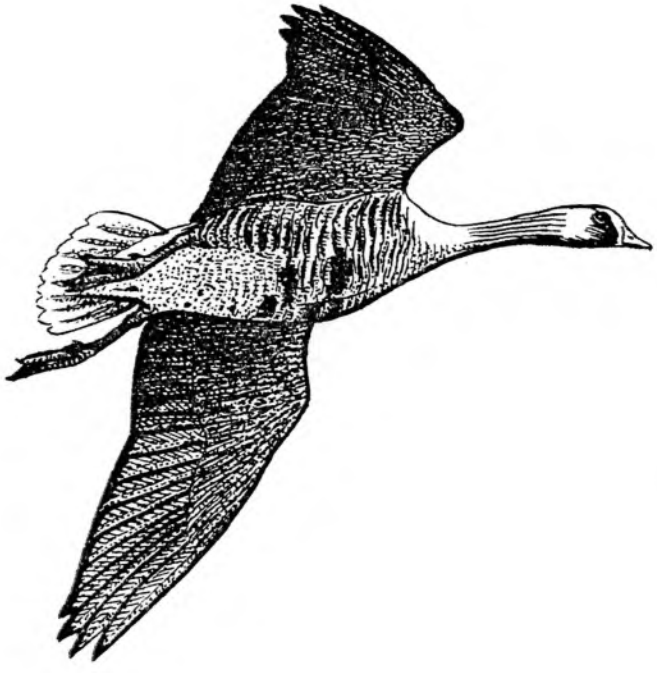

WILDFOWL

19

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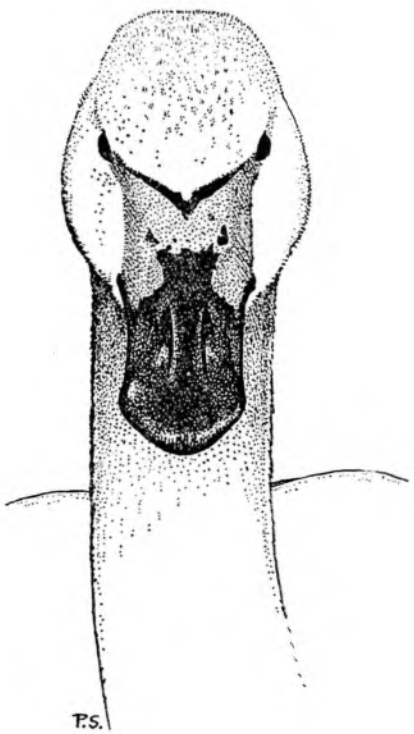

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The Wildfowl Trust, Slimbridge, Gloucestershire, England

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Contents

Editorial

Since 1961 the Annual Report of the Wildfowl Trust has been divided into two parts. One was the annual report proper, an account of the Trust's activities for its Members. The other was the Yearbook, consisting of papers relating to the conservation and study of wildfowl, not necessarily written by members of the Wildfowl Trust staff. The value of the forum thus provided has been widely acclaimed.

Two difficulties have arisen, however, from the continuing use of the title *Wildfowl Trust Annual Report*. On the one hand some Members have felt that too much money was being spent on an 'annual report'. On the other hand, libraries and individual research workers, not conversant with its contents, neglected our journal because they did not want, understandably, to clutter their shelves with 'annual reports' from sundry organisations. Apart from the question of sales (and the larger the number printed the lower the cost per copy), the library at Slimbridge could benefit by an increase in the number of exchanges which already brings in many journals to its shelves. After considerable discussion by our Council and Scientific Advisory Committee, it has been decided that both the difficulties could be resolved by a change of name, to a title more truly indicative of its contents.

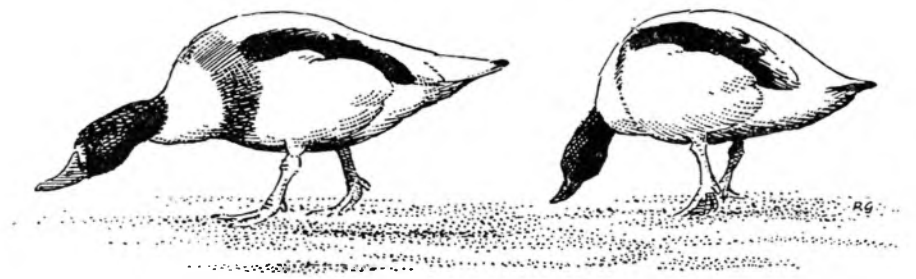
As will be appreciated, the choice of name has not been easy. It was desirable that continuity of reference to previous issues of our journal should not be lost. This meant that there should not be a complete change of title, for instance to *Anser*. For a time *Wildfowl Trust Annual Review* seemed a possibility, particularly as we hope to increase the number of review articles. However, other types of article would still appear and there is certainly a preference nowadays for short, snappy, titles. The decision has therefore been made to take the first word of the previous title and to call our journal 'Wildfowl'. The numbering sequence of the volumes will be retained, so this successor to the *Wildfowl Trust Eighteenth Annual Report, 1965-66* published in 1967, will be known as WILDFOWL 19, published in 1968. The annual report section will continue to be bound in, unless there is a strong demand for it to be printed as a 'drop-out'.

In these days of the 'information explosion' when specialist journals proliferate (the prospectus for the 'Proceedings of the Society for the Study of Inborn Errors of Metabolism' is the latest to come our way), we would emphasise that we are not starting a new journal, nor will it be a particularly specialist one. Apart from their own fascination as a group of birds, the wildfowl are 'biological indicators' for the condition of wetlands, of all habitat the most threatened by Man's attrition of his environment. A wide range of disciplines and interests thus come to bear on wildfowl and their ecological associates, the wading birds. Our aim will be to publish articles readily understandable by specialists in other fields and by the intelligent layman. And, since most of the species involved are migratory, the international aspects of the research and conservation methods need no stressing. It is reflected in the wide geographical coverage of the articles.

Definitive articles and research reports form the bulk of WILDFOWL. They are followed by a series of Current Reports on regular research and conservation activities concerned with wildfowl, both wild and in captivity, mostly under the auspices of the Wildfowl Trust. Finally comes the Annual Report of that organisation to its Members. The photographic section has been dispersed through the volume instead of being gathered in one group, as in the past.

We would like to emphasise that there is nothing sacrosanct in any of these arrangements and we welcome suggestions from readers as to how WILDFOWL could be improved. We also welcome articles and reports of the range and type indicated above, likewise photographs and line drawings of high quality. Instructions to contributors are printed on the inside back cover.

It would be inappropriate to close this editorial without a tribute to the energy of Hugh Boyd, who, building on the inspiration of Peter Scott, raised the *Wildfowl Trust Annual Report* to the status of an international journal. We wish him well in his new post in Canada, and seek to carry on, and develop, his good work.



The moult migration

FINN SALOMONSEN

Introduction

The flight- and tail-feathers are shed simultaneously in wildfowl, auks, divers, rails and a number of other groups, thus rendering the birds flightless and rather helpless for a period each year. The birds withdraw at this critical time to special areas where they are safe, usually to secluded places in dense marshes, lakes, coastal waters or the open sea. The main requirements of such areas are sufficient food, safety from predation, and (in water birds) an adequate depth of water. If these conditions are not met on the breeding ground or its immediate vicinity, the birds make a pre-moult shift to areas further away. This has in some cases resulted in a mass transfer of individuals in a fixed direction towards localised moulting places. This so-called 'Moult Migration' is particularly highly developed in wildfowl.

A comparative analysis of our recent, and incomplete, knowledge of moult migration has hitherto not been attempted.

History

The existence of moult migration was unknown until 30-40 years ago, but in recent years many investigations have been carried out. The first to draw attention to this form of migratory movement was the Swedish zoologist Sven Ekman, who in 1922 described it in the Eider*, the Mute Swan and the Lesser White-fronted Goose (Ekman 1922). He called it *ruggnings-flyttning* in Swedish, and this term is now used in all languages (English: *moult migration*, French: *migration de mue*, German: *Mauserzug* Danish: *fældningstræk*). The importance of this phenomenon was not realised until 10-20 years later. In 1937-39 the Russians Vuczeticz and Tugarinov published the results of wildfowl ringing in the Soviet Union and demonstrated that enormous numbers of dabbling ducks originating from northern Europe and Asia, gathered in the Volga delta in order to moult their flight-feathers there. Subsequently, Stresemann (1940) described a similar phenomenon from a lake on the border between Tibet and Sikkim where, at an altitude of about 4,500 m., a number of dabbling ducks and Tufted Duck shed their flight-feathers after a migration of about 2,000 km. from their breeding places in northern Siberia.

Not until 1942, however, was the moult migration of a species in Europe described, i.e. that of the Shelduck (Hoogerheide and Kraak 1942). In North America no real movements to moulting areas were described until well after 1950.

General Remarks

In the best developed form, moult migration is from the breeding place to a special moulting area, common to a large number, in some cases hundreds of thousands, of birds. When the flightless stage is over the ordinary autumn migration to the winter quarters starts. This form of moult migration cannot be regarded as the first part of the autumn movement for three reasons. Firstly, the flight direction is often different, some-

* Scientific names will be found in the section dealing with individual species.

times the opposite of the autumn migration. Secondly, certain sections of the breeding population, usually the adult females, do not participate in the moult migration. Thirdly, the sharply circumscribed geographical situation and enormous population density in the moulting area are something quite unique. In the winter quarters the birds scatter over larger areas. In populations with typical moult migration the individuals adhere to a rigid schedule, which is followed regularly year after year. In other populations the system is less clear or only slightly developed.

The timing of the moult migration is dependent on that of breeding. When in late springs or unfavourable summers breeding is postponed, the moult migration falls correspondingly late, as demonstrated in various dabbling ducks and diving ducks in America (Hochbaum 1955) and in Europe (Bezzel 1964). The moult migration may in certain years be so delayed that the birds are forced to stop and shed their flight-feathers *en route*. This has been described in the Shelduck, which occasionally moults in Kent on its way to Germany (Eltringham and Boyd 1960), and in Steller's Eider, which sometimes moults in eastern Siberia on its way to Alaska (Jones 1965).

Some species (or populations) of ducks have no moult migration. The males remain in the breeding place and withdraw to a quiet, remote spot in a marsh or lake, sometimes within their own breeding territory. Here they carry out the wing-moult solitarily or in small groups, but never in large flocks. An example is the Pintail in Denmark, and, probably, in the whole of Scandinavia. At any rate I have observed solitary wing-moult in Swedish Lappland. This also illustrates the geographical variation in moulting behaviour, for this species performs extensive moult migrations in Russia and northern Asia and also in America.

Some species undergo wing-moult in the winter quarters and mass congregations may develop. In others, for example Brent Geese, immature birds may halt on the spring migration for this purpose.

It is possible therefore to distinguish between the following situations during the post-nuptial moult when an individual may shed the flight- and tail-feathers:

A. In the breeding territory or in the immediate surroundings.

B. During the ordinary autumn migration, or immature birds during spring migration.

C. In the winter quarters.

D. In a special area which is reached through a pre-moult migration starting in adult birds from the breeding range and in immature birds often directly from the winter quarters or from intermediate stations during spring migration.

It is clear that only in case D is it possible to speak about a genuine moult migration.

The size of the moulting flocks is another important character of the moult migration. Individuals may during the post-nuptial moult shed their flight- and tail-feathers:

I. On their own or in very small groups.

II. Assembled in comparatively small flocks, usually no more than a few hundred, occasionally up to a thousand birds.

III. Gathered in huge aggregates, in extreme cases numbering more than a hundred thousand birds.

All combinations of the classes A—D and I-III occur, except that the combination A III is found only in immature birds. If falling within class D, individuals belonging to all three groups I-III may be said to carry out a moult migration, but type D III represents moult migration as generally understood.

An obvious question is what purpose is served by concentrating in huge flocks in a special moulting area, sometimes situated more than 3,000 km. from the breeding area, when in other areas the same species can perform the moult on the breeding ground, solitarily or in small groups? It is evident that both forms of behaviour have certain advantages. In northern countries with short summers and early onset of cold the birds may run a considerable risk if they moult their flight-feathers on the breeding ground. Under such conditions selection for development of moult migration must be strong because it is, obviously, advantageous to transfer the time of wing-moult to areas with a milder climate situated nearer to the winter quarters, or even to postpone it until after the arrival in the winter quarters. There is also a high selective advantage when a part of the population (adult males and/or non-breeders) perform a moult migration, leaving the breeding areas and their food resources for the female and the ducklings. It is probable that in many (or most) species the ultimate cause of the development of moult migration has been a potential shortage of food on the breeding grounds.

It is possible that the enormous concentrations of individuals within a small moulting area may serve some social function (Wynne-Edwards 1962). Traditions, which play an important role in the ecology of wildfowl, may also be of significance in mass moult gatherings. Such traditions need not even be genetically fixed, although they evidently must be so in populations with a pronounced moult migration. In such populations the direction of the moult migration and the position of the moulting area are rigidly determined and the same area is used by the birds one year after another. The biological reason for choosing this particular area may date back to a distant past, the original migration pattern being maintained where it is still advantageous. In other species or populations the situation is more unstable. The populations then segregate in a number of moulting areas, each of which is frequented by a comparatively small number of birds, at most a few thousand individuals. Such minor concentrations may move, suddenly or gradually, to another place for no apparent reason.

A well-documented case of locality change has been demonstrated at the Ismaninger Reservoir in Bavaria. A small number of dabbling and diving ducks traditionally underwent wing-moult in this lake area, but when in 1955 the water surface was raised 2 m. artificially the number of moulting diving ducks increased considerably in the subsequent years. The Red-crested Pochard from 10-90 to over 300, the Tufted Duck from 100-200 to about 2,000, and the Pochard from 500-1,000 to no less than 9,000-11,000 individuals (Bezzel 1964).

In the majority of dabbling and diving ducks the post-nuptial (eclipse) moult in the males is initiated on the breeding ground. In the Mallard in Denmark the first body-feathers are shed as early as the middle of April. In species with moult migration the males leave the breeding place at a certain time, usually solitarily, but as a rule soon gather in small flocks. These gatherings increase gradually to some hundreds and occasionally to more than a thousand. At the same time the flocks move to intermediate resting places. During this movement the males perform the greater part of the eclipse moult, excepting the wing-moult which in the dabbling ducks constitutes the final stage. When this stage is imminent the birds leave for the moulting area together. The biggest moulting flight ever described was observed at Mud Lake, Idaho, where during one night (5th August) no less than 52,000 dabbling ducks, belonging to six species, arrived (Oring 1964). The postponement of the final flight until shortly before the wing-moult makes it possible to reduce the time spent in the moulting area to about three to four weeks. The moulting area is then abandoned, but new flocks are continuously pouring in and moulting males of a particular species are present for much longer, from two months in high arctic species (such as the King Eider) to four months in the Shelduck.

The final phase of the moult migration in ducks takes place rapidly and must be controlled by a very strong migratory urge. This is contrary to the usual more leisurely movements of ducks, interrupted by long pauses in resting places. The distance between the gathering place of the males (near the breeding place) and the moulting area is usually covered by a non-stop flight without deviations. The entire moult migration of the vast majority of the population is sometimes concentrated into a few days.

Many marine species, which during their usual migrations keep to coastal waters and avoid the interior, may cross large land-masses during the moult migration. The best known examples are the crossing of England by the Shelduck, the migration over the mountains of Baffin Island by the King Eider, and the crossing of Jutland by the Shelduck, Common Scoter and Eider (although the latter three species may occasionally cross the mainland during spring and autumn migration).

A review of the known moult migrations in the different groups of wildfowl is now given.

Swans and geese (Anserini)

The moult migrations of the swans and those of the geese have much in common. Moult migration is restricted to non-breeders, mostly to young, immature birds. Breeding birds remain with their young and indeed, in most swans and in many geese, the immature birds themselves undergo wing-moult in the vicinity of the breeding ground, usually gathered in small flocks (type A II), which means that such populations have no moult migration.

Swans *Cygnus*

The adult birds perform the wing-moult in the breeding period, first the female and then the male. In this way there is always one of the parents to defend the nest or the young. The wing-

moult certainly takes place in this way in the Mute Swan *Cygnus olor* (Szijj 1965), the Whooper Swan *Cygnus cygnus* (Scott and Fisher 1953) and the Trumpeter Swan *Cygnus buccinator* (Banko 1960).

In the post-breeding period the swans roam about with the young, which still need parental care. The wing-moult cannot, therefore, be postponed until after the young are fledged because the flightless adult birds could not then follow their offspring.

From the point of view of moult migration the adult swans represent a primitive stage.

The non-breeding one year old and (usually) two year old swans gather in summer in flocks, numbering up to some hundreds of birds, occasionally many more. In most species the flocks remain in the vicinity of the breeding area (moulting type A II) and, evidently, do not carry out a real moult migration which is known only in the Mute Swan. The immature Mute Swans usually frequent shallow water along low and protected sea-coasts, performing the moult rather slowly, from the end of May to the end of August, the flight-feathers being shed in the latter half of July and the first days of August. In Denmark and southern Sweden smaller congregations of moulting birds are found in various places along sea-coasts with a water depth less than one metre. The southern Sound and adjacent areas off the island of Amager and in Køge Bay form a very important moulting area (type A III). This moulting area has been known for centuries because the shooting of the flightless birds was formerly a prerogative of the Danish kings and, the hunt being a spectacular performance, was often described, the first time being in 1557. The royal hunting stopped about 1750 but subsequently shooting of the flightless swans was for many years practised on the Swedish side of the Sound where it was a privilege of the prefect of Scania (Schiøler 1925, Weismann 1931). In the beginning of the 20th century the swans were virtually exterminated, particularly by excessive winter shooting. In 1926, however, full protection was given to the swans by the Danish and Swedish governments, and this resulted in an immense increase, which has continued to the present day. Probably climatic influences have also been involved in this population explosion.

In the 17th century moulting swans were numerous in late July from Gedser along the east coast of the islands of Falster, Møen and Zealand right to Amager and Saltholm in the southern part of the Sound, but in recent years the centre of the moulting area has shifted to the Swedish side of the Sound. According to Mathiasson (1964) more than 10,000 moulting birds were gathered in 1963 along the east coast of the southern Sound, and a further 200 in Skälderviken and 1,200 in Kungsbacka Fjord in Halland, further north (Figure 2). In another paper Mathiasson (1963) concludes that this enormous number of moulting swans comprises not only the entire population of non-breeding swans from Zealand and Scania, but also large numbers of birds from more remote breeding places. In this he is undoubtedly correct and the majority of the immature swans of southern Sweden, eastern Denmark and the northern coastland of East Germany probably gather there. Future ringing must decide whether this view is correct. Presumably, non-breeding Mute Swans comes from all directions to the moulting area in the Sound, the moult migration thus resembling that of the Shelduck, although on a smaller scale.

The flightless period in the swans lasts for about seven weeks. During the wing-moult the birds must have access to firm land or at least to very shallow water as they cannot preen while swimming.

Geese *Anser, Branta*

The adult breeding geese have no moult migration. Both sexes share the parental care, as in the swans, and both remain with the goslings on the breeding places, in late summer undergoing the wing-moult which, contrary to the ducks, begins the post-nuptial moult. Generally the moult of the female precedes that of its mate by about a week. The immature birds, joined (or led) by a small number of adult non-breeders, gather in flocks usually of some hundreds but occasionally amounting to several thousand individuals. They often remain within the breeding area of the population (type A II, A III) but in many species a real moult migration has developed of the type D II or even D III. It is noteworthy that this movement, at least in all known cases, invariably goes in a northerly direction, leading to areas situated beyond the boundary of the population's normal breeding range.

All known cases of moult migration in non-breeding geese are briefly outlined below and shown in Figure 1, represented by the numeral included in the description.

Pink-footed Goose *Anser fabalis brachyrhynchus*. Moves from Iceland to northeast Greenland, the migration involving more than 10,000 birds (1) (Taylor 1953, Christensen 1967).

Bean Goose *Anser fabalis*, various subspecies. Moves from northern Russia to southern Novaya Zemlya in great numbers (5) (Johansen 1945, Portenko 1959, Uspenski 1965a). Very important moulting places are found in northern Siberia on the tundra in central Yamal (6), western Taymyr (7) and the delta of Indigirka (11) (Uspenski 1965a). Portenko (1959) adds the Lena delta (8). All these places are situated in the northern part of the breeding range. Pleske (1928) states that moulting birds are found in small numbers on the New Siberian Islands (9), north of the regular breeding range of the Bean Goose.

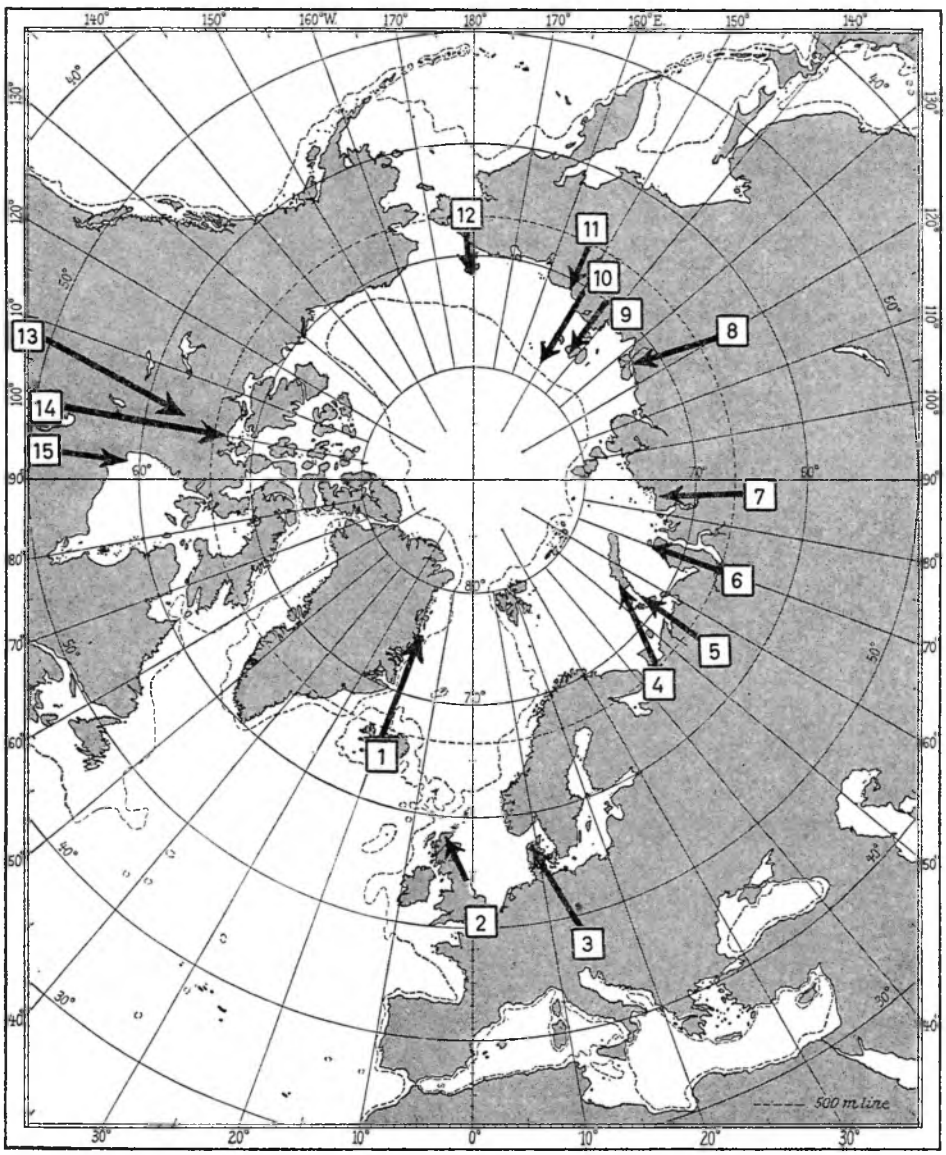


Figure 1. All known cases of moult migration in non-breeding geese. The arrows show direction and distance from origin to destination of the migration. The numerals refer to literature statements enumerated in the text pp. 8-10.

White-fronted Goose *Anser albifrons.* This makes similar movements in the Eurasian tundra to the Bean Goose, often mixing with that species in the moulting areas. Great moulting concentrations are found in Novaya Zemlya (5), central Yamal (6), western Taymyr (7), and the delta of Indigirka (11) (Uspenski 1965a) and moulting birds are also found in considerable numbers on the New Siberian Islands (9) (Pleske 1928), where the species breeds only rarely. Immature birds of the Greenland population *flavirostris* are strictly stationary, moulting in the breeding areas, assembling in small companies of at most a dozen individuals, probably the offspring of a few pairs. A similar situation is, apparently, present in North America.

Lesser White-fronted Goose *Anser erythropus.* According to Ekman (1922) the moulting birds of the alpine zone of Scandinavia withdraw to the uppermost parts of the mountains, where they gather in large flocks. No moult migration has been recorded from Siberia.

Greylag Goose *Anser anser.* The only known case of moult migration is found in the Danish population, of which the non-breeding birds moved to Vejlerne, an extensive marshland in northern Jutland. From ringing results it seems probable that many of these moulting birds originated from northern Germany, Poland and Austria (3) (Paludan 1965). The species did not breed in Vejlerne until about 1925 and individuals from other places did not use the area for moulting until the 1930s. In 1934-37 at most 200 non-breeding birds were moulting there, in 1934 500 (Salomonsen 1943) and in 1955 about 3,000 (Paludan 1965). The numbers began to decrease in 1959 and now only few are left. In 1959 summering Greylag Geese suddenly began to turn up in Holland, and in 1964 the number of moulting non-breeders at the lagoon Saltbækvig in Zealand (Denmark) increased considerably. It is probable, therefore, that these and other areas have now replaced Vejlerne as moulting areas (Paludan 1965).

Brent Goose *Branta bernicla.* During the spring migration of the nominate form from Europe towards the breeding range in northern Siberia, many immature birds remain to moult in eastern Kola Peninsula and northern Kanin Peninsula (type B II), while others divert from the eastward flight direction of the breeding birds and turn northwards to Novaya Zemlya, where they occur on both the southern and northern island (4). Many thousands moult in the New Siberian Islands (9), originating from the coast of NE. Siberia between Yana and Kolyma Rivers (Uspenski 1960). According to Uspenski there are many observations of birds flying north over the Polar Sea north of the New Siberian Islands and at Henrietta and Bennett Islands (10). It is very unlikely that they continue across the central parts of the Polar Sea to North Greenland or to some sterile ice-island. Uspenski's view that they turn eastwards to moulting areas in Alaska is borne out by recoveries in the New Siberian Islands, on Wrangel Island, and at the Kolyma Delta of birds ringed in previous years at moulting stations in western Alaska (Uspenski 1960, 1965b). Finally Wrangel Island (12) forms the moulting area of at least 10,000 non-breeding Brents, coming from the south, while only 1,000-2,000 pairs breed there (Uspenski 1965b).

No case of moult migration has been described in the North American populations. Apparently the immature birds moult in small flocks in the breeding areas of the adult birds (Scott 1951). Uspenski (1960, 1965a), however, reports that Brent Geese ringed during the moult in Alaska are recovered in subsequent moulting periods in eastern Siberia.

Canada Goose *Branta canadensis.* Moult migrations are known to go northwards to the Thelon River district (13), to Perry River (14) and to the western coastland of Hudson Bay (15) (Scott 1951, Hanson 1965, Sterling and Dzubin 1967). The last named authors have delineated the movements of the different races, and banding results (the earliest being those of Kuyt (1962)) have now indicated the movements of localised populations. The number of moulting birds is considerable, at Thelon River up to 16,000 individuals have been observed. In Great Britain numbers of moulting birds gather in Inverness-shire, Scotland, and ringing has demonstrated that at least some of them originate as far south as Yorkshire (2) (Dennis 1964).

The Canada Goose was introduced to Great Britain and the moult migration to Inverness, therefore, must be a comparatively recent phenomenon, certainly less than 300 years old, and probably of much more recent origin. It is reasonable to assume that it is a result of an ancient adaptation based on hereditary factors.

Very likely moult migration will be discovered in other species than those mentioned above, but it does not appear to be the case in those species which have been thoroughly studied. Uspenski (1965a), however, is of the opinion that

the non-breeding Snow Geese *Anser caerulescens* of Wrangel Island perform a moult migration.

The flightless period in geese covers about 35-40 days, but less than a month in the Snow Goose (Uspenski 1965a). The non-breeders begin the moult a fortnight earlier than the breeding birds, in most arctic species in the middle of July, compared with early August in the breeding birds, but according to Uspenski (1965a) the two groups moult simultaneously in the high-arctic Brent and Snow Goose. Cooch (1957), however, states that in the Snow Goose in Southampton Island the non-breeders moult much earlier than the breeding birds.

It is my belief that the ultimate cause of the moult migration of non-breeding geese is an endeavour to avoid heavy competition for food on the breeding places, but it is difficult to understand why the migration invariably moves in a northern direction while all other moult migrations in wildfowl lead to regions with a milder climate. There are three alternative explanations:

(1) It may have something to do with so-called 'prolongation of migration'. The immature birds are still in a migratory state when the time comes for them to leave the breeding grounds only a few weeks after arrival. Under such circumstances it is most likely that the choice of a flight direction will be the same as used during the spring migration, i.e. northerly. If the northern direction is genetically fixed it will be kept provided that selective forces do not favour any other direction.

(2) I was at first inclined to believe that the northerly direction of the moult migration in geese expressed a phenomenon similar to the so-called nonsense orientation in British and American Mallard, which demonstrates an instinctive selection of a northerly flight direction under certain circumstances. However, recent investigations by Matthews, Eygenraam and Hoffmann (1963) and Bellrose (1963) have shown that other species of wildfowl choose other directions during nonsense orientation, and that different populations of the same species may do likewise (Matthews 1963). I am now satisfied, therefore, that nonsense orientation is not involved in the northward moult migration in geese.

(3) The north direction may be the result of climatic influences. In arctic regions the length of time of snow-cover is of decisive significance for many ground-feeding birds and mammals. According to Uspenski (1965a) a snow-free period of three months is necessary for a successful accomplishment of the breeding cycle in most species of geese. Only the Snow Goose and the Brent Goose are able to manage the full breeding cycle in slightly over two months, owing to a particularly rapid development of the goslings and an accelerated wing-moult in the adults. Although the snow-free period in high-arctic areas is too short to permit breeding in most species of geese, the food resources can be utilised by non-breeding birds when the snow-melt in the latter part of June has made the food plants available to them. A high selective premium is paid to such populations in which the immature birds move north to the high-arctic region in June, leaving the food resources on the breeding places to the goslings and their parents, in this way enabling the breeding population to raise its productivity.

Shelduck (Tadornini)

The moult migration of the Shelduck *Tadorna tadorna* in northern Europe is of impressive dimensions. In this species both the immature non-breeding individuals as well as the adult breeding birds participate in the moult migration. Male and female share the parental care, but many leave the ducklings before they are fledged. Shelducks from the British Isles, the North Sea countries, Scandinavia and the Baltic countries move in the summer from all points of the compass to the German Waddensea coast in order to perform the wing-moult there (type D III). The biggest concentration of birds is found on the tidal flats Knechtsand, east of Cuxhaven, where at the peak about 100,000 gather. Smaller centres are found off the North Sea coast of Schleswig-Holstein, northward to the Ejdersted Peninsula. Before the migration the Shelduck collect in flocks and then leave at sunset, probably covering the whole distance in a single night. The migration usually follows a straight line, these normally coastal birds crossing the mainland of England and Jutland. The moult migration begins in Denmark in June (immature birds) and continues until September-October, but in England virtually the entire migration takes place in July. When the post-nuptial moult has finished, the autumn migration takes place more leisurely. It covers the period October - November and, paradoxically enough, transfers the British population back to its breeding range, while the Scandinavian and East European populations scatter, to winter in the coastal areas of the southern North Sea, France

and the British Isles (as shown by ringing of Danish birds; cf. Salomonsen 1967). Some flocks move northwards in the North Slesvig Waddensea or to the lagoons in western Jutland, but many thousands of birds winter within the moulting area proper.

The moult migration of the Shelduck, which in recent years has attracted much attention, has been studied particularly by Hoogerheide and Kraak (1942), Coombes (1950), Goethe (1957, 1961a, 1961b) and Lind (1957).

It is noteworthy that a moulting congregation of Shelduck, totalling more than 3,000 birds, was recently discovered in Bridgwater Bay, Somerset, in England, possibly being of Irish origin (Eltringham and Boyd 1960). Apart from this, apparently all European Shelduck west of the Soviet border perform the wing-moult in the German Waddensea. In Lake Rezaiyeh in Iranian Azerbaijan about 300 flightless Shelduck were observed in August by Savage (1964). This locality serves probably as a local moulting centre for Shelduck which assemble here from wide areas within Iran.

Dabbling ducks (Anatini)

The dabbling ducks breed when they are one year old (Wigeon often not until they are two years old) and it is, therefore, not necessary to distinguish between the moult migration of immature and adult birds. The males do not participate in brooding and parental care, but soon leave the female in order to perform the eclipse moult. Only the males perform a moult migration, whereas the females stay with the ducklings. A few females may join the males but only those which have given up breeding for the year.

The time for the males' desertion of the females varies somewhat. In the Mallard *Anas platyrhynchos* and Pintail *Anas acuta* the female is abandoned as soon as the clutch is complete, before incubation. In the Mallard in Europe this is in the second half of April. In most other species the males remain near the female until various stages of incubation. According to Hochbaum (1955) and Oring (1964) the Shoveler *Anas clypeata*, Blue-winged Teal *Anas discors* and Cinnamon Teal *Anas cyanoptera* sometimes remain even until hatching, in spite of well developed body-moult. The males of most holarctic species moult the wing-feathers in the period from the middle of June to the end of August. The Mallard is on average slightly but not significantly earlier than other species. The flightless period covers three to four weeks, and is shortest in the small species.

The females remain with the ducklings until they are more or less independent. They then withdraw to suitable areas in the same marsh or in its vicinity and perform the wing-moult, much later, of course, than the males. They may sometimes assemble in small parties, but never in big flocks, and usually they are solitary. The wing-moult in most species takes place from the middle of July to September or even October.

The females may in exceptional cases remain with the ducklings during the flightless stage, or they may occasionally commence the autumn migration before the moult, performing the wing-moult alone or in small groups during the migration (type B I) or in the winter quarters (C I). In the winter quarters of the Gadwall *Anas strepera* in Louisiana, Chabreck (1966) found two or three dozen females in the flightless stage in October. Lebret (1952) records a single flightless female of Gadwall in September and a number of flightless females of Wigeon *Anas penelope* in October, during their migration in Holland. However, no breeding females of any species of dabbling duck perform a real moult migration.

The extension and proportions of the moult migrations in the males is subject to considerable variation, both specifically, individually and geographically. In Denmark the greater number of males of all species moult on the breeding place proper, either solitarily or in very small groups (A I). Only the Mallard, and in some places also the Shoveler, has something approaching a moult migration. The males within an area collect in small flocks, usually less than two dozen birds, but occasionally up to about 200 (type A II). The same behaviour is displayed in most other European countries where the Mallard is non-migratory. It is even the case in Greenland, where the largest concentration of flightless males I ever saw amounted to only eleven birds. In western Europe also all other species of dabbling ducks evidently adhere to the moulting types A I or A II. In the flightless stage they prefer large marshes, also densely overgrown lakes, the Mallard even lagoons or quiet bays in fjords.

Populations breeding in regions with a continental or arctic climate carry out regular and often long migrations to winter quarters. In these populations the males have highly developed moult migrations, leading to large moulting centres where individuals coming from

very extensive areas collect in a restricted locality, usually 50,000 - 100,000 birds together, occasionally even more. These moulting areas, frequented year after year, are as a rule situated on the migration route (B III) or in the winter quarters (C III). True moult migrations of the type D III are hardly known within the dabbling ducks. A number of species assemble on these moulting places and form part of the huge congregations, but there are definite local and specific differences. Usually the Mallard and the Pintail predominate, but this is not always so.

In the Old World particularly large concentrations of moulting males are found in the West Siberian lakes, the Transuralian forested steppes, northern Kazakstan, Kuban flats, Rybinski Reservoir (north of Moscow), Volga delta, Russian - Finnish lakes, and Matsalu National Park in Estonia (Ottow 1956, Teplov and Kartashev 1958, Kumari 1962, Wolff 1966). In Matsalu Park there were formerly (until the 1930s) 'many hundreds of thousands' of birds, mostly Mallard and Teal, but also some Wigeon, Shoveler and Garganey *Anas querquedula*, but now, owing to human interference, only about 10,000 birds (Kumari 1962).

In North America great moulting centres are the Delta Marsh at Lake Manitoba (Hochbaum 1955) and the Camas Reserve in Idaho (Oring 1964), and probably many more. The main species moulting in Delta Marsh are Mallard, Pintail, American Wigeon *Anas americana*, and American Green-winged Teal *Anas crecca carolinensis*. In the Camas Reserve all these species moult, also Cinnamon Teal and Blue-winged Teal. Some of these may be local birds (probably only a small fraction) but certainly Pintail and Wigeon are not found breeding until many hundred kilometres further north. The greatest moulting concentrations are probably found in the American Green - winged Teal and American Wigeon, of which species Sowls (cited by Bezzel 1964) records congregations of 125,000 individuals in a particular locality.

Moulting congregations of this order of magnitude are not found in western Europe, as said already, but some localities approach them. In the Lake Tåkern in southern Sweden males of Mallard and Wigeon gathered in summer at least in hundreds (Lönnberg 1935) and the same is evidently the case with other lakes in south Sweden, such as Hornborgasjön. While Mallard, at least partially, may belong to local populations, Wigeon are uncommon breeders so far south in Sweden, and the greater part of them must obviously have originated from further north, now performing the wing-moult at a resting place situated on the ordinary autumn flyway (type B II).

The other known moulting areas in western Europe are principally of the same kind as Tåkern, holding some hundreds of moulting males, the majority of which having performed a B II migration, but a small fraction being local birds with an A II moult. A typical B II locality is Ijsselmeer in Holland, in which Mallard, Gadwall, Teal, Garganey, Pintail, Wigeon and Shoveler spend the flightless stage (Lebret 1950). In Lake Constance some hundred individuals of Mallard, Teal, Gadwall, Garganey and Shoveler moult the flight-feathers, but apparently no Pintail or Wigeon (Szijj 1965). The Ismaninger Reservoir in Bavaria is characterised by the large number of moulting Gadwall (about 400), but only a few of other species of dabbling ducks (Bezzel 1964). The Himalayan lake, described by Stresemann (1940), in which many dabbling ducks spent the flightless period is of a similar B II type as the above-mentioned European lakes. Even the locality in Scotland (Beauly River in Inverness-shire) described by Dennis (1964) as being full of moulting male Mallard may belong to this type, but it is more probable that the birds observed are of local origin (A II type). There are, of course, other localities of this kind in Europe than those mentioned, but the wildfowl ecology in these places has not yet been thoroughly studied.

I have selected three species for some special comments.

Pintail *Anas acuta*. Individual variation in moult migration comprises the types A I, A II, B II, B III. In Scandinavia and Denmark the males usually moult the wing-feathers in the breeding range, solitarily or in small parties. In other places they gather in large flocks in the breeding area, such as described by Scott (1951) from Perry River in arctic Canada. As a rule, however, arctic and sub-arctic Pintail make very extensive pre-moult migrations in a southerly direction, spending the flightless stage on intermediate resting stations, from which they continue the migration southwards when their wings can again carry them. These moult migrations are generally longer than in most other dabbling ducks. Sometimes the Pintail collect in hundreds in the moulting areas (type B II), as in Ijsselmeer in Holland, but in Soviet and U.S.A. the moulting congregations usually reach enormous dimensions (type B III).

In Bear River, Utah, 7,500 individuals have been recorded, in Camas Reserve, Idaho, 20,000 (Oring 1964), in lakes in Kazakstan 30,000 (Cuisin 1966). The autumn passage migrants of this species in Denmark, originating from Scandinavia, north Russia and some even from western Siberia (as demonstrated by recoveries of ringed birds; cf. Salomonsen 1967) belong to populations which perform the wing-moult in the breeding areas or in resting stations north of Denmark. The males pass through Denmark, all with new wing-feathers, from the end of August to the middle of September, well ahead of the adult females and juvenile birds; the rear party, passing after the middle of October, consists exclusively of juveniles (Schiøler 1925). The segregation on the migration of the two sexes reflects the different timing of the wing-moult, and is the rule also in Teal and Wigeon.

Teal *Anas crecca*. Like the males of the Pintail, those of the Teal moult either in the breeding area or on suitable resting places on the southward migration in autumn. The flight-feathers are shed within the period from the middle of June to the middle of August, usually in early August (Wolff 1966). There is a notable difference in the movements between Pintail and Teal, at any rate in the passage migrants passing Denmark. A substantial part of the males of northern Teal leave the breeding places soon after incubation has started and appear in Denmark, in small flocks, as early as the middle of June on their way to moulting areas further south or south-west (Palm 1950). Such an early passage has not been noticed in Denmark in any other dabbling duck. The Teal apparently do not spend the flightless period in Denmark, but are known to do so in some numbers in Holland and a flightless male ringed in Holland was recovered next autumn in Poland (Wolff 1966). Flightless males have often been obtained in Denmark in August but they may be local birds. During the ordinary autumn migration, starting in August, males (with new wings) arrive in advance of females, just as in the Pintail (Schiøler 1925). In Russia and U.S.A. huge concentrations of moulting males (type B III) have been recorded, as mentioned before.

Wigeon *Anas penelope*. This species differs from most other dabbling ducks by the postponement of breeding in most individuals until the second year. Many of the one year old non-breeding birds may spend the summer and moult the flight-feathers in areas south of the breeding range. The adult males moult the flight-feathers in June - July, the females in August-October. The majority of the males evidently leave the breeding range very soon after incubation, shedding the flight-feathers in areas further south, gathering in flocks (type B II). Lebret (1950) during a visit in August to the breeding places in Jämtland, in northern Sweden, observed hundreds of females with young, but virtually no males. The latter had already left and were moulting the wing-feathers in lakes situated further south or south-west on the flyways of the subsequent autumn migration. Flocks of moulting males are known in north-west Europe from the end of June onwards in Estonia (Matsalu), southern Sweden (Tåkern and Hornborgasjön), Denmark (Vejlerne, N. Jutland) and Holland (Ijsselmeer). The males leave the moulting areas and begin the genuine autumn migration as soon as the flightless period is over, usually in August. In Denmark as well as in Holland males (with new wings) predominate during the early stages of the autumn migration, while females and juveniles follow later.

