. Bouts of wing-shivering averaged 8 min (2–20 min, $n = 10$) in females on platforms in early May. I have described 'wing-shivering' in Ruddy ducklings which were cold, and have suggested that it might be a form of thermogenesis (Siegfried, 1973). After hauling out on platforms, adults normally rested on their bellies often lifting and holding both legs stretched and so exposing the feet to the sun; later, when sleeping, the legs were folded forwards and the feet held tucked into the flank feathers—a common resting posture of oxyurids. I suggest that while wing-shivering may be a comfort movement promoting the drying of wet feathers, it should be investigated as a possible thermoregulatory strategy.

So much for the possible function of platform-building. What of the motivation for this behaviour? I suggest that platform-building might result from a lack of co-ordination between a female's readiness to breed (in particular the nest-construction 'drive') and the availability of suitable nesting habitat. The situation in males is, however, different and the influence(s) motivating them remains obscure. Ruddy Ducks arriving in southern Manitoba are in 'good condition' and have relatively well developed gonads. Food is abundantly available, and the birds possess extensive deposits of fat. In short, females are physiologically ready to lay soon after arrival. Emergent vegetation, however, generally does not show new growth before the middle of May. At the end of May new emergent growth of hardstem bullrush and cattail, measured about 50 cm in height. Hence, females are generally denied suitable nesting habitat during the first 4 weeks or so of their stay on the breeding grounds. Weller (1959, 1964) in commenting on the Ruddy Duck's tendency to drop eggs on the ground and in the nests of other birds, says that this presumably results from variation in synchrony of nesting and laying behaviour, and that it occurs most often early in the breeding season.

If the above suggestion is correct then it explains why platform-building was observed so much more often in females than in males. Further, if the behaviour does in fact result in enhancement of the efficiency of thermoregulation, then one might expect a saving of energy to the bird. This might be relatively more important to the female, which produces larger eggs for its size than any other anatid. I have information indicating that it is advantageous for Ruddy Ducks to lay as early as possible in the season.

Acknowledgments

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Summary

Behaviour appropriate to nest-building is relatively common in both male and female Ruddy Ducks *Oxyura jamaicensis* at a time preceding by 3–4 weeks, the egg-laying season in southern Manitoba, Canada. The birds spend much time resting and sleeping on these platforms at a time

of the year when the water is still cold. It is suggested that the platforms are used as a means of enhancing the efficiency of thermoregulation.

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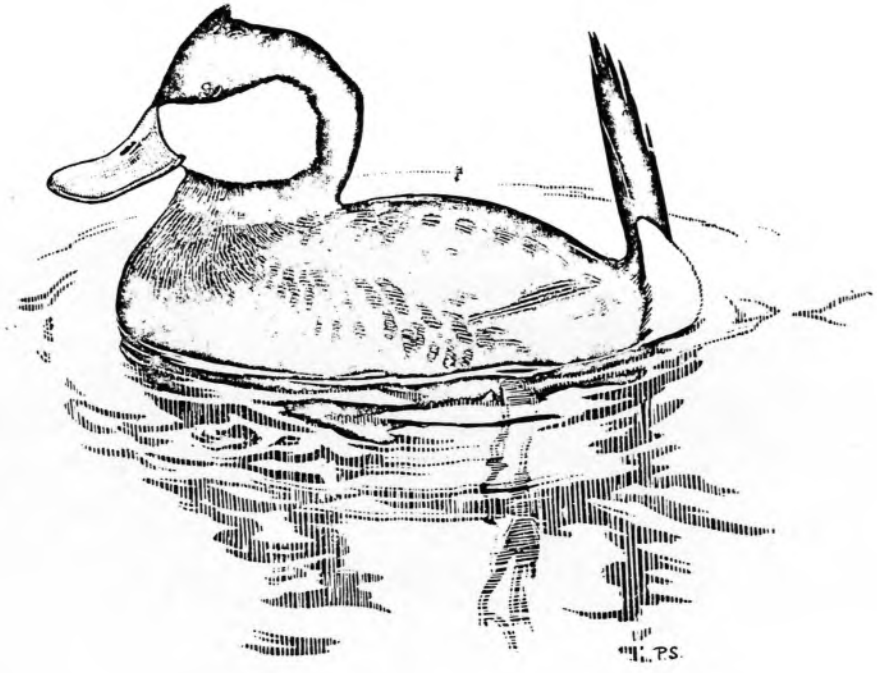

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Icelandic eiders—a few observations

RALPH S. PALMER

Introduction

These notes are based on a visit, 25–29 May inclusive, in 1972, to the eider farm of Gisli Vagnsson, at Mýrar, on the north side of Dyrafjord in northwest Iceland. After previous experience with nesting wild eiders in the Baltic, in northern New England, the Canadian high arctic, Hudson Bay, and the Bering Sea region, it was a tremendous experience to be able to dispense with a hide, or blind, and to stand for long stretches of time, quietly, surrounded by hundreds of pairs of nesting eiders. One became more or less a part of the landscape, or perhaps was assumed to be a scarecrow (or should I say scareraven?), while the birds went about their affairs at one's very feet. It was the time of year when the drakes were keeping station ashore near their incubating mates (Figure 1).

Predation

Such predators as large *Larus* gulls and Ravens are shot, throughout the nesting season, and there were several scarecrows on the eider flats. Ravens were shy of a man with a gun; they flew over frequently—once a flock of twenty-four—but I never saw one alight where the eiders nested. The mink *Mustela vison* is said to occur and to be a predator; it is hunted with dogs. At some Icelandic colonies small cubicles are built, of flat stones, and many of the ducks nest in these shelters, but not at Mýrar. I asked Gisli about this and he said that they were

Figure 1. The farm of Gisli Vagnsson: view from the flats where the eiders nest toward the farm buildings. The principal crops are sheep (and wool) and eiderdown.

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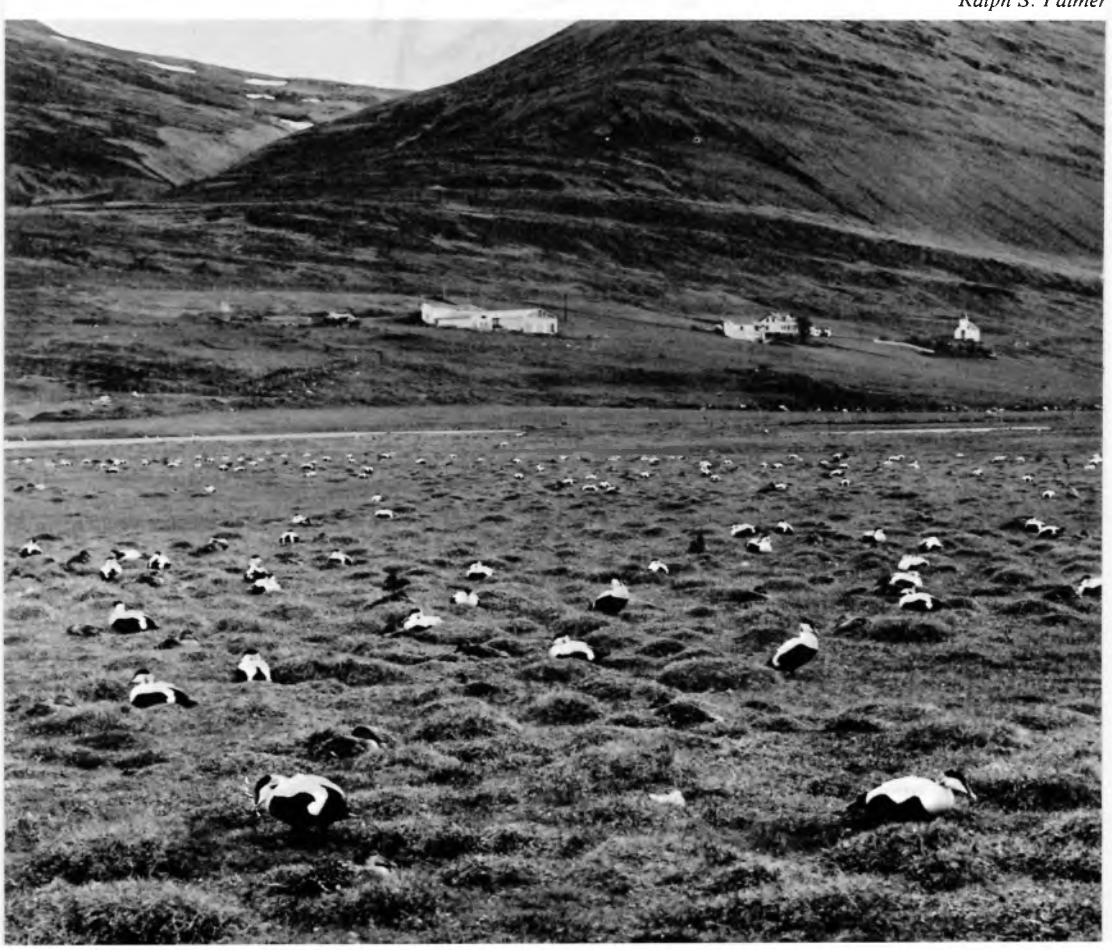

unnecessary; there is minimal predation while the birds are ashore. But he said that predation, especially by the Great Black-backed Gull *Larus marinus*, is very severe on ducklings after they reach the sea. At the colony I did not see a single sick, injured, or dead eider, nor any evidence of nests having been robbed of clutches.