The moulting areas of the dabbling ducks are wetlands with dense vegetation and very shallow water, usually open reed beds or other plant formations along the shore, furnishing cover and sufficient food. The really big moulting centres are extensive and secluded. The moulting birds must have access to firm land because they do not preen while swimming.

Diving ducks (Aythyini)

The diving ducks resemble the dabbling ducks in being able to breed at one year old and have, therefore, no distinct moult migration of immature birds. The general character of the moult migration is also very similar. The most striking difference is the participation of a certain number of adult females, but these are always much fewer than the males and they migrate considerably later. The moult migration of both sexes belongs to type B II, but moulting congregations of more than 10,000 individuals (type B III) are occasionally found. Probably a large number of individuals of both sexes remain in the breeding territory, spending the flightless period there (type A I or A II), but only scanty information is available. The performance of moult migration in females may have something to do with the fact that the females sometimes leave the brood before the young can fly. This has been observed in the

Redhead *Aythya americana*, and the Canvasback *A.valisneria*, whereas in the Lesser Scaup *A.affinis* the females remain with the young until they are fledged (Oring 1964).

These three American species, as well as a fourth, the Ring-necked Duck *A.collaris*, perform striking moult migrations, sometimes gathering in concentrations of more than 10,000 birds. Among the Palaearctic species the Tufted Duck *A.fuligula* and the Pochard *A.ferina* have moult migration, at least in some populations. Both species appear in large numbers on the Ijsselmeer in Holland in July-August but breed only sparsely in Holland (Lebret 1950). In Ismaninger Reservoir in Bavaria about 9,000-11,000 Pochard and more than 2,000 Tufted Duck spend the flightless period. The males arrive in June-July, the females (less than 10% of the numbers) not until August. Just as in Holland the two species are only scattered breeders in Bavaria, and the large flocks must have originated from rather remote breeding places (Bezzel 1964). The occurrence of these two species in central European moulting areas is probably the result of a pre-moult migration due east-west because northern birds apparently spend the flightless period in the breeding range, or at any rate on localities situated much further north. Extensive ringing in Denmark of Tufted Duck during autumn migration has demonstrated that these birds breed in Scandinavia, north Russia and NW. Siberia, and winter in Germany, France and England, occasionally in Italy (Salomonsen 1967). They do not arrive in Denmark until October, with new wings, and consequently must have spent the flightless period further north. Something similar can be said about the Pochard which appears as a passage migrant in Denmark in September - October. No moulting areas for these species are known in Scandinavia, but a great number of Tufted Duck and a smaller number of Pochard are known to moult their flight-feathers in Matsalu National Park in Estonia (Kumari 1962).

Possible the well-known strict sexual segregation in the winter quarters (allohiemy) in the Pochard and the Tufted Duck is a consequence of the difference in the moult migration in males and females. The males, having finished the wing-moult much in advance of the females, arrive earlier in the winter quarters where they apparently occupy all available space within the specific niches and pre-empt the food resources. The females, consequently, are forced to continue their migration to areas beyond, the two sexes performing a so-called leap-frog migration (Salomonsen 1955). Such a situation is unknown in dabbling ducks.

The Red-crested Pochard *Netta rufina* has a moult migration similar in many respects to that of the *Aythya* species. A comparatively large number spend the flightless period in various lakes in central Europe, about 300 individuals in the Ismaninger Reservoir, and about twice this number in Lake Constance. The males begin to arrive in the last part of June, the majority in July and early in August, the females not until August. The males moult the flight-feathers in July-August, the females in August and the first half of September (Bezzel 1964, Szijj 1965). In Ismaninger all birds leave in September for the autumn migration, while in Lake Constance, on the contrary, a new influx of birds which have finished the moult occurs in September-October, when about 4,000 birds can be present. In November they all leave again (Zink 1964). Ringing has definitely shown that the birds moulting in Lake Constance originate from the Camargue in southern France (Mayaud 1966). In certain years they do not move so far eastwards, but use lakes in Lorraine as a moulting area. The autumn migration, which takes place in September-November, goes the opposite way, towards the south-west, the main wintering places extending from the Camargue to Albufera de Valencia in eastern Spain. The ducklings from the Camargue move directly to Spain, naturally without performing any moult migration (Mayaud 1966). The eastward moult migration and subsequent westward return migration in the autumn strikingly resembles the situation in the British population of the Shelduck. The individuals which arrive in Lake Constance in September-October must originate from eastern breeding places (Balkans, S. Russia, SW. Siberia). Just as in the *Aythya* species mentioned above, these individuals perform a moult migration to Central Europe in a due western direction. Even so they winter probably somewhere in Spain. Ringing of Red-crested Pochard at breeding places in Denmark has demonstrated that the greater part of this population spend the winter in SE. France and NE. Spain (Preuss 1965) but apparently they perform the wing-moult in the breeding area.

The Scaup *Aythya marila*, although belonging to the same genus as the Pochard and its allies, is a marine species, which mainly frequents coastal waters.

Nothing is known about its moulting behaviour.

The moulting areas of the diving ducks are fresh-water lakes of varying size, though not very small ones. The moulting birds frequent the areas of open water off the riparian zone of vegetation (reed beds, etc.), usually in shallow water with a depth of less than 5 m., not too far outside the belt of vegetation. They do not need access to firm land, being able to preen while swimming. The Red-crested Pochard differs by preferring open reed beds, much like the dabbling ducks.

Eiders, scoters and sawbills (Somaterini and Mergini)

The moult migrations of the marine ducks are more diverse and better developed than in any other group of wildfowl. Those of the eiders and scoters are, however, similar. In the marine ducks, contrary to the situation in the dabbling ducks and the diving ducks, the one year old birds and in some species even the two year old birds do not breed but join the males in their comprehensive moult migration. The participation of the adult females in the moult migration varies considerably from one species to the other. They may spend the flightless period on the breeding places (type A I) or in the winter quarters (type C I), or they may participate in the moult migration together with the males, or more usually join them later in the autumn. Part of the female population at any rate must remain in the breeding places because the young are too small to be left alone. The departure of some of the females is compensated for by individuals which remain and are possessed of a strongly developed tendency to collect and keep large flocks of ducklings, as in the eiders. It is also developed in the Shelduck in which both sexes show 'crèching' behaviour.

The Common Scoter *Melanitta nigra* breeds in the arctic and northern high-boreal areas of the Old World. It has been known for a long time that summering and moulting individuals occurred in small flocks in the inner Danish waters and in the Limfjord, but only fairly recently was it pointed out that the actual moulting area was in the North Sea just off the west coast of Jutland (Salomonsen 1950a). Moulting birds occur in flocks of varying size right from the Danish-German boundary northward to the Skaw (Figure 2). The moult migration to this area, which is very spectacular and has been known for a long time, passes through the southern Baltic Sea, south of Denmark, and crosses Jutland along the fjord Slien (Jørgensen 1941), going westwards to the Waddensea of North Slesvig where the flocks gradually spread northward along the west coast of Jutland. The greatest concentrations of moulting birds are found, therefore, along the southern part of the west coast of Jutland; the flocks off Rømø Island amount to about 150,000 individuals, according to an aerial census made by Joensen (1964). A smaller proportion of the migrating birds pass somewhat further northward and have been recorded over southern Zealand (Sjaelland), in the Little Belt and at the town of Ribe, following the south-eastern fjords in Jutland westward (Flensburg Fjord, Åbenrå Fjord, Vejle Fjord) the most northerly observations being from Horsens Fjord (Schiøler 1926, Behrends 1955). Small flocks of some hundred birds, have been observed in early August to pass northwards through the Great Belt (Bruun and Schelde 1957), possibly heading towards moulting areas in the western Kattegat. By far the majority, however, spend the flightless period off the west coast of Jutland, and the densely packed flocks congregating there comprise undoubtedly the greater part of the Scandinavian and north Russian breeding population. It should be noted that the Common Scoter is the only species of wildfowl occurring off the sandy coast of West Jutland. The shedding of the flight-feathers takes place in August and early in September. The birds frequent the zone of shallow water over sand, with a water depth of less than 10 m., usually less than 5 m., often just off the heavy surf.

The moult migration across Jutland takes place at sunset or during the night and passes at a considerable height. It is initiated as early as the middle of May by the one year old birds which have curtailed their spring migration to the north-east before reaching the breeding range. Some individuals probably move directly from the winter quarters to the moulting area. The immature birds are joined by the adult males from the beginning of July until the middle of August. In the last part of this period some adult females probably participate in the migration, but this has not been observed with certainty. The greater part of the moulting birds disappear in September or October, spreading in the surrounding waters or continuing the autumn migration to the English Channel or the Bay of Biscay.

It is not known whether some individuals make a return flight across Jut-

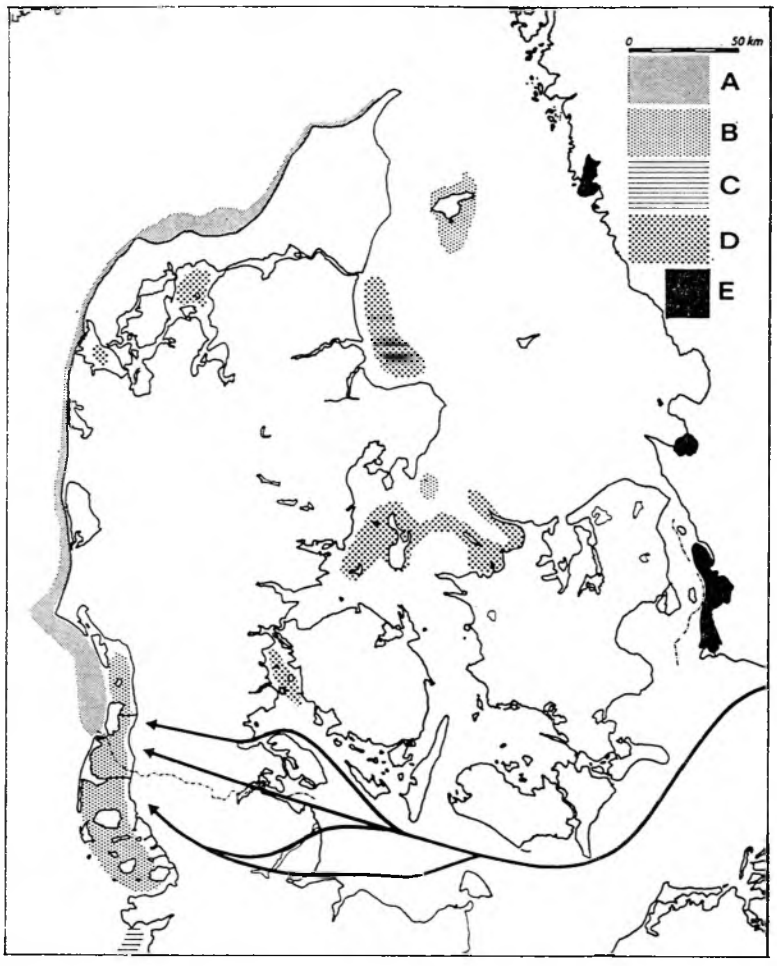


Figure 2. Moulting areas of northern wildfowl in Danish waters. A, Common Scoter *Melanitta nigra.* B, Eider *Somateria mollissima.* C, Shelduck *Tadorna tadorna.* D, Velvet Scoter *Melanitta fusca.* E, Mute Swan *Cygnus olor.* The solid lines (with arrow-heads) indicate the most important migration routes for the species A, B, and C.

land to winter quarters in the Kattegat, but it is unlikely. During spring migration part of the population may perhaps cross Jutland on their way to Scandinavian-Russian breeding places but there are no certain records. On the other hand, in the early part of April many thousands daily pass the Skaw on migration north-east (Hansen and Christensen 1954), and it is probable, therefore, that the main spring migration passes north of Jutland, not across the country.

No other moulting areas of the Common Scoter are known except in Great Britain. According to Atkinson-Willes (1963) large congregations of moulting males have been recorded off east Scotland in late summer 'and others may be found elsewhere'. These birds are either of Icelandic origin, or constitute flocks which have continued the pre-moult migration from Jutland across the North Sea.

Velvet Scoter *Melanitta fusca* also spend the flightless period in Danish waters. Flocks of immature birds occur commonly in the coastal waters. They are most numerous in the southern Kattegat, in the Little Belt and in the western Limfjord, where they are particularly common in Løgstør Bredning (Figure 2). A number of adult males join the immature birds in July and August, but quantitatively the moult migration of this

species in Danish waters is much less pronounced and much more scattered than that of the Common Scoter. The adult females do not arrive until much later. I have examined flightless females obtained in the Little Belt and in the southern Kattegat in October. Part of the population remains in Danish waters in winter but many continue the migration to western Europe in November-December. The Velvet Scoter occurs only exceptionally along the western coast of Jutland.

In the Eider *Somateria mollissima* the immature birds and males perform large-scale moult migrations to the Danish waters, where they collect in great numbers in a restricted area. The population of Bohuslän in western Sweden and, possibly, of southern Norway, gather in the Læsø area, particularly off the north-eastern coast of this island. Large flocks are seen also off Hjelm Island further south in the Kattegat. The large population of the Baltic segregates in various moulting areas, situated off Gotland and along the coast of Estonia and Latvia. The majority, however, perform a moult migration south-west through Kalmar Sound (Svärdson 1959), across the southern parts of the Danish islands or just south of them, and across southern Jutland to the North Sea coast. Tens of thousands of birds spend the flightless period in the North Slesvig Waddensea, from Fanø and Rømø Islands south along the German coast (Figure 2). The moult migration across Jutland takes place from the end of June until early August, usually following Flensburg Fjord westwards, i.e. somewhat further north than the main migration of the Common Scoter. However, flocks of Eider on moult migration have been met with frequently right from Eckernförde as far north as Åbenrå, incidentally the same area in which the Shelduck of the Baltic region move towards the moulting area in the Bay of Helgoland. Many ornithologists have observed the impressive east-to-west Eider migration across North Slesvig; I have personally once observed a single flock moving westward across southern Zealand.

The Eider migration across North Slesvig has been carefully followed and mapped by Behrends (1955, 1966). The movements take place predominantly in the evening hours, just as in the Shelduck and the Common Scoter, and are performed, primarily by immature birds and adult males, in June-July with a peak (3,300 observed in one evening) in early July. At the end of July the migration of the males ceases, and the immature birds decrease in number. The adult females then begin to arrive, reaching a peak (1,400 in one day) in early August, and the migration then soon comes to an end. Behrends made the interesting observation that a substantial part of the females remain in the western part of the Baltic and spend the flightless period there, i.e. they do not cross the peninsula of Jutland.

The more northern populations, which have undergone the wing-moult in the Baltic region proper, arrive in the south-western Baltic Sea and the eastern fjords of North Slesvig in September-October during their ordinary autumn migration but do not continue across Jutland to the North Sea. The three migration peaks (early July, early August, and September-October) correspond exactly with those which have been demonstrated for the migration along the coast of Kalmar Sound in southern Sweden (Svärdson 1959).

The moult migration of the Eider in Scotland, recently studied by Milne (1965), is much smaller than that in the Danish waters, but agrees with it on certain points. The migration passes southwards along the east coast, but only over short distances, at most 100 km., and quite slowly. The females follow one month after the males and go through the wing-moult more rapidly than the latter. The males move further generally than the females. Immature birds do not have such a well-defined moulting areas as the adult birds, but spread more evenly along the coast. The moult migration in Scotland is of the type B II, but the winter quarters are situated only about 50 km. further to the south. The condition in Great Britain is thus interesting in demonstrating the moult migration in an initial stage.

The Eider performs a moult migration, to a greater or lesser degree, in other areas, i.e. in Canada, the White Sea and the Baltic Sea (Milne 1965) and probably elsewhere. In Greenland and Norway the extensive areas of rocky skerries along the coast furnish, evidently, sufficient food and satisfactory protection to the moulting birds and, as far as is known, the flightless period is everywhere spent within the breeding range of the population (type A II).

The autumn migration of the population which spends the flightless period in the Waddensea off Slesvig, has not been investigated. A fair proportion of the birds remain in the area in winter but the greater part, undoubtedly, move gradu-

ally further south into the German and Dutch Waddensea. These two groups must, then, have performed a moult migration of type C III and B III, respectively. The birds do not winter off the open North Sea coast of Jutland north of Skallingen Peninsula and the moulting population of the Waddensea has never been observed to return across Jutland in an eastward direction in order to spend the winter in the Kattegat area, nor is this likely. The great number of Eider wintering in these waters do not arrive until October-November, having performed the wing-moult somewhere else. Ringing has demonstrated that these birds mainly belong to the breeding populations of Bornholm and south-eastern Sweden (Salomonsen 1967).

The spring migration of the Waddensea birds appears to pass across Jutland, judging from the fact that they do not then pass the Skaw. There are some observations on flocks of Eider passing eastwards across the eastern Danish islands.

It appears from Figure 2 that three species of ducks, differing considerably from each other in life habits and feeding biology, have divided the Danish North Sea coast between each other, using separate regions as moulting areas, the Shelduck in the Bay of Helgoland, the Eider in the Waddensea of Slesvig, and the Common Scoter off the west coast of Jutland. To these species should be added the other species which spend the flightless period in the eastern Danish waters, i.e. the Velvet Scoter and the Goldeneye (discussed below) in the Limfjord region and the southern Kattegat, the Mute Swan in the southern Sound and elsewhere, and the scattered flocks of Mallard in shallow water off the coasts of eastern Jutland, Zealand and other eastern islands as well as in freshwater lakes and marshes.

The King Eider *Somateria spectabilis*, which breeds in the high-arctic zone, performs a moult migration of an even more grandiose character (Figure 3). The entire population (i.e. the immature birds

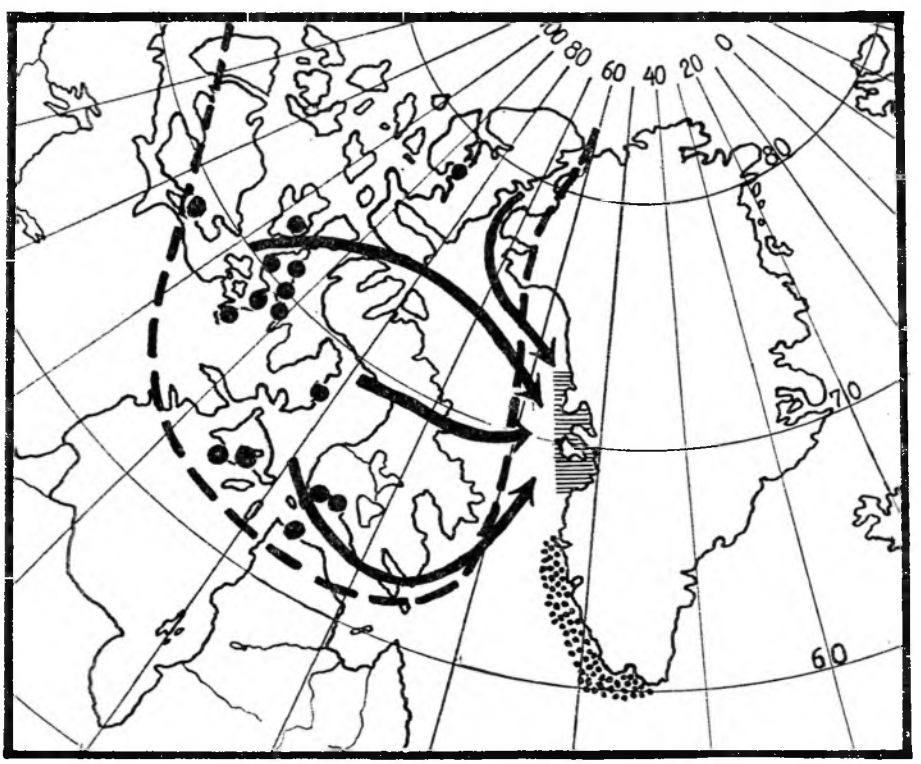


Figure 3. Moult migration of King Eider *Somateria spectabilis* **in Canada and Greenland.** From the breeding area within the dashed line males and non-breeders move along the routes indicated by solid lines (with arrow-heads) to moulting area (horizontally hatched). Solid circles give localities for recoveries in the breeding places (not in the winter quarters) of individuals ringed when flightless in the moulting area in West Greenland. The dotted area represents the winter quarters.

and the adult males) of the greater part of arctic Canada, the Canadian Archipelago and North Greenland congregate in a comparatively restricted area of western Greenland, extending from the southern Upernavik District southwards to Egedesminde District, with a maximum density in the Disko Bay. The males leave the brooding females early and by the first week of July the first have arrived in the moulting area. This is only about three weeks after the last breeding pairs passed on the northward spring migration. During the moult migration the males may move north or south of Baffin Island, but the majority cross through the mountain passes in the middle of the island, south of the ice-cap. In the latter half of July flock after flock numbering hundreds of birds, all adult males, flew in a north-eastern direction from Clyde Inlet, often at a height of 1,000-1,200 m. (Wynne-Edwards 1952). The number of King Eider in the moulting area reaches a peak in early August when some hundred thousand individuals are gathered there. This figure includes the immature birds, of which part move directly to the moulting area from the winter quarters. Others approach the breeding range, but interrupt the migration and return to the moulting area early in summer (June).

After the flightless period, in September-October, the King Eider begin the autumn migration which leads due south along the west coast of Greenland to the ice-free coasts of SW. Greenland, to Labrador and Newfoundland. This implies that the Canadian population changes the flight direction from east (during moult migration) to south (during autumn migration), demonstrating that the moult migration, at least that of the adult males, belongs to the type D III.

When previously describing the tremendous concentrations of King Eider in the moulting area in West Greenland (Salomonsen 1950b) I advanced the opinion, for several reasons, that the majority of these birds must originate in Canada. The correctness of my assumption has now been proved by the extensive ringing of flightless King Eider in West Greenland, carried out in recent years under my direction. The recoveries in the breeding places are shown in Figure 3. The birds breeding farthest to the west must migrate about 2,500 km. before reaching the moulting area in Greenland.

The adult females do not participate in the moult migration to West Greenland, where they occur in the area only exceptionally. Some of the females, however, perform a separate moult migration which takes place later than in the males and does not go so far. In the middle of August 1934 Dalgety (1936) observed thousands of females in Clyde Inlet where they probably intended to spend the flightless period. This resembles the situation in the Common Eider in Slesvig, where at least some of the females halted their moult migration on the east coast of Jutland.

The males of the King Eider must possess a strong urge to leave the high-arctic region before they lose the power of flight. Being marine birds they cannot fly southwards into the interior of America, but must choose to fly either eastwards or westwards from the Canadian breeding places to reach low-arctic regions where they do not risk being overtaken by the new ice in the flightless stage. The nearest low-arctic area is central West Greenland and the Bering Sea, respectively. The ringing recoveries have demonstrated that the migratory divide between the two diametrically opposite movements (to W. Greenland and the Bering Sea) is situated near Victoria Island, exactly the geographical centre between W. Greenland and the Bering Sea. This shows that selection for the most appropriate (i.e. the shortest) route of moult migration has operated very precisely. The moult migration of the western population, which moves to the Bering region, has long been known as a spectacular phenomenon at Point Barrow in Alaska, but the position of the moulting area is unknown. It is probable that it is situated on the Soviet side of the Bering Strait.

Evidently there is a similar migratory divide in Siberia, the immature birds in particular collecting in enormous numbers in easternmost Siberia and near Kolguyev in north Russia, respectively (Portenko 1959), but the phenomenon has not been closely studied.

Steller's Eider *Polysticta stelleri*, breeding in high-arctic east Siberia and west Alaska, winters in a comparatively restricted area at the easternmost Aleutian Islands and the outer (western) part of Alaska Peninsula. It arrives there usually as early as August and immediately begins the wing-moult, i.e. it spends the flightless period in the winter quarters (type C III). It resembles the King Eider in congregating in enormous flocks, amounting to some hundred thousand individuals, within a restricted area. Ringing of flightless birds has been carried out also in this species (Jones 1965)

and recoveries have demonstrated that the majority of the birds originate from the east Siberian polar coast, westwards to the Lena delta which is situated 3,200 km. away. In unfavourable summers, when the breeding cycle is delayed, the moult migration is also postponed. The birds are then unable to reach the usual moulting area and are forced to perform the wing-moult at some (unknown) place *en route* (type B II or B III). In such years they do not arrive in the winter quarters until November (Jones 1965). A variation of this kind is not found in the King Eider in Greenland, and is altogether unknown in other species of ducks with large and compact aggregates of moulting birds. According to Jones both males and females participate in the moult migration and arrive simultaneously at the moulting area, although in separate flocks. The males, therefore, are probably not dependent on the females in their moult migration. It is incomprehensible to me, however, how the adult females can arrive in the moulting area as early as August. Jones does not mention the presence of immature birds and may probably have confused females with immature birds.

Evidently the Goldeneye *Bucephala clangula* has developed a moult migration but our knowledge about it is very fragmentary. Large flocks of males are known to gather and moult in the Matsalu National Park in Estonia (Kumari 1962) and a smaller number is known to spend the flightless period in Lake Tåkern in Sweden (Lönnberg 1935). In Denmark, which is situated much to the south of the Goldeneye's breeding range, one year old birds are commonly present from May to August in the Limfjord region in northern Jutland, frequenting the shallow brackish water of the coasts of the fjord as well as nearby fresh-water lakes. The Goldeneye is a numerous winter visitor in this area, and the young birds are probably remaining in the winter quarters through the subsequent summer, performing the wing-moult there without making any migrations. Certainly flightless specimens have been obtained in July and August. Adult females arrive in the Limfjord in September and a number of flightless individuals have been obtained there (Schiøler 1926). The scanty information available indicates that the moult migration of the males belongs to type B II, that of the females and immature birds to C I and C II. Apparently this species does not usually gather in large aggregates in the moulting areas.

The Long-tailed Duck *Clangula hyemalis* is a circumpolar species, breeding in the entire arctic zone. Everywhere in its breeding range this species is known to moult the flight-feathers in the breeding area proper, either solitarily (A I) or in small flocks (A II). Strangely enough the east Siberian population differs from this general pattern. Non-breeding birds, i.e. the males joined by the immature non-breeders, from Anadyr Land and the Tchuktch Peninsula perform an extensive northward moult migration across the Arctic Ocean to Wrangel Island where they gather in thousands although the species does not breed there (Portenko 1959). It has been mentioned already that this big island also forms an important moulting area for the Brent Goose.

Concluding Remarks

The description above has shown that the moult migration differs widely in the wildfowl. Within each tribe, however, the migration pattern is basically similar, at any rate as far as the participation of the sex and age groups is concerned. The migration pattern, therefore, can be used as an additional taxonomic character (Table I).

Table I. Participation in moult migration according to sex and age. xx : all individuals of group in question participate. x : only a small fraction of group in question participates.

	Adult males	*Adult females*	*Immature birds*
Anserini			xx
Tadornini	xx	xx	xx
Anatini[1]	xx		
Aythyini	xx	x	
Somateriini[2]	xx	x	xx
Mergini[2]	xx	x	xx

[1] Only the Wigeon has a tendency to moult migration in immature birds.

[2] These two tribes have been united in many recent studies, for example by Johnsgard (1960).

It is a common character in most species of ducks (not geese) with a separate moult migration that the individuals gather in moulting areas which have a milder climate than the breeding areas. In some cases they even perform the wing-moult in the winter quarters. It has been mentioned already that the high-arctic King Eider has a low-arctic moulting area, and the same holds good for the high-arctic Steller's Eider. The low-arctic and north-boreal species, such as Common Scoter, Velvet Scoter and

Eider, move to south-boreal (temperate) moulting areas, and the same holds good for various dabbling ducks. Only the Mute Swan, the Shelduck and the Red-crested Pochard, which as breeding birds belong mainly to the south-boreal zone, have their moulting areas in Europe situated in the same climatic zone. Apparently in these southern latitudes, with a milder climate, the necessity for moult migration is not so pronounced. Most species of wildfowl moult here in the breeding place proper or in its near vicinity. It also appears to be a general rule that stationary populations do not have any moult migration either. This may explain the fact that, so far as is known, no tropical species have developed a moult migration.

The moulting area is not always the first climatically suitable to be passed by the population during its post-nuptial migration. Traditions, historic factors or other circumstances may have caused it to be placed in areas which are further removed from the breeding area than appears to be necessary. The choice of moulting area is to a considerable degree dependent on the suitability of the locality and on biotic factors, primarily on peace from predators (foxes, man). The water depth is highly significant, for dabbling ducks as well as for diving ducks; the latter evidently has the capability of diving considerably reduced in the flightless stage. Extensive areas of shallow water, rich in food, and difficult of access or with good cover constitute the optimal conditions.

Some tendencies towards a development of moult migration are found also in other groups of birds made vulnerable by a simultaneous loss of flight-feathers. In all other groups than wildfowl it appears, however, to be developed only to a slight degree and in most species it awaits further study. The phenomenon is best known in the Coot, both the European species *Fulica atra* and the North American one *F. americana.* It has been noticed in many places (also in Denmark) that in certain suitable lakes the number of Coot increases in the summer time, and large flocks are known to congregate and spend the flightless period in places like Delta, Manitoba (Hochbaum 1955), and Ismaninger in Germany (Bezzel 1964). At the latter locality also the Water Rail *Rallus aquaticus* and probably even the Little Crake *Porzana parva* collect in order to perform the wing-moult. Apparently grebes *Podicipedes* sometimes have a moult migration, but only to a slight degree and not yet demonstrated with certainty. Savage (1964) observed that small flocks of Flamingo *Phoenicopterus ruber* spent the flightless period, in early September, in the salt Lake Rezaiyeh in north Iran, where they evidently did not breed. Elsewhere flamingos appear to moult the flight-feathers near the breeding place just before or after the breeding period. A most interesting case of moult migration in the Crane *Grus grus* has recently come to light. During a visit in May 1962 to the salt Lake Selety-Tengis, in Kazakstan, Gavrin observed a flock of about 3,500 flightless individuals, probably constituting birds which did not breed that year (Cuisin 1966, Stresemann 1967). Cranes apparently do not breed each year and perform a moult of the flight-feathers only in those years in which they do not breed. Gavrin's observation is the only known record of wing-moult in the Crane in the field (outside zoos) and this species must be extemely secretive during the flightless period.

Moult migration is definitely not developed in divers *Gaviae* and in auks *Alcae.* The latter may sometimes perform the autumn migration in the flightless stage, swimming very large distances, which in the case of Brünnich's Guillemot *Uria lomvia* off West Greenland may be more than 1,000 km. (Salomonsen 1967).

Birds with a gradual replacement of the flight-feathers do not perform moult migrations in the way that has been defined above. Nevertheless, some shore birds with extensive migrations divide the autumn migration into two parts separated by a resting period during which the wing-moult takes place in a definite moulting area. This parallels the situation in many species of wildfowl. Such a moult migration has been described only in one species, the Wood Sandpiper *Tringa glareola,* but it is undoubtedly developed similarly in some other related species, at least in the genus *Tringa.* The northern European breeding Wood Sandpipers leave the breeding area during high summer, usually in the latter part of July, and move in a non-stop flight southwards to southern Europe, for example the Camargue, where they temporarily interrupt the migration and, during a long resting period, perform the wing-moult before they start on the actual autumn migration to tropical Africa (Hoffmann 1957).

The moult migration is still imperfectly known and there is in most species much to be done before it is properly understood. The present review may, I hope, encourage further study of this interesting biological phenomenon.

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Some field notes on the breeding of the Greater Kelp Goose

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Introduction

Together we spent from November 1964 to March 1965 in the Falkland Islands, South Atlantic, with the purpose of studying the Greater or Falkland Kelp Goose *Chloëphaga hybrida malvinarum*. It was also possible to make observations on the majority of other species of birds found in these islands.

We arrived separately in the islands on 4th November transported as guests of the Royal Navy. Peter Gladstone travelled in H.M.S. *Protector*, the Ice Patrol Vessel. Charles Martell travelled down the west coast of South America in H.M.S. *Tiger* and from South America to Port Stanley in the tanker R.F.A. *Wave Chief*. We arrived at our first camp on 12th November, the day the first Kelp goslings of the season left their nests.

Our chief area of study was at Port San Carlos on the west side of East Island, particularly on narrow Big Island ($1\frac{1}{4}$ miles long), named on maps as Fanning Island, but not so known locally, near Fanning Head. We also made observations round the coast of Port San Carlos, which covers an area about the same as the Isle of Wight, on the north end of Great Island in the Falkland Sound, on West Point Island, Carcass Island and New Island to the west.

We were probably lucky in visiting two areas where the Kelp Goose is particularly abundant, Great Island and Fanning Island. Roddy Napier, a leading ornithologist who has spent his life in the islands and knows them well, told us he knew of no other areas with so high a population.

In spite of the fourpenny bounty on the bills of other 'geese' the Kelp Geese suffer little from persecution by man. The bills are not acceptable for the bounty and are easily recognised, the female's being pink and the male's having a white spot on the upper mandible—a fact that may well have saved the bird from near extinction. Other factors favouring their survival are that the eggs are laid rather later than those of the other *Chloëphaga* species, at a time when lamb marking and castrating keep the local inhabitants busy; the nests are usually less accessible to human settlements than those of the Greater Magellan Goose *Chloëphaga picta leucoptera* and the eggs are said to be foul-tasting. Furthermore, the eggs of various species of penguin are more easily collected in large numbers—and fresh.

We had evidence that the breeding population was in many places at or near saturation with a reserve of non-breeding birds. When one female died egg-bound another arrived in the territory and paired with the gander within twelve hours. When a pair with young were washed from their territory by a storm, a new pair moved in within a few days. Apart from the area immediately around the town of Port Stanley we found no suitable territory which was unoccupied. It is almost certainly the specialized demands of the bird's ecology which keep the population comparatively low.

Habitat

The Kelp Goose feeds almost exclusively on green algae on the shore. Very occasionally birds feed on short grass and, probably more regularly, on the berries of 'Diddle-dee' *Empetrum rubrum* in the austral autumn, again nearly always close to the shore.

The breeding territories are found on rocky shores where the fine green algae, like *Enteromorpha*, grow in the intertidal zone, on comparatively calm coasts. Thus breeding Kelp Geese are found in bays, in sheltered sounds, in areas where there is a wide shallow underwater shelf, or, frequently, where the shore is protected from the main waves by the blanketing effect of the vast kelp seaweed *Porphyra umbilicalis*. This grows to great length and the fronds often cover the surface of large off-shore areas. The birds can even find territories on the north coast, where kelp abounds, though there is no land between there and the British Isles and the sea is seldom calm. It has been recorded by Boyson (1924) and by Cobb (1933), and frequently repeated, that the birds feed on this seaweed. This is certainly not the case. Their basic requirements appeared to be at least seven yards width of intertidal zone (tides average seven feet in height) with enough algal growth to make it appear greenish, rocks which will not move in storms and so destroy the algae, some nest cover close to the high tide mark, and shelter or a blanket of kelp.

During the breeding season territories are closely defended by both sexes, the

male being seen to chase away intruding males and females, and the female other females. The size of the territories varies considerably with local conditions. A single pair may be alone in miles of coastline because there is only one small bay with the necessary conditions. In other places nests may be as little as fifty yards apart, though seldom does a territory cover less than a hundred yards of shoreline.

Nests

We found 56 nests in use and a number which had been in use before we discovered them, or were from previous years. Some of the latter were close to present ones, suggesting traditional attachment to sites. Indeed in some cases we found several layers of old down and grass, one on top of the other.

Nest cover varied from a dense cover of ten-foot high tussac grass *Poa flabellata* to planks of old sailing ships (which littered the coast and provided much of our fuel for cooking and for heating hot-water bottles—for our tame goslings). However, with practice, we could usually pick out where the nest would be in any given territory. It would be partially hidden, but allowing the highly cryptic female to have a view out. Usually the bird could walk at least a couple of yards to the nest, though she might have to fly direct to a small hole in the vegetation. All nests save one were within ten yards of the high tide line, and most were closer than that. The exception was 100 yards from the shore of Great Island, against the first bit of cover inland from an otherwise perfect feeding territory. Where available a ledge amongst stunted tussac grass four to eight feet up a little cliff was preferred. On Great Island, where sheep have exterminated the tussac grass except on such cliffs, ground nests were beside drift-wood, an outstanding boulder, amongst *Empetrum*, or in the coarse white grass *Cortaderis pilosa* with which most of the islands are covered.

The scrape was lined with any available vegetable matter and down was added when the last egg was laid and incubation started. Where incubation was advanced there was normally a considerable quantity of grey down and the eggs were covered with this when the female left to feed. The white male does not take any part in incubation and has no brood patches.

Eggs and clutch size

The fresh eggs have a greasy texture and are a slightly creamy white. The shape varies very considerably, some being long and thin but the majority tending to a blunter ovoid.

The clutch sizes of 44 nests found in which laying was complete and where there was nothing to suggest disturbance or that they were second clutches were as follows:

Clutch size	6	5	4	3
No. of nests	21	17	5	1

We heard that a clutch of eight has been seen but could not get details. Clutches of seven eggs do appear occasionally. Mr. Napier found one on West Point Island in 1957 but he considered it unusual. Pettingill (1955) records one on Kidney Island. Boyson (1924) recorded clutch size as 2 to 4. This is suggested as the normal size for the Lesser Kelp Goose *Chloëphaga hybrida hybrida* on off-shore islands in Chile by Johnson (1955). We found two newly-hatched broods of seven young after a storm in territories where neighbouring adults were missing and there may have been amalgamation, also two broods of seven well-grown young in February on New Island. Mr. Napier saw a brood of nine on Dunbar Island in 1957.

We measured the eggs of 10 clutches, 48 in all, and found the average to be 82.5 × 55.6 mm. (ranges 78-89 × 53-58). One exceptional egg from an otherwise normal clutch measured 105 × 65 mm. Schönwetter (1960-1) gave the measurements of 27 eggs as 83.5 × 54.0 mm. (75-91 × 53-58). Boyson (1924) gave ranges of 80-84 × 55-58 mm.

When we arrived on 4th November most clutches were well incubated and we did not get a chance to discover the incubation period. (Delacour (1954) gives it as 30 days.) From the first sign of chipping, individual eggs hatched within 12 to 48 hours and the young normally left the nest together some hours after the last eggs hatched. In the majority of cases this was about 48 hours after we had found the first egg chipping, but sometimes considerably longer. Cobb (1937) states '. . . young leave the nest one by one as they hatch . . .' and '. . . but the Kelp Ganders just sit about or feed, and do not appear to care if they lose the lot or not. This is perhaps a good thing, or the place would become smothered in Kelp Geese'. We saw one newly-hatched young tended carefully by a gander on one occasion whilst the goose sat up a cliff on a nest and Cobb's description is not of a normal situation. The first young to leave the nest did so

on 12th November and the majority of nests had hatched by 25th November, though several hatched some days later. A few still had eggs on 5th December. One nest had four eggs which started chipping on 9th January and the young left the nest on 14th January but we saw no evidence of other late broods. We suggest that reports of later hatching may be derived from underestimation of the ages of the young due to their extremely slow growth rate, particularly during the first few weeks.

Goslings

We got to know the goslings intimately as the two of us lived in a tent 4 ft. 4 in. by 6 ft. 6 in. with all our equipment and reared 25 goslings in it. This was not always an easy task as there were frequent gale-force winds often with near-horizontal hailstorms. We also had to guard the birds against the attentions of Cassin's Falcon *Falco peregrinus cassini* and the local Buzzards *Buteo polysoma* or *Buteo erythronotus*—we confirmed what had been suspected before that the Blue Buzzard is the male and the Red-backed Buzzard the female of the same species, as we found two nests and saw several other pairs. Johnson (1965) mentions no sexual dimorphism for the Red-backed Buzzard *B. polyosoma* in Chile. The Falkland bird may prove to be a distinct species. If so it is one of the rarest birds in the world.

We also had to protect our 'family' from the attacks of the Greater Magellan Geese which held the territory in which we placed our tent. 'Martha', the female of this pair, came each morning to attack the goslings round the tent. She also stole our porridge whilst we were protecting the goslings, being completely fearless of human intervention. Picking up Martha and enclosing her in our little pen whilst the goslings grazed round the tent solved this problem at times—the Lorenz Inverse Cage Law in reverse! A few near-hits with a red plastic bucket made the buzzards wary of it even when it was slung flapping on a drift-wood pole near the tent.

The newly-hatched goslings are delightful little white birds with pitch black feet and bills. The egg-tooth is white. They have sharper claws than any other Anatidae we know and stumble over and round the rocks following their parents. They are only able to feed at comparatively low tide for a few hours each day, the actual period depending on the weather and the direction of the wind. This may explain why they grow so slowly, a feature we noticed both in the wild and amongst our tame birds. The actual pre-flight period for any individual bird was not measured; it varies considerably but is always more than twelve weeks. The wild goslings fed on fine green algae of the *Enteromorpha* type, and a little on similar brown algae. Our birds fed on turkey starter crumbs which we had imported, short grass, leaves of dandelion *Taraxacum officinale*, an introduced plant found round settlements, porridge oats, flour and anything else available. Some even had hard-boiled eggs of Rockhopper *Eudyptes crestatus* and Gentoo Penguins *Pygoscelis papua*. As many of the local inhabitants feed their chickens and tame ducks and geese on carcasses of cattle and sheep we reckon our birds did well! We lost a few by chilling in spite of taking them into our sleeping bags, one was lost down a covered hole (together with our only young Flightless Steamer Duck *Tachyeres brachypterus*) and one was killed by Martha.

The slow growth rate was worrying to both of us as we had had experience of hand-rearing other waterfowl. The white down soon becomes greyish and the first feathers showed through after 17 to 25 days. This period varied with the weather and hence the available feeding time, both for our birds and those living under natural conditions. The first feathers of the females appear before and are darker than those of the males. It is easy to differentiate between the sexes some days before the feathers appear as the females start to get a croaking edge to their voices, the first sign of the musical 'qwa' of the adult females. The normal note of the young is a double 'cheep', and as the female 'qwa' appears the males develop a triple 'cheep' which is later further multiplied and develops into the adult male's whistling 'si'.

In getting the birds home we had great help from Ian Strange, the crew of R.M.S. *Darwin* and the firm of Maclean and Stapleton of Montevideo. We made cases of weldmesh lined with sacking, and having long since run out of turkey starter we fed the birds on dandelion, cabbage and porridge. From Port San Carlos to Port Stanley we travelled on the *Darwin*, the local steamer, on the after deck. This was an easy trip although it was necessary to struggle through sheep to reach the birds. From Stanley to Montevideo we had five days of hell, the only available space being on the forward deck and the sea being rough. Tending the goslings, together with the other ducks, geese and penguins which we brought

back, was a task not lightly to be undertaken again! Before the trip we had tried to inject the birds against aspergillosis but unfortunately the drug proved to be too granular for normal syringes. Hampered by this and the prevailing weather conditions, which were such that even the *Darwin's* sailing was delayed two days, we had to abandon the attempt after succeeding with three birds. At Montevideo we had fifty-six hours in a heat-wave feeding, cleaning out, repairing crates and keeping the birds cool with an ever-running fire hose.

By plane from Montevideo was an easy 17 hours though we were worried by the rise in temperature of the hold during a delay in Rio de Janiero. We then syringed water forcibly into the birds using a long-necked garden syringe. This had proved invaluable on many occasions, particularly when it was too rough to leave water in the crates. We landed at Gatwick in snow and soon had the birds on the Land Rover, to arrive at Slimbridge at dawn to a right royal welcome. We released the birds looking as if they had never been crated. It is sad to relate that in spite of devoted care and the use of drugs every bird had died of aspergillosis within a few months. The January-hatched birds, which we had collected, survived best and were easiest to handle on the trip although they had only just started to feather when we left.

The goslings became well imprinted on us which made caring for them much easier than it otherwise might have been. They took the vicinity of the tent as their territory and seldom wandered more than twenty yards. In the wild they are (contrary to Cobb (1933)) attended by both parents and clearly imprinted on both (Plate Ib, facing p. 28). It is noteworthy that they are able to imprint on both parents despite such dissimilar plumages and voices. There are few other Anatidae where the parents show sexual dimorphism and both look after their young and there is no other species in which the sexual dimorphism is more strongly marked. The female normally guards the young and when she is present they follow her, keeping close behind on the side opposite danger. If the female is removed from the brood the young follow the male, creeping away along the shore, as closely as they normally follow the female, but when the female is released they again switch to her. The female usually broods the young, although if the male is sitting down they sometimes snuggle under him.

Causes of losses

It was little encouragement to two men in a tent to be told that they had experienced the worst summer in living memory in the Falkland Islands. The weather in these islands has not a pleasant reputation and during November and early December the temperature was constantly low with a little frost some nights. The wind was often gale force and a spade was as useful as armour plating against hailstones as for its accustomed purpose during the calls of nature. However there were glorious short periods when the wind dropped and we did witness better weather later in our stay.

We saw no predation of Kelp Geese in the wild, but major gosling mortality that season was easily ascribable to storms. These were so violent at one stage when the birds were hatching that we were unable to move round the south side of Fanning Island even at low tide. These conditions lasted several days and we then found one colour-ringed pair a mile across rough sea from their territory, with two dying young.

Of 166 eggs we found on Fanning Island or the opposite shore, about eight did not hatch. We removed 25 newly-hatched goslings from this area leaving about 129 in the natural state. There were probably two broods (about 11 young hatched) from nests we did not find. Of these 140 young less than 20 were alive at the end of February. This 14% survival rate may be exceptionally low, but it would probably have been but little higher if we had left all the goslings hatched. Few pairs had complete broods left by February when we removed two or three others. In a storm the parents do not appear able to protect stragglers, and always stay with one or more young, so all our captives might have been surplus. In some other areas the survival rate had obviously been higher as we saw well-grown large broods, but many had apparently been heavily reduced to one survivor and many adults had lost all their young. The survival rate of our tame birds was about 76% from hatching to Slimbridge.

We heard reliable accounts of goslings being attacked by Dominican Gulls *Larus dominicus*, but did not see this. Great Skuas *Catheracta skua antarctica* and *mackormici* are numerous in some areas and probably attack goslings. We found two Kelp nests with eggs apparently eaten by Brown Rats *Rattus norwegicus*. The parent birds were not alarmed by the large Carancho *Caracara caracara* though

Philippa Scott

Plate I. (a) A pair of Greater Kelp Geese *Chloëphaga hybrida malvinarum* photographed in the Falkland Islands during the first British tourist excursion to Antarctica.

(b) Young Greater Kelp Geese following the adult male, the female was bringing up the rear with two other young. (See p. 28)

Philippa Scott

Philippa Scott

Plate II. (a) A pair of Falkland Island Flightless Steamer Ducks *Tachyeres brachypterus* photographed in the wild.

(b) The first Magellanic Flightless Steamer Duck *Tachyeres pteneres* to be bred in captivity, at 14 days old. (See p. 32)

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these were constantly on and around some of the territories. Sea Lions *Otaria byronia* and Leopard Seals *Hydruga leptonyx* would certainly take any young or adults they could catch, but the latter is now uncommon round the islands and the birds never move voluntarily into water in which seals could swim. Few birds except Scoresby's Gulls *Gabianus scoresbyi*, Sheathbills *Chionis alba*, Turkey Vultures *Cathartes aura* and some passerines are seen around Sea Lion colonies. The gulls and vultures feed on dead seal pups and afterbirths and the Sheathbills, which look like angelic fantail pigeons in flight, feed mainly on the seal faeces, starting before the evacuation is complete. Obviously the presence of a seal colony eliminates the possibility of a Kelp Goose territory. The buzzards appear to feed largely on passerines and we did not see them taking goslings though they constantly hovered over our tent whilst our tame birds were small. No gosling remains were found at their nests. Cassin's Falcon is reported as taking young chickens from settlements but at Cape Dolphin two adults and a fledged young shared a territory with a brood of well-grown Kelp goslings. Here the falcons were feeding on Belcher's Prion *Pachyptila belcheri* which were often in large flocks within sight of land. We saw a male Kelp drive off a Turkey Vulture which landed in its territory.

The mysterious Falkland Island Fox which early explorers including Darwin report as having been abundant in the islands may have been a danger in the past. Patagonian Foxes have been introduced to a few of the western islands of the group to kill penguins and geese with the faulty idea of aiding the sheep. However they turned on the sheep and have cleared them from some islands. There are no other wild land carnivores except the feral cats which we never saw on the shore-line though they inhabit the wildest areas. We found one adult goose that died egg-bound. Two dead ganders were found eaten by scavengers near a deserted nest on Great Island. It is possible that these had been killed by a Magellan gander in whose territory the nest was situated.

The Kelp Geese in many areas show no fear of man and it is possible to catch them with a fish landing-net, but when they have young they often take to the water between and round the rocks on the approach of humans. (The birds normally dislike getting their feet wet.) It is difficult to get within ten yards of some non-breeders on a beach and of all adults when they are flightless. We did not, unfortunately, see their reaction when surprised with young by the local sheep dogs. When a dog is near them they simply made for the water.

Kelp Geese fed quite close to parties of young Sea Lions and Elephant Seals *Mirounga leonina*. On Carcass Island a brood fed between the water and moulting bull Elephant Seals of several tons weight even when these monsters were wallowing their way ashore a few yards away. A pair was seen feeding close around a dead Sperm Whale *Physeter catodon*, 51 feet long, and they showed no reaction to White Dolphins just off the rocks.

It is interesting to note that none of the geese showed alarm at the helicopter (in which we were privileged to make several excursions). This contrasts markedly with the reactions of other species of geese, in Europe for instance.

Behaviour

When a trespassing bird invaded a territory, the territory-holding gander flew low over the ground towards it and landed facing it a few feet away. He landed with his chest raised and puffed out and his head tucked in above it, with the tail lifted to make an angle of about 130° to the ground. This is very similar to the aggressive display of the male Andean Goose *Chloëphaga melanoptera*. On landing he maintained this posture whilst running directly towards the intruder with his wings slightly open, possibly to display the calouses, possibly to add to his apparent size, but certainly to aid his balance over the rough rocks. Throughout the aggressive run the attacking male repeats a 'si-si-si' whistle, frequently composed of three, seven or eight syllables although any number up to and including nine was heard, at constant pitch and at a rate of about five notes per second. In many cases that we saw, the intruder invariably retreated, running if not near water, then flying low, nearly always over water a few yards off-shore. When moving the birds prefer to fly over water, but seldom many yards from the shore. Kelp Geese are short-winged and not strong fliers. We never saw them fly more than forty feet above the ground or water. They very seldom even flew over Fanning Island, 30 feet high and 100 yards wide, after a visit to the 'mainland'. Instead they would make a detour right round the island, each paired gander displaying as they passed.

The female will also chase straying birds in the same posture as the male,

with her white patch on the wing-joint showing (as it does every time she lands). She resembles an old woman with an enormous swaying front angrily chasing chickens, as she stumbles over the rough ground, with flank-feathers flapping like an apron in the wind. On one occasion an incubating female was seen to leave the nest and drive off a stray female to whom her gander was making advances.

When a paired female was picked up it was usually easy to catch the male as well as he either attacked us or displayed violently within a few feet. On some occasions we picked up the male whilst handling the female and threw him into the air several times to be rid of him, but he kept coming back to display at us and to attack. If there were young present the male usually slunk off along the shore instead, with the brood following. When we caught a male the female stood around looking bewildered, though again if there was a family she would make off along the shore with it. When we caught the young the parent birds showed no sign of aggression but rather appeared to try to call the young from us, keeping meanwhile within a few feet. The female would give a constantly repeated single 'qwa' note, the same as when leading the young. It may be that the female did not recognise humans as dangerous animals but rather reacted as if the young had got trapped behind a rock. On these occasions the male's call seldom had more than three notes and sometimes only one or two. We did record up to eight notes a few times.

Occasionally a brood of Greater Magellan Geese would wander on to the shore in a Kelp's territory. On these occasions each gander would display at the other, but neither responded to the other's aggressiveness by flight and there was some fighting, the caloused wings being brought into use. Once a Kelp female was seen to drive off a Magellan female. Kelp Geese took little notice of Ruddy-headed Geese *Chloëphaga rubidiceps*, Flightless Steamer Ducks *Tachyeres brachypterus*, or Crested Ducks *Lophonetta specularoides specularoides* (which are possibly distinct from the South American birds). These might well all share the territory together with a pair of Black Oystercatchers *Haematopus ater* and a pair of pied Garnot's Oystercatchers *Haematopus leucopodus*. Magellan Penguins *Spheniscus magellanicus* were constantly on the shore in Kelp territories and the birds took no notice of each other. Intra-specific fighting was not observed, one bird always acting recessively, but territories were well established when we arrived. There was a little squabbling in non-breeding parties.

When the female left the nest either to feed or when disturbed she flew at once to the male who was standing guard some distance away, landing sideways on, almost touching him. She immediately took up a breast-down position with the tail right up, similar to that seen in the aggressive run, with the white wing-joint well forward and very distinct. Meanwhile she gave a repeated musical 'qwa-qwa-qwa' (frequently three notes, varying to seven), and the male would almost fall over backwards with an upright posture, his neck pumping up and down and his chest puffed up, uttering a 'si-si-si' whistle, seven or eight syllables being the most usual, at constant pitch but sounding more sing-song than when he is aggressive. This whistle of the male is less fluting than that of a Magellan gander. The birds would move and repeat the performance several times until the female either flew to fresh water to drink or started to feed. On Fanning Island there was no fresh water except temporary rock puddles and some birds went over to drink at rivulets on the coast of East Island. Birds also appeared to drink more at dawn than at other times of day, though there were many birds that we never saw take water. The male seldom ate when the female was on the nest. Some pairs flew to a neighbouring non-territorial beach to feed when the female came off.

We could see no significant difference between the greeting display and the presumed triumph display which occurred regularly when the male returned to the female after a chase.

Although we witnessed and filmed distraction display in the Greater Magellan Goose, we did not see it in Kelp Geese.

Several times we saw display with calling as the male flew close behind the female low over the water, especially early in the morning as the pair flew back from drinking. Here the neck pumping was semi-horizontal although there was considerable vertical movement, with the chest again puffed forward, making flight appear difficult. The male called (usually seven syllables) and the female answered during this display.

Non-breeding movements

The non-breeding birds form flocks and move about depending on the conditions of the weather and the availability of 'sea lettuce', bright green and similar to luche *Ulva*, growing below high tide level. This is normally washed up on shores

not used by breeding birds. It does not appear to occur on the most exposed beaches where there was a lot of driftwood. The birds do not often move as a flock, but rather in small parties or singly. Several times we watched this food accumulating on the beach near our tent and the number of birds would gradually increase until there were more than 50. On 10th February we saw one flock of 316 Kelp, all over a year old and many flightless, on a beach on New Island. The first flightless bird we saw was a male on 26th November. Throughout males moulted earlier than females though there was considerable overlap.

There is some winter movement round the coasts, but we were unable to ascertain its extent. Apparently some of the birds remain in their summer haunts. They occur regularly in the bay of Port Stanley and we saw some there in early March before we left.

Although the birds normally keep their broods within their territorial limits until fully grown, they are occasionally driven from it by storms and then some young may become separated to join another family. Though this behaviour could be considered accidental and may be uncommon, we found one pair of adults feeding on grass beside a sandy beach with twenty-five well-grown young of varying ages. The area did not seem suitable for a breeding territory and we can only conjecture how they arrived there. Also this beach was sometimes infested with Leopard Seals which eat sea birds freely and have even attacked swimming dogs, cattle and men.

While breeding males were white, nearly all non-breeding ones had one or more black wing-feathers, usually primary-coverts. We saw three breeding males with black feathers, one with a thin broken line down the back of his neck, one with some black tail-feathers and one with a black primary. One female of a territory-holding pair had black feathers on her rump. There were pure white males in non-breeding groups and these tended to be the most aggressive. They may have been adults which were unable to secure a territory. On the whole the legs of the birds which were not breeding were less bright in colour than those of the breeders, and this may be a method of telling fully mature from other post-juvenile birds. In the areas we visited there were more birds in flocks than there were holding territories.

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First breeding of the Magellanic Flightless Steamer Duck in captivity

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In 1966 and again in 1967 a pair of Magellanic Flightless Steamer Duck *Tachyeres pteneres* have bred at Philadelphia Zoo, Pennsylvania, U.S.A. The male was received in July 1962 as an immature and the female in January 1964 as an adult; since then the two birds shared a large enclosure with a group of Rhea *Rhea americana*. In the centre of this paddock is a concrete pool about 10 feet in diameter and in the area adjacent to the water the weeds were allowed to grow up to provide shade and cover for the ducks. Near the pool an open-fronted wooden nesting box was placed and this the Steamers used. In 1966, five eggs were laid, the first on 18th May, the second on 20th, the third on 21st and by 25th the clutch was complete. We believe that incubation started on this date and as a single egg hatched on 24th June (the only one to do so), the incubation period is estimated at 31 days.

In 1967, four eggs were produced and three ducklings, one male and two females, hatched on 20th July. We hand-reared the young without the least difficulty on a mixture of dry meal (a high protein turkey mash), grated hard-boiled egg and chopped lettuce; however, at about five months of age they were all lost to aspergillosis. A greater catastrophe was that their father, our only male bird, attacked a Rhea and was killed in the process. At post-mortem he also was found to be suffering from aspergillosis and acute hepatitis.

Eight of the eggs measured on average 80 × 56 mm. with extremes of 78-82 × 52-58 mm. and four of the 1966 eggs weighed before incubation 137.25 gm. with a range of 131-140 gm. The 1966 duckling, a female (Plate IIb, facing p. 29), weighed 99 gm. at hatching, 101 gm. at two days, 116 gm. at five days and 128 gm. at eight days of age; at 35 days she was 3 lb. (1361 gm.) and still growing. The 1967 downies weighed on average 87 gm. at 36 hours old, 93 gm. at three days and 88 gm. at five days.

This breeding record is especially interesting because relatively little is known about the Steamer Ducks and none have been bred in captivity before. (Zurich Zoo bred the Falkland species *T. brachypterus* in 1967). The group contains only three species, all birds of the coast, of which the Magellanic Flightless Steamer is the largest: Murphy (1936) gives 6050 gm. as the average male weight and 4110 gm. for the female. Our 1966 female, weighed in January 1968, scaled 10 lb. (4536 gm.) and the other (the mother of the ducklings) 8 lb. (3629 gm.). Such a wide variation in the size of healthy adults may be normal in a flightless species.

Thus, using our weights, each egg constituted 3.8% of the adult female and the day-old duckling about 2.7%. These figures (see Lack (1968) for comparative table) together with an incubation period of 31 days are compatible with the view that the Steamers are related to the shelducks and sheldgeese (Tadornini) as Delacour (1954) suggested, although they alone cannot prove the connection. The eggs laid at Philadelphia are very slightly smaller than six wild-taken ones measured by Johnson (1965) who gives 81.7 × 55.6 mm. (ranges 79.9-84.1 × 54.9-56.5 mm.), and quite a bit smaller than 11 taken by Murphy (1936) which were 84.7 × 57.3 mm. (ranges 81-88 × 55-61 mm.). In the breeding grounds in southern South America, egg-laying probably starts in the spring month of October, and nests are found close to the sea-shore, under shrubbery or other concealment. Clutch size in the wild is said by both Murphy and Johnson to range from five to eight, and Murphy suggests that six is the usual figure. That our female, laying for the first time and second time in her life, should produce slightly fewer and smaller eggs than the average for these long-lived birds is, I think, not unexpected.

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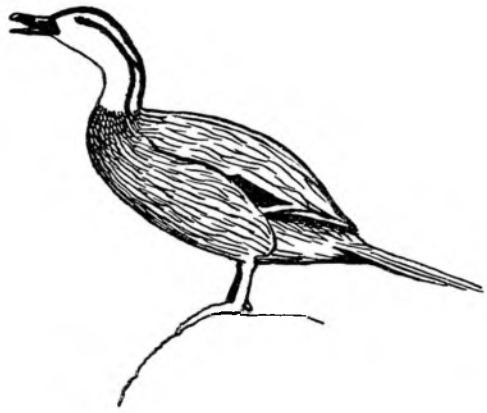

Plumages and wing spurs of Torrent Ducks *Merganetta armata*

MILTON W. WELLER [1]

Introduction

The Torrent Duck *Merganetta armata* of the Andean highlands is one of the most colourful and intriguing of all species of waterfowl. It has adapted to the demanding environment of cascading mountain torrents, and only rarely is seen in highland lakes. Taxonomically, the species has been a puzzle, and Johnsgard (1966) has recently reviewed its biology and taxonomy. Both he and Delacour (1956) recognize only one species but differ in the number of races accepted. Subspecific names here refer to Delacour's terms which were based on Conover's (1943) classification and which are recorded on most museum specimens.

My own experience with the species in life is restricted to observations of several pairs in Chile (Curico Province) and observation of its habitat in northern Patagonia (Provinces of Rio Negro and Neuquen) and sub-tropical Argentina (Province of Jujuy) during 1964 and 1965. Subsequently, this species was chosen as part of a study of the plumages of selected Neotropical anatids because of its dramatic sexual dimorphism despite its isolation from other ducks (see Sibley 1957, for a discussion of factors possibly influencing dimorphism).

Because of the difficulties of studying this species in the wild or in keeping captive birds, an attempt has been made here to utilize the specimens collected by scientists and professional collectors throughout the Andes. Pooling data from these museum specimens permits the biologist to visualize and even quantify many of the major patterns before attempting to solve problems in the field. Such museum study is still impossible with rarer species and at one time would have been difficult for Torrent Ducks. However, there is now an excellent collection in the American Museum of Natural History and an especially fine series of young birds in the Conover Collection at the Field Museum of Natural History in Chicago. The sequence of plumages was studied mostly from the latter collection but nearly 200 skins were examined in museums in the eastern United States.

Another unusual feature of the Torrent Duck is the presence of a metacarpal spur on each wing. True spurs are well-defined pointed projections of a bony core covered with horny material (as opposed to the bony knobs on the wings of geese) and are not common among Anseriformes. They occur in the three species of Screamers

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(Anhimidae), and in the well-named Spur-winged Goose *Plectropterus gambensis* (Rand 1954). It is interesting that Johnsgard (1966) has suggested placing the Torrent Duck in the Tribe Cairinini which also contains the Spur-winged Goose. It is known that Screamers and Spur-winged Geese fight with their wings but no such fighting has been reported among Torrent Ducks.

During examination of specimens, it became obvious that spur length differs with sex and age of the birds, as noted also by Conover (1943), Rand (1954) and Delacour (1956). Spurs were measured as a potential age criterion to aid in understanding the chronology and sequence of plumages.

Description of plumages

The colourful plumages of the various forms of torrent ducks have been described by Phillips (1926), Conover (1943) and Delacour (1956), and a general description of the species will suffice here. Adult males are characterized by a bold black and white head pattern and a brownish grey body, wings and tail. The crown, nape and the area at the base of bill are black, and the face is white with an eyeline extending down the neck to the upper breast and connected to the nape by another black stripe. In the southern *Merganetta a. armata*, the eyeline continues in a circular fashion forward and downward and connects to a black chin, throat and ventral neck. The back and scapular feathers are elongated and pointed, and various races have brown, tan, grey or white edges to these feathers. The chest, belly and side are very dark and rufous in the southern race, but others have pale grey breasts streaked with black.

Adult females also are greyish dorsally and on the head and neck, but they have finely vermiculated feathers in the eyeline area that extend down the side of the neck and along the side. The lower face, chin, thoat and entire ventral surface are rich cinnamon.

An iridescent green speculum is present on the secondaries of both sexes at all ages. It is bordered by a narrow white line anteriorly (on the greater secondary coverts) and at the posterior of the secondaries themselves. Both sexes have an extremely large alula, the function of which can only be theorized.

Both sexes have red bills and legs. The iris is said to be brown in both sexes (Delacour 1956) but specimens in the Field Museum have labels indicating a white iris in adult males *Merganetta a. garleppi* and 'coffee-coloured' eyes in other races. Both sexes have wing spurs but the colours of these in life have not been recorded.

The downy young are generally dark grey above with a narrow white dorsal stripe and two white bars on either side. They are white ventrally and on the face and have a grey eyeline and an indistinct dark patch in the auricular area.

The juvenile plumage is female-like dorsally but is pure white below in both sexes. Some individuals, especially of *Merganetta a. armata*, have an orange-cinnamon tinge to feathers in the neck or upper chest region. Apparently this occurs in both sexes although a conspicuous shortage of immature females in collections makes me question the data on some labels. The feathers of the side, flank and rump are broadly barred.

Sequence of plumages

Because the sequence and number of plumages do not seem to differ in the various races, comments here are for the species as a whole. The natal plumage is replaced in a pattern similar to that of other ducks. The tail is renewed very early and some natal down clings to the tail-feathers until the tail is fully juvenile and much of the body is feathered. Natal down also clings to back feathers. The advent of juvenile feathers on the ventral surface and side precedes those on the head and back. The entire body is essentially fully feathered before the primaries develop noticeably. Although body plumage precedes wing development in most species, flight usually is possible before or just as the back is fully feathered (Weller 1957). Presumably their diving ability and the habitat provides adequate safety and complete protective body feathering is more valuable than are flight feathers.

Replacement of juvenile by adult plumage begins as soon as the primaries are fully grown, as evidenced by five flightless juveniles with no tail moult (Field Museum 10400, 14295, 16068, 13762, 14491) and seven flying immatures which have some notched juvenile and some new adult tail-feathers (F. M. 13761, 14962, 88246, 16097, 12263, 17432, 14298). Concurrently, there is moult of the scapulars and upper back. These new feathers are adult-like, being darker, broader, more firm, and comparable in colour to those adults or to immatures in advanced stages of plumage development. Specimens with 1 to 7 adult tail-feathers uniformly show moult of the scapulars and often have new feathers on the side

of the neck and on the head. Specimens with 4 to 10 adult tail-feathers also show moult of the back, side, undertail-coverts, rump, head and occasionally the chest. Belly moult is rare until the tail is fully adult, but even then the belly feathers are the last to be replaced, being preceded by those on the chest, chest-side, and flank, in that sequence.

As Conover (1943) noted, the new feathers which appear on juveniles are fully adult in colour and pattern. There is no positive evidence of a dull first non-nuptial plumage (the first basic plumage of Humphrey and Parkes 1959). There are possible exceptions with regards to the head and chest. The white facial area becomes mottled white and black when the distinct black pattern forms on males. Specimens of what are assumed to be yearlings (see below) lack this mottling so that it is lost either by moult or by wear. The distinct pattern formed during this moult suggests that the latter may be the case. Another area of uncertainty is on the chests of both sexes when some rufous feathers appear during the loss of the juvenile plumage. Possibly these are first non-nuptial feathers but, if so, they are neither widespread nor regular in all individuals.

Some specimens of the northern *Merganetta a. columbiana* show little or no head moult even when the tail is nearly fully adult. However, several specimens of immature male *Merganetta a. armata* show the acquisition of its unique black throat when there is no moult or little moult of the juvenile tail (Phil. 5442 and F. M. 88246, respectively). New black feathers develop as a 'V' of two lines within the two halves of the lower mandible. Eventually a black throat and a ventral mid-line on the neck are formed. Either this head moult precedes that of northern races or too few specimens of other sub-species have been collected at an appropriate time.

Almost no data are available for females and I suspect that many of the immature specimens are mislabelled. Many immature females have reddish on the chest but so also do males of *Merganetta a. armata.* The best specimens showing the transition from juvenile to nuptial plumage of females are F. M. 17432 (April—mostly juvenile) and intermediate specimens which still have the white belly but show a red throat (A. M. N. H. 424855) or a red throat and chest (F. M. 17433—taken in May). Several near-adult specimens retain only a few white belly feathers (F. M. 17430—June; F. M. No. 19202—August).

Most nesting of the southern form probably occurs in October to January with a peak in November. Johnson (1963) reported two nests in October and November, and a female was captured on a nest in November at Cautin, Chile (F. M. 14296). Flightless juveniles have been taken in January and early March (Tables I and II). Birds dominantly in juvenile plumage were taken in January to April, and birds dominantly in first nuptial plumage were taken from May to September (Tables I and II).

Thus it appears that both sexes are essentially in full first nuptial plumage by the time of the normal breeding season. Whether yearlings actually breed is not known. There is no evidence of an intermediate body moult in the spring in yearlings, although tail replacement is not unlikely.

Once the first nuptial plumage has been acquired, the plumages of yearlings and adults are not readily distinguishable by

Table I. Series of specimens of male *Merganetta a. armata* showing the chronology of acquisition of the first nuptial plumage. For each column heading: + = some present; − = none present.

		Male				
Museum No.	*Date*	*Flightless*	*Juv. tail*	*Nupt. tail*	*Juv. Body*	*Nupt. Body*
A. M. N. H. 734385	January	+	+	−	+	−
A. M. H. H. 734384	January	+	+	−	+	−
F. M. 10400	March	+	+	−	+	−
F. M. 88246	March	−	+	+	+	−
R. O. M. 93534	May	−	−	+	+	+
F. M. 14298	June	−	+	+	+	+
F. M. 12263	June	−	+	+	+	+
R. O. M. 93536	July	−	+	+	+	+
F. M. 16097	July	−	+	+	+	+
R. O. M. 93535	July	−	−	+	+	+
F. M. 16096	September	−	−	+	+	+

Table II. Series of specimens of female *Merganetta a. armata* showing the chronology of acquisition of the first nuptial plumage. For each column heading: + = some present; − = none present.

		Female				
Museum No.	*Date*	*Flightless*	*Juv. tail*	*Nupt. tail*	*Juv. Body*	*Nupt. Body*
A. M. N. H. 734383	January	+	+	−	+	−
A. M. N. H. 424855	March	−	+	+	+	+
F. M. 17432	April	−	+	+	+	+
M. C. Z. 96607	April	−	−	+	+	+
F. M. 17433	May	−	−	+	+	+
F. M. 17430	June	−	−	+	+	+
F. M. 19202	August	−	−	+	+	+

body plumage. However, in examining wing spurs and other characters as possible age criteria (see below), some characters of the male wing were observed which show reasonably good agreement with known juveniles and with those individuals assumed by their spur length to be either yearlings or adults. As is usual in waterfowl, the juvenile wing is retained for nearly a year until the simultaneous wing moult following the first breeding season. The greater secondary-coverts of the juvenile wing are white-tipped like those of adults but adult males have a slight black edge proximal to the white band which is reduced or lacking in immatures. Females show a less clear-cut pattern because both juvenile and adult females have the black band on the wing coverts but usually it is larger than in adult males.

Annual moult

Following the acquisition of the first nuptial plumage, there is permanent sexual dimorphism in colour with no evidence of any intermediate non-nuptial ('winter' or 'eclipse') plumage. Subsequent plumages are merely replacements of feathers of the same colour. Only three flightless adults were observed in collections: a male from Junin, Peru (F. M. 12797— no date), a male taken in Ecuador in April (F. M. 14268) and a female taken in December in Ecuador (F. M. 11769). All three were in body moult but the new feathers were of the same colour as were the worn ones, confirming the general observation that there is no 'eclipse' plumage.

Because of the extensive nesting period of Torrent Ducks in northern breeding areas (Johnsgard 1966), the chronology of the plumage cycle is difficult to appraise. Assuming that the breeding season is more restricted in the southern *Merganetta a. armata*, six adult females and nine adult males of this race were examined. Ten of the 15 had tail moult while only seven had body moult. Five of the seven in body moult were taken in autumn (Feb.-April), one was taken in spring (Nov.), and one in winter (June). It seems probable that a late summer or autumn moult is regular, concurrent with and following the wing moult. More data are needed to determine whether a late winter or spring moult is regular in adults but it seems common in other Neotropical anatids (Weller, in press).

Tail moult seems to be a more regular and a less seasonally restricted event in this species than in typical northern species. Some tail moult was found in 79% of 49 adult birds, representing all seasons, examined for this feature. This suggests a constant replacement or a double moult each year. There was no apparent serial pattern to the moult although central tail-feathers seemed to be replaced first.

One female taken on a nest of 5 eggs (F. M. 14296) near Cautin, Chile, in November, had tail moult but no body moult. It did have long, plumose, grey nest-down, characteristic of many nesting ducks (Weller 1957).

Wing spurs

While examining the plumage of specimens of various ages and both sexes, it was noted that considerable variation occurs in the size, shape and colour of wing spurs. To clarify and quantify this, spur length, shape and colour were recorded for 191 specimens.

Spur lengths were plotted according to season for males and females of all ages and from all areas. Data on unsexed downy young were used as a base. A summary of means and ranges of specimens from all regions is presented in Table III which shows clearly the pattern of size in relation to age. In addition 9 unsexed downy juveniles had the smallest spurs (up to 1 mm.). Because the great variation in the breeding season

tends to obscure patterns, data for Argentine and Chilean males only are plotted in Figure 1.

Growth of the spur starts as a rounded burr which is broader than long. Presumably, growth of horny material initiates at the base (Rand 1954) so that growth must be a continuous process that moves tissue upward to form a point when the spur length equals its width. Spur size increases to 2.8 mm. (both sexes combined) when the juvenile is full-winged. Thereafter rate of growth differs by sex and when they are in nearly full first nuptial plumage males average 5.8 mm., females only 3.7 mm. From the chronology of nesting in the southern race, many birds still recognizable as sub-adults are present during June and a few are recognizable in October and November (Figure 1). Thus, it appears that the age of acquisition of the complete first nuptial plumage is approximately nine months to one year and that spur length of males at that time is less than 6.5 mm. in the southern race (Figure 1). Spurs of all such immatures are rounded or have a blunt tip. (Plate III *a* and *b*, facing page 44.)

Spurs of adults develop an enlargement at the base so that a constriction is apparent near the point of attachment to the wing (compare Plate III *b* with *c*). Males in full nuptial plumage have spurs

Table III. Spur length (mm.) of Torrent Ducks of various ages and all sub-species.

	Male			*Female*		
	No.	*Av.*	*Range*	*No.*	*Av.*	*Range*
Partial Juvenile	5	1.8	1.0-2.4	—	—	—
Flightless Juveniles	7	1.9	1.0-2.8	1	1.7	—
Juvenile	5	2.8	2.1-3.4	—	—	—
Immatures	6	3.8	3.2-3.8	2	3.2	3.0-3.4
Sub-Adult	10	5.8	4.5-7.0	7	3.7	3.1-4.1
Adults	84	10.5	4.1-16.5	55	6.1	2.7-12.8

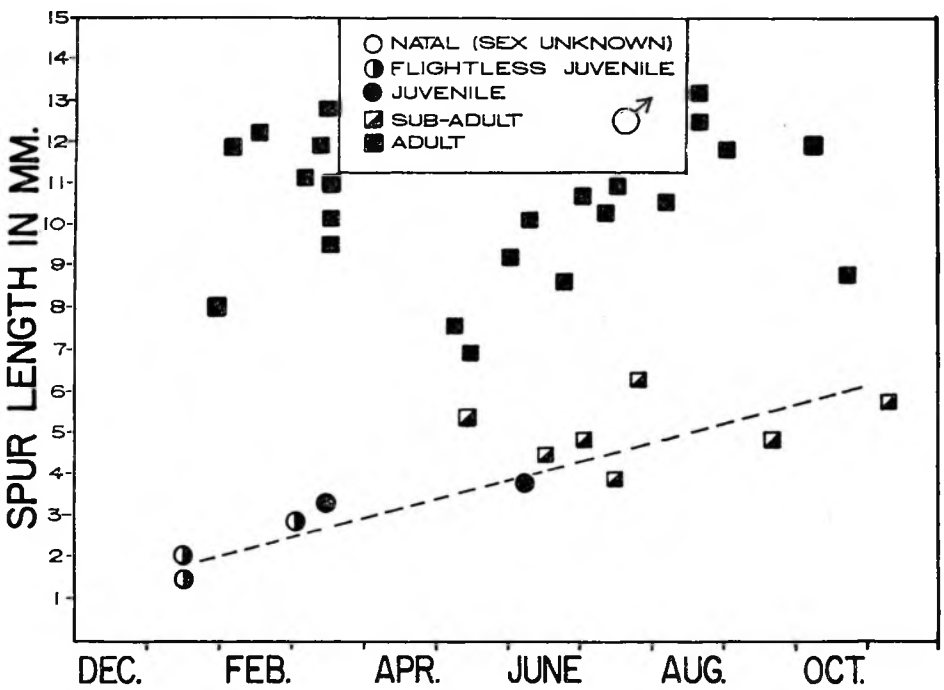

Figure 1. Spur lengths of males of Argentine and Chilean specimens plotted by age and time.

which tend to fall into one of the following classes: short and blunt, intermediate and pointed, or long and sharp (Plate III *a*, *b* and *c*). Long spurs often are extremely sharp, occasionally are curved and may bear a translucent tip (*c* and *d*). Although the colour of horny material varies with the conditions at the time of preservation, blunt spurs are dominantly yellow, the longer spurs horn-brown or nearly black with a yellowish tip.

A frequency distribution (Figure 2) of spur length of males in full nuptial plumage shows a small peak at six to seven millimetres which may represent yearling males. The fact that some males in adult plumage have spurs no larger than birds still recognizable by their plumage as sub-adults, further suggests that males with spurs of less than 8 mm. may be considered yearlings. The relative bluntness of the spur seems to be an even more reliable character. Blunt spurs, or spurs that are pointed but are as short as they are wide, are probably those of yearlings. Spurs which are longer than they are wide, with a well-developed point, presumably represent older males. Spur length probably increases with age but individual variation cannot be ignored.

Adult females have shorter spurs with less variation in shape. These also can be grouped into categories, but there are many that are intermediate in length and which cannot be aged with certainty. A frequency distribution of their lengths shows no obvious breaks (Figure 2).

A further check on the use of the spurs as an age criterion was made by comparing the age assessed from wing coverts with that derived from the spurs. Of 35 adult males checked, there was 89% agreement between age classification by spurs and by wings, and agreement for 15 young males was 93%. However, there was only a 62% agreement for 21 adult females. Only four young females were available and only one showed agreement. Problems of agreement in the adult males were about equally divided between interpretation of the spur length and of the wing characters. In females, wing characters were the most variable.

No specimens were found without spurs, indicating that they are not shed.

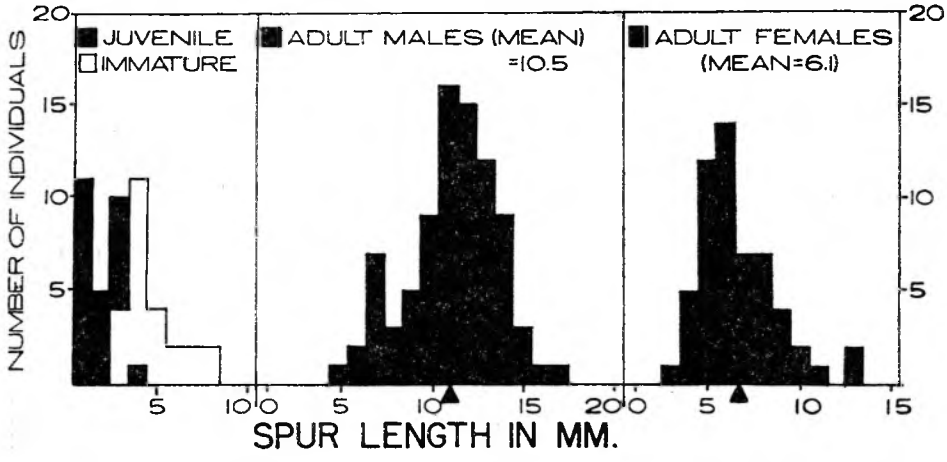

Figure 2. Frequency distribution of spur lengths of juveniles, immatures and birds of both sizes in adult plumage.

Only one had been damaged in some way and this may have been by a shotgun pellet. The function of these spurs is still unknown, but they show no wear. Occasionally, there are irregular rings near the base or in the middle (Plate III *d*) but they show no pattern suggesting annular growth rings.

To determine whether some internal characteristic of the spur might aid in determination of age (as do annuli of fish scales or bones), spurs of three sizes were sectioned by grinding. I am indebted to Drs. Rand and Blake of the Field Museum for permitting the sectioning of spurs from three specimens in their charge. Three males were examined: a clear-cut sub-adult (identifiable by some white juvenile feathers on the abdomen) which possessed a short, blunt spur (F. M. 208109), an adult with a sharply pointed, black spur (F. M. 208112); and a male with the longest spur recorded (F. M. 15682).

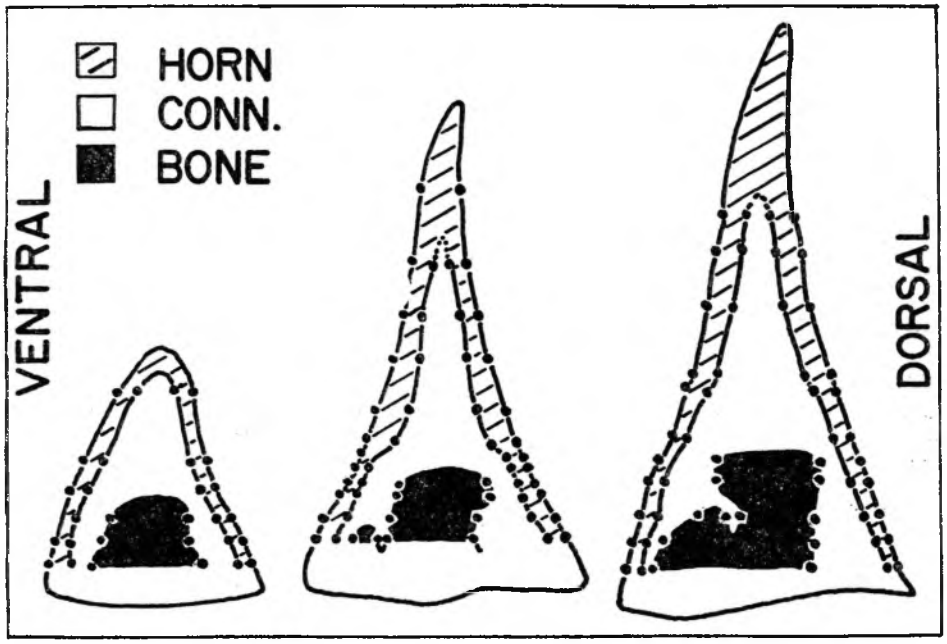

Figure 3. Spur size, shape and internal structure of a sub-adult male (Field Mus. 208109) and two adult males (Field Mus. 208112 in centre; Field Mus. 15682 at right). Dots indicate points at which sections and measurements were made.

Cross-sections demonstrate that spurs have an outer horny layer, grey in adults, grey or yellow in sub-adults. The major portion of the spur consists of a clear yellow material (presumably connective tissue) which surrounds and grows above a small whitish central bony core (Plate III *e*). A narrow dark brown or black line separates the outer grey horn and the central yellow connective tissue.

Diagrams of these three spurs are shown in Figure 3. They show the small size of the true bony core which apparently increases very little in length with age. They also demonstrate that much of the growth of the spur is in the solid horny tip. Although several irregularities of the horn layer in older birds suggests new overlapping external layers, their pattern was not sufficiently distinctive to be used as an age criterion. Both adults examined did have a more complex bony core at the base of the spur, being bi-lobed in vertical cross-section (Figure 3) rather than a single spike and by being mushroom-shaped at the base rather than round. However, the significance of these differences cannot be appraised on the basis of this sample.

Acknowledgments

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Summary

A study of nearly 200 museum skins of Torrent Ducks has made possible some generalizations on plumages and biology of this species which will facilitate future field work. Torrent ducks are distinctly and permanently sexually dimorphic, lacking any seasonal change in colouration. Juveniles lack sexual dimorphism and are characterized by a white belly and heavily barred sides. There is no evidence of a well-defined first non-nuptial plumage and the first nuptial plumage seemingly is acquired by the time the bird is 9-12 months old. Adults apparently have one complete annual moult in late summer but a partial spring moult is probable.

Both sexes have prominent metacarpal spurs on their wings. These spurs increase in length, dark colouration and sharpness with age. However, most yearling males and some females can be distinguished from adults by their short, blunt, yellowish spurs.

Spurs are made up of a small and short bony core, a more extensive layer of yellow connective tissue, and a relatively thin outer layer of horn. No clear-cut growth rings are observable but the bony core, and probably the horn, increases in complexity with size.