Feeding

In disturbed colonies off the Maine coast the drakes are ashore very briefly, usually only in company of the duck when she is laying; most of their limited sojourn is spent close by on the sea. In the Baltic at Utholmen, near Gotland, a few spend some time ashore, but mostly they remain on shallow water near shore. As in Maine, the duck joins her mate on the sea when off-duty. At both localities I have watched the birds (both sexes) on the sea, over several days. Sometimes they appeared to be feeding; at least they were up-ending in shallows and tidal pools, but I could not be sure that they ingested any food. There never was the lively activity ordinarily associated with intensive feeding.

At Gisli's farm small, somewhat weathered, patches of ground-up marine shells were scattered in and near the nesting areas. Presumably the birds defaecated these when they first came ashore. While I was at the colony, flying eiders seldom went as far as the waters of the fjord; usually they circled over the flats. Nor when standing in view of the fjord did I see any traffic to or from salt water. The meltwater pools and streams in and near the nesting area, which get much usage by the birds, are probably very low in oxygen content and contain no animal life whatever. The few ducks that 'defaecated' when frightened from their nests (most did not react this way) produced only a very thin watery liquid. I watched the ducks during their off-duty visits to water and could not observe that they defaecated either ashore or afloat, nor did I find any evidence in quiet shallow pools of faecal matter in suspension or on the bottom. Both sexes drank fresh water regularly, but ate nothing while ashore—at least while I was there.

The eider's 'sails'

All eider species have a cycle of two moults annually. At least in the 'large eiders' *Somateria*, the feathering of the head-body is renewed twice—with the notable exception that the modified long scapulars ('sails') are renewed only once and this renewal apparently is offset temporally from either period of moulting of the adjacent feathering. (The tail and wing also are renewed only once per cycle.) The duck has her 'sails' (concealed, or at least not erected) even after the spring period of moulting into Basic ('eclipse') head-body; the drake then is wearing them also, while otherwise in Alternate ('display') head-body plumage.

In Reykjavik, while waiting for the weather to clear for the flight to Thingeyri (the trip from there to Mýrar is by auto), I spent several days observing the free-flying wildfowl at the lake, Tjörnin, in the city. People bring bread here to feed the various waterfowl and a few of the eiders actually will climb onto one's knee and take food from the hand. If a group of eiders swam by, and the birds quarrelled for any reason, sometimes a drake's 'sails' would become erected and then would gradually lower so as to vanish among the other white feathers of the back. Their erection, on yearling and older drakes, seemed to be an involuntary reaction during a stress situation. I saw it happen again, repeatedly, among the nesting pairs at Gisli's farm. At first it was rather startling to be photographing a drake whose 'sails' were up and then soon to find that my subject had a smoothly-contoured back. When a hybrid (King × Common) drake performed his Pushing display in the direction of a drake Common, the latter's 'sails' appeared, only to vanish during quieter spells. Now and again somebody adds to the list of subspecies of Common Eider having 'sails.' From examination of museum skins, however, it is obvious that they are present in both sexes of all of the Common Eiders. Apparently they are not erectile in the duck. In the drake, it is probable that they are erected (or kept erect) during periods of tension or stress—such as pair-formation, defence of mate, and so long as the drake remains near the nest. Later, when drakes (or the sexes together) are flocking on the sea, their backs are smooth.

The trek to water

At the eider farm it was quite evident that a duck could cover her clutch and then, quietly, and by careful choice of route, make her way to water without creating a

commotion. The drake followed, afoot or, to avoid conflicts, by taking wing. On reaching water, the duck immediately performed a double Wing-flap and, soon after, drank and Splash-bathed. The drake might swim before doing a Wing-flap. If a duck got off her eggs in a state of apparent excitement, croaking and flipping her bill (Inciting), and headed for water, this created much disturbance. As she passed near pairs, the drakes, even sometimes their mates, took after her, squabbling. An increasing tangle of birds moved on to water. The duck would Wing-flap and begin to bathe. Her retinue would then disperse and soon return to their nests.

Incidentally, sometimes as I moved slowly past a nest, the sitter would wait until I had gone by, then get up hastily, Wing-flap, and move away. The sudden Wing-flap behind one's back can be quite startling. Then, as I moved farther away, the bird usually would return and settle on her eggs; some, however, went to water.

Recruitment

When the number of nesters is increasing in a colony, one would expect a large percentage in the youngest year-class (cohort); the reverse was to be expected at Gisli's farm. The colony had been in existence since at least 1912. Numbers reached a peak of 6,200 pairs in 1964 and, for reasons unknown (oiling of birds while at sea is suspected) had declined to 4,300 pairs in 1972.

In trying to examine several hundred females without disturbing them from their eggs, I could not be sure as to which were younger birds. It may be that those of the youngest cohort are darker or more muted in overall colouring, or have less (sometimes no) white at the tips of their secondaries. This white wears off the exposed (outer) webs; that remaining on the inner may not be visible on the folded wing. There was much variation in overall colouring, some ducks being dark and nearer neutral-coloured, others varying to a quite rufescent brownish. Occasional birds were quite pale, in part due to bleaching. Some of the dark birds showed two full wing-bars; some of the brown and pale birds did not. Usually, however, the matter was not determined because the ends of the secondaries could not be examined properly without actually handling the bird.

The King Eider

Speaking in the vernacular, the King *Somateria spectabilis* is a high-octane eider—the drake's dorsal 'sails' are permanently erect, pointed, and sometimes vibrate; displays are much faster in tempo than those of the Common Eider; the frontal lobes and various feathering are 'exaggerated' in character; even the voice is speeded-up so that the cooing has a trembling quality. The few drake Kings that form pair-bonds with female Commons and then accompany their mates to the great Icelandic colonies of the latter are regarded as quarrelsome. There is an old Icelandic belief that the drake King really is an aged and changed Common Eider, a crotchety and overbearing individual—a king! At Gisli's farm, in the case of a triobond of two drakes (King and Common) sharing a female Common, relationships appeared to be amicable; the King usually kept station farther from the sitting female than did the Common. If another drake (Common) approached, the King would swiftly attack at a greater distance than seemed to be the case with Commons. During actual fighting, both species seemed to act in a similar way and with equal speed.

The writer has observed and photographed wild Kings of both sexes, separately and together, in near-desert high arctic environment. There the King accompanys his mate ashore when she is laying. However, in such exposed situations in the wild where predation is a constant hazard, so conspicuous a drake is unlikely to spend much time near his mate when she is incubating. He keeps station for a time on nearby fresh water. Thus it is an unusual situation in northwest Iceland, where a few drake Kings more or less behave like those Commons that have entered into a symbiotic relationship with man.

The drake Common has soft feathers on its cheeks which are quite puffed out in times of tension. On the drake King the corresponding feathers are different, being plushlike (as they were to a lesser extent on the extinct Labrador Duck). One day at Gisli's I kept edging nearer to a drake King, to get close-up photos. The bird became disturbed, got up, and moved several metres farther from his mate, but soon settled down. I approached again. The drake raised his head, turned it sideways, and erected the plushlike cheek-feathers in

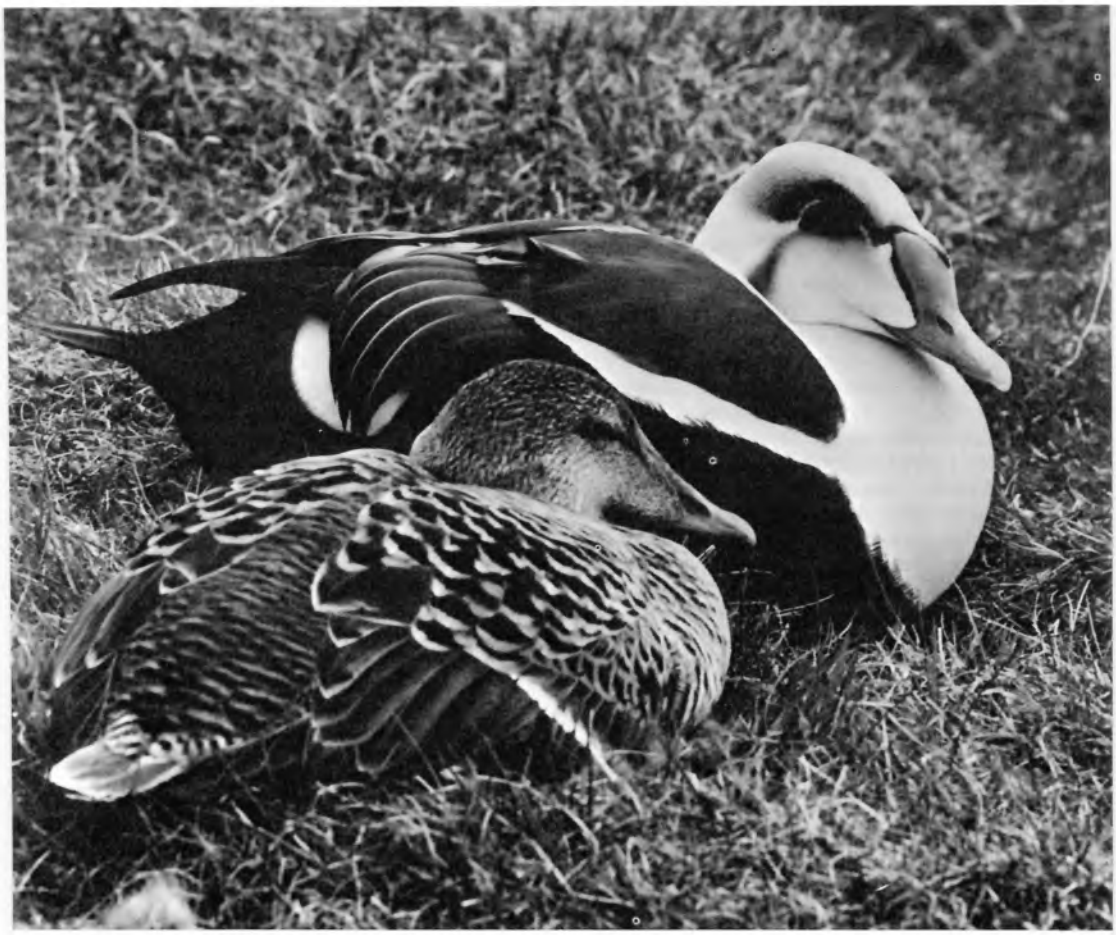

Figure 2. Drake hybrid King × Common Eider, mated to a Common Eider who was incubating four eggs.

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an anterior direction. This caused a 'break' in the feathering along or near the black line down rear of cheek—a V-shaped trough or opening. A similar effect is obtained when manually moving the edge of the facial disc of an owl to examine the ear-opening underneath.

Hybrids

Drake crosses of King × Common Eider, and occurrence of mated mixed pairs (Figure 2), have been known for a long time. Localities for these extended at least from Novaya Zemlya to Spitzbergen to northwest Iceland. It is believed that mixed pairs produce few progeny. Only drakes are known. Although I searched in Gisli's colony, I did not see a female having any recognizable King Eider characteristics—but any such bird would be easy to miss.

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Wildfowl (1973) 24:158–161

Maternal nesting behaviour by male Mallards

CHARLES DANE, WILLARD STEFFEN AND PATRICK CALDWELL

Drakes of waterfowl species often accompany their mates during nest-site selection and have been observed to perform nest-building movements (McKinney, 1968). Males of *Anseranas, Cygnus atratus, Dendrocygna* and *Thalassornis* (Kear, 1970) share incubation responsibilities with their mates, but the only reported observations of Anatini males settling on nest scrapes or incomplete clutches of eggs are those noted for male Mallards *Anas platyrhynchos* and a male Blue-winged Teal *Anas discors* (Best, 1939; McKinney, 1968). Rollin (1957) reported a drake Wood Duck *Aix sponsa* sitting on his mate's deserted clutch for varying lengths of time during at least a 12-day period. To these observations we wish to add two records of male Mallard sitting on completed clutches.

Our first observation, which occurred near the Delta Waterfowl Research Station, Manitoba, involved a male, first-year, hand-reared wild Mallard *Anas p. platyrhynchos* and a female Mallard with some game farm parentage. The drake, in full nuptial plumage, had previously accompanied the female to the nest and sat alongside her. While the site was bare, the drake was not sitting in what would normally be described as a nest bowl nor had he added any down or nesting materials around him. At that time, a record of the female's behaviour on the nest was being obtained by means of a camera sequenced to take a picture every 6 minutes with the aid of a strobe light. Temperature probes were also positioned in the air space of three eggs in the nest.

The sequence of photographs and temperature changes (Figure 1) indicates that the female left the nest at 02.55 hours on 10 May 1970. The next photograph showed the drake on the nest, and in the following picture the male had settled further into the nest. He could have been influenced to sit on the eggs by the warmth radiating from the nest or could have been responding to an urge to 'incubate', brought on by the visual stimulus of the eggs, or to 'mimic' the behaviour of the hen. The temperature record shows that for the 30 minutes the male was on the nest insufficient heat was supplied to maintain egg temperature, and it dropped from 38° to 32°C. Ambient air temperature was between 4° and 6°C. When the male left the nest, the nest and egg temperature began to decline sharply and had reached 20°C when the female returned 15 minutes later. When compared with the rate of decline occurring between 00.45 hours and 01.05 hours when the female had left the nest presumably covered (Figure 1), the rate of temperature decline indicates that the male left the nest uncovered. The male was apparently gone from the nest site for almost an hour before returning to again sit in the same location alongside the female. Later that morning the female left and subsequently deserted the nest, perhaps as a result of disturbance from the camera strobe light and temperature monitoring equipment or due to possible harassment by the drake. There are no observations to support either of these suppositions.

The second observation involved a pair of Greenland Mallards *Anas p. conboschas*, C. L. Brehm held at the Northern Prairie Wildlife Research Center in North Dakota.

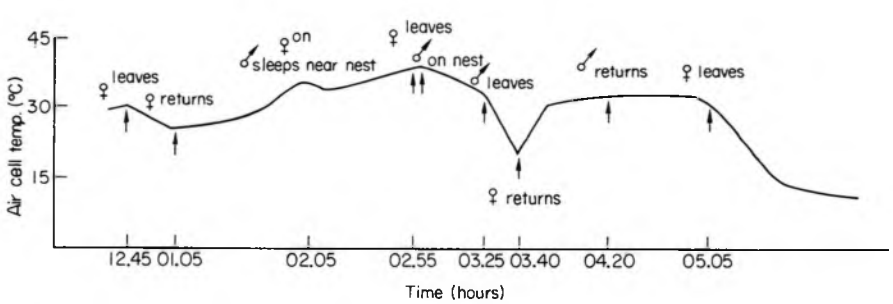

Figure 1. Egg air cell temperature correlated with nesting behavior of female and male Mallard.

On 16 June 1969 the drake was discovered sitting alongside his mate. He was in an unlined nest bowl with down, presumably from the female, around him. The female's nest was lined and covered in the normal manner, and contained five eggs which were not more than 4 days incubated. Because the male was unable to fend off a wild male Mallard that had flown into the pen, the genetic strain of the eggs was questionable, and they were destroyed.

Upon consideration of the closeness of the male to the female's nest and in an attempt to further study the nest behaviour of this Mallard pair, fifteen unincubated mallard eggs were placed in the female's nest during the afternoon of the same day that the original eggs were taken. Neither the female nor the male were within 5 m of the nest site at this time, but on the next day, the male was observed to have settled on the nest. The female chose another nest site and proceeded to lay another clutch, beginning within 7 days after the first clutch had been taken.

The male continued to occupy the nest site and on 24 June exhibited defensive behaviour whenever an observer came close to the nest. Facing the observer, the drake would extend his head forward, fluff his back and scapular feathers, raise and spread his wings slightly, and fan his tail. He would turn and exhibit this typical female nest defence posture (Middleton, 1969) when approached from any direction and would strike with his bill any object, such as a hand, placed near him.

On 26 June, the male was off the nest, but the eggs were covered with down and were warm but wet because it was raining. A visit the following morning revealed the male off the nest and the eggs cold. However, the drake was again seen on the nest that afternoon and all fifteen eggs were still in the nest although ten subsequently became broken. Having reoccupied the nest, the drake was seen on the nest daily and remained until after the estimated hatching date of 13 July. On 21 July, the five remaining eggs were replaced with five star-pipped Gadwall *Anas strepera* eggs. At this time the drake was extremely aggressive and his behaviour was filmed. The following day two Gadwall ducklings hatched successfully. Two eggs were crushed before they hatched and the third embryo died while pipping. The behaviour of the drake and the newly-hatched ducklings at the nest site was also documented on film. When one or both ducklings were placed about 2 m from the nest, the male would utter a low call and the ducklings would return. That same afternoon the male was observed on the pond with the two young Gadwall, but he appeared to have lost interest in them. The ducklings raised themselves and at 2 weeks of age were doing well.

When first observed sitting on the eggs, the drake appeared to have begun his post-nuptial moult. He had a few brown head feathers and a 'ratty' appearance on the breast due to incoming female-like feathers of the eclipse plumage. On 21 July, when the pipped Gadwall eggs were substituted, 50% of his head and back and almost all of his nuptial breast feathers had been replaced with eclipse plumage. However, a portion of the white neck ring was still visible, and his moult during the 'incubation' period may not have proceeded as rapidly as usual.

On 10 September the drake was laparotomized and the presence of testes confirmed. The left testis measured 5 × 11 mm. At that time the bird was acquiring new nuptial plumage typical of the male and 40% of his breast and most of his belly had new nuptial feathers. However, only nine primaries had completely regrown, suggesting that the nesting experience may have delayed the time of wing moult.