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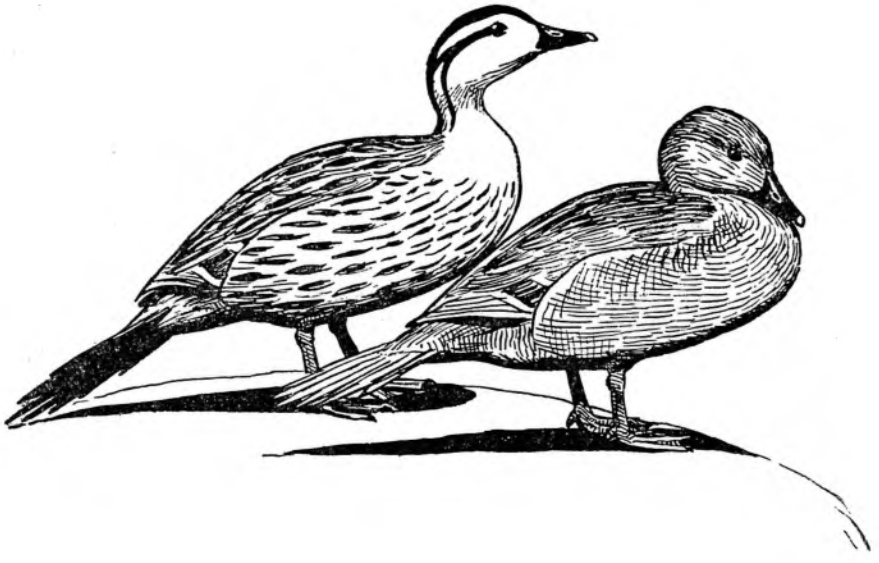


Pairing and breeding of Mute Swans

C. D. T. MINTON

Introduction

The Mute Swan is a species about which numerous legends abound, particularly regarding their faithfulness to their mates and their long life span. When improved swan rings were made available in 1960 the species became an obvious one to study and to test some of these popularly-held beliefs, because of the feasibility of marking and regularly recapturing a large proportion of the population. It was also an opportune time to carry out a study as there were widespread suggestions in the press and elsewhere that the Mute Swan was becoming too numerous and that control measures ought to be taken. Fact finding studies are a desirable preliminary to any control, both in enabling the most effective means to be prescribed and also in preventing or delaying the implementation of actions based on over-hasty decisions. Very little previous work had been carried out on the Mute Swan in Britain, it having been considered too uninteresting a species to ring.

Accordingly the present spare time study was started when the author went to live in south Staffordshire in October, 1960. The principal objects of the study were to examine in detail (a) pairing and breeding; (b) non-breeding herds; (c) moulting; (d) the complete life cycle. The study is still in progress and will continue for several years yet. However, sufficient data have now been accumulated on pairing and breeding for firm conclusions to be drawn on many aspects of the Mute Swan's behaviour. This paper is based on work carried out in the years 1961-67.

Study area

The study area was roughly centred on the author's home at Shenstone, near Lichfield, Staffordshire, and was a rectangle extending 40 km. to the north and 36 km. to the east of National Grid co-ordinate SO.900900 (an area of 550 square miles). This was the maximum size of area which could be covered effectively while containing sufficient Mute Swans (approximately 100 pairs plus 300 birds in non-breeding herds at the start of the study) for the results to be significant. The majority of the area is in Staffordshire, but small parts of N. Warwickshire, N.E. Worcestershire and S.W. Derbyshire are also included. A large part of the area is open farmland traversed by the valleys of the Rivers Trent, Tame, Sow and Penk—the first two being heavily polluted by industrial waste from the west Midlands. These rivers are fed by several fresher and cleaner streams, notably the Mease and the Blyth, which in fact form a more suitable habitat for nesting swans. Canals are also extensive but are not an important habitat for Mute Swans because of pollution, lack of food

and disturbance. However, the most widespread habitat for Mute Swans in the study area is the large number of small pools, typically half to two acres in size, most of which are fringed with reedmace. Some of these pools have resulted from coal mining subsidence in the Cannock and Tamworth areas while many others are 'industrial flashes' in and around the south-western portion of the area, which takes in much of the heavily industrialised 'Black Country.' Gravel pits in the Tame and Trent valleys provide another useful habitat while there are a number of larger lakes of 5-15 acres scattered over the whole area—mainly in the grounds of large estates. The largest individual pieces of water are the Blithfield (800 acres), Cannock and Gailey reservoirs and the most concentrated area of suitable habitat is formed by the numerous subsidence pools of the Alvecote Pools Nature Reserve near Tamworth.

Several small towns—Burton-on-Trent, Tamworth, Stafford, Rugeley, Lichfield and Cannock—are scattered around the more rural parts of the study area and most of these act as centres for non-breeding herds on the rivers running through the towns or on nearby large areas of water. It is fortunate, though largely fortuitous, that there are no other non-breeding herds particularly close to the study area. This has meant that most of these relatively sedentary birds have stood a good chance of being ringed in the non-breeding herds before pairing for the first time. The nearest points to the study area where other non-breeding herds occur are at Leicester (23 miles E.), Nottingham (22 miles N.E.), Derby (8 miles N.E.), Stoke (10 miles N.), Shrewsbury (24 miles W.), Worcester (25 miles S.W.) and Stratford-on-Avon (20 miles S) —but only the last mentioned herd has been ringed (by J. A. Hardman) as extensively as those inside the study area.

Catching and marking

Most of the swans in the study area are rather wild and comparatively few could be enticed close enough with bread to be picked up by hand as they have been on the Thames and elsewhere in England. Most birds were therefore caught with a 'swan pole'—an aluminium shepherd's-crook attached to the end of a 12-14 ft. bamboo pole. Nesting birds were the easiest to catch because their aggressiveness tended to overcome their fear of man (and his swan pole). In particular if the female could be caught first the male would normally attack sufficiently strongly to enable him to be hooked also. Pairs which were not nesting (and the non-breeding herds) were caught after being gently herded, often with boats, into a confined space where they could be reached if they attempted to fly off. A team of ten people, or even twenty for the big flock round-ups, was needed for these operations. No permanent disturbance was caused to the birds by the ringing operations and no desertions of nesting birds resulted.

Most of the work on paired birds took place in March, April and May, when virtually every weekend was devoted to locating, catching and determining the breeding success of this section of the swan population. Family parties were located again in August and September to determine the number of young reared to fledging and to ring them. Regular round-ups of the non-breeding herds took place at various times of the year, including spring, to establish which birds were definitely not paired, and in late July to determine their moulting grounds.

Each spring a high proportion of the paired population of Mute Swans in the study area was caught (Table I).

Swans were ringed on the left leg with a conventional numbered metal B.T.O. ring. Spiral plastic colour rings were added to the right leg to indicate the age of the bird (if known) and the non-breeding herd(s) in which it was found. In addition a yellow plastic ring was added to the right leg of all paired birds and in 1966 to the left leg as well. In 1967 two yellow rings were used on the left leg.

Table I. Number of paired Mute Swans caught in each breeding season.

Year	*Pairs present*	*Both birds caught*	*One bird caught*	*% caught*
1961	92	71	13	*84*
1962	96	83	9	*91*
1963	88	79	5	*93*
1964	98	93	4	*97*
1965	110	99	8	*94*
1966	95	88	5	*95*
1967	81	72	5	*92*

No attempt was made to give birds individual colour codes, this being impracticable with the numbers handled over the period of study. However, a number of birds did collect unique colour combinations as a result of their travels from flock to flock. The use of colour rings in this way enabled limited data to be obtained (e.g. the age) from a bird which could not be caught, and also enabled interesting birds to be recognised and caught for checking of the ring number (e.g. a paired bird which had moved into a non-breeding herd).

The actual colour code (right leg) used was: hatched 1961 (white), 1962 (mauve), 1963 (two white), 1964 (light green), 1965 (black), 1966 (dark green), 1967 (brown); Burton-on-Trent flock (orange), Tamworth/Alvecote (light blue), Cannock Reservoir (dark blue), Stafford (red), Blithfield Reservoir (pink); paired (yellow), paired 1966 (yellow each leg), paired 1967 (yellow right/two yellow left).

The paired population

The number of pairs located each spring remained relatively constant during the seven years, averaging 94 and ranging from a low of 81 in 1967 to a high of 110 in 1965 (Table I). In the first two years up to ten pairs may have been missed, thereafter it is unlikely that more than two or three pairs a year were overlooked. The lower population in 1963 was the result of mortality in the severe winter (Ogilvie 1967). The high population in 1965 and the apparent subsequent decline in 1966 and 1967 is however less easily explained and is considered later in this paper.

Frequent visits were paid to each pair of swans throughout the spring—whether or not they had already been caught—in order to determine their nesting success. It became apparent in the first year of the study that a substantial number of pairs were not going to lay eggs. The percentage of the *paired* population which was non-breeding (Table II) was remarkably constant from year to year at about 30%. The high percentage (37%) of non-breeding pairs in 1963 reflects the preceding cold winter, which killed off many of the regular breeding birds, and the subsequent late spring which prevented others from coming into breeding condition in time to nest.

The low percentage (23%) of non-breeding pairs in 1967 was due to a low recruitment of young birds from the non-breeding flocks which had suffered an overall decrease, and to the oiling disaster at Burton-on-Trent in 1966 (see later). There were only two non-breeding pairs within a 10 km. radius of Burton in 1967 compared with eight in 1966 and six in 1965. The number of breeding pairs, which were unaffected by the oil, was similar in all three years.

The existence of non-breeding pairs had been noted before at the time of the 1955-56 and 1961 national censuses (Campbell 1960, Eltringham 1963) but in only a few areas was the non-breeding portion of the paired population as high as in the present study. However, this could be due to non-breeding pairs being overlooked rather than to a major variation from one area to another. Evidence to support this suggestion comes from the 1955 census in the Staffordshire study area which recorded only 6% of the pairs as non-breeding.

The behaviour of non-breeding pairs varies considerably from one pair to another. Some are very similar to breeding pairs in that they hold a defined territory on a stretch of water throughout the spring, driving off all intruding swans, and displaying regularly to each other. Many even build part nests. A few remain together on their territory throughout the year but most return to the non-breeding herds in June, prior to moulting. Other non-breeding pairs are much more loosely associated, often holding territories on one vacant water after another, sometimes two or three miles apart, and frequently only remaining paired for a part of the

Table II. Division of paired population between breeding and non-breeding pairs of Mute Swans.

Year	*Total pairs*	*Breeding pairs*	*Non-breeding pairs*	
			No.	*%*
1961	92	69	23	*25*
1962	96	66	30	*31*
1963	88	55	33	*37*
1964	98	72	26	*27*
1965	110	78	32	*29*
1966	95	68	27	*28*
1967	81	62	19	*23*

spring (as little as 3-4 weeks) before adjourning again to the non-breeding herds. Non-breeding pairs are not normally aggressive towards human intruders in the same way that nesting birds are and a non-breeding male will rarely attack even if its mate has been caught.

Most pairing originally takes place in the flocks. Pairs may even be observed displaying to each other within the non-breeding herds in the spring but only those pairs which have actually split away from the flock completely have been considered in this study. The roving and transient nature of many non-breeding pairs may account for many not being recorded in censuses based on one visit to each water or on an aerial survey. Thus the 20% of pairs holding territories, but without nests, recorded by Eltringham's 1961 aerial surveys is probably a mixture of failed breeders and non-breeding pairs still remaining together at the time of the census.

The density of pairs in the study area was approximately one pair for every 5½ sq. miles. Other published data refers mainly to the density of breeding pairs and in the Staffordshire study area the number of breeding pairs average 70 each year (omitting the exceptionally low figure of 55 pairs in 1963) giving a density of one breeding pair per 8 sq. miles. The 1955 census (Campbell 1960) gave an estimated average density of breeding pairs in England and Wales of approximately one pair per 16 sq. miles (estimated 3,500 nesting pairs in 58,000 sq. miles). Only in Middlesex (one per 3 sq. miles) and Dorset (one per 7 sq. miles) was a higher density than for the present study actually recorded. In Staffordshire as a whole the breeding pair density was recorded as one pair per 12 sq. miles and Campbell's estimate that about 25% of the nesting pairs were missed therefore seems to be near the truth as far as Staffordshire is concerned if allowance is made for the 'swanless' areas of the north Staffordshire moors.

Examination of the 1955 records for the present study area shows that 64 nesting pairs were recorded. These were mainly situated in or near the heavily populated areas or at waters regularly visited by bird watchers. There is a conspicuous absence of records from the remoter pools and areas of streams and rivers known to be used regularly by nesting pairs throughout the period 1961-66. Since these particular habitats have remained largely unchanged since 1955 it is likely that most of these were in fact occupied then. It is estimated therefore that the true breeding population of the study area in 1955 was around 85 pairs. This had declined to about 75 pairs in 1961, contrary to the national trend which indicated similar numbers of breeding pairs in both years. However, much of this decrease had probably taken place in the Black Country due to the disappearance of habitat by the filling in of industrial flashes and the draining or cleaning out of canals. In this part of the study area 15 nesting pairs were recorded in 1955 (probably an accurate figure for it is an area heavily populated by humans), compared with five in 1961 and only three in 1966. The total paired population in this region had dropped from 16 pairs in 1955 to 8 pairs in 1961 and 1966—the increase in the proportion of non-breeders being a further indication of the present unsuitability of the area for nesting.

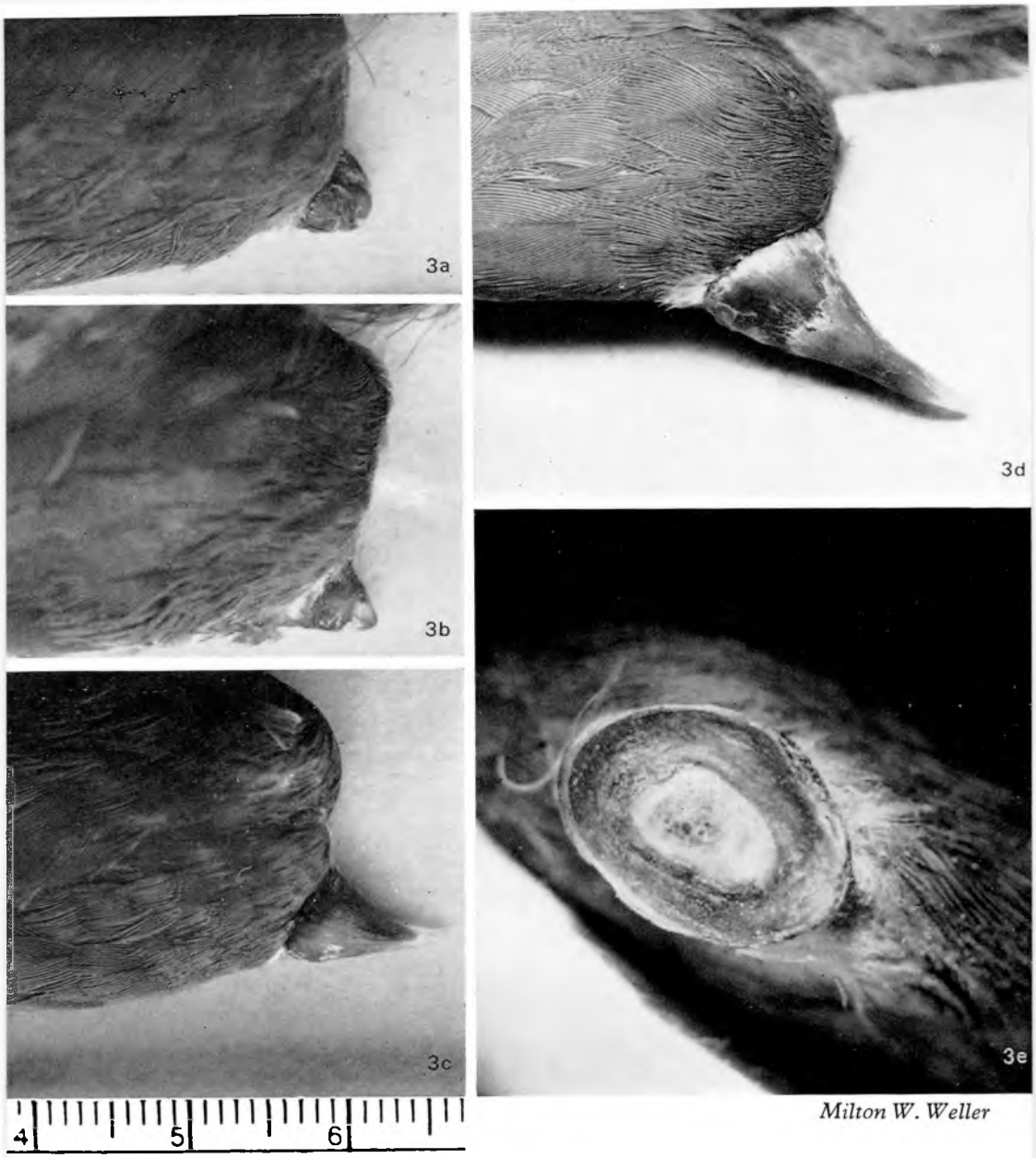
During the period 1961 to 1967 there has been a marked decrease in the population of the non-breeding flocks in the study area—from approximately 330 birds in April 1961, to around 140 birds in April 1966. The 33% decline from 1961 to 1966 is similar to that noted from much of the remainder of England and Wales over the same period (Ogilvie 1967). This makes the comparative constancy of the paired population—both breeding and non-breeding—all the more remarkable.

The sharp decrease in numbers in the non-breeding flocks between 1966 and 1967 was due to the oiling of the whole of the summer moulting population at Burton-on-Trent (the largest flock in the study area) which resulted in the death of between 80 and 90 birds.

The percentage of the population which is paired each spring has increased from around 40% in 1961 to nearer 57% in 1966, while the percentage of the population actually nesting has increased correspondingly from just under 30% to nearly 39%. The figure of 30% for 1961 agrees very closely with the figures given by Campbell and Eltringham for the 1955 and 1961 censuses; they found approximately twice as many non-breeding birds as breeding birds. The figure for the study area is probably a little lower than it really should be because its arbitrary boundaries contain rather more than its fair proportion of non-breeding flocks.

Age

The age of Mute Swans can only be determined with certainty until about August following the year of hatching and therefore there was no direct way of telling the age of the paired birds present at the start of the study. However, as the



Milton W. Weller

Plate III. Wing spurs of Torrent Ducks *Merganetta armata* from Argentina and Chile. (a) Juvenile male showing blunt point and wrinkled surface. (b) Yearling male taken in September in nearly full first nuptial plumage; spur point becoming evident. (c) Bird presumed from its wing to be an adult at least two years old. Note the elongated shape, acute and translucent tip (Scale in cm.). (d) Adult male showing overlapping layers of horn and translucent tip. This was the longest spur recorded (16.5 mm.). (e) Cross-section of a spur near the base showing the central bone, the yellow connective tissue, and the outer layer of horn. (See p. 33)

J. A. Middleton

Plate IV. (a) An adult African White-backed Duck *Thalassornis l. leuconotus*, the first species to lay in the Tropical House at Slimbridge.
(b) A drake Smew *Mergus albellus* 'bridling'.

J. A. Middleton

study has progressed an increasing proportion of the paired population has been of known age, having originally been ringed as pulli or as first-year birds. Thus it has been possible gradually to build up information on the ages at which Mute Swans pair and breed for the first time, and on the age structure of the breeding and non-breeding paired populations.

As such a high proportion of the paired population is caught each spring and as the non-breeding flocks are rounded up at this time of the year also, it has been possible to determine with fair certainty when birds have *paired* for the first time. Altogether 125 of these have been of known age (Table III). Nearly half were two years old and a further 30% were three years old; most swans can therefore be said to pair for the first time before they are four years old. A few even take mates when only one year old, while still in their brown-flecked immature plumage. (One year old birds are also frequently seen displaying in the spring within the non-breeding herds.) On the other hand, some birds do not take mates until they are five or six years old. Others have remained in the flocks for this period without ever pairing. This aspect will be covered in more detail in a subsequent paper dealing specifically with the non-breeding flocks.

The majority of birds have at least one non-breeding year paired before they commence nesting. Age plays an important part in the proportion (nearly a quarter) of birds which paired and bred for the first time in the same year. Only two out of 60 birds pairing first at one or two years old nested in the same year, compared with over half those paired for the first time at age four and over.

There are no major differences in these patterns between male and female birds. However, there is a slight tendency for female birds to be more precocious; four out of the five pairing at one year old and both birds which nested at the age of two were females. Males and females pairing for the first time at the age of three seem equally likely to breed in the same year.

The age of *breeding* for the first time is known for 60 Mute Swans (Table IV). Half nested and laid eggs for the first time at the age of three and a further third at the age of four—a pattern similar to that of first pairing but one year later. Most swans can therefore be said to commence nesting at the age of three or four. At these ages there was no difference between the sexes but only females have been known to nest at the age of two, whilst most of the birds not nesting for the first time until the age of five were males. This appears to confirm a slight tendency for females to mature earlier than males. These figures are very similar to those given by Perrins and Reynolds (1967) from their study of Mute Swans breeding around Oxford.

Birds ringed after their first year cannot be assigned to a definite age group, but only to *minimum age*. Ages of birds in 1961 and 1962 are omitted from Table IV as they would have incorrectly inflated the minimum age 2 and 3 years categories. The minimum ages still throw some light on the period which may elapse before nesting for the first time. It can be seen that a substantial percentage (12%) of swans live for five or more years before breeding. Four birds did not breed for the first time until at least six years old. There is again a tendency apparent for such old birds to be male

Table III. Age of Mute Swans at first pairing.

	Age and sex												
	1		2		3		4		5		6		*Total*
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
Breeders	—	—	—	2	9	7	6	5	3	1	—	1	34
Non-breeders	1	4	24	29	10	12	4	5	1	1	—	—	91
All paired birds	5		55		38		20		6		1		125

Table IV. Ages at which Mute Swans bred for the first time.

	2 years		*3 years*		*4 years*		*5 years*		*6 years*		*Total*
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
Actual age	—	2	14	12	11	10	7	2	1	1	60
Minimum age	17	29	21	20	19	9	8	3	2	2	130

and for more of the youngest age group to be female.

Although no one year old birds have been recorded nesting, two birds one and a half years old have been found with a mate and a brood of juveniles. The first was a male bird caught in early November paired to an unringed female, which continued to breed in the same area in subsequent years with a new mate. The male had not been seen since the previous December, when it was ringed as a first winter bird in a flock outside the study area, so nothing is known about its whereabouts during the intervening breeding season. The other bird under two years old with a family was found in early January and had been ringed as a one year old bird in a moulting herd the previous July. Its mate was not caught and its sex not determined. Although both parties of two adults and two juveniles were behaving exactly as a normal swan family, it seems most unlikely that either of the one and a half year old birds had been a parent of the young, since breeding even at the age of two is very rare. It is more likely that these young birds paired up with the adult of the family during the autumn, possibly replacing a mate which had died since the breeding season.

Age structure of the paired population

An accurate assessment of the age structure of the breeding paired population will be possible as more of the birds of unknown age drop out. An indication is however afforded by the situation in 1966 (Table V) when it was known that 70% of the birds were at least five years old, 50% at least six. In 1967 almost 60% were at least six years old and 37% were seven, but this may not be a typical age structure. Two females were then at least eleven and one male at least nine years old. At the other end of the scale, at most 15% of the population was under four years old in 1966.

In the case of 59 non-breeding pairs the situation in 1965 and in 1966 indicated that 25% of the birds were at least five years old, 16% at least six, and, conversly, that 61% were under four years.

Table V shows that there is a tendency for males and females in a breeding pair to be of similar age. But detailed examination of the data for 1963 to 1967 shows there is more likelihood of the male being older than the female, in 116 breeding and 58 non-breeding pairs, rather than *vice versa*, in 88 and 45 pairs. This again suggests an earlier maturing of the female.

There is a strong tendency for birds taking a mate for the first time in their

Table V. Age structure of breeding pairs of Mute Swans in 1966.

Age of female	*Age of male*											
	2+	3	3+	4	4+	5	5+	6	6+	7+	8+	All
2+	1											1
3	1	1			1							11
3+			1		1	1	2		3			
4			1	1								9
4+				1	3	1	1		1			
5			1	1	1				4	1		20
5+				1		2	1	1	3	3	1	
6			1					2				14
6+					1		1		7	1	1	
7+			1						4	6		11
8+												—
9+												—
10+								1	1			2
All	2		6		11		9		27	11	2	68

life to select a bird of similar status. For instance, in the years 1963-67 out of a total of 292 birds recorded as paired for the first time 218 (74%) were paired to birds which were also never known to have been paired before. This might be expected since much of the pair selection takes place within the non-breeding herds. These flocks are largely composed of birds which have not paired before, especially after those pairs which have come into the herd for the winter have departed in late January and early February to resume their territories. Birds paired for the first time with a previously paired bird are in most cases replacing lost (dead) mates.

Of all the swans thought to be paired for the first time 121 (41%) went on to nest in the same season. This is higher than the figure of 25% for birds of *known* age breeding in the first year, the difference probably being due to more older birds being of unknown age and to those pairs which had been missed in the earlier years of the study. Being mated to a bird which had previously been paired did not appear to have much effect on the chances of a newly paired bird settling down to nest. Thus the pairs which went on to breed included 35 (29%) with one experienced bird, while those 171 pairs that did not breed included 33 (23%). It is concluded therefore that sexual maturity, which is linked mainly with age, is the main criterion for determining whether a bird will breed on the first occasion it is paired.

The percentage of the total paired population which was composed of birds paired for the first time varied markedly from year to year in the period 1963-67 (Table VI). The high figure of 46% in 1963 was largely due to the high mortality during the severe weather in January and February 1963 leaving many vacancies in the paired population to be filled by new birds. The figures for 1964 and 1965, when around a third of the total paired population was paired for the first time, are probably a truer reflection of the normal figure. In 1966 and 1967 only 20% of the paired population was paired for the first time and this low figure seems to be mainly associated with an unusually low number of first time paired breeding birds.

The percentage of the breeding population composed of first time paired birds has fallen partly due to the increasing percentage of the existing breeding population which has survived (see later), itself due to the series of mild winters which have followed the severe winter of 1962-63. It could, in addition, be due to the comparative lack of birds three or more years old (the ages at which breeding in the first year paired is most likely to occur) in the non-breeding herds, due to the low number of young reared to fledging in 1963 (see later) and the heavy mortality in the 1962-63 winter of young reared in 1962 or before. However, a lack of such birds was not apparent in the 1965 non-breeding paired population as would have been expected if this explanation was correct.

The percentage of the non-breeding paired population which is paired for the first time has been relatively constant in the period 1963-67, and the level indicates clearly that a high proportion of non-breeding pairs contain at least one bird paired for the first time. Nevertheless the actual number of individuals involved in 1967 was significantly lower than in any previous year, again indicating a paucity of new blood available.

When birds paired at least a year previously and now breeding for the first time are added to those pairing and breeding for the first time in the same year, the overall percentage of new breeders in the paired population was 43%, 44%, 26%, 11% and 20% in 1963-67.

In the period 1963 to 1966, non-breeding pairs, for which the age or minimum age of both birds are known, included only 25 cases where *both* birds were aged four or more. This suggests that immaturity of one or both members of a pair is the main reason for non-breeding. In these

Table VI. Mute Swans paired for the first time showing the proportions they represent of the paired population.

	Breeding		*Non-breeding*		*All birds*	
	No.	%	No.	%	No.	%
1963	38	*35*	43	*65*	81	*46*
1964	34	*24*	32	*62*	66	*34*
1965	25	*16*	48	*75*	73	*33*
1966	8	*6*	30	*56*	38	*20*
1967	16	*16*	22	*58*	38	*24*

older pairs unsuitability of habitat—lack of food, no nesting site, human disturbance—is considered to have been the limiting factor in ten cases. Sometimes, despite deterioration of habitat since the previous breeding season, such as infilling of pools by tipping, the resident pair clung to the territory. The remaining 18 cases may have included birds maturing unusually late or newly-paired birds not settling down in time to nest. In one case the female was almost certainly infertile. But there remain six cases in which a pair that had previously bred together which did not breed in a subsequent year in spite of remaining together on an apparently unchanged territory and habitat. Three of these pairs subsequently resumed breeding together in the following year and another pair after a gap of two years. It is probable, therefore, that one or both of the birds in these six pairs did not come into breeding condition for some reason in the seasons in which breeding was missed.

One pair, of unknown age but said to have been present at the same park site for many years, reared young for the first time in 1961 after having their eggs stolen in all the previous years. They seemed so 'overjoyed' at having a family to rear that they made no attempt to drive off their young and no attempt to breed in 1962. The two young eventually stayed with their parents until the 1962 moulting period. Another pair kept their young of 1966 until the summer of 1967 and did not nest, though in this case they had reared young in the previous year. At another site two of a brood of five young reared in 1966 remained with their parents until at least the end of May 1967, but in this instance the adults were not inhibited from nesting at the same time. The same pair is usually the last to drive off its young from the previous year and in 1964, after rearing young for the first time in 1963 after failures in 1961 and 1962, this did result in egg laying taking place much later than in other established pairs.

Non-breeding pairs remaining together but not breeding for two consecutive years have been recorded on seven occasions when at least one of the pair has not been known to be more than three years old. Sexually immature three year old birds were probably the cause of non-breeding in four cases, unsuitable territories in two cases and infertility of what was probably an old female in the remaining case. Only one pair eventually survived together to a third season and this pair then bred successfully.

Mortality

The mortality rate of the paired population in the study area can be calculated each year from knowledge of the number of birds known to survive from one breeding season to the next. This method is possible because of the high percentage of the paired population which is caught each spring and the relatively sedentary nature of the species, particularly once paired. Since the non-breeding herds are regularly rounded up, those birds which are still alive but not paired in the subsequent season can also be detected.

The survival of paired birds from one year to the next (taken from 1st April to 31st March to coincide with the breeding year) is given in Table VII separately for breeding and non-breeding birds since there are significant differences in the age

Table VII. Mortality rate of paired Mute Swans.

Season (1st April to 31st March)	*Alive on 1st April of first year*	*Still alive on 31st March of next year*	*Dead by next 31st March*	*Missing after next 31st March*	*Minimum mortality rate*	*Maximum mortality rate*
Breeding birds					%	%
1961/62	122	100	4	18	*3*	*18*
1962/63	127	86	14	27	*11*	*32*
1963/64	107	79	10	18	*9*	*26*
1964/65	141	113	6	22	*4*	*20*
1965/66	153	129	5	19	*3*	*16*
1966/67	136	101	12	23	*9*	*26*
Non-breeding paired birds						
1961/62	33	17	5	11	*15*	*48*
1962/63	48	31	9	8	*19*	*35*
1963/64	56	39	6	11	*11*	*30*
1964/65	49	33	5	11	*10*	*33*
1965/66	54	29	11	14	*20*	*46*
1966/67	45	22	5	18	*11*	*51*

structure and habits of these two sections of the paired population which could lead to different mortality rates. The minimum mortality rate for each year is determined from the number of birds definitely known to have died, while the maximum mortality rate is determined by adding to this all birds never subsequently seen after 31st March of the year following. In practice some of these latter birds may have emigrated from the study area and may still be alive, while a few may have been living, uncaught, within the study area. However, the true mortality rate is probably close to the maximum rate.

For the paired breeding birds the usual maximum mortality rate would appear to be around 20%. Perrins and Reynolds (1967) give 18% for their breeding birds around Oxford. It was highest in 1962-63 due to the exceptionally severe weather that winter. The maximum mortality rate of paired non-breeding birds has a usual level around 35%. The high rate in 1961-62 might indicate that this segment of the population suffered more severely from the cold spell that winter than did the breeders. However, too much reliance should not be placed on figures in this first year of the study. The maximum and minimum rates in the non-breeders show a much lesser degree of association than they do in the breeders. It may be that the maximum rate for non-breeders is less reliable and more prone to influence by birds moving out of the area owing to a lesser attachment to a particular territory.

The combined data for breeding and non-breeding pairs in Table VII gave maximum mortality rates of 24%, 33%, 28%, 23%, 24% and 32% in the six seasons. The true mortality of the paired segment of the population is thus around 25%. This is of course remarkably high for a bird as large as a Mute Swan which has so few natural enemies. Ogilvie (1967), considering the complete swan population over one year of age, deduced a mortality rate of 38%. However, his data are based largely on recoveries of birds ringed in non-breeding flocks most of which are not more than three years old. Although experience may help older Mute Swans to avoid flying into objects (the major cause of death) another reason for the different mortality rates is probably the *amount* of flying done by the different sections of the population. Breeding paired birds fly comparatively little in the months March to September. Non-breeding paired birds, on the other hand, tend to move around more in the breeding season and then often join the non-breeding flocks from June onwards. Birds from the non-breeding herds fly around a lot at all times of the year, except in the July-August moulting season. Thus although younger less experienced swans are likely to have rather more fatal accidents per mile flown, a further cause of the differential mortality rates in different section of the population is the relative number of miles flown per year by the different groups.

Although Mute Swans are probably able, potentially, to live to a considerable age, their chances of surviving for many years the hazards of the obstacles set around the countryside by man are small. Only those pairs with territories in relatively artificial surroundings where flying is rarely possible are likely to achieve their full life span.

It seems as if the wheel has now gone full circle. After causing a major increase in the swan population by providing food to sustain large non-breeding flocks in areas where little natural food exists (particularly in the winter), man has now tipped the scales the other way by placing an ever increasing number of obstacles such as electricity wires (so frequently sited in river valleys) in the way of flying birds.

In Table VIII the breeding pairs are sub-divided on the score whether they were successful or unsuccessful in rearing

Table VIII. Mortality rate of successful and unsuccessful breeding Mute Swans.

	Successful breeders			*Unsuccessful breeders*		
Season	*Alive on 1st April of first year*	*Dead or missing by 31st March next year*	*Maximum mortality rate (%)*	*Alive on 1st April of first year*	*Dead or missing by 31st March next year*	*Maximum mortality rate (%)*
1961/62	48	7	*15*	49	12	*25*
1962/63	76	24	*32*	50	17	*34*
1963/64	64	11	*17*	43	17	*40*
1964/65	84	12	*14*	57	16	*28*
1965/66	97	17	*18*	56	7	*13*
1966/67	68	10	*15*	68	25	*37*

young during the years in question. In four of the years the successful breeders have a markedly lower maximum mortality rate than the unsuccessful breeders. Their advantage appears to be absent when the winters are exceptionally severe (1962-63) or mild (1965-66). The generally different levels may be related to a difference in the amount of flying normally done by the two groups. Failed breeders tend to behave more like non-breeding paired birds, joining the herds and moving around from place to place.

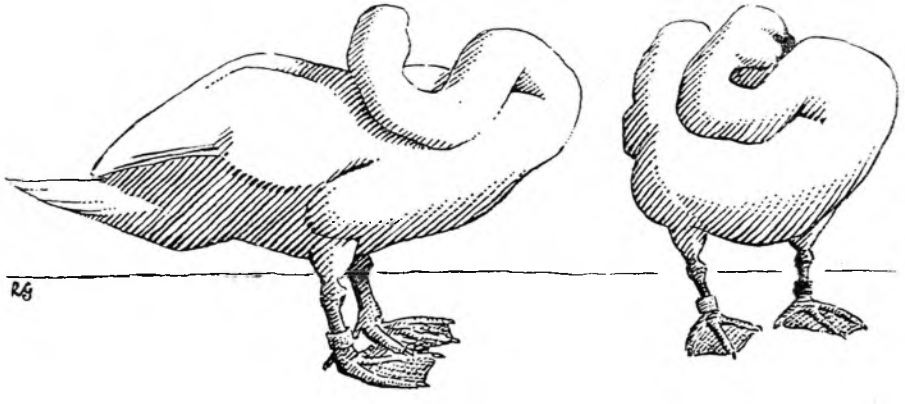
A useful piece of information deriving from this method of assessing mortality rates is an indication of the percentage of dead birds that is found and reported. Of 296 paired birds which disappeared from the study area 92 were reported dead, close on one-third. In areas less intensively combed by ringers or less densely populated by man the proportion is probably rather less.

The stability of pair bonds

If we wish to consider the strength of the pair bond, the tendency of birds to remain paired from one year to the next, we must obviously eliminate from consideration birds which were dead or missing by the following year. This is the more so as we have already seen (Table VII) that there is a difference in mortality according to whether paired birds are breeding or non-breeding. In Table IX the marital status of paired swans in the following year is set out. Of the birds that were paired and breeding in one year and alive in the next, about 85% were still paired together. The severe winter of 1962-63 obviously had a disruptive effect on the pairings of survivors, only half of the 1962 birds remaining paired together in 1963. Furthermore, a fifth of the survivors had not found new mates, probably because they lacked the time or were in no condition to take a new mate that season.

Table IX. Marital status of Mute Swans in following years.

Year	*Alive*	*Dead or missing*	*Status in following year*			
			Same mate		*New mate*	*Not paired*
			No.	%	%	%
Breeding						
1961	100	22	84	*84*	*5*	*11*
1962	86	41	46	*54*	*24*	*22*
1963	79	28	68	*86*	*6*	*8*
1964	113	28	98	*87*	*7*	*6*
1965	129	24	108	*84*	*12*	*4*
1966	101	35	88	*87*	*11*	*2*
Non-breeding						
1961	17	16	14	*82*	*6*	*12*
1962	31	17	10	*34*	*33*	*33*
1963	39	17	18	*46*	*37*	*17*
1964	33	16	26	*79*	*6*	*15*
1965	29	25	12	*41*	*31*	*28*
1966	22	23	12	*55*	*32*	*13*



The stability of the pair-bond of non-breeding paired birds was likewise adversely affected by the cold weather of 1962-63. The high figure in 1961 was probably spurious, associated with the first year of the study, but that in 1964 was genuine, though unexplained, and contributed to the unusually high paired population in 1965. It would certainly seem that the pair bond is more likely to be disrupted before breeding has taken place. However, several pairs in which both birds were young and paired for the first time have been known to spend one spring together without breeding, subsequently adjourned to the flocks and then re-paired the following spring. It seems therefore that they were able to retain the ability and desire to take the same mate again even though the pair bond appeared severed.

No significant difference in pair bond strength is shown between successful and unsuccessful breeders. Of birds surviving to the following years 82% of the former and 78% of the latter remained paired together.

The combined effect of mortality and divorce results in a continual fall in the number of pairs which remain intact over a period of years (Table X). There is no indication that the year to year survival rate changes the longer a pair remains together. Out of 71 pairs in which both birds were known in 1961, only three (4%) were intact in 1967. The magnitude of this decrease is in part due to the occurrence of an exceptionally severe winter during this period but even without this only 16% of pairs would have remained intact.

Those swans which survive as paired birds for several years are likely to have a number of different mates during their lifetime. During the seven years of the study, 22 birds, 14 males and 8 females have been known to have had at least three different mates. Three birds have even had four different mates. Nine birds had different mates in three consecutive years.

An example of how varied the breeding career of a swan can be is shown by the following example of a male bird:

1961	mate A, nested, success not known.
1962	mate A, nested, reared four young.
1963	alone on territory.
1964	mate B, did not nest.
1965	mate C, did not nest.
1966	mate D, did not nest.
1967 (March)	alone on territory.
1967 (May)	found dead.

The bird was on the same territory each year except in 1964, when it was on another stretch of canal two miles away and its original territory was occupied by another pair.

It has already been noted (Table IX) that some birds paired and breeding in one year have been alive in the following year but not known to be paired. Of 34 such males, 14 were found alone on the territory, but only 2 out of 16 such females. In the case of non-breeding pairs only 3 out of 18 males and none of 17 females were on the territory. Thus breeding males alone seem to have a strong tendency to remain in the original territory. The others probably return to the herds, where, in fact, 2, 3, 4 and 7 of the four categories were recaptured. Breeding males are thus less likely to meet up with an unpaired female and the chances of re-mating are further reduced by the aggressive reaction of even an unpaired male swan to intruders on its territory. One male swan, of a pair which had bred together for five years (the last four successfully), showed a remarkable attachment to its nesting territory. After its mate was shot in early March 1967 it built a complete nest on the usual site and incubated the empty structure for six weeks, a sad sight. However, in spite of the fact that many bereaved swans do return to an environment where they should be able to find a replacement mate quite easily, some seem to remain in the herds without re-pairing for one

Table X. Survival of pairs in the Mute Swan over a period of years.

		Pairs remaining intact until:											
		1962		*1963*		*1964*		*1965*		*1966*		*1967*	
Year	*Known pairings*	*No. of pairs*	*% intact*	*No. of pairs*	*% intact*	*No. of pairs*	*% intact*	*No. of pairs*	*% intact*	*No. of pairs*	*% intact*	*No. of pairs*	*% intact*
1961	71	49	*69*	18	*37*	13	*72*	8	*61*	6	*75*	3	*50*
1962	83	—		28	*34*	22	*79*	12	*55*	10	*83*	6	*60*
1963	79	—		—		43	*54*	31	*72*	22	*71*	13	*59*
1964	93	—		—		—		62	*67*	42	*68*	29	*67*
1965	99	—		—		—		—		60	*61*	37	*62*
1966	88	—		—		—		—		—		50	*57*

or more years. Thus there is some evidence to support the legend that a swan losing its mate will not take another.

Many individuals which fail to take a mate in the season following one in which they have been paired will eventually pair again in a later year. This is true both of birds which remain alone on their territory and those which move into the herds. However, there is sometimes a gap of two or three years before re-pairing occurs and in a few cases individuals appear to have given up pairing for good. For instance, a male bird which had probably bred for several years on the same territory with the same female divorced its mate after the 1962 season. It remained alone on its territory in 1963, 1964 and 1965 and had still not been known to pair again when it was reported dead in early 1967.

Another swan, a female, took a mate for the first time in 1965 when it was at least six years old. It did not breed and its mate was subsequently killed. It then rejoined the flock and had still not taken a mate again when it was last seen in April, 1967.

Birds which have bred and then taken a new mate show a strong tendency to return to their original territory. This holds for males (19 out of 25 cases) and for females (29 out of 40). Birds which had not bred although paired showed a less strong attachment to their territory when taking new mates. About half were found on new sites (10 of 26 males and 9 of 17 females).

Divorce and change of mates

The usual reason for a change of mate was the death or disappearance of the old mate. Cases of true divorce, when both the original partners are known to be alive, account for some of the changes. Among paired non-breeding birds divorce was noted in 11 out of 44 cases of mate-change (25%), whereas it occurred in only 9 out of 65 cases (14%) of changes in breeding pairs.

These figures refer only to divorces where one or both of the divorced birds took a new mate in the following breeding season. Quite a number of pairs also broke up without either bird taking a new mate, at least in the following year. The total number of true divorces among birds which were paired in the years 1961 to 1966 was 52, i.e. in 26 pairs both birds were alive the following breeding season but were not paired together. Half of these were breeding pairs (representing a divorce rate of 3%) and half were non-breeding pairs (a rate of 9%). Just under a third of both groups had taken a new mate by the following year. The disruptive effect of the severe winter of 1962-63 has probably inflated the divorce rate figures, for 22 of the divorces occurred in that season including 16 of the 26 divorces of breeding birds. In three years only two birds divorced and twelve birds divorced in each of two other years.

Some divorce histories are quite complicated, as when mates are exchanged between pairs on adjacent territories. In one case the respective pairs occupied adjacent territories on a group of small rushy pools and an adjoining stretch of canal. Territorial fighting regularly took place and it was presumably in one of these battles that the exchange of mates took place. The males occupied the same territories each year and it was the females which changed in 1963 and changed back again in 1964. All the birds involved had a history of nest failures or non-breeding and the divorces may have partly accounted for neither pair breeding in 1963 and only one of the pairs in 1964.

The circumstances of the exchange of mates between another two breeding pairs between the 1965 and 1966 breeding seasons could not be more different. Both pairs had successfully bred in 1964 and in 1965. They occupied adjoining stretches of an attractive 20 ft. wide stream. Each had a territory one to two miles long and the nest site was usually about two miles apart. On 20th March 1966, one pair was caught, still together, on its usual territory but there was no sign of a pair on the other territory. Returning to the latter territory on 22nd May 1966, the expected female bird was located on a nest at the usual site but the accompanying male bird was the one from the other territory. On revisiting the territory checked in March the usual female was present on a nest, with the male bird from the other territory in attendance. Thus after two successful breeding seasons together the pairs had both divorced and, surprisingly, it was the male birds which had changed territories. Presumably the interchange took place during a border dispute. Both of the new paired combinations successfully reared young and both pairs remained together in the 1967 season also.

A male bird of a pair which had nested successfully together for at least two years had its mate taken by a new male the following year. It remained alone on its territory and then re-paired again to its original mate after the lapse of a year. 'Come home, all is forgiven' may have been its motto.

The divorce percentages given above rather underestimate the frequency of divorces in Mute Swans as they only refer to divorces from one breeding season to the next. A number of mate changes within the same season have been recorded. For instance, two birds caught paired together (both paired for the first time) on 17th March were both found with new mates on 28th April. The male was on the same territory with a new mate and this pair did not breed. The female was on a nest on a new territory about a mile away. Both of the new birds were also paired for the first time. These new pairings remained intact until both of one pair were killed two years later and one of the other pair was killed after four years.

Another bird which divorced its mate in mid-season was one of a pair originally caught on 11th February. The female was found with a new mate on 8th April but although they remained together all summer they did not breed. This pair then also split up and each bird took a new mate the following year—the female therefore having had two divorces in the space of a season. The original divorced male also took a new mate the following year.

Other mate changes within the same breeding season were not necessarily attributable to divorces. For instance, a female was caught on 13th March still paired to the same mate as the previous year, but was recaptured on 20th May at a different site with a new mate. Since the original mate has not been seen again, it was probably dead. A very rapid replacement occurred one year when a male was killed by flying into wires on 6th April just as it was at the nest building stage with its mate from the preceding year. The bereaved female disappeared almost immediately but had returned by 20th April with a new mate. Although this new pair completed the nest they did not actually breed until the following year. Similarly a male whose mate was shot at the end of March had obtained a new mate by the end of April. Yet they did not breed that season although both were four years old and the female had bred the previous year.

A number of instances of birds, paired in the spring with one mate, being caught with a new mate in the following autumn or winter, have been recorded. In most cases the pairs involved had been non-breeding or failed breeders. For example the male bird of a non-breeding pair had divorced the female and taken a new mate by the following November. Similarly, the female of an unsuccessful breeding pair had a new mate by the following December, having divorced its previous mate. In a third pair, also failed breeders, the fate of the male bird was not known but the female bird was with a new mate by December. All three of these pairs cited remained together and bred in the following season while neither of the birds left without a mate by the divorces took a mate the following year.

Two possible instances of changes during the year in successful breeding pairs, involving new mates less than two years old, were mentioned earlier. In another, definite, case the male of a pair nesting together in April was found with a new mate and a brood of two juveniles at the same place in December. The original female was not seen again and was presumably dead. The new female remained at the same site the following year but with a new male bird—the original one having also disappeared, presumed dead.

The other instance was actually witnessed. The male bird of a pair which had nested together for at least two years was driven off by an unpaired intruding male from its mate and brood of 4 two month old unfledged young. The female took no part in the battle and after it was over sailed off down the stream with the new mate and the rest of the family as if nothing had happened. This female was not seen the following year and was therefore probably dead. Neither male was then paired but the original male had returned to his old territory.

Another unusual incident which was witnessed occurred in September when three adults were found displaying to one another. Two of these were an established pair—the performance took place in the presence of their offspring—and the third was a previously unpaired male bird. It is not clear why such an intrusion on their territory was tolerated by the pair but their bond survived the incident and they remained together in the following season. The other male bird found a mate the following year also.

These autumnal changes of mate suggest that there is then a resurgence of pairing activity in the Mute Swan. Pairs have been observed at this time of the year without the yellow colour rings denoting a previously paired bird. Furthermore, pairs have later been found in which both birds were known to have been present in the same moulting flock the previous summer and it is possible that these paired in the flock and left together in the autumn. The extent and

role of autumn pairing will be studied further in the future.

This section on odd pairings may perhaps be concluded by two examples of the pairing of closely related birds—though neither pair actually bred. In one case a one year old male bird remained with its mother for the whole of its first spring, after its father had died and the rest of the brood had dispersed. Mother and son displayed to each other and held a territory just like a normal pair and the partnership did not dissolve until the July moulting season.

The other instance involved a female bird found paired in October to one of its two-and-a-half year old offspring. They were attempting to drive off the pair of swans which had taken, during the previous spring, the territory which had belonged to the parents of the male in the two preceding years. After losing their territory the original pair had split up; the male remained unpaired and the female was not seen until this occasion in the autumn, so it is possible that it had even been paired to its two year old youngster in the spring also. The female was not seen again after October and the young male took a new mate the following year, eventually carrying on to breed on the territory where it had originally been reared.

Movements

Mute Swans move around a fair amount from flock to flock before they eventually take a mate and hold a territory. These movements will be described in a future paper. This section deals only with movements subsequent to the taking of a territory for the first time—changes of territory—and movements of paired birds outside the breeding season.

Once a Mute Swan has established a territory it tends to return there in subsequent breeding seasons even though it may have been away for several months since the end of the previous breeding season. The affinity is strongest in breeding birds, particularly those which have nested successfully. Only three out of the sixteen birds which changed territories by more than five miles had previously bred, and it may be significant that two of these birds had had their previous mates shot. Most of the birds which moved far had lost (or in two cases divorced) their previous mates and only two complete pairs changed territories by more than five miles. The greatest shift in territory was 17 miles. Only 2% of the total surviving paired population moved its territory more than five miles from the previous year.

One bird changed its territory by more than five miles three times, although one of these related to pairing in the autumn:

May 1961	nested unsuccessfully.
Jan. 1962	13m. NNW, in flock.
Feb. and Mar. 1962	14m. SE, in flock
Sept. 1962	6m. N, pair, new mate.
Jan. 1963	6m. S, in flock.
May 1963	3m. E, paired, new mate, nested successfully.
1964 and 1965	same territory and mate, nested successfully.
1966	not seen again — presumed dead.

Many pairs or individuals have been recorded changing their territory by distances less than five miles. Although in some cases this is the result of territorial fights, in other cases there was no obvious reason. For instance, one pair after nesting for three years at one site (the last time successfully) moved to a new site four miles away (never previously occupied by a pair of swans), leaving their old site vacant. In spite of nesting successfully again they returned to their old site for the following two seasons, both times being unsuccessful.

One female swan has had a remarkably eventful breeding career, occupying three territories and having four mates in six breeding seasons:

April 1961	in flock, 1st winter (i.e., age 1).
May 1962	8m. S, paired, did not nest.
May 1963	same territory and mate, nested unsuccessfully.
April 1964	5m. SW, new territory and mate, nested unsuccessfully.
April 1965	same territory and mate, nested successfully.
May 1966	4m. NE, new territory and mate, nested unsuccessfully.
Feb. 1967	4m. SW, alone on 1964–65 territory.
March 1967	4m. NE, same territory, new mate.
26 Mar. 1967	shot.

The most frequent movement of paired swans is from their territory into one of the non-breeding herds, usually the nearest. Such movements of non-breeding pairs or failed breeders take place extensively in June, prior to moulting in July. This results in up to a third of some moulting herds being birds which paired

in the spring. Successful breeding pairs and others which have stayed on their territory to moult often move into the herds during October to February, especially during hard weather when their territories become frozen over. Although pairs appear to merge completely into the flocks and the pair bond appears to have broken down, they nevertheless usually emerge paired again in late winter. Birds losing a mate travel to a herd and are frequently found back on their territory, paired with a bird from the herd they were known to have visited.

Movements are usually of less than ten miles and only about twenty paired birds, representing about 5% of around 450 individuals known to have been paired in the period 1961-67, moved further than this from their territory. However, some pairs have travelled together up to twenty miles and then returned to their orignal territories. Other individuals have travelled further. A non-breeding paired bird which held a territory in the spring was recovered dead 47 miles away in September of the same year; a failed breeder was reported 28 miles away the following February. There thus appears to be a tendency for non-breeding paired birds or failed breeders to move around over greater distances than successful breeders.

Many paired birds are recaptured annually in the non-breeding herds to which they have gone to moult or for the winter, thus indicating the regularity of such movements. One female showed an interesting series of movements before pairing, a strong attachment to a particular moulting ground, and a considerable wandering between breeding seasons:

Dec. 1963	1st winter, in flock at Burton-on-Trent.
Jan. 1964	ditto.
March 1964	in flock at Tamworth 11 miles SSW.
June/July 1964	in flock at Stratford-on-Avon 30 miles S.
July 1964	moulting in flock at Cannock 35 miles NNW.
July 1965	moulting in flock at Cannock.
May 1966	paired, nested, hatched three young, Handsworth 11 miles S.
July 1966	moulting in flock at Cannock 11 miles N.
Oct./Nov. 1966	alone at Handsworth 11 miles S.
Jan. 1967	alone at Solihull 8 miles SE.
March 1967	in flock at Stratford-on-Avon 15 miles S.
May 1967	paired, new mate, did not nest, Great Barr 30 miles NNW.
Feb. 1968	paired, same mate, Great Barr.

So strong was her preference for the Cannock moulting ground that in 1966 she deserted her 3 two month old young and left them to rear themselves, which they did successfully. The male bird had been killed in April before the young had hatched.

Breeding success

All the pairs of Mute Swans which nested in the study area were visited at regular intervals throughout the spring and summer to determine their hatching and rearing success and to find the causes of failures. In the earlier years of the study the number of eggs laid and the number of young hatched were not recorded because most of the available time was taken up in locating and catching pairs. However, these data are now being collected and will be reported later in a separate paper.

The percentage of nesting pairs which eventually hatched young has been fairly constant at around 58% over the five breeding seasons 1962 to 1966 (Table XI). It was probably also at a similar level in 1961, when 14 additional nests were not followed to completion, since most of the unsuccessful nests were recorded while it was those which had been sitting for a long period which were omitted. This

Table XI. Hatching success of breeding pairs of Mute Swans.

Year	*Breeding pairs*	*Hatching*		*% of nesting pairs hatching successfully*
		successful	*unsuccessful*	
1961	55	30	25	54
1962	66	39	27	59
1963	55	33	22	60
1964	72	42	30	58
1965	78	52	26	67
1966	68	37	31	54
1967	62	31	31	50

percentage figure includes those pairs which were successful at the second attempt.

Pairs which have lost their first clutch of eggs have been recorded re-laying in all years. It is possible that a few repeat clutches may have been missed in the earlier years. Of 22 pairs which failed in their first nest, 12 (55%) hatched their repeat clutches successfully.

One pair in 1966 had already completed its second clutch by the end of April. Re-laying does not normally take place after early June. However, one pair just outside the study area laid three times one year and still had a single half grown young in mid-December. Another pair laid a repeat clutch in each of the four year it lost its first, but in only one of these years was the repeat successful.

In the study area nearly 80% of nesting failures is due to predation by humans —mainly boys stealing or breaking the eggs (Table XII). Vandalism is particularly marked in the urban areas and while most accessible nests are robbed, those which cannot be reached are bombarded with sticks, bottles, bricks and stones until the eggs are smashed or the parents desert. Some of the failures due to injury or death of one or both of the adults (7% of the causes) are also the result of human persecution. Fortunately if one adult is killed after the eggs have been laid the other adult will often carry on alone and may successfully rear a brood. This is particularly true of females. Breeding birds most frequently meet their death by flying into wires. However, one bird was found dead on the nest apparently eggbound (it had laid a half size egg the previous year), another choked to death on a potato and a third was killed on the nest by a fox. Signs of the immense struggle which had taken place could be traced from the nest, with its scattered eggs, to a point nearly 50 yards away. Groups of feathers showed where the fox had put the dead swan down for a rest on the way back to its den in the woods. It had, however, been unable to lift the bird up a wall at the edge of the field and the body was found there, almost completely eaten. The upper mandible had been bitten off half way along, this presumably being the first hold the fox got on the swan and the one used to drag it away from the nest.

Flooding also causes some nesting failures (8%), particularly of those pairs nesting by streams and rivers. Desertions are rare and in only one case was the cause known. This was when an intruding pair of swans (failed breeders) drove the pair from their nest and territory.

The higher than average percentage of nesting pairs which hatched young in 1965 (67%) was probably due to the relatively inclement weather which kept predatory humans indoors and because the incubation period of most of the pairs was fortunately timed between the Easter and Whitsun bank holidays— peak periods of human predatory activity. In all other years either Easter or Whitsun has tended to coincide with the period when many pairs had eggs. In 1966 the lower than average success rate (54%) was due to the greater opportunities for human predation provided by the very extended breeding season—some birds had full clutches by mid-March, while others were delayed by subsequent cold weather from laying until late April or early May. Losses due to flooding were higher than in any previous year and severe April frosts were thought to be the cause of two clutches failing to hatch—one after being incubated for three months. The very low success rate in 1967 was also due to a combination of a late and extended season and exceptional floods at the end of May.

Table XII. Causes of failure of 192 Mute Swan nests 1961-1967.

Eggs taken or destroyed by humans	*Adult(s) injured or dead*	*Flooded*	*Deserted*	*Infertile*	*Unknown*
150	14	15	5	5	3

Almost all the pairs which hatched eggs subsequently reared at least one young to fledging. Only 12 of 264 broods lost all their young, usually for the same reasons that other broods decreased in size— predation by pike, foxes and humans or as a result of disease or infection. The latter was particularly responsible for the small average brood size of 3.0 in 1964 when many young died in June during a spell of cold wet weather.

The average brood size at fledging over the seven years 1961-67 was 3.5, with the maximum at 4.0 young in 1967. This is slightly higher than the 3.1 found by Perrins and Reynolds (1967). Brood sizes at fledging ranged from one to nine young

Table XIII. Brood size at fledging in the Mute Swan.

Year	*Broods of known size*		*Number of young*									*Total reared*	*Reared per breeding pair*
	No.	*Av.*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*		
1961	23	3.3	4	4	3	8	3	—	1	—	—	—	—
1962	39	3.9	5	4	5	10	9	2	3	1	—	154	2.3
1963	32	3.7	2	5	5	10	5	4	1	—	—	119	2.2
1964	42	3.0	9	9	10	7	4	2	—	1	—	125	1.7
1965	49	3.5	5	12	13	4	9	4	—	1	1	170	2.2
1966	34	3.6	2	8	9	5	5	3	1	1	—	123	1.8
1967	29	4.0	4	5	5	5	3	1	3	2	1	116	1.9
Total	248	3.5	31	47	50	49	38	16	9	6	2	—	2.0

(Table XIII). Two, three and four were the commonest but 13% of the broods were greater than five. One of the two broods of nine young came from a clutch of eleven eggs, ten of which hatched; the other brood came from a clutch of nine eggs. The brood size distribution varied markedly from year to year. Whereas in 1961-63 the commonest brood sizes were four and five, in 1964 they were one to three due to the dying off of many of the young. In 1965 and 1966 two and three were the most frequent sizes but in the former year the average brood size was brought up by the larger than usual number of pairs rearing five or six young as well as by single broods of eight and nine young. In 1967 the warm dry weather throughout June resulted in few young dying after hatching and consequently the brood size was higher than in any other year, and there was an exceptional number of large broods (20% had 7 or more young).

Two examples of young changing from one brood to another have been recorded. In one case a pair occupying a territory on a river and having three half grown young of their own had a fight with an intruding pair of swans. The latter retreated leaving behind their own three young, which were then adopted by the resident pair, which went on to rear all six successfully. The other instance involved one of a brood of five, ringed in its family in September, which was recaptured in another family party three miles away the following January.

Another unusual circumstance occurred in 1966 when a pair, which had hatched young on a remote and rather unsuitable pond, flew off after about a week and left their young to die. It is possible that the desertion was due to the parents' inability to lead their young to more suitable waters. The same thing happened in 1967 but the two young wandered up to a nearby farm where they were fed with the poultry. One adult returned for a short while on each of the next two days but did not stay. The two young were therefore introduced to another family which already contained six cygnets. One was accepted and successfully reared but the smaller one was driven off and perished.

The average number of young reared per breeding pair was 2.0, the same as that found by Perrins and Reynolds (1967), with figures ranging from 1.7 in 1964 to 2.3 in 1962. The total number of young reared to fledging in the study area each year varied from a low of 116 in 1967 to a peak of 170 in 1965. Total production did not correspond closely with average brood size (in fact it was lowest in the year of highest brood size) but depended also on the interaction of the following factors, each of which varied from year to year: (a) total paired population; (b) percentage of the paired population which nested; (c) percentage of pairs hatching young successfully. The good output of young in 1962 was the result of a high average brood size. The very low number of young reared in 1963 was primarily the result of a low paired population and a lower than normal percentage of breeding pairs (Table II) which were not compensated for by an above average brood size. The low production of 1964 was associated with an unusually low brood size due to the dying off of the young in the first few weeks after hatching. The record output in 1965 was due to the combination of a high paired population and an above average hatching success, while the low figure for 1966 came mainly from the poor hatching success. In 1967 the low number of pairs and the very poor breeding success outweighed the effects of the higher than normal percentage of the paired population which nested and the high average brood size to result in the lowest total of young of any of the seven years.

When breeding successes of 13 pairs together for five or more years are considered, we find only 54% of these nests were successful, slightly below the aver-

age for the whole population. This is rather surprising as one might have expected long-standing pairs to have been more successful in repelling human intruders—the main cause of failure.

Two pairs did not rear any young in five seasons. In one of these this was because the female bird was probably infertile due to old age. There is evidence that this pair had been together for many years before the study commenced. The female usually laid only one or two eggs and one of these in each year was only half the normal size. This continued even after it took a new mate in 1966.

One pair reared young in each of the five seasons they were paired together, while another pair reared young in four consecutive seasons after a failue in their first year. The former pair nested on a remote stream and the latter pair in a garden where almost constant watch was kept against egg thieves. Just as human predation is the main cause of nest failures so human protection is the main reason for certain sites being more successful than others, even though one or both of the birds occupying the territory may have changed. Two sites were successful in each of the seven years of the study, two sites in six years and four sites in five of the years.

The breeding success of pairs in which both birds were nesting for the first time (53% of 77) was a little lower than the average for all breeding pairs. There is an indication that new pairs in which at least one bird had bred previously were more successful (66% of 47). The only two birds (both female) which have nested at the age of two were both successful at the first attempt even though both were paired to another bird also nesting for the first time. One laid seven eggs and eventually reared five young while the other reared two young and went on to rear seven young the following year, when it was aged three. Furthermore, both birds of the pair which laid eleven eggs and reared nine young in 1965 were nesting for the first time, but the exact ages of these birds were not known.

Habitat

The habitat occupied by the territories of breeding and non-breeding pairs each year have been divided into five categories (Table XIV). Arbitrary limits, of greater than 10 acres to define large waters and greater than 20 ft. width to define rivers, were chosen. Small waters down to half an acre, the minimum size normally used by swans for nesting, were counted.

An almost equal proportion—more than half—of both the breeding and non-breeding pairs were situated on small waters. The breeding pairs showed rather more preference for streams and large waters, rather less for rivers and canals, than did non-breeders. The main reasons for these differences seem to be in the relative attractiveness of the habitats as breeding sites. Breeding pairs seem to occupy the choicer habitats, such as the clean weed-filled streams, while non-breeding pairs tend to be found on habitats with less suitable feeding and nesting sites, such as the larger polluted rivers.

Table XIV. Comparison of habitats occupied by breeding and non-breeding pairs of Mute Swans 1961-1967.

		Large waters		*Small waters*		*Rivers*		*Streams*		*Canals*	
Status	*Total*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Breeding pairs	470	53	*11*	266	*56*	34	*7*	72	*15*	45	*11*
Non-breeding pairs	190	13	*7*	110	*58*	29	*15*	14	*7*	24	*13*
All pairs	660	66	*10*	376	*57*	63	*9*	86	*13*	69	*11*
Amount of habitat		25 waters		193 waters		128 miles		73 miles		206 miles	

The greater aggressiveness of breeding pairs probably results in a stronger hold on to the more attractive territories for breeding. They also have an advantage in taking up their territories earlier in the spring than non-breeding pairs.

The pattern of site occupation has remained relatively constant over the seven years except that the number of breeding pairs on canals has steadily decreased (from ten to three), due largely to the cleaning out and increased usage of the operational canals and the filling in of the more attractive weed-filled areas of disused canals.

The incidence of pairs in the various habitats also needs to be related to the extent of those habitats in the study area. Thus small waters were eight times as numerous as large waters but only had 5½ times as many nests. So, per water, the latter were more favoured. Again, the mileage of canals was three times that of streams but the latter held more nests. So, per mile, the streams were by far the most utilised. On one stream, the Mease,

there were three nesting pairs on a stretch of seven miles in most years. Another, the Blyth below Blithfield Reservoir, usually had three pairs on four miles. Pairs in these remote country districts were generally the most successful in hatching and rearing young, except when late spring floods washed away nests.

Thirty-eight of the territories have been occupied in at least six of the seven years even though the individuals occupying them have changed several times. Thus over a third of the pairs each year are on traditional sites, most of which, even to the human eye, appear the most attractive for feeding (shallow, weed-filled water) and nesting (reed-fringed margins). The fact that some of these are also particularly susceptible to human predation not surprisingly does not seem to be taken into account by the swans during territory selection. Seven (18%) of the sites occupied in six or more years have never reared young during the seven years of the study.

Many sites in all types of habitat have only been occupied for one or two years. At many of these young have been successfully reared on these occasions, indicating that such territories are suitable for swans. Yet they may remain unoccupied for several seasons. This, together with the fact that only about 38% and 28% of the large and small waters are occupied on an average, seems to indicate that the paired population level each spring has not been primarily controlled by the amount of habitat available.

The future

One of the most interesting features revealed by this study has been the constant level of the paired population each spring during the first six years of the study. Yet the annual output of young has varied widely and the total swan population has decreased by at least 25%. In fact, the highest paired population was probably in 1965, even if allowance is made for a few pairs being missed in the early years of the study. Again, the mortality rate has varied due to two severe winters (one exceptionally so). Such a constant paired population level when so many other factors were varying suggests a habitat availability limitation, and yet there is evidence of suitable habitats remaining unfilled in many years.

The reason for the constancy of the paired population level in 1961 to 1966 therefore remains uncertain at present but the continuation of the study in future years may reveal the answer. There is perhaps already an indication that the decrease in the total population level is at last starting to have an effect on the paired population. There was a significant drop in the number of pairs in 1966 compared with 1965 in spite of a low mortality rate associated with the mild 1965-66 winter. A further indication of the beginning of a downward trend was the lack of new blood in the 1966 breeding population.

It is particularly unfortunate therefore that the oiling disaster at Burton-on-Trent in July 1966 has clouded the picture. It is not clear whether the exceptionally low paired population in 1967 was entirely due to this or in part due to a continued decline from other causes in the number of new birds coming into the paired population which started in 1966. Already by the winter of 1967-68 (18 months after the oiling took place) the size of the Burton-on-Trent flock is back to the normal winter level though the age structure is significantly different from previously. It may therefore be a further year or two before it will become a fully effective reservoir of birds suitable to join the paired population and before the latter's overall trends can be established again. Man has been the primary controller of the swan population level in the past and only time will tell how the various ways in which he is at present influencing the situation will balance out in the future.

Acknowledgements

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I am also indebted to the Wildfowl Trust for providing free rings and for six annual grants for expenses. The British Trust for Ornithology gave permission for the use of recovery data.

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Finally I must thank my wife for putting up with a husband with such a full time hobby!

Summary

During seven years, 1961 to 1967, the population of Mute Swans *Cygnus olor* in an area of 550 square miles in the Midlands has been studied intensively by catching and ringing. The present paper deals only with the paired segment of the population. The number of pairs has remained fairly constant, around 95, but there is some evidence of a decrease since 1965. There were annual changes in the proportion of breeding pairs and in the recruitment of new pairs. The swans usually first paired at two and bred at three years old, but there were variations, and the age composition of pairs also had effects on their success. Mortality rates, based on the number of birds found dead, or missing from the area, were around 20% for breeding pairs, 35% for non-breeding pairs. There were other variations in mortality rates related to breeding success as well as to weather. Eighty-five per cent of paired breeders retained the same mate from year to year, if it was still alive. Non-breeding pairs were less stable. Divorce rate was 3% for breeding birds and 9% for non-breeders; some complicated pair histories are described. Movements of paired birds were very circumscribed. Only 58% of nests hatched successfully, human predation or interference being the major cause of loss. Most broods survived in part, with an average size at fledging of 3.5, representing 2.0 young per breeding pair. The production of young from the area varied widely between years, from 116 to 170. The relative attractiveness of different habitats was investigated. Despite the stability of the paired population, much apparently suitable habitat remained unexploited each year.

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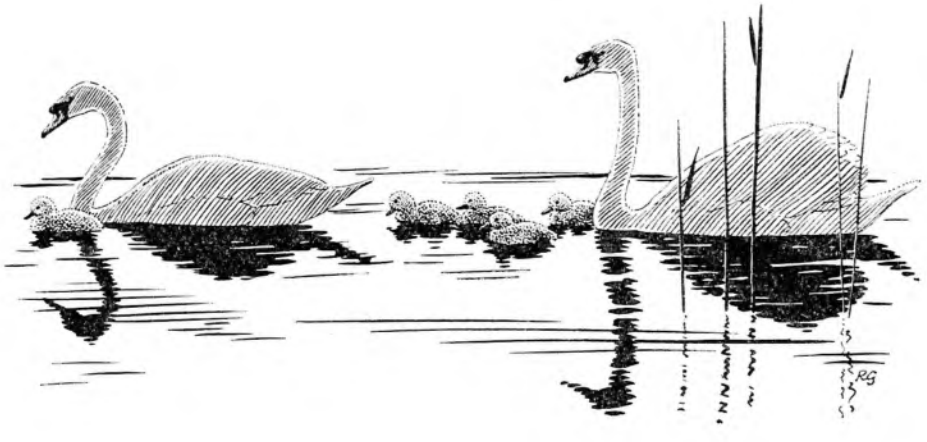

Inter-specific pairing in Scaup and Tufted Duck

SVEN-AXEL BENGTSON

Introduction

In no other group of birds are so many hybrids described as in ducks. The largest number of hybrids are found within the dabbling ducks, tribe Anatini but hybridization also occurs frequently in other tribes (cf. Gray 1958, and Johnsgard 1960). It is well known that peculiar pairs may be formed among ducks in captivity where many species are kept in relatively small pens. A great many of the recorded duck hybrids originated from birds in captivity but so far we know very little about hybridization among free-living birds. As it is very unlikely that a single person will be able to collect enough data on his own to be able to draw any conclusions, it is very important that incidental observations on wild hybrids and inter-specific pairs should also be published.

Johnsgard (1960) has summarized the hybridization within the tribe Aythyini and recently Gillham, Harrison J. M. and Harrison J. G. (1966) published a detailed description of plumages and bill characters of some *Aythya* hybrids including those between Scaup *A. marila* and Tufted Duck *A. fuligula* which are the subject of the present paper.

Scaup and Tufted Duck at Myvatn

During seven years of field-work on waterfowl at Myvatn in north-east Iceland I have been able to make a number of observations regarding the inter-specific relationships between the Scaup and Tufted Duck. Some of the findings throw light upon possible hybridization in the two species. The Scaup has for more than a hundred years been the most numerous duck in the well-known duck area around Myvatn. The Tufted Duck, however, did not start to breed in Iceland until the end of the nineteenth century. Today the Tufted Duck is the second most numerous duck in the area, of about 50 sq. km., where some 5,800 Scaup and 3,800 Tufted Duck pairs breed. Both species have recently declined, the Scaup in particular. They frequent roughly the same habitat and hence the opportunities for hybridization are good.

I have never been able to confirm any Scaup x Tufted Duck hybrid in the area but I have a dozen observations or so of 'suspect' individuals during my duck counts. In a few cases they may only have been Scaup and Tufted Ducks in aberrant plumages but most certainly some of them have been hybrids. To describe a hybrid bird acceptably the specimen has generally to be collected or you have to have a very good photograph or an observation at close quarters. At Myvatn no shooting is allowed during the breeding season and consequently it is hard to obtain evidence of the sort required. As far as I know no hybrid Scaup x Tufted Duck has been collected in the area of Myvatn. However, in 1956 P. L. Wayre got some Scaup eggs for hatching purposes from the area and the ducklings that hatched from them turned out to be hybrids (Sage 1963). When Dr. Jeffrey G. Harrison visited a pond in the middle of Reykjavik in May 1965, he saw and photographed a male hybrid (cf. Gillham, Harrison J. M. and Harrison J. G., 1960).

Inter-specific pairs

Pair formation in *Aythya* occurs later in the season than in *Anas* species and typical diving ducks (Mergini) which usually are in pairs early in the winter (e.g. Lebret 1961, and personal observations). At the end of May some Tufted Ducks and many more Scaup are still unpaired at Myvatn. Scaup arrive later than Tufted Ducks, some not until the first week of June.

In the years 1960-66 I have noted eleven certain inter-specific pairs and also five less certain cases. These are listed in Table I. Twice a male Tufted Duck has been accompanied by and apparently paired with a female Tufted Duck and a female Scaup at the same time. Polygyny has previously been found in the Tufted Duck (Bezzel 1964, Reichholf 1965). It is interesting to see that most of the observations are from June and not from the end of May, when I conducted most of my counts and had the best opportunities to find inter-specific pairs. Another interesting point is that there were fourteen instances of a male Tufted Duck paired with a female Scaup and only two the other way round.

Behaviour of inter-specific pairs

Only on two occasions have I been able to observe the behaviour of the inter-specific pairs in detail.

On 5th June 1963, I watched a pair of male Tufted Duck and female Scaup. In the immediate vicinity pairs of Tufted Duck and Scaup were displaying or loafing on the water. The male Tufted Duck displayed but with rather low intensity. I

Table I. Observations of inter-specific pairs of Tufted Duck x Scaup at Lake Myvatn, N.E. Iceland. Above dotted line certain cases, below less certain.

Date	*Tufted ♂ x Scaup ♀*	*Scaup ♂ x Tufted ♀*	*Tufted ♂ x (Tufted ♀ x Scaup ♀)*
29 May 1965	X		
29 „ 1966			X
3 June 1963	X		
5 „ 1963	X		
11 „ 1962			X
18 „ 1962		X	
20 „ 1961	X		
22 „ 1962	X		
22 „ 1964	X		
26 „ 1963	X		
4 July 1963	X		
27 May 1961		X	
28 „ 1963	X		
2 June 1962	X		
10 „ 1962	X		
16 „ 1963	X		
11 + 5 = 16 observations	12	2	2

recorded the most common display movements such as Coughing, Head-throw, various preening movements, once a sort of Sneak posture and several times he uttered the characteristic bubbling call, i.e. Kinkered-neck call (terminology after Johnsgard 1965). His mate (Scaup) remained inactive all the time. However, when suddenly a party of five male Scaup entered the arena the female became active and repeatedly performed Inciting and a couple of times rushed at the newcomers. The drake Tufted Duck now became the inactive partner and swam away, closely followed by the female and the five courting drakes. The Scaups constantly displayed and performed the same movements made by the drake Tufted Duck just before. After a short while the whole courting-party took off and disappeared. An hour later I observed an inter-specific pair, probably the same, at very long range and I witnessed a copulation.

On 29th May 1965, I watched an *Aythya* courting-party for about an hour. A drake Tufted Duck and a female Scaup were apparently paired and a varying number of Scaup drakes (2-6) displayed around them. The Tufted Duck led the party all the time and, so to say, served as pace-maker and director. All the time he was in an alert posture but I never saw him perform any display movements. His mate stayed close behind him and every now and then she turned, trying to fight off the pursuers. She even showed overt aggression. When hard pressed the female dived and so did the Tufted Duck and some of the Scaup drakes. The latter performed Head-throw and Kinkered-neck call and rushed after the female. Two of them were more aggressive and pressing in their attendance than the others. The courting-party moved around within an area of 50 × 200 yards. Finally the whole party flew away, the males still chasing the female. Flying courting-parties are common in these two *Aythya* species although Bezzel (1959) states that they are lacking in *Aythya*.

Discussion

The display movements and sequences of species belonging to the genus *Aythya* are extremely similar (Steinbacher 1960, Johnsgard 1965 and personal unpublished observations). It is evident that the sexual behaviour involved in pair-formation and copulation is not a very effective isolating mechanism in *Aythya* (cf. Johnsgard 1963). This is supported by observations on inter-specific pairs of Tufted Duck and Pochard *A. ferina* in Germany (Bezzel 1960).

The most noteworthy feature of my observations at Myvatn is that most mixed pairs comprise a drake Tufted Duck and a female Scaup. The females of the two species may sometimes be difficult to distinguish at some distance but, since typically Scaup females have white patches near the base of the bill and Tufted Ducks do not, if recognition was crucial inter-specific pairs of either combination should be equally plentiful. I do not think

Table II. Observations on pair-formation and sex-ratio in Scaup and Tufted Duck at Lake Myvatn, N.E. Iceland.

	Scaup	*Tufted Duck*
Number of birds observed	13,480	9,645
Percent females not paired		
15-31 May	12	7
1-15 June	8	3
Sex-ratios (males: 100 females)	120	138

my observation technique caused any discrepancies in the material, while observations by Bezzel (1960) show the same tendency.

Table II summarizes some information concerning the proportion of unpaired females in late May and June and the sex-ratios of Scaup and Tufted Duck. The greater excess of males in the Tufted Duck seems unlikely to provide a complete explanation of the preponderance of Tufted Duck males in the inter-specific pairs. The chronology of pair-formation is, however, somewhat different in the two species. Unfortunately I cannot present any figures from March and April when according to Bezzel (1959) pair-formation in *Aythya* in south Germany reaches its peak. According to my material from Myvatn a larger percentage of female Scaup is still not paired at the end of May and in the first half of June than is the case in the Tufted Duck. As pair-formation in the Tufted Duck proceeds, an increasing number of unpaired surplus males can re-direct their interest to female Scaups that are not yet paired. This, together with the similar displays of the two species, may explain the formation of our inter-specific pairs. Bezzel (1960) explained wild hybrids of Tufted Duck x Pochard in a similar way.

Recently Weller (1965) put forward a theory that late breeders of *Aythya* form pairs later than early breeders. This is consistent with the breeding of Scaup and Tufted Duck at Myvatn, where the Scaup breeds much later on average. It also supports the hypothesis about surplus males of Tufted Duck intervening in the pair-formation of the Scaup.

The problem of hybridization in the wild of sympatric species like the two *Aythya* concerned is of ecological, ethological and zoogeographical interest and deserves further attention.

Summary

In seven years observations on very large numbers of Scaup and Tufted Ducks at Myvatn, Iceland, sixteen mixed pairs have been seen. In fourteen the male was a Tufted Duck. Two such males were accompanied by both a female Scaup and a female Tufted Duck. Tufted Duck x Scaup pairs are probably more frequent than Scaup x Tufted Duck for two reasons: there is a greater excess of males in the Tufted Duck population and, because that species forms pairs and breeds earlier than the Scaup, unsuccessful male Tufted Ducks can more easily find unpaired female Scaup.

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Nest-building movements performed by male ducks

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In most Anatidae, the nest is constructed entirely by the female during her visits to the site before and during egg-laying or while she incubates. Males help in building the nest in species where both sexes incubate (*Anseranas* and *Dendrocygna*) or co-operate in active defence of the nest (*Cygnus*, *Coscoroba* and some geese Table I). The only published observations that I have found indicating that male ducks in the sub-family Anatinae are capable of performing building movements are those of Brock (1912) on Tufted Duck *Aythya fuligula* and Best (1939) on Mallard *Anas platyrhynchos*.

Table I. Species of Anatidae in which the male has been recorded nest-building.

Species	*Authority*
Anseranas semipalmata	Johnsgard 1961
Dendrocygna guttata	P. Alder (unpublished)
D. bicolor	J. Kear (unpublished)
D. arborea	P. Alder (unpublished)
D. autumnalis	J. Kear (unpublished)
C. coscoroba	Johnstone 1953
Cygnus olor	Poulsen 1949
C. atratus	Jones 1947; Guiler 1966
C. melanocoryphus	Copley 1963; Jones 1947
C. c. cygnus	Jones 1947; Jourdain, in Witherby, et al., 1939; Poulsen 1949
C. c. buccinator	Banko 1960
C. c. columbianus	J. Gebauer quoted by Delacour 1954
C. c. bewickii	Johnstone 1957
Branta canadensis	Collias and Jahn 1959
Anser albifrons leucopsis hybrid	Berry 1945
A. anser X Branta	Berry 1945
Cereopsis novae-hollandiae	Blaauw 1904

In these instances, the males were seen to make nest-building movements at the same time as females were building, but most waterfowl biologists would consider such behaviour highly aberrant in these species. The following additional observations suggest that such behaviour may be quite widespread in species where the male plays no role in constructing the nest.

My first notes on this topic were made on the European Eider *Somateria mollissima mollissima* during April and May 1953, on the Farne Islands. Pairs were observed walking around prospecting for nest-sites on the grassy top of the Inner Farne. Females slowly moved from one old scrape to another, sitting down, scraping with the feet, pecking at the ground, picking up pieces of grass and depositing it at their sides with the 'sideways building' action typical of all Anatidae. The males followed their mates, stopping when they stopped, and often sitting on the grass to wait. At these times, males were seen to peck at the ground, toy with pebbles, pull pieces of lichen off the rocks, and sometimes they also made unmistakable sideways building movements. All my records of this behaviour were made in the early mornings (on 26th and 30th April, 1st, 5th and 29th May), when site prospecting activity was most intense. Males were never seen to enter a scrape, nor did they make any foot movements suggestive of scraping.

In most cases, the Eider pairs were in groups when the females were testing scrapes, and there were many signs of mild hostility between pairs. Males frequently gave Cooing-movements, females gave Gog-gog calling and made Inciting movements, and occasionally pecks and short chases occurred. It is possible that the male nest-building movements were reactions to 'social' situations, but my notes suggest that they occurred also in pairs which had moved some distance away from other birds.

On 21st April 1954, while watching birds at the Wildfowl Trust, I saw a male Ruddy Duck *Oxyura jamaicensis* sitting in the reeds at the edge of a pond making

complete sideways building movements for several minutes. A female was building a nest several yards away, at the same time.

On 6th May 1957, Dr. Robert I. Smith and I were watching a pair of Pintail *Anas acuta* near Tilley, Alberta. The birds had alighted on a slight rise on the prairie, and were walking around slowly, at times sitting down and preening. Then the female squatted down out of sight. The male tugged at a piece of sage-brush, then sat down and made sideways building movements, pulling grass and tossing it to his side, for about five minutes. At times he made chewing movements with the mandibles. On three occasions, when a single male Pintail flew over, the male crouched with his neck stretched forward, with the sort of response that might be seen from an incubating female.

On 21st April 1961, Dr. Richard E. Phillips tells me (*in litt.*) that he watched a captive pair of Mallard at an empty nest-scrape in the flight pen at the Delta Waterfowl Research Station, Manitoba. " The male was very attentive and when the female left the scrape after a crow passed overhead, the male began to poke about in the straw around the edges of the scrape. He did this repeatedly, then squatted, breast down, in the scrape in a posture similar to that of the female. He did not scrape in the course of ten minutes while I watched. After squatting a couple of times and poking in the straw, he began to pick up mouthfuls of straw and to push them over his shoulder in the trembling shoving movement used by the female for nest-building. He continued this for two or three minutes with pauses. When I checked this scrape there were no eggs."

On 8th June 1960, while observing several breeding pairs of Blue-winged Teal *Anas discors* in a large flight pen at Delta, I saw a male walk on to a nest containing an incomplete clutch of fresh eggs. He stood on the nest and made rapid nest-building movements. The nest belonged to a female with which he had been paired until a week previously, but another male had taken over his mate leaving him unpaired. A similar event occurred on 3rd June 1961, when an unpaired yearling male Blue-winged Teal crept stealthily on to a nest, in the female's absence, settled down on the eggs and poked under them in the same way as an incubating female would do. The owner male approached, chased away the intruder, and then walked on to the nest himself, thrusting his head down deep among the eggs. Then he left the nest and joined his mate.

Finally, in 1965, when James March and I were making daily observations on eight pairs of breeding Shovelers *Anas clypeata* in two large flight pens at the University of Minnesota's Cedar Creek Natural History Area, we recorded sideways building movements in four different males. In all cases, the bird had been sleeping or sitting quietly on a grassy bank, some distance from his mate's nest. One male was seen to make building movements on 25th May, 7th, 10th and 14th June, while records for three different males were made on 16th June. Their mates were in various stages of the reproductive cycle on these dates (pre-laying, laying, incubating). In one case, the female was sitting nearby, but the other records involved males sitting alone or close to other males. This activity was undoubtedly infrequent in my captive Shovelers, since these are the only records for five years of observation, totalling about 322 hours in the months of May and June.

These scattered observations show that the motor patterns appropriate for functional nest-building (and egg-moving and settling also in the case of the Blue-winged Teal) occur in the males of species where nest construction is accomplished exclusively by the female. In none of these cases was there any indication that the male behaviour could have been functional in contributing to the nest. In the Eiders and Shovelers the sideways building movements were infrequent and they were performed away from the nest-site. It is noteworthy, however, that all the observations were made at the same time of year as females were nest-building. It is possible that the sight of the mate engaged in this activity was a factor in producing the male building in the Eider, Pintail and Ruddy Duck cases. In the Blue-winged Teal, the males appeared to be influenced by their position on the nest with eggs, but in the Shovelers often the behaviour was given while the bird was out of sight of the nest and the female. I have no evidence that the movements have been serving a signal function.