Discussion

The cause of the initial behaviour of two male Mallards sitting on nests may have had either a hormonal or non-hormonal basis. Males and females of other species have been induced with proper stimuli to incubate before they had constructed nests or laid eggs (Poulsen 1953; Ytreberg, 1956; Lehrman, 1961, p. 1285; Tinbergen 1953).

Progesterone or an endogenous progestagen is needed to induce incubation behaviour, although a previous priming with testosterone (Riddle and Lahr, 1944; Eisner, 1960; Lehrman, 1963; 1965; Stern and Lehrman 1969) or presumably oestrogen, prepares neural centres for full effectiveness of the progestagen in inducing incubation. There was usually a latent period between exposure to the eggs and performance of incubation behaviour (Lehrman, 1958; Stern & Lehrman, 1969).

After the start of incubation, the act of sitting on the eggs or, in some instances, the sight of eggs or an incubating mate has resulted in the release of prolactin needed for maintenance of incubation (Patel, 1936; Saeki & Tanabe, 1955; Lehrman, 1961). As long as the proper stimuli are present,

birds incubate, even beyond normal incubation periods (Riddle & Lahr, 1944; Saeki & Tanabe, 1955; Kuroda, 1956). Removal of the physical or visual stimulus of eggs results in a decrease in prolactin (Saeki & Tanabe, 1955; Kuroda, 1956), which causes the cessation of incubation behaviour and, in some instances, an increase in follicle-stimulating hormone in females, followed by a renesting effort (Lehrman, 1961; Sowls, 1955).

The full nuptial-plumaged male that sat briefly on eggs in early May was probably attracted by the warmth of the eggs, or driven by a vestigial behavioural response to the sight of eggs. The behaviour of this bird might have been influenced by high testosterone levels and resultant prolactin levels (Tixier-Vidal, 1969). The Greenland Mallard male, which presumably had had enlarged testes producing testosterone capable of sensitizing the neural sites, may also have had circulating progestagens at the time he was noted sitting alongside the female. Progestagens have been shown to be present in extracted seminiferous tubule lipids following testicular metamorphosis and steatogenesis (Lofts & Marshall, 1959). Marshall & Serventy (1956) note that the appearance of lipids in testicular tubules coincides with incubation for at least some species in which the male incubates, and progestagens may occur in the tubules at some stage prior to complete collapse of the testes. Since the postnuptial moult had begun, progestagens probably were present in the two known instances of prolonged sitting by Anatinae males which do not normally incubate (i.e. the Greenland Mallard reported in this study and the Wood Duck reported by Rollin, 1957).

Lipid staining material has been noted in the peripheral cells of the seminiferous tubules of Mallards at the same time that sperm were found in the lumens of the tubules (C. W. Dane, unpublished). This is presumed to be the first recognizable stage in testicular metamorphosis, and is associated with the beginning of postnuptial moult. Therefore, it is possible that the Greenland Mallard male had begun to undergo testicular regression when first observed sitting alongside the nest. The presence of progestagens in the seminiferous tubules and blood stream of the Mallard may have been sufficient to induce incubation behaviour upon absence of the female from the nest and sight of the eggs. Continual contact with the eggs could have been sufficient to induce the production of prolactin, with the result that the male remained on the nest, even beyond the normal incubation period.

Acknowledgments

The authors are especially thankful to Richard Madson for his photography of the Greenland Mallard. Manuscript review comments by Frank McKinney, Forrest Lee, Paul Springer and Gary Pearson are also much appreciated.

Summary

A wild male Mallard *Anas platyrhynchos* in full nuptial plumage sat alongside his mate who was on a nest. Later when she left, he sat on the nest for 30 minutes. A penned, hand-reared Greenland Mallard *A.p. conboschas* in partial moult who had been sitting along his nesting mate, occupied her nest site for 36 days after eggs were exchanged and female apparently deserted the nest. The hormonal balance likely to induce such behaviour is discussed.

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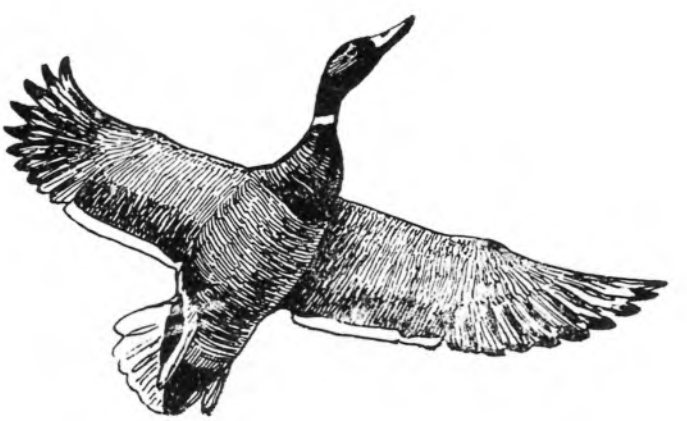
C. W. Dane and Willard Steffen, Northern Prairie Wildlife Research Center, Jamestown, North Dakota.
Patrick Caldwell, Delta Waterfowl Research Station, Delta, Manitoba.



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Research

The Wildfowl Trust's contribution in 1972

Early in the year our monograph '*The Swans*' was published. This team venture, aimed at presenting scientifically based facts in a readable and attractively illustrated form, appears to have been successful, to judge by initial sales. Other publications by staff, or using Trust material and facilities, are listed on p. 176. Since 1953, when our research effort began to bear fruit, there have been 283 papers by staff and 131 assisted by us, together with six books and three booklets. We believe that research without communication is largely wasted.

The long-term monitoring services of the Trust, based on the counting and ringing of wildfowl, were continued and are summarized in the following pages. The duck counts entered their 25th year. Following the decision to place the Third London Airport at Foulness, the Department of the Environment made funds available for connected research. Some of this came to the Trust to enable aerial surveys to be made of the Brent Geese and to develop techniques of catching and marking them.

Research on the feeding ecology of geese at Slimbridge and Caerlaverock continued to make good progress and is already paying dividends in improving the management of our refuges (p. 123).

The individuation and behaviour studies on the Bewick's Swans at Slimbridge were maintained, and extended to Welney. Some alarming facts on the hunting pressure exerted on these protected birds were brought to light (p. 56). An important new comparative study on the flamingos at Slimbridge was begun by Dr P. Kahl, from Florida. The Bristol Ph.D. study on the orientation of birds was completed by A. Whiten, giving definite proof of their measurement of the sun's position in the sky to estimate their displacement in latitude. A Cardiff M.Sc. study by I. McAlpine-Leny was brought to a successful conclusion with the development of a telemetry system for recording heart-rate of free-swimming and diving ducks.

Investigations of the nutrition and growth of young birds led to improved methods of husbandry. Similarly, the post-mortem examinations continually monitored the health of the captive birds and suggested methods for their better care. Much preserved material was made available to our museum and to outside workers. A Cardiff Ph.D. study on avian sperm structure and fertility by P.N. Humphreys was completed.

Towards the end of the year we were heartened by a magnificent gift of £30,000 from Mr Jack Haywood. This will enable the building of the Research and Education Centre to be continued into Phase II.

Wildfowl censuses and counts in Britain, 1972–73

Goose censuses

Pink-footed Goose *Anser brachyrhynchus*. 73,000 Pinkfeet were counted during the annual autumn census held over the weekend 4–5 November 1972. This is 8,000 more than the previous year but only 1,000 more than in 1970. The breeding season was rather poor with 11·4% young birds and mean brood size of 1·6.

European White-fronted Goose *Anser albifrons albifrons*. There was a peak count of 9,000 in mid-January 1973. The mild winter undoubtedly contributed to this figure being lower than might have been expected from the excellent breeding season experienced (42·2% young, mean brood size 2·7).

Greenland White-fronted Goose *Anser albifrons flavirostris*. The second poor breeding season in succession (12% young birds) led to a reduction in numbers at the main haunts covered during the winter.

Greylag Goose *Anser anser*. The annual autumn census on 4–5 November 1972 produced a total of 68,000 Greylags, about 4,000 more than the previous year. Breeding success was below average with 15·1% young birds and mean brood size 1·8.

Barnacle Goose *Branta leucopsis*. The Svalbard population reached a record peak of 4,400 on its Solway wintering grounds following a good breeding season (28·9% young, brood size 1·8). The Greenland population had a less good breeding season (12·1% young, mean brood size 2·1). The first complete census of this population to be carried out since 1966 took place between 25 March and 8 April 1973. The total of 23,600 compared with 20,000 in 1966.

Light-bellied Brent Goose *Branta bernicla hrota*. The maximum count at Lindisfarne, Northumberland, was only 400. In Ireland an early November census revealed about 12,000 which is similar to the total counted in the previous census in November 1970.

Dark-bellied Brent Goose *Branta bernicla bernicla*. An excellent breeding season (44% young birds) helped the total to a new record of 28,000 in mid-January.

M. A. O.

Duck Counts

Shelduck *Tadorna tadorna*. Few birds had returned before the turn of the year, but thereafter numbers soared to the second highest monthly index recorded.

Teal *Anas crecca*. The drying out of the latest polder in the Ijsselmeer was expected to produce an influx of Teal. November saw the highest count since the hard winter of 1963. By December the wave appeared to have moved through and there were unusually high numbers in the Camargue and in the Marismas.

Mallard *Anas platyrhynchos*. Over the whole season Mallard were substantially lower than for several years. Not only had the British production been poor, but immigrants did not move into the country on account of the mild winter.

Wigeon *Anas penelope*. Large numbers were again present on the Ouse Washes, but overall the index was not exceptional, again presumably because of restricted immigration.

Pochard *Aythya ferina*. The very high level of last year was maintained, the index being the same.

Tufted Duck *Aythya fuligula*. Overall there was little change in levels reached in recent years. In Scotland, however, numbers were down and may reflect poor breeding in this segment of the population which is largely home-bred or from Iceland.

Seasonal indices 1972–73 (1959/60 = 100)

Shelduck	121	Wigeon	124
Teal	75	Pochard	193
Mallard	87	Tufted Duck	134

International Wildfowl Census 1972–73
The seventh census was held in mid-November 1972 and mid-January 1973. The full computer analysis of the international counts is under way.

G. L. Atkinson-Willes
Jennifer M. Coldrey

Wildfowl ringing in Britain, 1972

Trapping at the main stations was hampered by the mild weather, both early and late in the year. Not only did this mean fewer immigrants from the mainland of Europe, but those that did arrive found a wide range of abundant food sources. Furthermore, the British-breeding Mallard had a poor production year due to inclement spring weather. Thus there was not the usual abundance of naive, easily trappable youngsters in the early autumn. The overall total of duck ringed, 5,304, was, however, almost exactly the same as in the previous year.

The cage traps at Abberton were once more by far the most successful and provided the richest variety of species (see Table 1). Mr King again acted as warden for the 1,240-acre reservoir on behalf of the Essex Water Company and helped materially to improve their public-access site and observation hide. Borough Fen had the poorest take since the present operator, Mr Cook, took over in 1958. The 'lead' on the decoy pond just did not build up. However, intensive efforts with the cage traps operated on the ballast pits of Deeping Lake a mile away nearly doubled the catch there. The combined total was not very different to last year's. Mr Cook carried out

Table 1. Ducks ringed by the Wildfowl Trust, 1972

	Abberton	Nacton	Borough Fen	Deeping Lake	Slimbridge	Others	Totals
Shelduck	6	·	·	·	·	·	6
Pintail	36	207	·	9	2	14	268
Teal	698	103	199	19	·	3	1,022
Mallard	1,043	651	566	522	222	28	3,032
Gadwall	13	1	1	1	1	·	17
Wigeon	59	133	·	9	1	1	203
Garganey	12	·	·	·	·	·	12
Shoveler	22	11	·	3	2	·	38
Pochard	105	·	·	4	·	·	109
Tufted Duck	534	1	·	54	·	·	589
Scaup	4	·	·	·	·	·	4
Goldeneye	2	·	·	·	·	·	2
Smew	2	·	·	·	·	·	2
Totals	2,536	1,107	766	621	228	46	5,304

a number of orientation releases, and also served on committees concerned with the effects on wildfowl of the proposed Empingham Reservoir and the Wash Barrage schemes. Mr Revett in his first full year at Nacton kept level pegging with the previous year which had seen the retirement of his illustrious father-in-law decoyman. He also began orientation releases and was able to break new ground with Wigeon and Pintail, as well as Mallard.

At Slimbridge the small catch in the decoy is now normal because of the greatly increased counter-attractions of the surrounding grounds housing the captive collections. Bewick's Swans were caught in useful numbers, 91, and were dye-marked as well as being ringed, weighed, measured and X-rayed (p. 56). The more numerous recaptures and repeats were particularly important in this study, as in that at Abbotsbury and Radipole, South Dorset, on the colonially-breeding Mute Swans—44 ringed.

At Caerlaverock, cage-trapping began on a small scale and useful knowledge was gained on the siting of traps. A lot of effort went into attempting to rocket net Barnacle Geese, but without success because the birds persisted in feeding on the sanctuary merse rather than on the farm fields. A new venture, cannon netting Brent Geese in the Foulness area, began in October by Mr St. Joseph, but had not been fruitful by the year's end.

M.A.O.

Education

The Wildfowl Trust's contribution in 1972

The demand for the Trust's educational facilities continued to increase and some 25,000 children from 712 schools took advantage of the facilities for day visits. The Youth Hostels Association Field Study Centre is now operating smoothly and twenty-two courses concentrating mainly on wildfowl and their environment were supervised by Trust staff. Two one-day courses for in-service teachers were held at Slimbridge. Eight final year students from Redland College of Education assisted with the schools programme from May to July. Professor Matthews and Dr Kear again provided a series of lectures for the psychology and zoology departments at Bristol and Cardiff Universities. External lectures were given to thirty-six societies.

A new display in the form of twelve double-sided wall book panels was prepared for the New Observatory at Caerlaverock.

E. E. Jackson

Wildfowl (1973) 24:165–175.

Conservation

The Wildfowl Trust's contribution in 1972

The results of the research programme were applied in many ways, not only with the Trust's own refuges, but in support of the Nature Conservancy's activities. Close liaison was maintained with other bodies concerned with conservation of the natural environment. Threats to its integrity were resisted at Foulness, the Exe Estuary, Langstone Harbour and Loch Strathbeg.

Activities on the Trust's own refuges at Slimbridge, Welney and Caerlaverock are recorded in the following pages. The developing plans for new wildfowl collections at Martin Mere, Lancashire, at Arundel, Sussex, and at Washington, Durham, will require a comprehensive and scientific system of records, stud books, recruitments and exchanges. Dr Janet Kear took up the duties of Avicultural Co-ordinator towards the end of the year. The Slimbridge Curator, S. T. Johnstone, retired after 26 years service with the Trust.

International conservation activities were channelled through the International Waterfowl Research Bureau headquarters at Slimbridge. The massive Proceedings of the Ramsar, Iran, Conference in 1971 were published. Conferences were attended in Romania, Iceland, Jersey and Czechoslovakia. Three of the Trust research team were flown into the Thjorsarver oasis in central Iceland to see and advise on the programme of research on the vast, and threatened, Pink-footed Goose colony there.

Slimbridge: the wild geese 1972–73

European White-fronted Goose
Anser albifrons albifrons

The first to arrive were twenty on 2 October, immediately followed by several more parties to give a total of 140 on 5 October. Thereafter, the rate of increase slowed right down and there were still only 182 on 13 November. On 21 November the flock went up to 282, then to 738 on the 26th and 1,100 on 28 November. There was little change during early December but further influxes brought the total to 2,000 on the 28th and to 3,500 on 2 January. Soon after the numbers went over 5,000 and reached a brief peak of 6,000 on and about 15 January. After remaining above 5,000 for the rest of January they declined quickly so that in early February there were not more than 4,000. By the middle of the month there were only 2,600 but this level was maintained until early March. There were 1,000 on 7 March, ninety on the 8th and none on the 9th.

It was an excellent breeding season with 42% young birds in the flocks with an average brood size of 2·7.

Lesser White-fronted Goose
Anser erythropus

No authenticated record of this species was received during the winter. A number of reports could be traced to a full-winged collection bird.

Bean Goose *Anser fabalis*

A first year bird referable to the Russian race *A. rossicus* was present from 2 January to 2 March.

Pink-footed Goose
Anser brachyrhynchus

The sighting of ten birds in flight over the estuary on 12 September brought back memories of the days when Icelandic Pink-feet spent the early winter at Slimbridge, but they did not stay on this occasion. A single adult was present from 1 December to mid-February.

Barnacle Goose *Branta leucopsis*

A first year bird was seen on 2 January and subsequently there were up to four different birds present, being last seen on 2 March.

Dark-bellied Brent Goose
Branta bernicla bernicla

An adult was first seen on 2 December. It stayed throughout the winter and was last sighted on 2 March.

M.A.O.

Slimbridge: The wild swans 1972–73

Until this winter the earliest the Bewick's Swans had ever returned to Slimbridge was in 1968, on 20 October. This year the first swan, Drift, arrived on 15 October. Rather amazingly, she had left with the last swans on 22 March 1972. Next back, the following day, was Pie, a particularly welcome arrival, as he is the bird that X-rays have shown to be carrying twenty-one lead pellets (p. 57).

Attendances built up to sixty in 8 days, and it took another month for this figure to just more than double. Another sixty arrived towards the end of November, and daily counts were then around 200 until just before Christmas. An influx towards the end of December produced attendances of around 300, and on 8 January the greatest number present in one day for the season was reached, 325. The climax was, however, short-lived. Fifty had disappeared on 13 January, another eighty by the next day, and two days later the day total was only 105. More left gradually towards the end of January, so that by 31 January there were only seventeen left. Numbers were very low during February and most of March, the last swan leaving on the 20th.