I suggest that the most plausible explanation for this unexpected behaviour is that these motor patterns have persisted in the males of these species since the time when they were functional in contributing to nest construction in some remote ancestor, and that they are truly 'vestigial'. Perhaps closer study will reveal an adaptive value for this behaviour, but it is difficult to imagine what this can be. Opportunities for further observations of this phenomenon are especially good at

the Wildfowl Trust, but records for wild birds also would be especially valuable.

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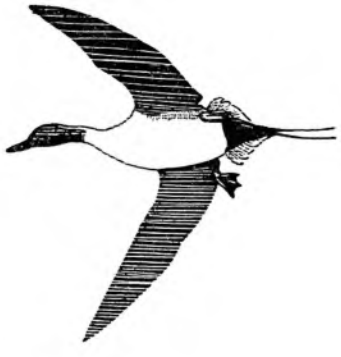

The proportion of yolk in the eggs of waterfowl

DAVID LACK

In an earlier publication (Lack 1967), I showed that the weight of the egg proportionate to body-weight differs greatly in different species of ducks, from 2½ per cent in the White-winged Wood Duck *Cairina scutulata* to a little over 20 per cent in two stiff-tails *Oxyura maccoa* and *O. dominica*. Subsequent investigations have shown that these two latter figures, derived from published sources, were wrong, and the highest figures are around 15 per cent, in the stiff-tails *O. vittata* and *O. dominica*. Even so, this represents a considerable range of variation.

I also showed, following Heinroth (1922), that the proportionate egg-weight in relation to body-weight is higher the smaller the species, and included graphs to demonstrate this relationship within each tribe of the waterfowl. (Note that the two right-hand points in this graph, for figures over 20 per cent, are wrong, as just noted.) I then compared the point for each species on the graph with the mean curve for the points for all the species of Anatidae (this curve not being shown on the graph) and thus determined the 'relative' egg-weight of each species after allowing for the regular variation in proportionate egg-weight with body-weight. (Note that the 'proportionate' egg-weight is the weight of the egg expressed as a percentage of the body-weight, while the 'relative' egg-weight is the weight of the egg relative to that of other species of similar body-weight.)

It was suggested that the disadvantage of a larger egg may be that it necessitates a smaller clutch, and the compensating advantage that it enables the chick to hatch at a relatively advanced stage or with a proportionately large food reserve derived from the yolk sac. The next step, therefore, was to determine whether the proportion of yolk in the egg varies with its proportionate or relative size. For this, fresh, infertile eggs laid at Slimbridge were weighed, and then hard-boiled, which enables the yolk to be separated easily from the white, after which the yolk, white and shell were weighed separately.

There was a very small change in weight after boiling, but this did not appear to affect the weight of the yolk or the shell. After this, the yolk was dried in an oven, weighed again and analysed for its fat content. Since most of the eggs could not be treated in this way at once, they were placed in deep-freeze.

Table I. Weights of fresh eggs of Anatidae from Slimbridge.

Species	*Number weighed*	*Mean weight in grams*	*Percentage of weight formed by*	
			shell	*yolk*
Dendrocygna bicolor	3	42.4	14	45
Cygnus atratus	3	235	14	49
Anser anser	8	158	14	43
A. c. caerulescens	3	119	12	40
A. c. atlanticus	4	113	13	36
Branta c. canadensis	1	198	11	42
Alopochen aegyptiacus	1	82.6	11	43
Anas platyrhynchos	5	55.7	11	39
A. undulata	2	49.1	11	42
Somateria mollissima	5	108	9	44
Netta rufina	2	49.1	14	41
Aix sponsa	3	43.5	9	41
A. galericulata	1	44.9	10	42
Cairina moschata	8	68.4	12	42
Plectropterus gambensis	7	115	14	40
Bucephala clangula	7	65.4	11	44
		(b) by J. Kear		
Cygnus olor	2	312	13	34
Anser anser	3	182	—	41
Branta sandvicensis	1	140.5	9	37
Anas platyrhynchos	10	53.1	—	37
A. specularis	3	69.4	11	42
A. chlorotis	1	52.5	8	44
Marmaronetta angustirostris	1	31.9	—	41
Aix sponsa	14	37.5	—	39

Some had to be kept there for several months, and were often found to have lost about 5 per cent in weight, and occasionally 7 or even 10 per cent. A comparison of eggs from the same clutch, some of which were wrapped and lost hardly any weight, while others were not wrapped and lost much, showed that virtually the whole loss was due to loss of water from the albumen, which accumulated as ice outside the shell. In eggs to which this had happened, the yolk and shell were weighed in the usual way, while the weight of the albumen was calculated from the difference between these two figures and the total fresh weight of the egg.

The average fresh weight and the average proportionate weight of the yolk and shell have been set out for each species that I weighed in Table I, together with some further measurements obtained by Dr. J. Kear. In Table II these figures, with those published earlier by Heinroth (1922, 1928) and Härms (1929-30), have been set out for each species grouped according to its relative egg-weight. Heinroth's figures are a little lower than those obtained by others, and his for the Mallard *Anas platyrhynchos*

Table II. Proportion of egg consisting of yolk (all sources).

Species	*Source*	*Yolk*	*egg/body wt. category*
Relatively large eggs			
Cygnus atratus	Lack	49%	C
C. olor	Heinroth	40%	A
C. olor	Kear	34%	A
C. cygnus	Heinroth	37%	A
Branta sandvicensis	Kear	41%	C
Relatively fairly large eggs			
Anser anser	Lack	43%	B
A. anser	Kear	41%	B
A. c. caerulescens	Lack	40%	C
A. c. caerulescens	Heinroth	35%	C
A. c. atlanticus	Lack	36%	C
Tadorna tadorna	Härms	39%	D
T. tadorna	Heinroth	43%	D
Anas specularis	Kear	42%	D
A. chlorotis	Kear	44%	E
Melanitta fusca	Härms	40%	E
Bucephala c. clangula	Heinroth	40%	E
B. c. americana	Lack	44%	E
Mergus serrator	Härms	40%	D
Relatively medium eggs			
Dendrocygna bicolor	Lack	45%	C
Branta canadensis	Lack	42%	A
Cereopsis novae-hollandiae	Heinroth	34%	A
Alopochen aegyptiacus	Lack	43%	B
Tadorna ferruginea	Heinroth	35%	C
Anas undulata	Lack	42%	C
A. clypeata	Härms	38%	D
A. clypeata	(Heinroth	50%)	D
Somateria mollissima	Lack	44%	B
S. mollissima	Härms	43%	B
Aythya nyroca	Heinroth	40%	D
A. fuligula	Härms	38%	E
Aix sponsa	Lack	41%	D
A. sponsa	Kear	39%	D
A. galericulata	Lack	42%	E
A. galericulata	Heinroth	38%	E
Plectropterus gambensis	Lack	40%	A
Relatively fairly small eggs			
Anas platyrhynchos	Lack	39%	B
A. platyrhynchos	Kear	37%	B
A. platyrhynchos	(Heinroth	33%)	B
Netta rufina	Lack	41%	B
Cairina moschata	Lack	42%	A
C. moschata	(Heinroth	32-35%)	A
Relatively small egg			
Marmaronetta angustirostris	Kear	41%	C

and Muscovy Duck *Cairina moschata* are so low, and for the Shoveler *Anas clypeata* so high, that they have been excluded from the following analysis. My own abnormally high figure for the Black Swan *Cygnus atratus*, though genuine, may relate to an abnormal individual.

I have then averaged the figures for each species grouped according to relative egg-weight in Table III and according to proportionate egg-weight in Table IV, which show that the proportion of yolk

Table III. Mean proportion of yolk in eggs of different relative size.

Relative size of egg	*Number of species in Table II*	*Mean percentage of yolk*
Large	4	41
Fairly large	10	41
Medium	13	40
Fairly small	3	40
Small	1	41

in the egg does not vary significantly with either factor. Hence the idea that the chicks of species with relatively or proportionately large eggs might hatch with proportionately large yolk sacs, and hence food reserves, has presumably to be discarded. It may be added that neither the dry weight of the yolk (around 50 per cent) nor the proportion of fat in it, appeared to vary significantly in different species.

Table IV. Mean proportion of yolk in eggs of different size proportionate to body-weight.

Egg-weight in proportion to body-weight	*Number of species*	*Mean percentage of yolk*
A under 5.0%	6	38
B 5.0 - 5.9%	5	42
C 6.0 - 6.9%	8	41
D 7.0 - 7.9%	6	40
E 8 and over	6	41

Notes: The species composing each group for egg-weight in proportion to body-weight are indicated by A-E in Table II. Where two figures were available for one species, they were averaged before taking the average for each group (but the figures bracketed in Table II were ignored). In the totals subspecies are treated as full species.

Table I shows that there are rather large differences in the proportionate weight of the shell. Since the eggs were from captive birds, and the thickness of the shell is known to vary greatly with diet in poultry, these variations might have been due to diet. It is possible, on the other hand, that hereditary differences between species are involved. The unusually thin shell of the Eider *Somateria mollissima*, despite a large egg, is remarkable.

Acknowledgements

I am extremely grateful to Dr. J. Kear for help and advice throughout.

Summary

The yolk forms about two-fifths of the weight of the egg in waterfowl. This proportion does not differ significantly in species with eggs of different size proportionate to body-weight.

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The hatching and nest-exodus behaviour of Mallard

A. BJÄRVALL

Introduction

In laboratory investigations on the early ontogeny of behaviour in nidifugous birds, Mallard ducklings *Anas platyrhynchos* have been the commonest subjects apart from the chicks of domestic fowl. As a result, much information has been obtained about the principles of the learning process known as imprinting and the so-called following-response of this species. Briefly, the experiments have consisted of a period of isolation from hatching up to a certain age, a subsequent training to a specific object (and/or sound) and finally a test to that object. The response of the duckling in the test has been considered as a measure of imprinting. The imprinting process is thought to be initiated by the following-response during training and to result in a gradually increased preference for the training object. In this way it has been shown that the strongest and most complete imprinting is restricted to a short period, usually called the critical period, which in Mallard occurs between 13 and 16 hours of age (Ramsay and Hess 1954, Hess 1959).

Our knowledge of how these laboratory results relate to events in the real nest, after the eggs hatch, is very limited. In his work on 'the law of effort' Hess (1959) obtained results indicating that the degree of imprinting may be directly proportional to the physical effort expended during training. This suggested that imprinting under natural conditions might be linked to the actual departure of duck and ducklings from the nest, and provided part of the background for the present study.

PART I. DETERMINATION OF HATCHING AND DEPARTURE

Methods

Some of the methods used have already been described (Bjärvall 1967), but a few remain to be defined.

The time of hatching was determined by visits to the nest and, when necessary, flushing the female. The use of a conducting paint described in Salter and Vince (1966) would probably be as disturbing, since the method requires a long stay at the nest after the eggs have pipped; moreover it is extremely expensive for natural clutches, containing normally 9 and 10 eggs. The time of hatching was ascertained as precisely as possible usually by visiting the nest twice

during the hatching process and then using the following score-system. An egg found on the point of hatching was scored 1 to that hour. A dry duckling was considered to be older than 2 hours, determined in accordance with data presented by Low (1945) for the Redhead *Aythya americana.* Thus a wet duckling of unknown age gave the score $\frac{1}{2}$ to each of the 2 preceding hours. A dry duckling in a nest that 5 hours earlier contained unhatched eggs, thus gave the score $\frac{1}{3}$ to each of the 3 hours following the time of the first control, and so on. In this way figures up to and including 8 have been used as divisors (the longest interval of inspection being 10 hours).

The time of departure from the nest was determined by close inspection, with the aid of an electric temperature-recorder or by long-distance visual control at irregular intervals by means of field glasses. The last method has in a later analysis also given rise to a score system. When the interval was for instance 3 hours, each of the hours has been given the score $\frac{1}{3}$.

It is obvious that by these methods it was impossible to know the exact age of more than a few ducklings. Therefore they are described as being 'older than' and 'younger than' (Table I).

Observations and results

Length of stay in the nest

In 1964 and 1965 the age of ducklings at the time of departure from 21 nests was determined. Twelve of these were situated on the ground and nine in baskets or boxes, the latter being referred to as hole-nests in the following text. The results have been published already (Bjärvall 1967). In 1966 observations were made of a further 29 nests, 20 of which were on the ground. The combined results are shown in Table I.

The available values, for 50 nests over three years, do not give a simple figure for the age of ducklings at the time of departure. The variation is from less than 9 to more than 46 hours. In the earlier study it was shown that the ducklings, to a large extent, spent the first 16 hours of their lives (the supposed upper limit of the critical period) in the nest. Some further notes can now be added. At 13 hours, referred to as a lower limit of the critical period, 75% (27 out of 36) of the observed broods were still in the nest, and if the oldest duckling of each brood is considered alone, the corresponding figure was 94% (47 out of 50). The youngest duckling of the brood was younger than 13 hours in only 14% of the observed broods (6 out of 42).

It is very rare that every duckling of the brood is younger than 16 hours at the time of departure. This was observed in 8% only (2 out of 26) of the broods and on both occasions every duckling was less than 11 hours old.

Summarizing these results, it is found that, although the majority of ducklings are older than 16 hours on leaving the nest, it is quite common for the younger ducklings of the brood to be below this age. Most of them, however, are older than 13 hours. Consequently Mallard ducklings, with very few exceptions, spend at least part of the critical period in the nest.

Some comparison has been made already between ducklings from different nest sites (Bjärvall 1967). It was suggested that Mallard broods hatched in holes stay

Table I. Age in hours of Mallard ducklings at the time of departure : 50 nests from 1964, 1965 and 1966. Also given are results of rank-sum tests for difference between hole- and ground-nests.

	Hole-nests			*Ground-nests*		
	No.	*Average*	*Range*	*No.*	*Average*	*Range*
Oldest duckling is older than	18	$25\frac{3}{4}$	$16\frac{1}{2}$-$46\frac{1}{4}$	32	$19\frac{3}{4}$	$9\frac{3}{4}$-$34\frac{3}{4}$
		$T'=623.5$	*$z=3.34$*		*$P<0.001$*	
Youngest duckling is younger than	14	$21\frac{3}{4}$	$14\frac{1}{2}$-46	28	$16\frac{1}{4}$	$8\frac{3}{4}$-$27\frac{3}{4}$
		$T'=408.0$	*$z=2.86$*		*$P<0.001$*	
All ducklings are older than	13	20	$13\frac{1}{2}$-$35\frac{1}{2}$	25	$14\frac{1}{2}$	4-$22\frac{3}{4}$
		$T'=317.5$	*$z=2.55$*		*$0.01<P<0.001$*	
All ducklings are younger than	8	$25\frac{1}{2}$	$20\frac{1}{4}$-$30\frac{1}{2}$	18	$21\frac{3}{4}$	$10\frac{3}{4}$-$36\frac{3}{4}$
		$T'=142.5$	*$z=1.94$*		*$0.1<P<0.05$*	

longer in the nest than those hatched on the ground. The conclusion was based on limited data but results from 1966 have now been added and rank-sum tests (Dixon and Massey 1957) are shown in Table I. For three of the four age-groups the difference is significant at the 0.001 level and the group in which no difference is found is that with the least material. The results essentially confirm the original conclusion, that ducklings from hole-nests are older at the time of departure than those from ground-nests.

It should be possible to establish a reason for this difference and, to this end, the processes of hatching and the departure from the nest have been subjected to a more detailed analysis.

The chronology of hatching

Material collected on the chronology of hatching and presented in Figure 1, shows that although Mallard eggs can hatch at any time of the day or night, most seem to hatch during the day. Indeed, more than 35% of the eggs hatched between 09.00 and 15.00 hours. The purpose of this part of the study is to see whether the difference in age at the time of departure from different nest types could be caused by differences in the hour of hatching. Besides the peak at the middle of the day, Figure 1 seems to indicate a lesser peak between 02.00 and 06.00. Is it possible that either peak is represented mainly by hole- or ground-nests? To examine this, the median-values of 35 known cases have been analysed in respect of their distribution around 06.00. The result, shown in Table II, clearly indicates that there is no difference between the two types of nest in this respect.

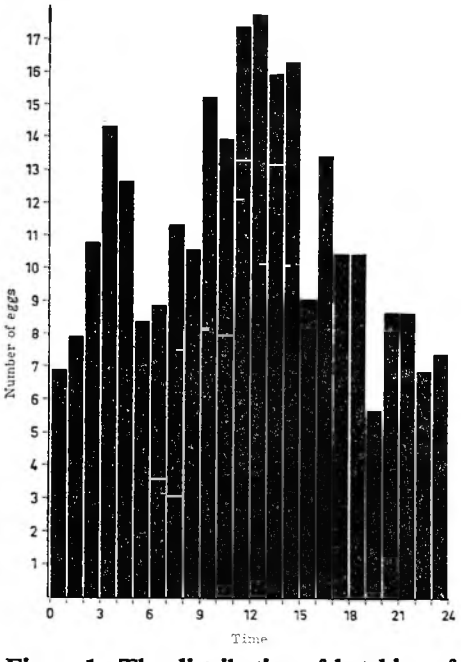

Figure 1. The distribution of hatching of 269 eggs in 43 different Mallard nests.

Hour of departure

The time of departure of the female and brood from the nest is shown graphically in Figure 2.

Every departure from a nest has occurred during daylight although a departure after 17.00 has never been recorded. The figure shows a distinct peak in the forenoon and more than 60% of nests were quitted between 04.00 and 10.00. During the afternoon there is an indication of a second lower peak. The material in Figure 2 has been re-analysed to see whether the greater part of either peak might be caused by departures from nests of a particular type. Certain departures that occurred at about noon, without the precise time being recorded, have been excluded, plus one nest that was situated in an old Magpie nest in a low bush (because of the difficulty of classifying it

Table II. Distribution of the median values of the hatching times.

Nest site	*Hatching time* *Before 06.00*	*After 06.00*
Hole	1	10
Ground	7	17
Total	8	27

$\chi^2=0.752$ f=1 0.5> P>0.3

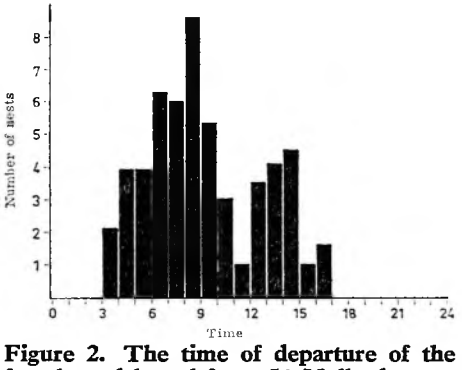

Figure 2. The time of departure of the female and brood from 54 Mallard nests. Note that daylength runs from approximately 02.00 hours to 22.00 hours.

as a real hole-nest). The remaining cases have been categorized as ground- or hole-nests and the distribution of exodus in relation to noon analysed. The result given in Table III shows that the second peak in Figure 2 is probably related to late departure from hole-nests.

The material has also been examined with a rank-sum test. Only nests of which the precise time of departure is known, have been used and in those cases where the whole brood has not left the nest simultaneously, the time of the first duckling has been used. The result (T^1 = 209.5, z = 2.11, P <0.05) showed very good accordance with that in Table III.

Table III. Distribution of the time of departure.

Nest site	*Departure time* *Before 12.00*	*After 12.00*
Hole	8	7
Ground	29	5
Total	37	12

χ^2=4.15 f=1 P<0.05

The possible influence of hatching success upon length of stay in the nest

Thus data have been obtained indicating that duckings hatched in hole-nests are older at the time of departure than those hatched on the ground. This does not seem to depend on any difference in the actual hour of hatching, but on a delay in the time of departure from the hole.

It is well known that many female birds continue to incubate much longer than normal if the eggs fail to hatch (Sowls 1955). This has been described, for instance, for domestic fowl (Manson-Bahr 1946) and Mallard (Wheeler 1966) and has been observed occasionally in this study. One might suppose, therefore, that the presence of unhatched eggs stimulates the female to stay longer than normal, even if the nest also contains ducklings capable of leaving. If the hatching success was found to differ between the two nest types, this might explain the delayed departure such as that observed in hole-nesters.

The normal manner of describing hatching success is to present the clutch-size and the hatch as a percentage of this, for example Hunt and Naylor (1955). In the present study, however, the percentage figure is considered to be of less interest and instead a distinction has been made between clutches which have hatched completely and those that have contained at least one unhatched egg after departure of the brood. (There was no significant difference in clutch-size between hole- and ground-nests.) In the three earliest nests in 1966, egg-laying occurred between 6th and 18th April when the night temperature was as low as −10°C. on several occasions. The hatching success in these nests, which were all situated on the ground, was exceptionally poor. Since comparative material from early hole-sites is not available, these three nests have been excluded from Table IV in which the hatching success of 77 later nests is shown. About 50% contained unhatched eggs and these seemed commoner in hole-nests than in ground-nests.

Table IV. Hatching success in 77 nests in relation to site.

Nest site	*Hatching success* *Complete*	*Incomplete*
Hole	5	15
Ground	31	26
Total	36	41

χ^2=4.02 f=1 P<0.05

Data from nests in which hatching was incomplete have been analysed once more with reference to the number of unhatched eggs. One nest has been excluded because the precise number was not recorded. The result from 40 others can be seen in Table V, which shows that if a nest contains 2 or more eggs at the time of departure, it is likely to be a hole-nest.

Table V. Hatching success in 40 nests containing at least one unhatched egg.

Nest site	*Number of unhatched eggs* *1*	*≥2*
Hole	2	12
Ground	16	10
Total	18	22

χ^2=6.41 f=1 P<0.05

To test whether the presence of a small number of unhatched eggs stimulates the female to stay longer on the nest after hatching and thus cause the ducklings to be older at the time of departure, the material in Table I has been further analysed by a rank-sum test. For all age-categories and for both hole- and ground-nests no differences were found (at the 0.05 significance level) between nests which hatched completely and those con-

taining unhatched eggs. This conclusion is also confirmed by consideration of the afternoon peak in Figure 2. If the females were influenced by a small number of unhatched eggs this peak should be, to a great extent, composed of nests containing such eggs, but from Table VI it can be seen that this is not the case.

Table VI. Time of departure compared with presence of unhatched eggs.

Hatching success	*Number of departures* *Before 12.00*	*After 12.00*
No unhatched egg		
Hole-nests	3	2
Ground-nests	16	3
Unhatched egg(s)		
Hole-nests	4	4
Ground-nests	12	2

PART II. THE BEHAVIOUR OF THE FEMALE AND THE DUCKLINGS DURING THE STAY IN THE NEST: THE PERIODS OF ACTIVITY

It has been demonstrated that most Mallard ducklings spend at least part of the age-period 13 to 16 hours in the nest; and from laboratory experiments it is known that the greatest possibilities for strong and complete visual imprinting exist during this period. Preliminary observations during the present study indicated that while the ducklings are in the nest they behave in such a way that they are exposed to visual and auditory stimuli of the kind that induce imprinting (Bjärvall 1967). This hypothesis has been investigated further by observations, from a hide, of the behaviour of female and ducklings in the nest.

Besides visual imprinting, the existence of auditory imprinting has also been recognised. This is considered to be of great importance in holding the members of the brood together during the later period of growth. Such imprinting is said to occur during the ducklings' stay in the nest when the females of several duck species have been found to utter sounds (Collias and Collias 1956, Collias 1962, Gottlieb 1963a, 1963b). A closer investigation of this call in the Mallard was made by using a tape recorder in conjunction with visual observations.

Methods and results

Gottlieb (1963a, 1963b, 1965a) studied the vocal activity at nests of Mallard and North American Wood Duck *Aix sponsa* from the pipping of the first egg to exodus. He found that the female started vocalizing during the hatching of the young and continued to do so through to departure, that the amplitude (intensity) and calling rate rose during this period, and that the rate of the hole-nester (Wood Duck) was higher than that of the ground-nester (Mallard).

In view of Gottlieb's results, the initial plan was not to make continuous sound-recordings, but to take samples of vocal activity at intervals. Thus tape-recordings of half-hour lengths and at four hour intervals were made. Contrary to Gottlieb's findings, these showed that although many sounds came from female and ducklings there were also long periods of complete silence. Since other lengths and intervals gave the same result, recordings were later combined with simultaneous observation from the hide.

No extensive study of the behaviour of the female and nidifugous young at the nest seems to have been made. Collias and Collias (1956) reported observations from one nest of Blue-winged Teal *Anas discors* that suggested that the ducklings were not covered by the female the whole time, but later Gottlieb (1965a) indicated that ducklings of both Wood Duck and Mallard were covered by the body of the mother during the period in the nest. Observations in the present study, however, have given a considerably more varied picture of events between hatching and exodus.

After hatching, the wet ducklings are covered by the female for a couple of hours. When they are dry they appear beside her and start moving around the nest. Within a short time, a pattern of activity is set up; the ducklings behave in a synchronised manner and periods of high activity alternate with periods of rest when the ducklings lie still, usually under the female but sometimes in warm weather wholly or partly outside her plumage.

The early movements are very stumbling and at first physical contact between the ducklings and the female is seldom broken. The ducklings then show a rapidly increasing mobility and, during periods of activity near the end of their stay in the nest, normally leave the female and make short excursions. They usually go 10-20 cm. away but, in a few cases, walks up to 1 m. have been noted. These observations refer to nests situated on the ground, but for ducklings hatched in hole-nests the possibility of movement must be considerably restricted.

During periods of activity, when the ducklings move around in the nest, they

utter continuous ' contentment-notes ' the normal function of which is to keep the brood together (Collias 1962). Sometimes, for example when only a single duckling is outside the female's plumage, ' distress calls ' can be heard. These attract the female to a duckling temporarily out of contact (Collias 1962). During periods of inactivity the ducklings are almost completely silent although sometimes short series of sounds can be heard.

The female regularly utters her maternal call during periods of activity and, without exception, also answers distress calls from the ducklings. On the other hand during inactivity the female, as well as the ducklings, is almost completely silent. It is thus obvious that her vocal performance reflects both the physical and vocal state of her offspring. This fact has been of great importance in collecting information on the distribution of activity and rest in the Mallard nest.

The determination of activity and rest cycles, as registered from a hide, must to some extent be subjective. It is obvious that an alternation occurs and, while both activity and quiescence in their most pronounced forms are easy to characterize by ear or eye, difficulties lie in defining the limits particularly, for instance, when a single duckling shows movement during an otherwise idle period. The following principles were employed: a period of activity was considered to begin when more than one duckling came out from under the female. Thus the appearance of only one duckling was discounted. The period terminated when the last duckling disappeared beneath the parent. A short pause was not counted if most of the ducklings were actually outside. The vocal activity in the nest also helped in defining the limits of different periods.

As a result of the discovery of activity cycles different techniques of vocal recording were employed. The intention now was to give a general description of the distribution of activity and rest, and thus in 1966 the sound-recordings were taken in two lengthy sessions at each nest, one just after hatching and the other at the end of the ducklings' stay. Eleven nests were observed from hides for a total of 58 hours, during which time the sounds produced in most of the active periods were recorded. Five of these nests were observed for a period shortly after hatching (in the afternoon and evening of the day of hatching) and for a second period before and including the exodus (in the morning of the day after hatching). The remaining six nests were observed only before and through the exodus.

In order to give a general description of events in the Mallard nest, material from all nests has been treated together. This assumes that no major differences exist between different types of nests and that the pattern of activity does not show any regular change such as a decrease in interval length as the ducklings grow older. No statistical tests have been made but, in general, data confirm the validity of these assumptions. From the results shown in Figures 3 and 4, it can be seen that the interval between the start of one period of activity and the beginning of the next has been usually 30-50 minutes, and that each period of activity has lasted 3-12 minutes.

The sounds produced by female and ducklings were recorded in 53 out of the 73 active periods studied. In 7 out of 11 nests studied, the vocal activity before and through the departure was taped and

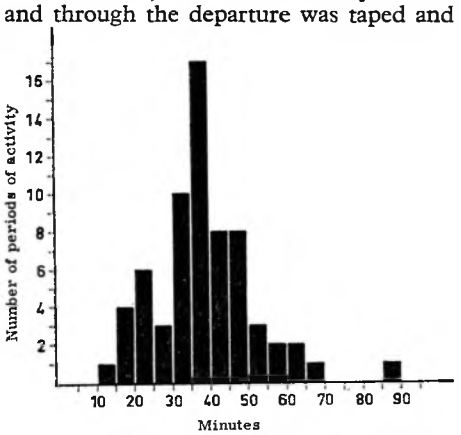

Figure 3. The time between two consecutive periods of activity. The time is taken from the beginning of one period to the beginning of the next.

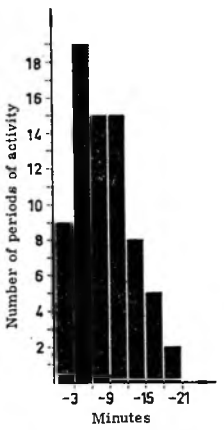

Figure 4. The length of 73 periods of activity studied in 11 different Mallard nests.

thus recordings from 60 periods of activity are available for analysis. The rate of the female's vocalizations has been determined as the average number of calls per minute and the figures have been rounded to the nearest whole number. The result is given in Table VII, which shows that, although the rate of female vocalization shows great fluctuation, it very obviously increases as the time of exodus approaches. During the period that included the departure from the nest, vocal activity was very high, in the range of 66-200 calls per minute.

Table VII. The vocal activity of the female during periods of activity in seven different nests.

Number of calls/minute from the female during periods of activity					
20-10 hours before exodus			*7.5-0 hours before exodus*		
Periods	*Mean*	*Range*	*Periods*	*Mean*	*Range*
14	8	0-46	46	40	0-219

Discussion

The laboratory experiments on imprinting and following in artificially-hatched nidifugous birds have been fully summarized by, for instance, Bateson (1966). Records of the length of the ducklings' stay in the natural nest, however, seem rather scattered. For the Mallard, the age of the ducklings at the time of departure from the nests has been reported as 6-12 hours (Raitasuo 1964) and 10-12 hours (Girard 1941, Weidmann 1956). Kear (1965) found that Mallard ducklings leave the nest 10-12 hours after the last duckling has dried, but that the time varies according to the time of day and weather conditions. Kear's results show the closest agreement with those of the present study. For other *Anas* species, the age of ducklings of Blue-winged Teal has been found to be 18 hours (Collias and Collias 1956) and less than 12 hours (Bennet 1938, Glover 1956), and of Pintail *A. acuta* less than 24 hours (Sowls 1955). Ducklings of Cape Shoveler *A. smithii* were observed to depart from the nest in one study as soon as they were dry (Brand 1961) which should mean at an age of only a couple of hours, and in another before 48 hours old (Siegfried 1965). For ground-nesting diving ducks the figures reported for Canvasback *Aythya valisineria* are about 24 hours (Collias and Collias 1956), for Tufted Duck *A. fuligula* often more than 24 hours (Fabricius 1964) and about 48 hours (Nordberg 1950), for Redhead 3-18 hours (Low 1945) and for Eider *Somateria mollissima* less than 24 hours (Flint 1955) and about 48 hours (Nordberg 1950). For hole-nesting ducks the corresponding figure for Goldeneye *Bucephala clangula* is 24-37½ hours (Siren 1953) while the ducklings of Wood Duck are found to leave the nest on the day after hatching (Leopold 1951), presumably about 24 hours old. For Canada Geese *Branta canadensis*, 24 hours has been reported by both Kossack (1950) and Brakhage (1965).

Of the values presented, many are notably multiples of 12, and since the methods used in determination are not described, it seems likely that some are very approximate. Nevertheless, it is reasonable to assume that the ducklings of many species are older than 16 hours when leaving the nest.

Weller (1964) reports of ducks in general that if the weather is bad departure can take place 2-3 days after hatching, and 3 days has been mentioned for Eider (Gerasimova and Barabanova 1960) in a similar situation. Leopold (1951) was also of the opinion that departure can be delayed in bad weather, but for a few hours only and in any case for less than half a day. In the present study no obvious correlation with weather has been observed, although detailed measurements of temperature, precipitation, etc., were not taken. Nevertheless, broods were sometimes seen to leave the nest during heavy rain, apparently ignoring it. Temperature might be of greater importance since, in chicks of domestic fowl, it has been found that cold slows the appearance of the following response due to its physiological effect on general motor activity (Salzen and Tomlin 1963).

In the course of the present study the possibility of the ducklings becoming imprinted on the female during the stay in the nest was examined. Of special importance was the length of time the ducklings must be exposed to the female and her calls for imprinting to be established. An approximate idea might be obtained from some of the laboratory experiments previously mentioned in which, at ages ranging from just a few hours to 50 hours, Mallard ducklings were exposed to synchronous visual and auditory stimuli in a training situation (Ramsay and Hess 1954, Klopfer 1957, 1959, Gottlieb 1961, Klopfer and Gottlieb 1962a, 1962b).

Tests have shown that exposure to the object for 10-30 minutes was sufficient for imprinting to be established, although to a varying extent in different age-classes. Weidmann (1956) considered that some of the results presented by Ramsay and Hess (1954) indicated that 10 minutes might be too short. He devised an experiment in which the ducklings were first exposed to an object emitting a sound and then tested in a choice-situation of the same object without sound and another object with that sound. In this test only a small fraction of the ducklings chose the silent training object. This might be caused by a conflict between visual and auditory stimuli.

Gottlieb (1961, 1965b) has used only visual stimuli and exposed ducklings, all less than 27 hours old, to an object for 20 minutes. The following-reaction during the training in this case was less intensive, but a fairly high percentage of the ducklings that followed also became visually imprinted. Finally, Klopfer (1959) used solely auditory stimuli, with the total exposure time of 30 minutes. Here also a following-reaction was observed during training. It was less intensive, however, than that in experiments with combined visual and auditory stimuli, and in a later test imprinting on sound only was not observed. Gottlieb (1965b) also reported that newly-hatched Mallard ducklings seem to have an unlearnt preference for the maternal call of their own species and that this preference was highly resistant to change through experience.

It is probably impossible to establish from a hide the length of time that ducklings in any nest are exposed to stimuli that might result in imprinting on their mother. Some generalizations must be made and to begin with it will be assumed that imprinting only occurs when the ducklings are 13-16 hours old. From Figure 3 it can be calculated that, on average, 38 minutes pass from the beginning of one period of activity to the beginning of the next. There were no observations indicating exceptional activity of the birds during the period 13-16 hours as compared to that during the adjacent periods on either side, so four bouts of activity usually occurred during this, as in any other 3 hour period (except perhaps in the first hour or two). The standard deviation of intervals between activity bouts amounted to 13 minutes and thus it was quite common for three or five active periods to occur in the same 13-16 hour period. The duration of active periods was 9 minutes on average and the standard deviation 4.6 minutes. Although every duckling does not spend all periods of activity completely outside the female, these figures suggest that it must be quite common for most of the brood to spend at least 30 minutes of the 13-16 hour period outside, and it is very unlikely that each duckling has been outside her plumage for less than 10 minutes of the period. These figures correspond with the 10-30 minutes that, in laboratory experiments with visual or combined visual and acoustic stimuli, were sufficient for imprinting to occur. Hence, it is concluded that visual imprinting in natural conditions can occur during the Mallard ducklings' stay in the nest. Further evidence for this is provided by experiments where a degree of imprinting has been observed even earlier than the critical period (Fabricius 1951, Ramsay and Hess 1954, Gottlieb 1961). These, and the present observations that the behaviour of the birds during the 13-16 hour period does not differ from that during the rest of their nest-life, indicate that the critical period is much less limited in time than Ramsay and Hess (1954) postulated. The appearance of escape-reactions, for instance, has often been said to define the upper limits of the age when imprinting can occur. Ramsay and Hess (1954) did not observe escape-reactions in the laboratory until their ducklings were over 24 hours of age, but under natural conditions these can be seen much earlier, even before the ducklings are 10 hours old. In a laboratory test at Oster-Malma 32% of the ducklings aged 13-16 hours showed escape-reaction when confronted with an object after previous visual isolation (Fabricius, Bjärvall and Fält unpubl.).

Little information seems to have been published about the chronology of egg hatching. Among certain Central American passerines, Skutch (1952) described the eggs of flycatchers *Myiozetetes* hatching at the end of the night or in the morning but almost never in the afternoon, *Ramphocelus passerinii* in the morning but almost never at night and many other species in the afternoon. One Mallard and three Blue-winged Teal nests (Girard 1941, Glover 1956) were reported to hatch during the day. The reason for the tendency to hatch at some times of the day rather than others was supposed by Skutch to result partly from a very constant incubation-period combined with egg-laying at the same time every day and partly from an innate daily rhythm in the embryos. Klopfer (1957, 1959), in studying incubator-hatched eggs of several species of waterfowl including Mallard, stated that hatching at night was less

common than hatching during the day. In an incubator the light, temperature and humidity are more or less constant, so a difference in hatching time could be caused either by a circadian rhythm or by auditory stimulation between the unhatched eggs, as Vince (1964, 1966a, 1966b) has described for some Quail species *Coturnix*. Such auditory stimulation might occur when the number of eggs is small, as in Klopfer's study, for large numbers of Mallard eggs have been artificially hatched at Oster-Malma without any difference between day and night being observed. It seems more probable that the difference between day and night hatching in natural clutches (Figure 1) is caused by the activity of the female. Her excursions from the nest take place almost exclusively during the day (Girard 1941) and on her return she brings moisture which is of very great importance for the actual hatching (Baerends 1959, Collias 1962).

Departures of duck and ducklings from the nest observed in this study have occurred during the day, with an obvious concentration in the morning hours (Figure 2). Information in the literature on the time at which broods leave for the first time after hatching, is rather scattered; for Mallard, Robinson (1940) and Girard (1941) have reported that, on single occasions, it occurred at 11.00 and before 08.00 respectively. Single broods of Blue-winged Teal, Canvasback and Canada Goose have been observed leaving their nests at 08.21 (Collias and Collias 1956), 09.01 (Collias and Collias 1956) and 08.00 (Craighead and Stockstad 1958) respectively. For Goldeneye, Siren (1952) stated that departures always occurred between 07.36 and 10.51. For Wood Duck and the Canada Goose respectively, Leopold (1951) and Brakhage (1965) reported departure to take place in the morning. Apart from the old concept that 'the night must be the calmest and most peaceful time for such an undertaking' (Merikallio 1916), previous findings are in good accord with the results of the present study. The only divergence seems to be in the departure of Mallard from hole-nests, where to a certain extent (Table III) a delay is to be found and departure takes place in the afternoon.

The difference in hatching success between ground- and hole-nests (Tables IV and V) could be the cause of this delay if unhatched eggs in the nest stimulated the female to stay longer. Table VI, however, indicates that this is not the case. At present it seems more probable that the difference lies in the behaviour of the ducklings. The actual departure from the nest has occurred, in every case observed, in the course of a period of activity and although the initiative is taken by the female it is apparently released by the behaviour of the ducklings.

The structure of a hole-nest reduces the light and restricts the movements of the ducklings. This might reduce the possibilities for visual, and even also for auditory imprinting, during the nest stage. Furthermore, the ducklings' actual departure from a hole seems to be solely in response to an auditory signal from the mother on the water below, while departure from an ordinary ground-nest is directed by both auditory and visual stimuli (a heterogeneous summation). In an earlier paper (Bjärvall 1967) these factors were thought to contribute to the delay and some observations of holdups in departures from hole-nests were related.

Kear (1967), in studying the behaviour of young nidifugous birds on a visual cliff, obtained some results of interest here. She found that young of ground-nesting species avoided the drop side of the visual cliff, while those of hole-nesting species chose equally the drop and the shallow side. The Mallard, which nests principally on the ground but on occasions also in trees, gave an intermediate score. Partial avoidance of the drop, therefore, may also contribute to the observed delay.

On two occasions holdups like those earlier seen at hole-nests were observed at ground-nests. In the first case the female tried to leave the nest at 11.32 at which time every duckling of the brood was younger than $9\frac{3}{4}$ hours and the youngest less than $7\frac{3}{4}$ hours. When none of the ducklings showed the least sign of following her she returned to the nest. About an hour later, at 12.38, she made a second attempt and this time the whole brood followed immediately. In the second case the female tried to leave the nest at 08.25. At that time the eldest duckling was older than $23\frac{3}{4}$ hours but the youngest less than 14 hours. The female stopped about 1 metre away, with the ducklings spread out in a line between her and the nest, and then returned. At 09.00 she made a second attempt and this time all but two ducklings followed but these stayed in the nest giving vigorous distress-calls. At the third attempt at 09.35 the whole brood except one duckling followed the female about 3 m. away from the nest. The final departure, when all ducklings followed, did not occur until the fourth attempt at 10.13.

In these two nests the ducklings' initial refusals to follow the female could not

depend on any 'visual-cliff' effect, since the nests were situated on flat ground, but the events show obvious similarity to those observed several times at hole-nests. It is suggested that the reduced possibilities for imprinting that occur in the hole, the fact that the exodus is largely in response to auditory stimuli only and, perhaps, an avoidance of the drop, are the factors contributing to the delay found in leaving nest-sites that are elevated and enclosed.

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Summary

Under experimental conditions the strongest and most complete imprinting by Mallard ducklings has been found to occur at the age of 13-16 hours. This interval has been called the critical period.

A study was made of the chronology of hatching and exodus from Mallard nests under natural conditions. It was found that the ducklings normally spend the critical period in the nest and that ducklings hatched in nests situated above ground (hole-nests) are older at exodus than are ducklings from an ordinary ground-nest.

The hatching success, expressed as the number of unhatched eggs left in the nest, was lower in hole-nests than in ground-nests. The female Mallard can, if all eggs of her clutch fail to hatch, continue the incubation for much longer than normal. The delay did not however seem to be correlated to the presence of a small number of unhatched eggs in the nest.

Observations were made on the behaviour of female and ducklings in the nest. The ducklings spent periods of activity outside the female's plumage and periods of rest, usually under the female. During the periods of activity the ducklings utter 'contentment notes' and the female 'maternal calls'. A description of the female's vocal activity is given.

A comparison between the pattern of activity of the ducklings in the nest and results of laboratory experiments suggests that the ducklings under natural conditions spend enough time outside the female's plumage to make imprinting possible.

The delay found in hole-nests is discussed. Contributory factors to the delay may include reduced possibilities for imprinting in hole-nests, the exodus being in response solely to auditory stimuli, and the effect of the 'visual cliff'.