The total for the season of individual swans was 452, which is lower than any of the previous three winters. Total numbers on the Ouse Washes were, however, also down, and, the winter being so mild, it is suspected that the birds may not even have come to Britain from the Low Countries. The cygnet proportion was 19%, which was an improvement on last year's 11%. Three families had four cygnets, eleven had three, eleven had two, and there were twenty singles. The mean brood size was 1·9. The return rate of adults and yearlings from previous seasons was 61%.

One hundred and eleven swans were caught this winter, bringing the number of Bewick's ringed at Slimbridge to 481. This year the feeder walked the opposite way round Swan Lake, starting with the pipe, and we think this may have helped the birds to associate the pipe area with the appearance of food. X-raying was continued (see pp. 56), and 107 Bewick's left Slimbridge with their tails and wing tips dyed yellow for easier recognition.

When the weather was mild, and so many birds left so early (some had also left in mid-January in the past two winters, but not in quite such large numbers), we rather expected a flood of reports of the dyed swans. This, however, in marked contrast to the past two winters, was not to be the case. Apart from the Moors, just a mile from the Trust, dyed swans were only reported from four places in Britain, and totalled only eleven birds. On the continent sightings of five dyed swans on the North Sea coast of West Germany on 17 and 18 January were the earliest ever. Similarly, there were early reports from the Netherlands and Denmark. Dyed swans were reported from these three countries during the next 2 months; also from Gotland, Sweden, in March and Estonia in April. The total reports of dyed swans seen on the continent is eighty-one, but this probably represents a minimum of thirty-one birds, as there were many cases of obvious duplications. These early reports, coupled with the low figures in Britain, confirm the view that many Bewick's Swans come to this country only when forced to by weather on the continent, returning as soon as they can to pass the rest of the winter. One particularly interesting sighting was that of a dyed cygnet in the Netherlands on 30 January. The whole family, which was all marked yellow, had disappeared from Slimbridge together on 25 January, but of the parents and the other two cygnets there was no sign. This cygnet was still in the same place on 17 March. Also in this flock was a rather famous ringed bird, called 'Sahara'. His portrait appears at the front of *Wildfowl* 19, as well as *The Swans*. After five consecutive winters here, he had not been seen since 1969–70. Perhaps he has taken to wintering in the Netherlands. Even without dye the rings are providing some interesting information: we now know of two 'Slimbridge' swans that have each spent two consecutive winters on the Slobs in Co. Wexford; and of one this winter, which appeared at Slimbridge for one day, and later turned up on the Slobs. Welney is also claiming its devotees. Of forty swans there in 1971–72, with Slimbridge experience, fourteen of them were there again this winter, only two of them coming to Slimbridge first. Another three missed out Welney, but did come to Slimbridge. Of those whose Welney experience we do not know about, one came from Welney to Slimbridge, and twelve went the opposite way. The total of 'Slimbridge' birds seen at Welney was forty-eight.

The swan study at Slimbridge was started 10 years ago with twenty-four birds being recorded. Two of these completed the decade this year! They were Lancelot and Amber (quite unconnected), and the latest

news of Lancelot is that he was on the Elbe estuary on 2 March, on that familiar route to the north!

The last bird to leave Slimbridge was called 'Folly'! He had first come in December 1968 but this season only arrived on 21 February, and was then trailing a large amount of nylon fishing line from his left leg. It became apparent that he was not going to lose it by himself, and fortunately we were able to catch him. It was then discovered that the gut was attached to him by two treble fish-hooks, five of the hooks being embedded in his leg. Part of an even larger treble hook was hanging amongst the rest of the tangle. By the time he left he had quite recovered from his ordeal.

A total of nine Whooper Swans came to Slimbridge during the winter. One was a pair that had been here before, in 1969–70 and 1971–72. They came with a cygnet, and another pair, but they all only stayed one day (16 November). However, another pair with a cygnet, and a single adult, arrived on 19 January, and stayed until 25 February.

Mary E. Evans

Slimbridge: Curator's report for 1972

The 1972 breeding season, the last of the twenty-five during my time at Slimbridge, has not been the most successful.

Before coming to the Wildfowl Trust, I used to spend my weekends playing golf. Being only a moderate player, each round one expected to make a showing worthy of Henry Cotton. Of course one never did, but somehow one never became completely demoralized. Likewise with the ducks and geese, each season was looked forward to in the hope of doing much better than in previous years, but each was a mixture of successes and failures.

A record number of forms laid eggs in the grounds, 114 if one includes Mute Swan, Atlantic Canada Goose and Mallard—none of whom are exactly encouraged. Ninety-three kinds were reared from Slimbridge eggs, plus three more, Greater Scaup, Maned Goose and Barrow's Goldeneye, brought in from elsewhere. The single Radjah Shelduck was of the Black-backed race *Tadorna radjah radjah* never previously raised at Slimbridge. There were also two leucistic young that give rise to the dark form of the Ruddy Shelduck (see Figures 1 and 2).

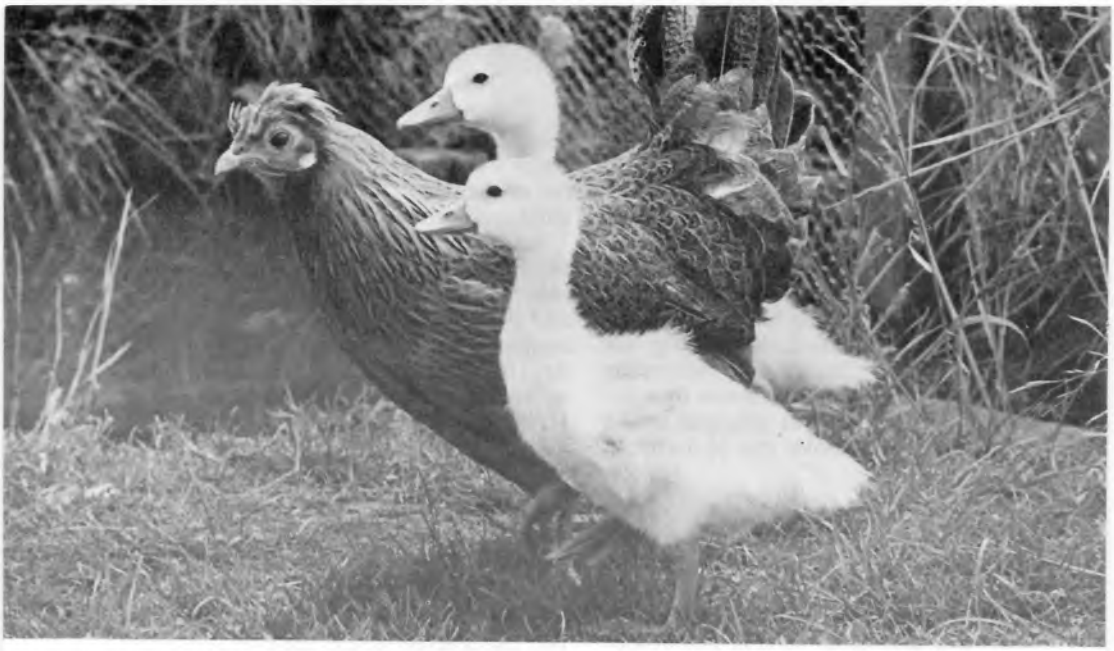
Sadly the hatchings of some of the more exciting species were lost in their entirety from Aspergillosis. These included Bronze-winged Duck, American Goldeneye, Buffle-head, Hooded Merganser and Red-breasted Merganser. There had been storm damage to the roof of the Propagation Building and the chipboard, which formed the ceiling of the internal duckery, became damp and mouldy. In consequence the Duckery was evacuated to brooders outside. A new dry ceiling was put in the building and the whole place treated with fungicide. Spores were also found in some sitting boxes.

It has become obvious over the years that the weakest link in the chain of events that produce fully grown ducklings is the incubation by broody hens. Their advantages are that, provided the sitting boxes are on an earth bank, the hens can control the humidity of the eggs by drawing up moisture. Again the eggs are turned by the bird at regular intervals. They also protect the young from the attention of predators, will teach them to feed and facilitate the nightly shutting up by leading the brood into the brooder.

The disadvantages are that the hen can carry diseases, in particular tuberculosis. They very easily become infested with insects, redmite, fleas, etc., which if not quickly detected may cause the death of the broody or at least cause the bird to give up incubating with the consequent loss of a clutch of eggs. Occasionally a hen or bantam will peck out the webs from the feet of the young or even peck them to death on hatching.

A further disadvantage is that on the scale of production at Slimbridge one has to keep a veritable poultry farm in order to produce broodies and even so I can never remember a season when there were enough broodies at any given time.

Incubators have never proved to be really successful and there have always been heavy losses during the early stages of incubation, possibly due to the Heath Robinson methods of controlling the humidity. However, they are satisfactory for finishing off well incubated eggs and are quite satisfactory as hatching machines. It would seem that there are ample reasons for research into producing an efficient incubator, holding twenty or thirty eggs which can be used in battery form.



K. Holder

Figures 1 and 2. The Ruddy Shelduck *Tadorna ferruginea* sometimes produces leucistic downies (above with bantam foster parent) which surprisingly turn into adults that are much darker than normal (below). The female (right) has an all-white head, however, reminiscent of the Paradise Shelduck *T. variegata*.