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Adoption of young by Versicolor Teal and other wildfowl

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It is well known that a pair of Common Shelduck or European Eider will, in the wild state, foster the families of other pairs. I myself have seen two Shelduck with 30 ducklings of widely varying ages. However, little is known about adoption in other species of waterfowl.

For some years I have reared ducklings on the free-range system, i.e. broods of ducklings with their bantam foster-parents are put out in small pens on the water's edge in the enclosure where I keep my breeding pairs of duck. The ducklings, during the day, range at will all over the enclosure mixing with adult ducks. They return to their bantam to rest during the day and to sleep at night. When they are all tucked under the hen in the evening I close the entrance to the rearing pen which is then rat-proof. They are let out first thing in the morning. My waterfowl enclosure, incidentally, consists of a stream about 150 yards long running through an acre of land.

Due to this rearing system and the opportunities it offers for observation, I have come to the conclusion that adoption is practised, in certain circumstances, by a variety of species of duck and probably geese. The circumstances which induce adoption appear to be:

A, when a sitting duck has had her eggs taken from her.

B, when a duck has recently lost her brood.

In one instance a bantam had two Versicolor ducklings aged about 3 weeks. A pair of Versicolor, whose second clutch I had recently taken, set about abducting these two ducklings. Wherever the ducklings went the Versicolor duck and drake shadowed them. Their approach was very gentle and accompanied by muffled quacks from the duck and a soft nasal purr from the drake. When the ducklings were shut up at night the Versicolor duck and drake slept as close as possible to the bantam coop, keeping up a continuous soft chatter. The duck sat in a brooding posture and shuffled to form a scoop. Within four days the adoption was complete, the ducklings no longer showing any interest in their bantam foster-mother. The Versicolor drake did not brood the ducklings but acted as escort and never left them.

A week or two later when the second clutch of Versicolor hatched (six of them) I put them out under a bantam just as I had done the first two. When these were two or three days old I was, for some reason or other, unable to shut them up one night. The following morning I looked under the bantam hen and found she had no ducklings. The Versicolor drake was looking after the two large ducklings but his duck was missing. I searched and found her brooding the six babies in a reed bed. During the night or early in the morning she must have enticed the lot away from the bantam. From then on the two broods amalgamated and all were reared. This business of Versicolors stealing ducklings from bantams happens here every rearing season. Last year, having stolen and reared their early brood, they nested again. This may indicate that the species is double-brooded in the wild.

It seems that Versicolors prefer to adopt ducklings of their own species. They ignore ducklings of other species if there are available ducklings of their own kind. However, I have found that they will adopt ducklings of other species rather than be deprived of a family altogether. I allowed a Cinnamon Teal to hatch her own eggs. She came off with four ducklings. The day they left the nest a vandal shot and killed their mother. The evening was chilly when I went down to the stream and heard the pathetic piping of the little orphans. To catch them would have been difficult and almost certainly they would not have accepted a bantam foster or mixed with another brood. Left to their own devices it seemed certain they would perish from cold but I decided they must take that chance. It was nearly dark when I revisited the stream, all was quiet, not a sound from the little ducklings nor was there any sign of them. The following morning there they were, full of life and escorted by a pair of Versicolors who must have brooded them overnight. All were reared.

Versicolors are wonderful parents, not only will they protect their ducklings from rats but they will, if approached too closely, attack a human being, keeping up the attack for a distance of 30 or 40 yards. When they do this their ducklings huddle together in mid-stream and await their parents' return, as if instructed to do so.

One year, a European Green-winged Teal duck, whose eggs I had taken, enticed away from their bantam a brood of European Wigeon which was two weeks old. Whenever I went down to the stream

the Teal duck swam right up to me and then flapped around just as a wild Teal will do if danger threatens her family. When she did this her Wigeon ducklings fled for cover.

On another occasion a Red-breasted Goose whose goslings had been stolen and whose gander had been beaten up by thugs, attached herself to a pair of Versicolors with a very young brood. The goose did her best to share the task of rearing them and would not be parted from them. The Versicolors did not seem to object to her presence.

I have also had a case of a duckling inviting adoption. A wild Mallard duckling was washed down the overflow pipe from the pool above my enclosure and into my stream. Being unable to find the way back to its mother, who kept answering its calls, the little creature drifted away downstream. Lonely and afraid, it came upon a Wigeon duck. To this it snuggled up, keeping close to the Wigeon's breast. This invitation to be adopted was rejected and it then made overtures to another duck with the same result. About half an hour after sunset a brood of Teal came swimming by on the way to their brooding pen. The Mallard duckling tagged on to them, followed them into the pen and without any hesitation ran up the ramp, into the coop and straight under the hen. From then onwards it lived with the brood of Teal and made no attempt to rejoin its mother on the pool about 100 yards away.

I have evidence that Red-crested Pochard readily adopt ducklings of their own species. At one time I used to rear ducklings under a bantam in small pens in which the ducklings were confined all the time. There were about twelve of these pens situated in the enclosure, all in line and semi-detached. Sometimes each pen held a brood of ducklings: Carolinas in one, Cinnamon Teal in another, Wigeon in another and so on. In one of these pens there was a brood of Red-crested Pochard. My Red-crested Pochard duck immediately picked out the pochard brood and sat outside their pen all day trying to entice or get to the ducklings. Ducklings of varieties other than her own did not interest her. Her behaviour was identical with that of the Versicolors when they were trying to entice ducklings except, of course, that the drake Red-crested Pochard showed no interest in his offspring.

Janet Kear adds:

Mr. Wintle's excellent observations show how much of scientific interest can be achieved by an aviculturist with even a small collection of waterfowl. We hope that others will be encouraged to study the behaviour of their birds in a similar way. Captive waterfowl seem to behave, within certain limits, much as they do in the wild and because many breed readily and become engagingly tame, all manner of interesting things happen in full view.

At the Wildfowl Trust we have also had a recent case of a failed breeder adopting the young of another bird. In 1967 our Spur-winged Goose female, who has no mate but often lays, was given some Mallard eggs to sit on, of which she hatched three. It was a comic sight to see these tiny creatures brooded, led and vigorously defended by such a monster. When the ducklings were about a week old, the party was adopted by a Mallard female, who had laid in the same pen but had recently lost her clutch. All five birds became inseparable, and at first the two females shared the duties of brooding and defence in apparent harmony. Finally, however, the Mallard took over the ducklings entirely and it was she they ran to when danger threatened.

It seems that frustrated parenthood produces, in some birds, the strongest urge towards adoption. It has been suggested by a number of workers that the 'guardian' adults, found with crèches of flamingo, shelduck or eider young, are not in fact the parents of any of the chicks, but failed breeders. In Common Shelduck, most parents leave on moult migration while their young are still downy. It is possible that in frustrated adults even this strong migratory tendency can be overcome by the sight and sound of deserted ducklings.

Mr. Wintle has also provided further evidence that newly-hatched wildfowl are not always irreversibly 'imprinted' on the first large moving object that they see, since the Versicolor babies were enticed away from their foster bantam by an adult pair of their own species.

D. S. Wintle, The Glen, Vine Road, Clent, Worcestershire.

Ecology of waterfowl in the region of Lake Neusiedl, Austria, particularly in the World Wildlife Fund Seewinkel Reserve

ANTAL FESTETICS and BERND LEISLER

In the List of European and North African Wetlands of International Importance (Olney 1965) the region of the Lake of Neusiedl, Austria, was considered of high importance for the future of European wildfowl populations. The first World Wildlife Fund Reserve in the region having been founded in 1965, the scientific council of the Austrian National Appeal (Chairman: Dr. A. Festetics), together with the Austrian Delegation of the International Wildfowl Research Bureau (geese: Dr. K. Bauer; ducks: K. Mazzucco; waders: B. Leisler), decided to start ecological research in the whole of the region and particularly in the Reserve with a view to establishing a management plan. The programme follows that of Szijj and Hudec (1968), namely: (1) compilation of wetland lists; there exists a good summary by Löffler (1959) and in 'Landschaft Neusiedlersee' published by Sauerzopf and Tauber (1959). (2) Quantitative faunistic research: useful quantitative data is only available from 1966 onwards. (3) Establishment of an ecological sketch: this paper is the chapter concerning waterfowl. (4) Research on the effects of habitat factors: some of our collaborators have started work on these problems. (5) Ecological report on the development of the wetland as a transition towards its practical management.

For advice and stimulation we thank Dr. Luc Hoffmann (I.W.R.B.), for support and help Dr. F. Sauerzopf (Burgenländische Landesregierung) and Dr. H. Freundl (W.W.F., Austrian National Appeal) and finally, but very sincerely, the students of zoology of the University of Vienna and the collaborators of the Austrian Bird Station to whose harmonious team-work it is due that the basis of this work has been established so quickly.

I. The region of the Lake of Neusiedl

(See Plates V to VIII, p. 84)

The region of Lake Neusiedl (hereafter called simply 'the Lake') represents a mosaic of varied types of habitats in the middle of Central Europe and is situated mainly in the Burgenland, the easternmost Austrian province; only a very small part is in Hungarian territory (Figure 1). It is confined by lateral spurs of the Alps (to the west), by those of the Carpathians (to the north), and by the Little Hungarian Plain (to the east and south). The Lake itself is bordered in the west by the Ruster Höhenzug and the Leithagebirge, in the north by the Wagram of the Parndorfer Platte, in the south by the Wagram of the alluvial gravel terrace between Sopron and Kapuvar (which is in Hungary). Eastwards the basin is open towards Hungary over the steppe of the 'Seewinkel' and the bogs of the 'Hansag'. The region may be sub-divided into five parts:

1. *Leithagebirge and Ruster Höhenzug*

The Leitha hills, an almost unbroken chain about 30 km. long and on average 400 m. high, and the Ruster Hills, 21 km. long and 280 m. high, were originally covered with oak woods. Their eastern slopes now hold chiefly abandoned pastures and vineyards. Besides a typical Central European fauna, e.g. Red Deer *Cervus elaphus*, Edible Dormouse *Glis glis*, Woodcock *Scolopax rusticola* and Chaffinch, *Fringilla coelebs*, many arid-region forms can be found on the eastern slopes, e.g. Green Lizard *Lacerta viridis*, Roller *Coracias garrulus*, Hoopoe *Upupa epops*, Ortolan Bunting *Emberiza hortulana*.

2. *The Parndorfer Platte*

This alluvial gravel terrace, on average 40 m. higher than the surface of the Lake, is about 20 km. long and 18 km. broad, and falls steeply southwards into the Lake. Originally covered with short grass pastures and grazed fairly extensively, it is now almost entirely arable. Some vanishing elements of the Pannonic steppe fauna, e.g. European Suslik *Citellus citellus*, Great Bustard *Otis tarda*, Stone Curlew *Burhinus oedicnemus*, Saker Falcon *Falco cherrug* and Bee-eater *Merops apiaster* are here gradually replaced by managed game, e.g. Hare *Lepus europaeus*, Roe Deer *Capreolus capreolus*, Partridge *Perdix perdix* and Pheasant *Phasianus colchicus*.

3. *The Lake of Neusiedl and its reed belt*

The Lake is 36 km. long, 7 to 15 km. wide, covers 320 km^2. (124 sq. miles) and on average is 1 to 1½ m. deep. Two-fifths of it is reed beds. Its only influx is the

River Wulka and the only outlet was the Einser Canal, built in 1910, by which the Lake should have drained towards the Danube. This artificial outlet, however, is silted up. The Lake is therefore without outlets and shows strong fluctuations. Long-term fluctuations have led to total drying-up more than once (for example in the years 1865 and 1872). Seasonal variations are very important for the breeding birds as the average difference between spring and summer water level is 25 cm. Sudden changes in level are due to changes in direction and strength of the prevailing winds. Waves of more than a metre high can then be raised and parts of the Lake's bed uncovered. Northerly or southerly winds often cause 'catastrophes'' i.e. mass death of fish, and the prevailing winds also limit the expansion of the reed belt on certain stretches of the Lake. The Lake is very slightly brackish with inorganic turbidity colouring it milky-white. Due to the strong turbulence no vertical stratification of plankton is possible, and horizontal dispersion predominates. One stretch of the Lake shore (at Podersdorf) is free of reeds, but along the southern, western and northern shores a large uniform reed bed is bordered lakewards by a zone of submerged plants such as fennel-leaved pondweed *Potamogeton pectinatus*.

The fish live mainly in the reeds and

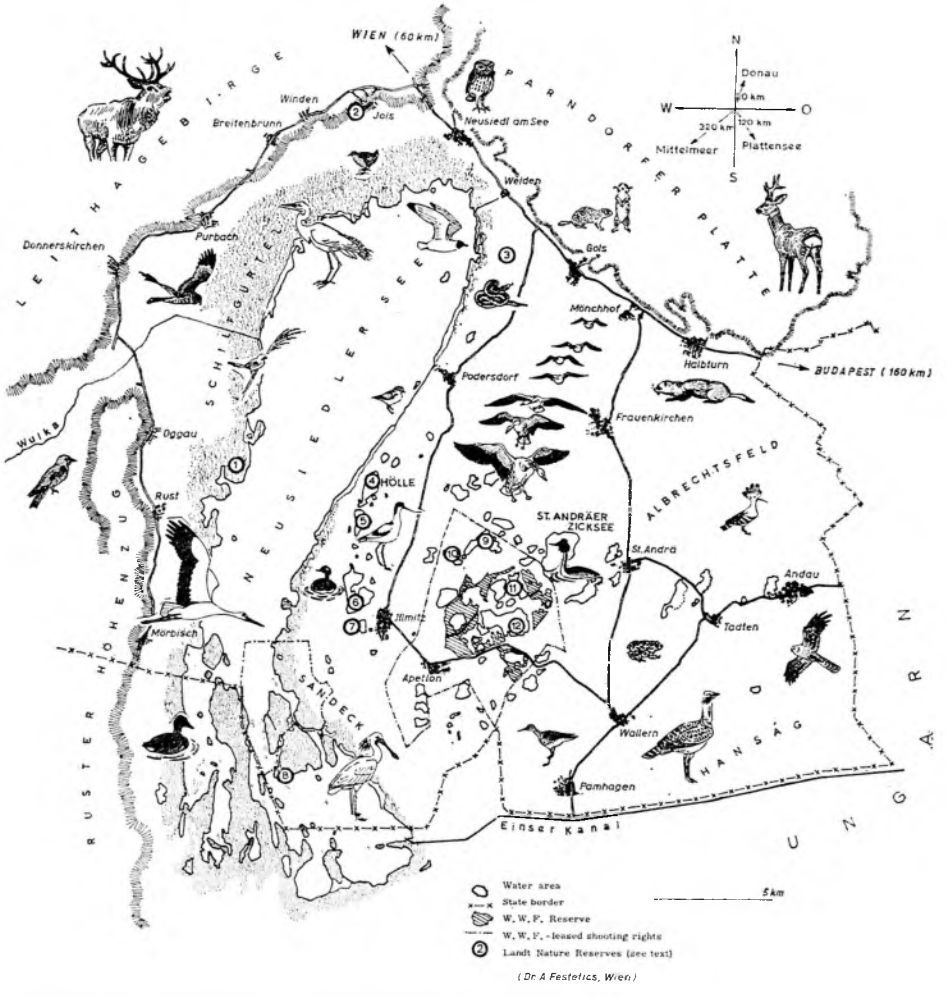

Figure 1. The whole region of Lake Neusiedl
The parts of the area are indicated with their German names and are explained in the text. Seewinkel (not mentioned on the map) is the whole area between the Lake Neusiedl, the Parndorfer Platte and the Hungarian border. Only the Hansag in the south-eastern point is to be considered apart.

A. Festetics

Plate V. Wildfowl at Lange Lacke, on the World Wildlife Fund Reserve, in Austria. (a) Greylag Geese. (b) Mallard (1,900 birds). (c) Mixed ducks at rest (See p. 83)

A. Festetics

Plate VI. The last herd of cattle in the Seewinkel (a) plays an essential role in the ecology, keeping the grassland (b) firm and short for the geese. The spiny plants which are left provide nesting cover for Pintail and Garganey. (See p. 94)

A. Festetics

A. Festetics

Plate VII. (a) The effect of grazing by Greylags which helps to limit the extent of reed cover.
(b) Where cattle do not graze, the grass becomes long and useless for geese. In the background are the encroaching vineyards. (See p. 94)

A. Festetics

A. Festetics

Plate VIII. Next to the Mallard, Teal (a) are the commonest wintering duck in the Lake Neusiedl area, their main feeding grounds being flooded pastures (b), here mainly *Aster pannonicus*. (See p. 94)

A. Festetics

pondweed belt because organic decay produces 'brown water' which is clear compared to the turbid open Lake. The main species are Hungarian Wild Carp *Cyprinus carpio* var. *hungaricus*, Pike *Esox lucius* and Rudd *Leuciscus erythrophthalmus*. The reed *Phragmites communis* can grow up to 5 metres high and forms large undisturbed areas. Great White Heron *Egretta alba*, Purple Heron *Ardea purpurea*, Grey Heron *A. cinerea* and Spoonbill *Platelea leucorodia* breed here in four to six large colonies totalling 800 to 900 pairs. In this continuously-flooded reed belt many other bird species breed, including 5 species of warblers *Acrocephalus* spp. Near the shore the reed belt is seasonally dry with an undergrowth of large sedges *Carex* spp., the breeding habitat of the Marsh Harrier *Circus aeruginosus*, Water Rail *Rallus aquaticus*, Spotted Crake *Porzana porzana*, Little Crake *Porzana parva*, Bluethroat, *Cyanosylvia svecica*, and Bearded Tit *Panurus biarmicus*. This zone is followed by sedge and rush marsh *Carex* and *Juncus* spp. and grass fields *Festuca rubra* in which breed Yellow Wagtail *Motacilla flava* and Lapwing *Vanellus vanellus*.

In between this large grassland zone and the first outliers of the mountains there is a wide zone of arable land and orchards.

4. *The Seewinkel*

This is the plain between the Lake and the Hungarian border, with the exception of the 'Hansag' in the south-east, about 120 m. above sea level. It can be divided into three soil regions: (a) the eastern Lake shore where a natural sandy dyke, 4 m. high, follows the whole length of the shore; (b) the northern part, together with the 'Albrechtsfeld' in the east, which consists of a black-earth terrace; and (c) the southern, Seewinkel, which has a continental salt soil. The W.W.F. reserve is at its centre (Figure 1). The eastern Lake shore (to the north of Podersdorf) is wet grassland with Orsini's Viper *Vipera ursinii*, Redshank *Tringa totanus* and Black-tailed Godwit *Limosa limosa*; to the south it is sandy and gravelly with Little Ringed Plover *Charadrius dubius*, Kentish Plover *Charadrius alexandrinus* and Stone Curlew as breeding birds, but most of this area is now vineyards. Further to the south, the eastern shore becomes marshy at Sandeck. There the W.W.F. has bought the hunting rights over 500 hectares. The black-earth terrace, originally used for grazing, is now almost entirely converted into arable land. The saline soil terrace is the most important part of the whole region for most of the bird groups. About 30 large shallow impermanent alkaline ponds, with white salt shores in summer, give their own charm to the region. They can be divided into 'black ponds' with rich vegetation and organic decay, and 'white ponds' with poor vegetation and inorganic turbidity. The average depth of these ponds is 40 to 60 cm., and only the St. Andräer Zicksee is 1.5 m. deep and so — by limnological definition — a lake, whereas even the Lake of Neusiedl should in fact be called a pond! The St. Andräer Zicksee and a few other of the bigger ponds hold water during the summer (Lange Lacke, Darscho Lacke, Fuchslochlacke, Ochsenbrunnlacke), the others drying up completely. In the last decades increasing expansion of reed in the pond region has caused the local replacement of coastal species like Common Tern *Sterna hirundo* and Avocet *Recurvirostra avosetta* by species typical of reed-covered inland lakes, e.g. Bittern *Botaurus stellaris*. The ponds which are in part very brackish (the main salts are Na_2SO_4, $NaCO_3$, $MgCl_2$) have a plankton relatively poor in species but locally and temporarily rich in individuals, especially small halophilous crustacean such as *Branchinecta ferox* and in Cyprinid fish such as Crucian Carp *Carassius carassius*.

On the open soda areas grow typical halophytes such as a pepperwort *Lepidium cartilagineum*, a saltwort *Camphorosma annua* and a saltmarsh grass *Puccinellia limosa*. Halophile sucking-bugs *Rynchota* and beetles *Coleoptera* such as the Salt Ground Beetle *Cicindela nemoralis* live there, also the southern Russian Tarantula *Allohogna singoriensis*. This is the breeding habitat of the Kentish Plover and Avocet. In addition to wet grassland with Lapwing, Redshank and Black-tailed Godwit, we find here the last grazed steppes of the whole region. The lower and less salty regions consist mainly of a plant association characterised by salt mud rush *Juncus gerardii*, the higher places being overgrown by dry grassland associations dominated by a fescue *Festuca pseudovinae*. Cattle have rendered this grassland felt-like by trampling, grazing and dunging. It forms, with some scattered prickly restharrow *Ononis spinosa*, musk thistle *Carduus nutans* and bermuda-grass *Cynodon dactylon*, a habitat for many burrowing rodents, such as the Common Vole *Microtus arvalis*, also the Asiatic Polecat *Mustela eversmanni*

and Skylarks *Alauda arvensis*. The main part of this region, however, has been converted into arable land and vineyards.

5. *The 'Hansag'*

The south-eastern end of the 'Seewinkel' is the tip of a boggy region mainly situated in Hungary and called the 'Hansag'. It consists of peat overlying alluvial gravel. The fields of large sedge and purple moor-grass *Molinia caerulea* associations are sparsely overgrown with solitary common sallow *Salix cinerea* and birch *Betula pubescens*. In the last decade the 'Hansag' has largely been ploughed up. On the remaining wet peatland live Great Bustard, Montagu's Harrier *Circus pygargus*, Curlew *Numenius arquata* and Roe Deer *Capreolus capreolus*.

Of these five main regions the first (Leithagebirge) has no direct ecological importance for wildfowl. The second (Parndorfer Platte) plays a role as a feeding ground. The third (Neusiedl Lake and its reed belt) is very important as a breeding, feeding, resting and moulting area. The fourth (Seewinkel) will be treated separately because of its outstanding importance, and the fifth (Hansag) is only of minor importance as a breeding and migrating area.

Although the first measures for conservation in this area date from the first World War when the Society of Zoology and Botany of Vienna leased the meadows of Zitzmannsdorf (to the north of Podersdorf), many of the efforts were unsuccessful. Indeed, this first region has been ploughed up, although it was declared a Nature Reserve by the provincial government in 1963. Since 1936 the Austrian Federation for Nature Conservation has leased the most important ponds. This lease was finally taken over by the Government of the Burgenland in 1964 and 1965 (nature conservation in Austria is not a matter of the Federal Government but of the various *Land*). In the region of Lake Neusiedl we now have twelve nature reserves (numbered on Figure 1): 1. Gade-Lacke for the heronries; 2. Hackelsberg for the Pannonic flora; 3. Meadows of Zitzmannsdorf for the Pannonic flora, arthropods, Orsini's Viper, and waders; 4. Oberer Stinkersee for the soda pond habitat; 5. Unterer Stinkersee for waders; 6. Illmitzer Zicksee for marsh birds; 7.

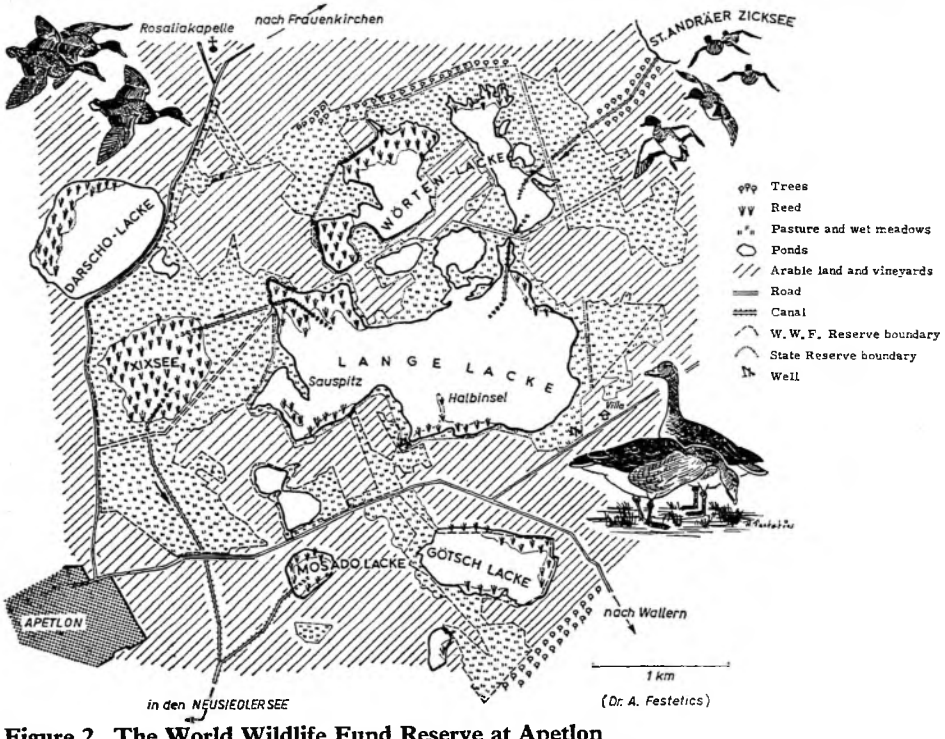

Figure 2. The World Wildlife Fund Reserve at Apetlon
The shorelines of the ponds are variable, e.g. the Wörtenlacke is given on the map at low water, at high water it is one continuous water surface. The channel connects five water surfaces and leads to the Lake Neusiedl. The limits of the reserve correspond roughly with the limits of the last pastures and wet meadows.

Kirchsee for waders; 8. Sandeck for the heron and Spoonbill colonies; 9. Fuchslochlacke for marsh birds; 10. Obere Halbjochlacke for waterfowl; 11. Wörtenlacke for marsh birds; and 12. Lange Lacke as the most typical of the Seewinkel habitat.

Nearly all these reserves are small or consist only of the water surface without any 'buffer zones'. The W.W.F. reserve Lange Lacke (barred on Figure 1, see also Figure 2) is therefore the first large refuge in the Seewinkel. It includes the previously existing government reserve Lange Lacke surrounded by the protective belt of the Hunting Reserve leased by the W.W.F. (Plate V).

II. Waterfowl

This paper will be one of a series forming a complete study of the birds of the Lake of Neusiedl. Each part will deal with one important ecological group. This one, dealing with 'waterfowl', will therefore cover 49 convergent species of various evolutionary origins, in the families: Gaviidae (2 species), Podicipitidae (5 spp.), Phalacrocoracidae (2 spp.), Pelecanidae (1 sp.), Phoenicopteridae (1 sp.), Anatidae (35 spp.), Rallidae (1 sp.) and Alcidae (2 spp.). Of the Anatidae there are 2 swans, 11 geese, 8 surface-feeding ducks, 11 diving ducks and 3 sawbills. They are grouped according to their ecological importance in the region, not according to the systematic order.

Group A includes the 18 species which either breed in the region or of which more than 100 individuals regularly visit it. Group B includes those 10 species of which less than 100 individuals regularly visit the region. Group C is composed of 21 occasional visitors. The species are further grouped according to their systematic position, but only their status and numbers are treated. The numbers are only approximate because systematic and synchronised censuses have only been undertaken since 1966, and are not yet fully analysed.

Group A. Breeding birds or species occurring in large numbers

1. Greylag Goose *Anser anser*

This is a typical breeding species of the region, with the largest stock in Central Europe. The Seewinkel breeding population is estimated at 70 to 100 pairs, and has increased recently because of the increase of reed on the ponds. About the same number may breed around the lake itself, but no *good* estimates are available. The nests, the size of a cart-wheel, are on the outer edge of the flooded reed belt towards the lake, mostly on dead reed. During the breeding season the birds are seldom seen, because they live in the reed and only the non-breeding population (about 200 in all) remains in the centre of the Seewinkel throughout the year. In late spring and early summer the parent birds with their young appear on the meadows which border the reed belt. After the young have fledged and after the moult, the Greylag concentrate mainly around the ponds of the central Seewinkel and along the eastern shore of the Lake. The autumn migration begins in September and a strong influx occurs in October, when numbers reach 2,000 to 5,000 birds. The geese leave in November. Lately there has been a tendency for a few birds (less than 50) to remain in mild winters. When the lakes freeze up completely most of the wildfowl of course leave. Part of the breeding population returns by early February. Up to 1,000 to 2,000 birds pass from the beginning to the middle of March, and are more evenly dispersed on the whole Seewinkel than the autumn migrants.

2. White-fronted Goose *Anser albifrons*

At present the most numerous goose in autumn, the White-fronted Goose visits the region from the beginning of October until the end of November with a maximum concentration of 10,000 to 15,000 birds in November. Compared with the low populations of this species recorded in the early nineteen-sixties, these numbers show a distinct recovery. A small number (less than 1,000) remains even when the lakes are frozen. The spring migration, from the end of February until the beginning of March, involves about 2,000 birds, and tails away quickly.

3. Bean Goose *Anser fabalis*

The large autumn migration, from the end of September to mid-November, reaches a maximum of 10,000 to 12,000 birds at the beginning of October. Its numbers have recovered since the eraly sixties, but less so than those of the White-fronted Goose. Both are far from being as plentiful as they were, sometimes over 100,000 in all (Olney 1965). The Bean Geese also winter in smaller numbers than the Whitefronts (less than 100). The spring migration starts at the beginning of March and goes on until early April with a maximum of about 3,000 birds in mid-March.

4. Mute Swan *Cygnus olor*

Although the Mute Swan is not indigenous, it is mentioned as an example of the risks taken by the casual introduction of foreign species by well-intentioned 'friends of nature'. Since 1941 one to two pairs of Mute Swan have repeatedly been introduced (by the Communities of Neusiedl and Rust) to the reed belt of the Lake. These swans have shown temporary increases but were also depleted either by hunters or by cold winters.

5. Mallard *Anas platyrhynchos*

The Mallard is the most numerous breeding duck. In the Seewinkel there are more than 200 breeding pairs. In the reed belt of the western and northern parts of the Lake itself there are many time more, but we do not have counts. It is all the more difficult to estimate the populations exactly since in the last 20 years semi-feral hybrids between Mallard and domestic duck have several times been introduced and have reproduced in the wild. These again cross-breed with the local wild Mallard and there is now a wide spectrum of colour and sizes. The Mallard nest on floating dead reed, on the banks of ditches, or sunken boats, in weekend-houses, on piles of straw, reed or maize stems, on nests of birds of prey (in the Hansag) and lately also in the nest-baskets put by hunters along the lake shore.

From July onwards the numbers increase rapidly and in mid-September reach a maximum of 15,000 to 35,000 birds for the whole Seewinkel. Of these, about 17,000 to 25,000 birds are on the Lange Lacke alone. The Mallard is the only dabbling duck which breeds and winters (maximum 2,000 birds). These small winter populations fluctuate strongly according to the amount of ice, probably by interchange with those of the Danube, only 20 km. away. The breeding birds return immediately there is a thaw, and begin to pair, becoming difficult to count as they disperse into the reed belt. A small spring passage takes place with a maximum of less than 1,000 birds in mid-March.

6. Teal *Anas crecca*

This species is the second commonest of the migratory ducks. It breeds on most of the nearby wetland areas, i.e. on the Danube, the Morava and in the marshes of the Pre-Alps. Strangely enough, no proof of breeding in the Lake Neusiedl area has been established, though the summering of a few pairs (less than 20) on the Lake, makes this probable. From mid-July onwards numbers increase, reaching a maximum of 2,000 to 5,000 at the beginning of October. The migration ceases in November and only a few birds (less than 50) winter on ice-free ponds. In a total frost they probably move to the Danube (Figure 1). The spring migration is much smaller, starting in mid-February and reaching its peak at the end of March and the beginning of April, but no numbers are available.

7. Garganey *Anas querquedula*

This species is the second commonest of the breeding species with more than 150 pairs in the Seewinkel, but probably none on the Lake. It is typical of the small ponds, ditches and flooded and dry pastures. They often nest up to 500 or even 1,000 m. from the water protected by spiny plants unpalatable to cattle, prickly restharrow and musk thistle. The populations increase from early July to a maximum in the first half of August, and then decrease rapidly in September. No Garganey winter in the region and the spring migration starts at the beginning of March, reaching its peak in mid-April with 1,000 to 1,500 birds. By the end of this month only the breeding birds remain.

8. Shoveler *Anas clypeata*

About 80 breeding pairs of Shoveler nest in dense sedge stands in the Seewinkel. It nests only sparsely and sporadically in the reed belt of the Lake. Breeding Shoveler are strongly dependent on water level fluctuations, having been rare for example in 1934 and 1935, but the commonest nesting duck, after Mallard and Gadwall, in 1940 (Seitz 1942). Autumn passage lasts from the second half of August until all have left by the end of November. The peak is as late as mid- or end October. More birds pass on spring passage which lasts from early March to mid-May and culminates with up to 200 or even 500 individuals in mid-April.

9. Gadwall *Anas strepera*

Fifty breeding pairs of Gadwall breed in the Seewinkel, but only a few in the reed belt of the Lake. They depend even more strongly than the Shoveler on fluctuations of the water level. Since 1937 the species has rapidly increased (Zimmermann 1944) and in 1951 (very high water) the Gadwall was the most numerous breeding duck species in the Seewinkel (Bauer, Freundl and Lugitsch

1955). After that, during some dry years, it has probably only sporadically bred around the lake. The nests are in the wet meadows and on the landward side of the reed belt. The autumn migration is relatively late, occurring in September and October, with a maximum of 500 birds, and all have gone in November. Spring migration starts at the beginning of March and also culminates rather late — from end March to mid-April — with a maximum of 500 to 1,000 birds (500 of them on the Illmitzer Zicksee alone).

10. Pintail *Anas acuta*

This is the rarest of the breeding dabbling ducks with a maximum of 15 pairs and these are restricted to the W.W.F. reserve in the Seewinkel. The nests are completely open in the short grass fields and are the furthest away from water (up to a kilometre). Like the nests of Garganey, they are often protected by prickly restharrow and musk thistle. A small autumn migration occurs, and a stronger spring migration with a maximum of 200 to 500 birds around the beginning of April. The Pintail does not winter in the region. All these numbers vary markedly according to the water level fluctuation.

11. Wigeon *Anas penelope*

There is a regular passage of Wigeon with the largest concentrations on the Lange Lacke from the second half of August until mid-November; the peak (less than 100) occurs in mid-October. None winter, but a very extended spring migration between the beginning of March and the end of May reaches a maximum of 100 to 200 birds in April.

12. Ferruginous Duck *Aythya nyroca*

This is the most numerous breeding diving duck, with about 50 breeding pairs in the Seewinkel and probably fewer in the reed belt of the Lake. Being the most dependent of the diving ducks on water level fluctuations, it is in dry years less common as a breeding species than the Pochard. Breeding has increased since the forties (Zimmermann 1944) and since the fifties it has been common (Bauer, Freundl and Lugitsch 1955). The Ferruginous Duck breeds in the reeds and other densely-growing vegetation along the pond shores. Autumn migration in the region is probably only small and no wintering occurs. Spring migration (from mid-March to the end of April) is more important with a maximum around mid-April of 100 to 200 birds.

13. Pochard *Aythya ferina*

This is the typical diving duck of the soda ponds with 30 to 40 pairs in the central Seewinkel (about half of the breeding stock is on the St. Andräer Zicksee). In the last few decades during its general expansion in Europe (Bezzel 1967) it has also distinctly increased in the Seewinkel. The nests are in the reed beds and on the flooded meadows, on small mounds in the water (the remains of sedges or gull nests), or on the shores of the ponds. The small autumn migration takes place in September with a maximum of less than 500 birds. There is no wintering. The Pochard is the only diving duck species which has a strong spring migration, and in mid-March there are 500 to 1,000 birds for a short while.

14. Goldeneye *Bucephala clangula*

The autumn migration of this species in November and December involves less than 50 birds. A small population of less than 30 birds may winter on the Lake and the St. Andräer Zicksee, if the weather is mild. Spring migration lasts from February to April, exceptionally until mid-May, and reaches its maximum in March with 100 to 200 birds mainly on the larger and deeper ponds and on the Lake.

15. Coot *Fulica atra*

This is a very numerous breeding bird over the whole region. It breeds on nearly all the ponds and along the Lake shore in homogenous stands of reeds, sedges and rushes with high cover; nesting mounds are built on shallow water. In late summer it concentrates on the St. Andräer Zicksee but the breeding birds disappear during September and the last Coot leave at the end of October or the beginning of November. Some single birds may winter on open water. Nothing is yet known about the spring migration. In March about 2,000 to 5,000 birds, including the breeding birds, are present.

16. Black-necked Grebe *Podiceps nigricollis*

Between 150 to 200 pairs breed on the ponds in the Seewinkel. On the Lake it nests only locally and sparsely, with probably less than 50 breeding pairs. There is wide variation between individual ponds, some having whole colonies, and others no breeding at all in some years. The largest colonies are to be found on the Illmitzer Zicksee (up to 70

pairs). It also breeds on small, milky-turbid, strongly-brackish ponds, where cover is good, and often in loose colonies near large colonies of Black-headed Gulls *Larus ridibundus*. The nests are either floating or built on small mounds of the remains of grass or sedge. They are found in the reeds, in sedges or in flooded fields. From the end of August until the end of November the numbers increase slightly but it is not possible to separate migratory from breeding populations. No birds winter and the spring migration, for which there are no quantitative data, lasts between the end of March and the middle of May.

17. Little Grebe *Podiceps ruficollis*

There are more than 100 breeding pairs in the Seewinkel and about an equal number on the Lake. The species has a different breeding habitat from the Black-necked Grebe. It avoids the strongly brackish ponds with inorganic turbidity or breeds there in very small numbers. Depth or the size of the pond are of less importance than the clarity of water together with cover. Suitable habitats exist in the reed belt of the Lake, on the flooded fields and meadows, on some of the ponds and in the many, often small, gravel pits. The floating nests are in loose vegetation, often grouped together but not in such distinct colonies as in the Black-necked Grebe. There is a small autumn migration between October and December. Wintering may occur exceptionally. The spring migration is between the end of February and the beginning of April.

18. Great Crested Grebe *Podiceps cristatus*

This bird breeds on the larger and deeper water areas with about 20 pairs in the Seewinkel and up to 100 on the Lake itself. When the water is low, breeding birds may be absent from the Lake (Koenig 1952). Years of high water have, however, caused an increase since 1940. The St. Andräer Zicksee holds the largest breeding population in the Seewinkel (15 pairs). The species needs a relatively large open water surface and a flooded reed belt where — on the open Lake border — the nests are found. A small autumn migration occurs between September and the beginning of December. No wintering occurs. Spring migration is also of little importance and takes place between February and April.

Group B. Species which occur regularly in small numbers in summer or on migration

1. Tufted Duck *Aythya fuligula*

For the last decade less than 10 pairs of this species have summered regularly in the central part of the Seewinkel. It is possible that the species, which is showing a general trend of expansion towards the south and the west (Festetics 1967), will shortly breed in the region. There is a small autumn migration in October and November and a larger spring migration, of less than 100 birds, in March and April.

2. Red-crested Pochard *Netta rufina*

For about three years, 2-3 pairs of Red-crested Pochard have been summering regularly on two small ponds. From mid-September to mid-November autumn migration takes place and from the end of March to the beginning of April there is a spring migration; both passages involve less than 50 birds.

3. Scaup *Aythya marila*

These are scarce passage migrants with less than 50 birds, mainly in the month of March, on the Lake and on the deeper ponds in the Seewinkel.

4. Goosander *Mergus merganser*

Single birds summer occasionally on the Lake. The species is regularly seen on migration with a maximum of 100 birds in autumn (November-December) and spring (March-April). The largest concentrations, about 50 birds, occur on the St. Andräer Zicksee.

5. Red-breasted Merganser *Mergus serrator*

A regular passage migrant with less than 50 birds, mainly on the Lake (up to 25 in one group) with a few on the deeper ponds.

6. Smew *Mergus albellus*

A regularly migrant with less than 50 birds in winter (December) and spring (February and March), mainly on the Lange Lacke (maximum of 10 birds) and on the St. Andräer Zicksee.

7. Cormorant *Phalacrocorax carbo*

Single birds occur erratically between July and September, mainly on the Lake and on the deeper ponds. Migrates regularly from February to April in varying numbers.

8. Red-necked Grebe *Podiceps griseigena*

These summer irregularly and even possibly breed on two small ponds of the Seewinkel. In the last two years they have regularly been seen on migration (generally less than 10 birds) on the Lake and the larger ponds in spring (between March and May) and autumn (November and December).

9. Black-throated Diver *Gavia arctica*

Regularly seen on migration (less than 20 birds) in November and December on the Lake and on the St. Andräer Zicksee.

10. Red-throated Diver *Gavia stellata*

Odd birds summer exceptionally. Rarely occurs on migration (less than 10 birds) in November-December, mainly on the Lake.

Group C. Irregular migratory species and 'accidentals'

Flamingo *Phoenicopterus ruber*, Whooper Swan *Cygnus cygnus*, Lesser White-fronted Goose *Anser erythropus*, Snow Goose *Anser caerulescens*, Pink-footed Goose *Anser brachyrhynchus*, Brent Goose *Branta bernicla*, Red-breasted Goose *Branta ruficollis*, Barnacle Goose *Branta leucopsis*, Ruddy Shelduck *Casarca ferruginea*, Shelduck *Tadorna tadorna*, Falcated Teal *Anas falcata*, Long-tailed Duck *Clangula hyemalis*, Common Scoter *Melanitta nigra*, Velvet Scoter *Melanitta fusca*, Eider *Somateria mollissima*, White-headed Duck *Oxyura leucocephala*, Slavonian Grebe *Podiceps auritus*, Pygmy Cormorant *Phalacrocorax pygmaeus*, White Pelican *Pelecanus onocrotalus*, Guillemot *Uria aalge*, and Puffin *Fratercula arctica*.

III. Ecology of the waterfowl in the Seewinkel

It is again stressed that this is only a first attempt to give a general idea of the ecology of water birds in a region where up to now a few scattered, specialised studies have been carried out; hence the questionmarks and gaps. Corrections will be necessary later through the further research that we hope will be stimulated. A study on bird ecology was carried out on the reed belt of the western shore of Lake Neusiedl (Koenig 1952). Papers on the Seewinkel (Seitz 1943) and on the whole region of Lake Neusiedl (Zimmermann 1944, Bauer, Freundl and Lugitsch 1955) were mainly faunistic reports. Extensive studies are in preparation on the breeding populations of Anatidae (Leisler and Mazzucco), on the migratory birds (Leisler) and on the ecology of grazing animals (Festetics).