K. Holder

K. Holder

Figures 3 and 4. An admiring group of Chilean Flamingos *Phoenicopterus ruber chilensis* round their youngsters. Below: feeding of the young on regurgitated fluid starts early in the Andean Flamingo *Phoenicoparrus andinus*.

K. Holder

After the depressing results with the ducks and with those geese not left to their parents, it is refreshing to turn to the swans, which had a very good season, and especially to the flamingos. For the first time in any collection in the world four of the six kinds reared young (Figures 3 and 4) and a fifth, the Lesser Flamingo, laid the first egg in captivity. Unfortunately it was badly holed by some predator.

The greater part of 1972 was taken up with the development of the 60 acres that has been added to the existing pens. This involved extending the Big, Asian, European and African pens out to the rhine in the 30-acre field and fox-proofing the area together with the two meadows beyond the rhine. The oak and lime spinney below the Acrow Tower is also enclosed. The Long Ground is likewise within the perifence. The 11-acre field to the north of the car park has been fenced as a rearing area. It is proposed to build aviaries to house all forms of the Mallard family and also to construct a row of enclosures for the White-winged Wood Duck. Large pens have been made for the swans and a considerable number of ponds and waterways dug and anti-eroded. Extra water is to be provided with the aid of a series of well points. It was intended to turn the Long Ground into a Nene Park with a series of side pens for potential breeding pairs.

S. T. Johnstone

Peakirk: Curator's Report for 1972

The breeding season began on 13 January when the *Cereopsis* laid its first egg. This was a month earlier than usual, and owing to the difficulty of obtaining broody hens at this time of the year, the eggs were left with the mother to incubate. Unfortunately cold weather and snow was experienced and all five eggs proved to be addled.

Apart from a fine spell during the latter part of March, weather conditions throughout the first half of the year were generally unsettled and wet.

The Nene pens on the Neaverson Area were not used this season and the breeding Nene were placed in the Main Side pens. Fertile eggs were obtained from all the pairs, and eight young were successfully reared. For the second year in succession, the Trumpeter Swans produced a clutch of seven eggs, from which four cygnets were reared. Ring-necked Duck bred for the second year and, with more than one pair of these birds now in the Gardens, it is hoped that this species will multiply in the future. The season ended with a late clutch of Southern Red-billed Whistling Duck that hatched on 28 September.

During the season some sixty-seven species and subspecies laid eggs, and of these, 370 individuals of fifty-one varieties were reared. The more notable species included Cackling Canada Goose, Red-breasted Goose, Patagonian Crested Duck, Garganey (for the first time for several years), Baer's Pochard and Maned Goose.

In general, 1972 appeared to be a poor year for geese, probably due to the wet weather conditions.

P. B. Vardy

Welney Wildfowl Refuge, 1972

Despite the relatively mild winter the numbers of duck on the refuge during January were consistently high. A count on 15 January produced 22,000 Wigeon, 2,300 Mallard, 2,000 Teal, 450 Pintail and 200 Shoveler. The high water level at this time drove the Wigeon to feed on the grass of the new screen banks, often within feet of the observation hides. The lagoon in front of the Observatory was the home of a great flock of Bewick's Swans, totalling about 400 through January, rising to a peak of 550 in late February and keeping at this level for about a fortnight. With them were up to thirty-one Whoopers and 100 Mutes. All these swans were fed daily by the warden and became completely accustomed to his appearances with barrows of wheat. The majority of the Bewick's left rather suddenly in mid-March though two did stay on until the middle of April.

Although Wigeon numbers dropped right away to 14,000 in February and 9,000 in March, there was a brief influx of Pintail in the latter month with 600 on the 11th, when there were also 500 Shoveler. Small numbers of wild geese were seen from time to time, with up to a dozen Whitefronts and two Beans being positively identified.

The breeding season had begun well before the last two Bewick's had departed, though early broods of Mallard suffered heavy losses in the wet cold weather at the end of April. Four pairs of Black-tailed Godwits bred as did two pairs of Ruff, and they and the later ducks successfully reared their young. Among the latter were more Mallard, plus Teal, Garganey, Shoveler, Tufted Duck and Shelduck.

The autumn build-up of ducks was fairly slow with only 2,000 Wigeon present in mid-October, together with 1,600 Mallard and 400 Teal. The first Bewick's arrived in early October but increased steadily so that by mid-November there were 350. At this time the duck numbers started to increase with 12,500 Wigeon on 23 November. However, this figure was dwarfed at the end of the year when it was estimated that there were not less than 30,000 Wigeon on the Refuge. Other duck numbers remained low, however, with no more than 2,000 Mallard and 1,300 Teal. Pintail and Shoveler both reached 500.

Bewick's Swans increased to 540 by the end of the year when there were also twenty-one Whooper Swans, and up to twenty-three Whitefronts.

M.A.O.

Eastpark Wildfowl Refuge, Caerlaverock, 1972–73

Barnacle Goose *Branta leucopsis*

The first fourteen geese arrived on 27 September. Numbers rose to 350 by 1 October, passed 1,000 on 7 October, 3,200 on the 13th and reached a post-war record peak of 4,365 on 15 October. Over 4,000 were present, except for short periods, until 8 February. By 18 February numbers had decreased to 3,500 and by 21 February all save fifty-three were at Rockcliffe. They remained there most of the rest of the season, paying odd return visits to Eastpark in numbers up to 2,100.

Two white juveniles, together with a normal sibling and normal parents were observed on 12 October. The next day a white adult appeared and the following day yet another. These two adults were in all probability the birds that overwintered last season; as then, they did not associate. One of these birds disappeared about 20 November and is feared dead as there was no change in numbers such as would have indicated a movement away of part of the flock. A close-up photograph of the remaining adult was obtained (Figure 1).

From a sample of 900 geese scrutinized in good light conditions, the proportion of young in the flock was estimated at 26%, nearly twice last year's figure. The average brood size was 1·9.

Not only were more geese present for much longer, but improvement in the stock management on the merse (see p. 123), and the mild weather, resulted in a much higher proportion of their time being spent there than in the previous 2 years (70·7% *v.* 31·6% and 42·1%).

Pink-footed Goose *Anser brachyrhynchus*

Thirty arrived on 10 September and numbers built up to 2,000 in February and March. Although these were lower than last season, they represent a bigger proportion of the population in the area which rose to around 5,000. Arrangements successfully concluded with the local wildfowling clubs to reduce shooting pressure on the land immediately across the boundary Lochar Water probably helped to bring about this improvement.

Greylag *Anser anser*

Numbers in the Solway area were lower than in the previous two seasons. Although small flocks used the refuge throughout the winter, the largest was seventy-two.

Other wildfowl

In August sixty-eight Canada Geese regularly flighted to the merse from Kinmount Estate near Annan, but wisely remained there once the shooting season opened.

A Light-bellied Brent was with the Barnacles as in the two previous seasons and came into the enclosure one day. Up to eleven wild Whooper Swans spent November to April within the enclosure, mainly feeding on grass but also taking some of the grain offered to the tame birds. Wild Bewick's also came in, up to nine and including a brood of two and another of three. They departed on 6 March. Wigeon

Figure 1. Adult leucistic Barnacle Goose *Branta leucopsis* at Eastpark, Caerlaverock, January, 1973. *Myrfyn Owen*

in the enclosure reached a peak of over 240 in January and the first wild Goldeneye and Gadwall were noted therein. Most surprisingly a male Baikal Teal *Anas formosa* flew in on 19 February and remained for several weeks.

C.R.G. Campbell

Slimbridge: Breeding results 1972

Species	Date of 1st egg	Eggs set under hens	Hatched by hens	Reared by hens	Reared from incubator	Reared by parents	Total reared
Fulvous Whistling Duck	·	44	7	7	·	10	17
Cuban Whistling Duck	·	7	1	1	·	·	1
N. Red-billed Whistling Duck	11·7	·	·	·	8	·	8
S. Red-billed Whistling Duck	28·4	8	6	5	35	·	40
Black Swan	23·1	·	·	·	·	3	3
Black-necked Swan	23·2	·	·	·	·	4	4
Whooper Swan	22·4	·	·	·	·	5	5
Trumpeter Swan	13·4	·	·	·	·	8	8
Swan Goose	13·4	5	1	1	·	·	1
Western Bean		6	1	1	·	·	1
Russian Bean	5·5	4	0	0	·	·	0
Pink-footed Goose	25·4	·	·	·	·	1	1
European White-fronted Goose	·	·	·	·	·	3	3
Pacific White-fronted Goose	2·5	4	1	1	·	·	1
Greenland White-fronted Goose	17·4	14	4	4	·	3	7
Lesser White-fronted Goose	5·5	14	9	9	·	2	11
Western Greylag	3·4	4	1	1	·	24	25
Eastern Greylag	6·4	6	1	1	·	2	3
Bar-headed Goose	2·5	·	·	·	·	2	2
Lesser Snow Goose	3·5	·	·	·	·	7	7
Greater Snow Goose	14·5	·	·	·	7	·	7

Species	Date of 1st egg	Eggs set under hens	Hatched by hens	Reared by hens	Reared from incubator	Reared by parents	Total reared
Ross's Goose	15·5	11	6	2	·	·	2
Moffitt's Canada Goose	8·4	·	·	·	·	2	2
Lesser Canada Goose	·	·	·	·	·	5	5
Taverner's Canada Goose	·	·	·	·	·	0	0
Cackling Goose	28·4	9	7	6	·	2	8
Hawaiian Goose	8·2	112	29	21	·	3	24
Barnacle Goose	14·4	·	·	·	·	32	32
Black Brant	25·5	3	0	0	·	·	0
Red-breasted Goose	15·6	19	6	3	·	·	3
Radjah Shelduck	10·5	4	1	1	·	·	1
Ruddy Shelduck	1·4	11	2	2	·	9	11
New Zealand Shelduck	26·3	8	1	1	·	·	1
Common Shelduck	8·4	·	·	·	11	·	11
Abyssinian Blue-winged Goose	23·4	10	2	2	·	3	5
Egyptian Goose	25·1	·	·	·	·	8	8
Orinoco Goose	24·3	·	·	·	·	0	0
Andean Goose	11·4	·	·	·	·	10	10
Flightless Steamer Duck	16·4	·	·	·	·	0	0
Ashy-headed Goose	24·4		·	·	·	4	4
Greater Magellan Goose	16·4	·	·	·	·	5	5
Cape Barren Goose	3·12	·	·	·	·	3	3
Patagonian Crested Duck	8·4	·	·	·	·	6	6
Andean Crested Duck	12·3	10	4	0	·	3	3
Bronze-winged Duck	24·4	3	2	0	·	·	0
Marbled Teal	31·5	·	·		12	·	12
Hottentot Teal	13·12	·	·	·	·	3	3
Versicolor Teal	11·4	20	7	7	·	·	7
Puna Teal	8·4	21	7	7	·	·	7
Red-billed Pintail	·	·	·	·	4	·	4
Bahama Pintail	·	·	·	·	30	9	39
Chilean Pintail	4·4	·	·	·	2	·	2
Kerguelen Pintail	15·4	13	4	3	·	·	3
Northern Pintail	5·4	10	6	6	1	·	7
Chilean Teal	23·3	·	·	·	2	·	2
Sharp-winged Teal	·	5	3	0	·	·	0
American Green-winged Teal	22·5	·	·	·	3	·	3
Falcated Duck	8·6	12	7	5	·	·	5
Australian Grey Teal	2·4	29	14	11	·	·	11
Chestnut-breasted Teal	7·4	24	3	3	4	·	7
New Zealand Brown Teal	20·4	7	3	1	1	·	1
Hawaiian Duck	23·3	6	5	5	2	·	7
Laysan Teal	20·4	16	9	9	2	·	11
Mexican Duck	28·3	·	·	·	4	·	4
Indian Spotbill	20·5	11	6	5	·	·	5
New Zealand Grey Duck	20·3	·	·	·	13	·	13
Philippine Duck	20·3	12	6	6	5	·	11
Abyssinian Yellowbill	2·3	·	·	·	5	·	5
Gadwall	16·4	·	·	·	5	25	30
European Wigeon	25·5	·	·	·	13	·	13
American Wigeon	·	8	0	0	·	·	0
Chiloe Wigeon	·	10	0	0	1	·	1
Blue-winged Teal	·	·		·	2	·	2
N. Cinnamon Teal	·	6	0	0	·	·	0
Argentine Shoveler	14·4	15	8	7	·	·	7
Cape Shoveler	·	8	3	0	·	·	0
Australian Shoveler	24·2	16	0	0	·	·	0
New Zealand Shoveler	·	4	0	0	·	·	0

Species	Date of 1st egg	Eggs set under hens	Hatched by hens	Reared by hens	Reared from incubator	Reared by parents	Total reared
Common Shoveler	11·4	·	·	·	1	·	·
Ringed Teal	17·4	45	9	8	·	·	8
European Eider	18·4	23	17	11	·	·	11
Red-crested Pochard	20·3	40	13	13	7	·	20
Rosybill	28·4	·	·	·	15	·	15
African Pochard	·	4	0	0	·	·	0
European Pochard	9·4	·	·	·	2	·	2
Redhead	20·4	·	·	·	5	·	5
Common White-eye	15·5	·	·	·	18	·	18
Baer's Pochard	4·6	5	1	1	·	·	1
Australian White-eye	1·5	·	·	·	4	·	4
New Zealand Scaup	28·4	9	4	0	9	·	9
Ring-necked Duck	31·5	8	7	6	4	·	10
Tufted Duck	6·6	10	10	10	9	·	10
Lesser Scaup	31·5	·	·	·	3	·	3
L. Brazilian Teal	18·6	7	2	0	·	·	0
Mandarin	3·4	13	6	6	15	·	21
North American Wood Duck	19·3	27	26	26	10	·	36
Comb Duck	7·7	41	14	12	·	·	12
White-winged Wood Duck	15·4	·	·	·	·	13	13
Muscovy	1·5	9	4	4	·	8	12
European Goldeneye	12·5	6	3	3	·	·	3
American Goldeneye	13·4	13	4	0	·	·	0
Bufflehead	11·5	6	5	0	·	·	0
Smew	12·5	43	9	2	·	·	2
Hooded Merganser	1·4	11	8	4	·	·	4
Red-breasted Merganser	16·6	14	6	0	·	·	0
North American Ruddy Duck	3·5	·	·	·	4	16	20
Greater Flamingo	30·4	·	·	·	·	5	5
Rosy Flamingo	7·6	·	·	·	·	7	7
Chilean Flamingo	31·5	·	·	·	·	16	16
Andean Flamingo	12·5	·	·	·	·	1	1
Lesser Flamingo	9·7	·	·	·	·	0	0

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Species	Date of 1st egg	Eggs incubated	Eggs hatched	Young reared
Fulvous Whistling Duck	19·4	24	8	7
Red-billed Whistling Duck	3·6	30	17	10
Black-necked Swan	4·3	5	0	0
Trumpeter Swan	11·4	7	5	4
Swan Goose	5·4	12	1	0
Western Bean Goose	22·4	6	0	0
Pink-footed Goose	20·4	10	6	3
Greenland White-fronted Goose	22·4	9	3	1
Lesser White-fronted Goose	20·5	2	0	0
Western Greylag Goose	13·4	13	7	7
Emperor Goose	22·5	13	3	2
Lesser Snow Goose	26·4	16	7	5
Ross's Goose	22·5	4	0	0
Taverner's Canada Goose	26·4	6	0	0
Cackling Canada Goose	26·4	10	8	8
Hawaiian Goose	22·2	31	10	8
Barnacle Goose	2·5	14	0	0
Red-breasted Goose	18·6	4	1	1
Ruddy Shelduck	19·4	7	2	2

Species	Date of 1st egg	Eggs incubated	Eggs hatched	Young reared
Cape Shelduck	30·3	13	3	3
New Zealand Shelduck	20.4	9	2	1
Common Shelduck	7·5	10	1	1
Abyssinian Blue-winged Goose	3·6	4	1	1
Andean Goose	20·5	4	4	3
Ruddy-headed Goose	24·4	8	6	0
Lesser Magellan Goose	4·4	13	12	4
Greater Magellan Goose	29·4	8	3	2
Cape Barren Goose	13·1	5	0	0
Patagonian Crested Duck	23·5	4	4	4
Marbled Teal	8·5	38	32	25
Cape Teal	28·4	6	5	5
Red-billed Pintail	27·4	7	1	0
Bahama Pintail	10·6	7	3	2
Chilean Pintail	5·4	18	11	9
Northern Pintail	18·4	51	28	19
Chilean Teal	18·3	30	11	8
Falcated Teal	7·6	6	0	0
Australian Grey Teal	29·5	9	0	0
Chestnut Teal	1·5	3	0	0
North American Black Duck	16·5	7	1	0
Hawaiian Duck	9·4	22	12	11
Laysan Teal	13·4	19	9	8
Mexican Duck	28·4	8	1	1
Philippine Duck	10·5	8	0	0
African Yellow-bill	25·5	6	6	5
Abyssinian Yellow-bill	31·3	17	16	8
Gadwall	23·4	38	21	20
European Wigeon	13·5	28	22	22
Chiloe Wigeon	28·4	8	0	0
Garganey	18·5	9	9	8
Common Shoveler	19·5	27	16	12
European Eider	5·5	17	10	8
Red-crested Pochard	9·4	49	11	5
Rosybill	18·5	43	20	17
African Pochard	11·6	6	2	2
European Pochard	14·4	24	12	11
Redhead	28·5	7	5	2
Baer's Pochard	9·6	8	4	3
Australian White-eye	8·6	18	14	4
New Zealand Scaup	8·6	10	8	7
Ring-necked Duck	22·5	14	7	3
Tufted Duck	29·5	27	22	11
Lesser Scaup	16·6	2	0	0
Maned Goose	7·3	34	20	10
Mandarin Duck	1·4	24	17	13
North American Wood Duck	16· 3	51	37	24
North American Ruddy Duck	15·5	41	28	10

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