Our quantitative data on the Lake region are still meagre, but, thanks to the smaller and more regular human influence there, the ecological problems are less urgent than in the Seewinkel. This latter region, about 450 km.^{2} between the Lake and the Hungarian border, underwent great changes at the beginning of the fifties, after the departure of the occupation force. Some of the larger ponds, e.g. Golser Lacke, and surrounding wet pastures were drained and two very important wetlands, the Zitzmannsdorfer Wiesen to the north of Podersdorf on the eastern shore of the Lake, were partly drained and ploughed. At the same time most of the pastures in the central Seewinkel were progressively converted into arable land, until the World Wildlife Fund leased the remaining 400 ha. at the last minute (1965) (Figures 1 and 2). Today, with the exception of repeatedly flooded areas, vineyards and other croplands border the ponds, the breeding and 'buffer'-zones (wet, damp, and dry meadows) which are so important for water birds are limited to small stretches of shore. At normal water level the water surface of the ponds in the Seewinkel still totals 2,800 ha. and their sinuous shorelines provide a maximum of edge. Furthermore, the rich variety of wetland habitat types provide highly interesting conditions. The main importance of the region to Anatidae is not for breeding, although Greylag, Gadwall and Shoveler find better conditions here than elsewhere in Central Europe, and the variety of breeding species is impressive. It is much more important for autumn migration, being situated on the western edge of the Carpathian basin and affected by the movements of the birds of the Hungarian plain. Lake Neusiedl is, therefore, one of the most important inland resting places in Europe. The sub-continental climate brings long dry summers and long winter frosts, both forcing water birds to leave the region. The spectacular autumn migration regularly ends with the start of the winter frosts.

1. *Breeding populations*

The 12 species, not including Coot, which breed most frequently in the Seewinkel total about 1,200 pairs, quite remarkable for the size of the water areas. Most of these are Mallard, Garganey, Greylag and Black-necked Grebe. Salt concentration is less important than the

nature of the soil and the consequent structure of the shore, in deciding which ponds are used by waterfowl. In the case of diving ducks, for instance, it seems probable that neither available food nor clearness of the water are the limiting factors, but rather the lack of suitable nest sites. The ponds which are most markedly 'white' with a strong inorganic turbidity and open shores with a scanty halophyte vegetation completely lack breeding dabbling ducks. On ponds with belts of the rush *Bolboschoenus maritimus* breed Coot and Garganey. The most favoured ponds for breeding dabbling ducks are those with dense vegetation belts including associations of reed, large sedges, small sedges and hay-meadows. In years of high water temporarily flooded fields and meadows become important and very rapidly colonised. In recent decades the breeding biotope of Pintail has decreased very much, with the decline of short-grass fields. On the other hand, the decrease of grazing on large parts of the area has led to strong development of the reed belt, providing Greylag with more opportunities for breeding. The Lange Lacke, for instance, was entirely reed free in 1940; now, its shores are one-third covered with reed (Figure 2) and this has attracted two to four breeding pairs of Great Crested Grebe and about 10 pairs of Greylag. The Illmitzer Zicksee, which started to develop reed as long ago at 1941, holds about 20 breeding pairs of Greylag.

Compared with the five species of dabbling ducks, only two species of diving ducks breed (breeding of both Teal and Tufted Duck are expected soon). The reason for this is the shallowness and impermanent character of the ponds (in dry years 20 to 25 of the 30 larger ones dry up completely), as well as the inorganic turbidity of most of them. The two diving ducks are mainly vegetarian and, therefore, ecologically close to the dabbling ducks, but they do not occur in the same biotope. The Ferruginous Duck live on the eutrophic, black, freshwater ponds with dense vegetation, whereas Pochard are to be found on the white, brackish ponds where only reed grows. Among the surface-feeding ducks Teal live on the fresh, clear water while Garganey breed on the soda ponds. Finally, the Little Grebe prefers clear ponds with much cover, the Black-necked Grebe very brackish and turbid ponds. Large uniform zones of marsh plants provide the breeding birds with undisturbed areas, but often lack nesting sites. Therefore, every small structure — old drowned boats, abandoned reed huts, empty nests, and islands of floating reed—form welcome bases for nests.

Very little is known about moulting places and dates. The majority of Greylag seem to moult in the thinner parts of the reed belt on the western and southern shores of the Lake, for instance, in the W.W.F. reserve Sandeck. The Mallard, and probably other dabbling ducks, moult mainly in the larger reed patches of the Seewinkel ponds, but also on the Lake.

Among the main egg predators are the very common Hooded Crow *Corvus corone cornix* and Polecat *Mustela putoris*. The Marsh Harrier takes young birds, but has greatly decreased of late because of strong persecution, to about 20 to 25 pairs in the reed belt of the Lake and about 7 pairs in the Seewinkel (Vande Weghe *in litt.*). The main threat to the breeding waterbirds of the province of Burgenland is the very early opening of the shooting season (1st August), with no distinction between species, because hunters are unable to recognise them. The inadequate biological basis of the legislation becomes evident when 'Rail' are protected the whole year whereas 'Reedhen' (probably Moorhen!) and Coot can be shot the whole year. 1st August is a dangerous opening date because of the late end of moulting of the females of the surface-feeding ducks and because the diving ducks may still have unfledged young at this time. Worse still is the late end of the hunting season (28th February) especially for Greylag which have by then returned, paired, to their breeding areas.

2. *Migrating birds*

A maximum of 50,000 Anatidae occurs in September to October in the Seewinkel, mainly consisting of the three geese, Mallard and Teal. While Greylag maintain their numbers during those two months, the Mallard is the most numerous species at the beginning of the autumn, replaced later by the Bean Goose which, in turn, yields first place to the White-fronted Goose. In spring no more than 13,000 Anatidae are simultaneously in the region. This low number is largely due to the remarkable reduction in migratory Mallard in spring. But the Garganey is then more numerous, and becomes the fifth most important species. In recent years the W.W.F. reserve at the centre of the Seewinkel has become very important as a refuge to the migratory birds. A strong preference for the Lange Lacke has developed

so that about half of all the ducks and geese of the Seewinkel are there in autumn and nearly *all* geese come to roost. This concentration is certainly a consequence of the protection afforded. Before the protection of the pastures, the hunters lined the shores during the autumn migration season and only the open water provided refuge to the birds. Now the wet meadows and pastures of the W.W.F. reserve and a large surrounding belt of arable land freed from hunting through the W.W.F., have created together an ideal refuge for Anatidae.

The large concentrations in autumn, of course, use it mainly as a resting and sleeping place, though Greylag and Teal feed within the borders of the reserve complex, mainly on natural vegetation. The large scale reclamation of arable land in recent years has therefore not had an adverse effect on them.

Mallard perform spectacular dusk flights in late summer and autumn north and north-east from Lange Lacke and Lake Neusiedl, to the corn fields, particularly to those of the Parndorfer Platte and the Albrechtsfeld. They come back from more scattered directions in the dawn. The diurnal White-fronted and Bean Geese reverse the pattern, heading north and north-east to the arable areas in the morning. The evening flight back is rather late. Greylags have been observed to have three different activity patterns. (1) A small number remains day and night near Lange Lacke (the breeding population in spring and early summer) and moves frequently from water to land, roosting on either. (2) The majority move mainly at night. During the day they feed or sleep in arable fields and towards the evening fly in small groups to the ponds to drink, preen and sleep. At dusk they move again to the shore and feed slowly through the natural habitats (*Bolboschoenus maritimus* stands, wet meadows and pastures) up to the corn fields. In the morning they are pushed back to the ponds by the arrival of the farm workers. (3) A small group flies every morning from the roosting pond to the corn fields and back again every evening in the manner of the White-fronted and Bean Geese and sometimes with them. They often visit distant corn fields away from the disturbance of farm workers. The proportions of the three groups vary throughout the season. It seems that the movements of our Greylag Geese have a pattern different from that of the Dutch coastal populations which depend on tidal rhythms (Lebret and Leisler, in prep.). The patterns have certainly also changed in recent years following the extension of agriculture.

Teal are confined to the natural habitats but make many local movements. Eight other duck species, in order of decreasing abundance: Garganey, Pochard, Gadwall, Shoveler, Pintail, Goldeneye, Ferruginous Duck and Wigeon, concentrate mainly on the Lange Lacke which always retains a sufficiency of water, though in spring the Illmitzer Zicksee may hold the largest numbers. This latter pond is often dry in autumn but presents very favourable conditions in spring. Fortunately it is, like the Lange Lacke, a full nature reserve. Gadwall concentrate in autumn on three small ponds (Fuchslochlacke, Auerlacke and Stundlacke), of which only the first is a government refuge surrounded by land leased by the W.W.F. The two others should also be leased as soon as opportunity offers. On spring passage they disperse over the whole Seewinkel with largest numbers on the Illmitzer Zicksee. Pochard stay in autumn on their breeding ponds (St. Andräer Zicksee, Auerlacke and Fuchslochlacke) and on the Oberer Stinksee, while in spring, as well as their breeding ponds, they frequent the Illmitzer Zicksee. The rarer wintering diving ducks, sawbills and divers, usually stay on the Lake and on the St. Andräer Zicksee.

Finally is should be mentioned that some natural predators on wildfowl have unfortunately been exterminated in recent years. Only one or two Peregrines *Falco peregrinus* visit the region during migration, despite the amount of potential prey. In similar wetlands in Hungary many more birds of prey hunt ducks and waders. The White-tailed Eagle *Haliaëtus albicilla*, which used to take the waterfowl wounded by hunters, has also become a rarity in recent years. Only the Fox *Vulpes vulpes* feeds abundantly on sick and dead wildfowl around the ponds. The shooting of geese over live decoys (despite its illegality) and on specially cultivated colza fields, as well as the shooting competitions in which as many as 30 to 50 birds per hunter per day may be killed, are very damaging to the populations. The hunting statistics of the district of Neusiedl over the last decade indicate an average yearly kill of 1,800 'wild geese' and 2,100 'wild ducks'.

3. *Food ecology*

The ecology of the region strongly

favours the vegetarian water birds. Fish-eating species, in summer the Great Crested Grebe, in winter three sawbills and two divers, amount to less than 200 birds. This is not due to a lack of fish, but rather to the opacity of the water. The two small grebes, which feed almost entirely on the larvae of aquatic insects, on molluscs and more rarely on small fish, amount to about 500 birds in the summer. Goldeneye and Tufted Duck, about 200 birds, stay in the region during the winter and feed for the most part on bottom-dwelling invertebrates and to a lesser extent on submerged plants.

An intermediate group consisting of Pochard, Ferruginous Duck, Shoveler, Garganey (all breeding) and Teal (only on passage) feed almost equally on animals and plants, but the proportion may vary according to seasonal availability. About 650 birds of this group stay in summer, about 8,000 in autumn and about 6,000 in spring. They are, therefore, the largest feeding group in the region. The Mallard is omnivorous and feeds to a great extent on human waste. Pintail are mainly vegetarian and animal food forms only a small proportion of their diet. During the breeding season there are about 30 birds of this species and during migration between 200 and 500.

There are two entirely vegetarian groups. Gadwall, Coot and Greylag feed on submerged plants (especially filamentous Algae, *Chara, Potamogeton* and their tubules), and seeds of marsh plants (especially *Bolboschoenus maritimus*). Coot and Greylag also feed on the young shoots of reed and of winter field crops. About 6,000 birds of these species occur in this region. Wigeon, White-fronted Geese and Bean Geese dabble a little but are typical grazing birds, the first two feeding mainly on the pastures and the Bean Geese preferring the winter arable crops. Fifteen thousand birds of these species occur in autumn and about 4,000 in spring.

4. *Management problems*

Recent changes in the habitat have raised three important problems. The first is the rapid increase of the reed belt. Originally the whole Seewinkel was to a large extent pasture land, the northern part (black-earth) being better for grazing than the southern part (salt soil). The Hansag in the south-east was the poorest of the whole area because of its acidity. When the Burgenland became a part of Austria and was progressively reclaimed in the twenties, the first efforts were of course made in the most fertile northern part, where the pastures were ploughed. Natural pastures remained longer in the less favourable south and the last remnant is still to be found in the W.W.F. reserve. The survival of grazing in this region therefore depended on the poverty of the saline soils which could only be used as pasture. In the last few years even these have been taken into use for vineyards and so pasture was restricted to regularly flooded transitional meadows. Cattle had maintained the short-grass habitat by trampling and grazing, and also checked the reed expansion, the rhizomes of *Phragmites* being very sensitive to mechanical damage. Therefore, although other factors may have contributed, the reduction of grazing during the last two decades has encouraged the expansion of *Phragmites* in the ponds and along the eastern shore of the lake. About a decade ago, for instance, the community of Apetlon still had three large herds, totalling 1,000 animals, grazing around the Lange Lacke between 1st May and 15th October. Today only one herd of 320 animals grazes the area. Consequently the peninsulas of the Halbinsel and the Sauspitz, which were then completely free of reed, are now covered with *Phragmites*. The first positive attempt at nature conservation in the region was to protect the shores of the pond and the Halbinsel and Sauspitz peninsulas from grazing because the greatest danger was thought to be the trampling of the nests. But the cows step on clutches only when they are driven fast in dense groups along the shore lines; grazing cows move slowly and avoid the sitting birds. The function of the cattle in treading down the reed rhizomes is far more important than any damage done to the nests.

For wildfowl these close-grazed fields are doubly important. Besides being breeding grounds for Pintail and Garganey, they are feeding grounds for Greylag and White-fronted Geese and to a smaller extent Bean Geese and Wigeon. The vegetation of wet meadows near the shores, including salt-marsh grass *Puccinellia* spp. and bentgrass *Agrostis* spp., form a dense carpet and are of particular importance to geese. These wildfowl are secondary grazing animals which follow the cattle (the primary grazing animals) and partly replace them during winter. High dry grass stands have developed on abandoned pastures of the eastern shore of the Lake and these are no longer used by wild geese. The influence of a goose flock of several hundred birds on a small area is quite comparable to that of a small

herd of cattle. Of course their manner of grazing and manuring differs, and they do not tread down the grass. The most important task for future management is to maintain short-grass pastures by securing sufficient grazing. (Plates VI-VIII).

Three species actually feed on *Phragmites* shoots in spring, namely Musk Rat *Ondathra zibethica*, Coot and Greylag Goose. Nevertheless, only the Greylag has a visible effect (Koenig 1952), by grazing reeds on the margins and thus locally preventing their expansion into the open water; the Greylags also restrict the reed around their nests, and during the summer moult when they stay in parts of the reed belt. During this time the birds move only by swimming and they make 'paths' and small squares of broken reeds in their resting and preening places. This factor is of less importance on the Seewinkel where no moult takes place.

Finally there is the question of damage to winter crops. Although the Bean Goose is more specialised to feeding on winter crops, the Greylag causes the only real damage because it concentrates in the Seewinkel when the crop is germinating and easily pulled out of the ground. The masses of Bean Geese and White-fronted Geese normally arrive after the first frosts. An accurate assessment of the damage caused in the W.W.F. Hunting Reserve is however necessary because indemnities have to be paid to the farmers.

Summary

As a first step towards a management plan for the Seewinkel area east of Lake Neusiedl, with a special consideration of the World Wildlife Fund Reserve situated in its centre, the most important landscapes of the whole Lake Neusiedl region are described biogeographically. The Anatidae are classified in groups according to their ecology, and Coot, grebes, divers and Cormorant have been included. Eighteen species which are ecologically most important for the region have been treated in detail, 10 species occurring in smaller numbers only briefly, and 21 species which are rare are simply listed. Quantitative, phenological and geographical data are given as far as available. The inter-relationships between the various habitats and the 1,200 breeding pairs (12 species) as well as the 50,000 autumn migrants (mainly 5 species) are described. The feeding habits of these birds and the three main habitat management problems (increasing expansion of reed, decrease of short-grass pastures and damage to crops) are discussed.

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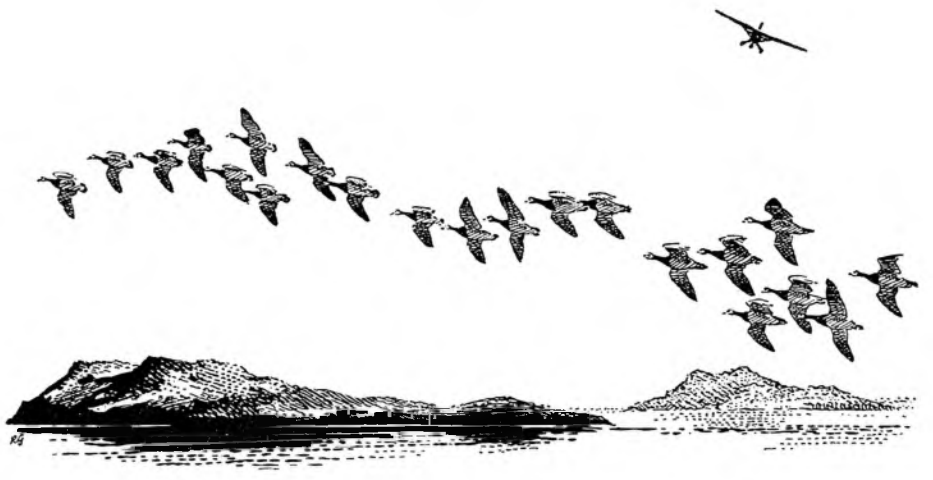

Barnacle Geese in the west of Scotland, 1957-1967

HUGH BOYD

Introduction

Twenty years ago it appeared to most of the few people with substantial knowledge that the Barnacle Goose *Branta leucopsis* had decreased considerably as a wintering bird in Scotland. That belief led to a successful attempt to have the Barnacle Goose excluded from the list of birds that might be shot under the Protection of Birds Act, 1954, effective on 1st January 1955. On 18th November 1955 the Secretary of State for Scotland issued an Order which allowed the geese to be shot in the months of December and January on 'those islands which are situated within any of the counties of Argyll, Inverness and Ross and Cromarty and which lie off the mainland of the said counties and to the west of longitude 5 degrees west'. Only those Barnacle Geese frequenting islands off the coast of Sutherland and those wintering on the Solway Firth continued to enjoy total legal protection after November 1955. This disappointing and potentially dangerous decision made it urgent to obtain detailed information on the numbers of Barnacle Geese in different parts of Scotland and to follow their changes over the years.

No attempt at a census had been made before 1955, because the geese were widely scattered through the Hebridean islands, many difficult of access and no longer permanently inhabited by man. The only estimates of population size were derived from adding together information, much of it second-hand, obtained in a haphazard way by a variety of recorders over an indeterminate period. Such an approach was clearly useless for reliable assessment of population changes. The only practicable alternative appeared to be an inspection of the islands from the air, a somewhat costly method about which little was known in Britain.

After some preliminary exercises in the techniques of aerial observation in 1956, a first survey of the Hebrides was made in 1957 (Boyd and Radford 1958). A second aerial survey of British Barnacle Geese, including those in Ireland as well as in Scotland, was conducted in 1959 as part of an international assessment of the entire population of the species (Boyd 1960). Subsequent surveys were made in 1961, 1962, 1965 and 1966. This paper has the limited objectives of making the results of the aerial surveys generally available, using them to find how the Hebridean stock of Barnacle Geese has fared during the last decade and investigating whether the lack of total legal protection has had the serious consequences that were feared.

Boyd (1960) inferred from the recoveries of ringed geese that there were three populations of Barnacle Geese which mixed very little. Those breeding in Siberia winter in Germany and Holland; those from Spitsbergen winter on the Solway Firth; and those breeding in east Greenland winter in the Hebrides and Ireland. Later ringing, and comparisons of the proportions of first-winter birds in different flocks, have confirmed this picture, although there is a puzzling discrepancy between the numbers wintering in Germany and Holland (some 20,000 in

recent years) and the few small breeding colonies known on southern Novaya Zemlya and Vaygach Island (Uspenski 1965). Jennov (1963) reviewing the breeding distribution in east Greenland, concluded that the Barnacle Geese occurring there were more than enough to account for the numbers reported from Ireland and north-west Scotland, and supposed that the excess might be fortifying the continental stock. That seems unlikely because 1,236 Barnacle Geese had been ringed in Holland by the end of 1966 and 2,396 in Greenland between 1955 and 1964: 97 recoveries of Dutch-ringed and over 140 of Greenland-ringed geese have been reported without providing any evidence of movement between Greenland and Holland. There is a single sight record of a Barnacle Goose, colour-marked in east Greenland in July 1963, in the Groningen province of Holland on 20th March 1966. The present strength of the Hebridean-Irish group seems to be consistent with Jennov's assessment of the situation in Greenland, and other explanations must be sought for the discrepancy between the Russian and Dutch evidence.

Since it is still uncertain to what extent the Greenland stock breaks up into subpopulations with distinct wintering areas, counts from Ireland in 1959, 1961, 1962 and 1966 are included here. Only the total numbers are used. The details will be included in a report on the distribution of Barnacle Geese in Ireland being prepared by Mr. D. B. Cabot.

Inventory methods (Plate IX, facing p. 108)

Conducting an inventory of geese in their winter quarters poses two problems: finding the geese and counting them. Finding the geese requires that you know where to look and that having reached the place you can then detect the geese. The Hebridean Barnacle Geese are much easier to find from the air than, for example, grey geese in central Scotland, because they mostly live on small islands and the areas of grass on which they might be feeding are even smaller. Provided there is enough light to see the time of day when they are looked for is unimportant, because the geese roost and feed in the same place. On the few parts of the Scottish mainland used by Barnacle Geese and on the larger islands, particularly Islay, searching is more difficult because the possible sites are less restricted and the geese fly from roosts, usually on offshore islands or sandbanks, to grasslands of several types.

There are several hundred islands in the Hebrides. Before embarking on the first aerial survey it was possible, after talking to people with local knowledge and searching for published records, to prepare lists of islands where Barnacle Geese had or had not been seen. There remained a formidable number lacking records, so that all the surveys involved 'exploration' as well as journeys to known haunts. Rather reassuringly, the number of newly-discovered haunts was quite small and nearly all the islands found unsuitable on the early surveys continued to lack geese.

Though in principle all the islands in the Hebrides likely to hold Barnacle Geese can be inspected from the air, there are many practical difficulties in arranging comprehensive itineraries. Searching has to be carried out at low altitudes and slow speeds, and it was necessary to hire the cheapest light aircraft, which, inevitably, has relatively limited endurance. There are very few airfields in the west of Scotland and suitable fuel is available on demand at only Prestwick, Ayrshire, and Stornoway, Lewis. The weather in the area is often unsuitable for light aircraft and cannot be forecast accurately, since most of the relevant weather systems are arriving from the Atlantic Ocean where the recording network is thin. Winds of only moderate strength (15-25 knots) can make an appreciable difference to the performance of a light aircraft and add greatly to the difficulty of manœuvring at low altitudes particularly in the vicinity of steep-sided islands. No two surveys were conducted in the same sequence, but care was taken to keep track of shifts of geese from one island to another close by. There is no evidence of frequent long-distance movements between winter quarters. The first aerial survey was made in February, the second in late November and early December. Those periods were chosen as being times when migratory movements were unlikely. The operational penalties of very short days, poor light and a high proportion of days when flying was not possible were so great that the later surveys were carried out in March or April. The greater risk of migratory shifts in early spring seems to have been unimportant and the increase in operating efficiency was considerable.

The most obvious gain was in the ability to take photographs of goose flocks and so obtain checks upon the counts and estimates made by the observer and pilot. One of the great merits of the highly dispersed distribution of Barnacle

Geese in the Hebrides is that few of the flocks encountered exceed five hundred birds and many are less than one hundred. Thus it is often possible to enumerate the birds individually or to estimate by groups of ten. That is important for the opportunities for counting are fleeting. A likely place for Barnacle Geese is approached at 400-600 feet above the sea, low enough to cause the geese to lift off the ground but not so low as to make them scatter in alarm or to make handling of the aircraft awkward. The pilot attempts to keep the entire group of geese clearly visible, preferably to both the observer and himself, for long enough to allow a count to be repeated two or three times. The flock is not closely pursued because that would alarm the birds unduly, which is objectionable in itself and may also defeat the end of the survey by scattering the geese. Photography, which calls for the geese to be set against a sufficiently contrasted background largely free from glare, was best done by the pilot using colour film in a hand-held 35 mm. camera. Earlier efforts with the observer using monochrome film in a K 20 aerial camera were rarely useful.

Photographic records cannot be relied upon for making a goose census, even though good photographs provide the only permanent evidence of location and numbers. On many winter days photography is scarcely possible, there is often uncertainty whether the picture will include the entire flock and there can be no assurance that technical failures in processing or the loss of a film may not destroy the evidence.

Results

Table I records the number of Barnacle Geese seen on each visit to each island or group of islands for which there were positive records from the aerial surveys. (Figure 1 shows the main island haunts). A single figure is used for each positive record, irrespective of the number of counts or estimates that could be made, and represents the value thought at the time to be the best. It is necessary to assess the reliability of these results before using them to establish whether the total population has varied appreciably in size and whether it can be divided into geographical groups. There are three sources of difficulty. First, in how many cases were geese present but not seen? Second, how accurate were the counts or estimates? Third, to what extent was the total falsified by movements of geese from place to place in the course of a survey.

Long-distance movements of geese were unlikely to be substantial enough to vitiate the results, largely because of the brief duration of the surveys. The extensive replication of counts that would be needed was too costly for the limited budget. Indeed routes were laid out to avoid covering the same ground twice, and only seven pairs of repeated counts are available. In February 1957 repeat visits at intervals of between five and ten days were made to Islay, the Treshnish Isles, Gunna and Gasker (Lewis); and the totals for the first and second visits were 1,600 and 2,400 respectively. In 1959, visits to Loch Bee, South Uist, yielded 21 Barnacle Geese on 26th November and 110 on 3rd December. In 1966 the Shiant Islands were visited on successive days (3rd and 4th April) and the 'best' totals were 440 and 480 respectively (the latter from four photographs). In six of the seven cases more geese were seen on the second visit, the total rising from about 2,060 to 2,990. Supposing that the mean (2,525) represents the best approximation to the numbers present on the mid-point dates, this suggests that a variation of about 18% resulted from a combination of short-term movements and counting errors.

Given the general impression from Table I that there has been a substantial increase of the numbers of Barnacle Geese in the Hebrides, it is important to examine to what extent that increase may be attributable to better observing or to systematic changes in the methods of assessment. The numbers on Islay, where the Barnacle Goose flocks are frequently much larger than elsewhere in the Hebrides and where the geese are widely distributed over a large area, are discussed in a separate section. There can, however, now be little doubt that the aerial counts there in 1957 and 1959 were too small.

Both an increase in the population and an increase in searching skill might lead to apparently larger numbers in the places already occupied, and to birds being found on more islands. Table II demonstrates that such tendencies have been found. A seasonal factor may also be involved, between earlier surveys in November/December and February and the later ones in March or April. It is probable that there are changes in distribution during the winter, as food supplies on some islands become depleted, and that the increased dispersion might reflect changes within seasons rather than between them.

Table I. Numbers of Barnacle Geese seen during aerial surveys of the Hebrides, 1957-1966.

Islands grouped by county and listed from south to north and west to east. Figures in brackets show the number of islands (and headlands) in each group on which geese have been recorded during the surveys. Full records are deposited at the Wildfowl Trust.

The symbol X indicates that the island was not visited, — that it was visited but no geese were seen.

	1957 12-22 Feb	*1959 24-27 Nov 2-3 Dec*	*1961 16-19 Mar*	*1962 7-10 Apr*	*1965 30 Mar 1 Apr*	*1966 1-4 Apr.*
Number of flying days	*8*	*3+2*	*3*	*4*	*2*	*4*
ARGYLL						
Islay (consolidated)	3000	2800	5500	4800	X	8500
Sound of Jura (9)	71	150	143	168	X	262
Oronsay	16	—	—	230	X	18
Iona and islets to south	5	—	—	—	X	61
Staffa and Erisgeir	60	80	72	10	80	151
Treshnish Islands (6)	257	219	398	380	430	644
Soa, off Tiree	—	—	80	130	X	—
Gunna	420	25	230	4	X	490
Coll	—	—	70	350	X	44
INVERNESS						
Outer Hebrides						
Berneray	85	—	—	14	18	13
Geirum Mor	—	—	30	—	—	51
Mingulay	32	35	70	114	90	250
Outer Heisker	—	14	—	—	—	4
Pabbay	42	—	—	18	90	95
Lingay	—	—	—	—	24	—
Greanamul	—	—	18	25	—	—
Sandray	—	—	24	—	—	30
Muldoanich	—	—	—	—	19	—
Biruaslam	64	—	—	—	—	—
Sound of Barra	238	86	431	395	428	360
South Uist (west of L. Bee)	200	110	250	—	23	—
Monach Islands (4)	330	470	519	863	750	1035
Sound of Harris (19)	490	304	599	498	490	578
Taransay	192	15	120	7	—	120
Gasker	41	110	10	70	190	122
Scarp	9	—	—	—	—	—
Inner Hebrides						
Eilean an Each, off Muck	19	—	—	X	X	X
Skye and islands off its NW coast (13)	526	190	370	646	992	888
ROSS						
Longa	38	56	15	20	5	—
Foura	21	—	—	11	—	—
Summer Isles (6) and Blarbuie, Rubha Mor	95	106	—	57	X	146
Shiant Islands (4)	303	290	214	317	450	483
Islands off Lewis (5)	37	—	—	32	52	109
SUTHERLAND (islands and headlands)						
West coast (9)	173	230	197	34	X	153
North coast (4)	X	X	359	379	X	545
TOTAL SEEN (to nearest hundred)	6600	5100	9700	9600	—	15200

Figure 1. Map of West Scotland showing places mentioned in text and Table I.

Table II. Numbers of Hebridean islands seen to be occupied by Barnacle Geese during aerial surveys, 1957-1966.
(Islay and immediately adjacent islands excluded.)

Islands	*1957*	*1959*	*1961*	*1962*	*1965*	*1966*	*mean*
with geese present	42	34	53	64	38	60	49
no geese seen	61	67	54	44	41	47	52
not visited	6	8	2	1	30	2	8
Total	109	109	109	109	109	109	109
% islands occupied	41	34	50	59	48	56	48
aver. no. geese on each occupied island	85	69	79	74	108	110	88
aver. no. geese per island visited	35	23	39	44	52	62	43

In the absence of independent counts, it does not seem possible to exclude the likelihood that growing experience led to more of the geese present being seen, but that is unlikely to be the cause of the great variation between surveys on particular islands. It is far more probable that these changes reflect movements of the geese. The only direct evidence relating to possible changes in observer skill is provided by comparing estimates of flocks with subsequent counts from photographs. Few photographs were successful in earlier years and most did not correspond exactly to observed groups. Figure 2 demonstrates the relationship between 45 pairs of counts made in flight and from photographs. Some of the observations deviate rather widely from the photographic counts but in general the fit is reasonably close. The sum of the 31 aerial counts by the observer is only 2% greater than that obtained from the photographs (5,157 v. 5,039). The estimates of the pilot were less close (3,205 v. 2,553, or 26% too large), though still remarkably accurate in view of his preoccupation with flying the aircraft and taking the pictures.

Figure 2 does not suggest any marked change in precision between the counts made in 1959 and 1962 and those made in 1965 and 1966. Furthermore, the ratio of 38 estimates made by the observer and by the pilot varied scarcely at all from 1961 to 1966, those of the pilot averaging 20% above those of the observer. In 1959, when a different pilot took part, 5 pairs of counts showed a wider difference.

The evidence of consistency in observer performances makes it unlikely that much of the apparent population increase can have been due to observational error. Little would be achieved by trying to adjust the figures in Table I to allow for counting errors, though some allowance for geese in places that could not be visited in 1957, 1959 and, particularly, in 1965 is necessary.

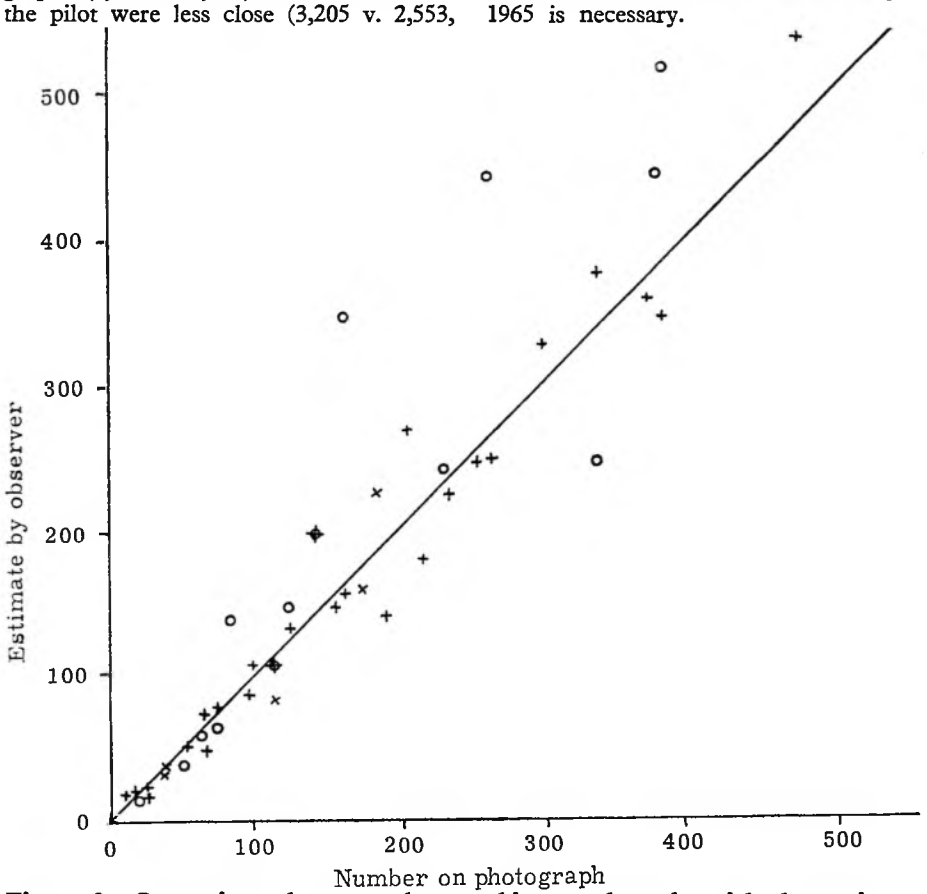

Figure 2. Comparisons between photographic records and aerial observations of Barnacle Geese flocks. O J. Radford (pilot); × H. Boyd, 1959 and 1962; + H. Boyd, 1965 and 1966.

The numbers of Barnacle Geese on Islay

The problems of counting Barnacle Geese on Islay are without parallel elsewhere in the Hebrides. Most of the geese occur in flocks of several hundreds or thousands and their roosts and feeding places are often several miles apart. They may be found on such typical Hebridean sites as Nave Island or the small islands east of Kildalton, or on the flat, wet, grasslands at the head of Loch Gruinart, or, most unexpectedly, on the rolling farmlands east of Bridgend.

Despite the scepticism of some people who know both Islay and the geese well, it is quite possible to count the geese present at any time with reasonable precision, either from the air or on the ground. The aerial surveys in February 1957 were thorough, but the numbers in *large* flocks of geese were then being grossly underestimated. It took much practice, spread over several years of searching for grey geese elsewhere in Scotland, and involving verification by photographs and counts from the ground, to improve the accuracy of estimates of a thousand birds or more. The December 1959 survey also very probably suffered from under-estimation of large groups. On later visits the flying was better planned and the estimates more accurate.

Since 1952 at least eighteen people have attempted to count the Barnacle Geese of Islay. With a vehicle, this can be easily done in two days, if the observer spends considerable periods counting large flocks bird by bird and if the geese are consistent in their movements. The mobility, tenacity and good fortune of the counters

Table III. Numbers of Barnacle Geese reported from Islay, 1947-67.
All estimates here rounded to nearest hundred; aerial counts in italic.

Winter	*Date*	*Number*	*Seasonal mean*	*Counters*
1952-53	Dec.	nearly 3000		J. M. Boyd
1953-54	autumn	2500-3000		J. Turner
1954-55	late Jan.	8000-10000		A. B. Duncan, G. A. Swanson
1955-56	late Mar.	under 3000		J. M. Boyd
1956-57	12 Feb.	*1200*		H. Boyd
	22 Feb.	*1700-3000**		H. Boyd, (*) J. D. H. Radford
1957-58	mid Nov.	over 10000	7100	M. F. M. Meiklejohn
	early Dec.	just over 5000		J. V. Weir
	early Dec.	7500		J. M. Boyd
	1 Apr.	5500		J. Sheppard
1958-59	16 Nov.	well over 10000	6300	M. F. M. Meiklejohn
	1 Dec.	*4200*		H. Boyd, S. K. Eltringham
	25 Jan.	5600		H. Boyd
	18 Mar.	4500		R. J. F. Taylor
1959-60	2 Dec.	*2800*	6000	H. Boyd
	mid Feb.	5800-8600		D. Jenkins *et al.*
	late Feb.	8000		M. F. M. Meiklejohn
1960-61	7 Nov.	4600	5700	H. Boyd
	6-8 Feb.	5600-8100		D. Jenkins *et al.*
	19 Mar.	*5500*		H. Boyd, J. D. H. Radford
1961-62	16 Nov.	5800	6300	H. Boyd, M. A. Ogilvie
	15-19 Feb.	6300		C. J. Cadbury
	2-3 Mar.	5800		D. Jenkins *et al.*
	4 Mar.	6800		D. Jenkins *et al.*
	12-15 Mar.	7500-8500		R. J. F. Taylor, W. H. N. Wilkinson
	10 Apr.	*4800*		H. Boyd, J. D. H. Radford
1962-63	31 Oct.	6100	7400	H. Boyd
	15-18 Mar.	8400-9000		R. J. F. Taylor, W. H. N. Wilkinson
1963-64	25-27 Feb.	10400		J. M. Boyd
1964-65	30 Oct.-2 Nov.	8300	8300	M. A. Ogilvie
	27 Jan.	8000-8500		R. N. Campbell, N. C. Morgan
1965-66	1 Mar.	9000		H. Boyd, J. M. Boyd
	1 Apr.	*8500*		H. Boyd, J. D. H. Radford
1966-67	11 Nov.	8400	8500	M. A. Ogilvie
	15-19 Dec.	6500		C. J. Cadbury
	22-23 Feb.	10500		N. C. Morgan
1967	8-9 Nov.	16500		M. A. Ogilvie

have varied in ways which do not lend themselves to precise comparisons. Their totals (Table III) are rounded to the nearest hundred, and in some cases a cautious estimate is reduced to a single figure. Correspondence relating to these observations is kept in the Wildfowl Trust files.

The range of 1,200 to 16,500 shown in Table III is very wide. The requirement is to obtain measures of any trend, and of year-to-year fluctuations, while reducing the effects of counting errors, and of movements in the course of the winter. Atkinson-Willes (1963) described the status thus: 'Taking the island as a whole the normal numbers are estimated at about 5-6,000, but by February there is usually an increase to 7,500 and in some seasons as many as 10,000 may be present for short periods.' This admirably concise summary of the position from 1955 to 1962 implies that there are usually more Barnacle Geese on the island in late winter than earlier. Figure 3, drawn from the data of Table III, does not support the inference that numbers increase in the late winter. Given the lack of any consistent pattern of change between November and April, all the counts in any one winter can, perhaps, be treated as estimates of a constant population. In order to use as much information as possible, the trend in population size can be estimated by calculating the regression of numbers upon seasons, using all the individual values in Table III, rather than seasonal means. (That involves giving all estimates the same weight, which is undesirable but scarcely avoidable without rejecting most of the counts, for which no measure of reliability is available.) A linear regression appears to fit the data rather better than a logarithmic one; and yields an estimated mean rate of increase of 6.3% annually.

There have been fluctuations in the breeding success of Islay birds, as indicated by autumn observations on the proportion of first-winter to older geese and in the mean size of broods (Table IV). Obviously mortality may also have varied importantly from year to year. No inde-

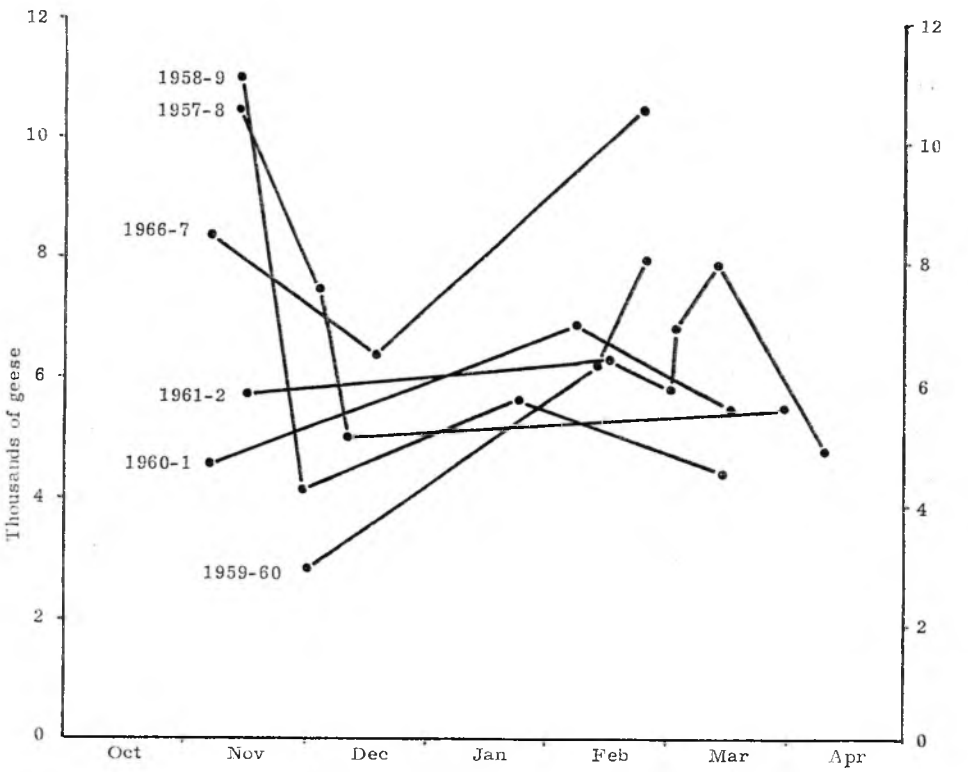

Figure 3. Changes in recorded numbers of Barnacle Geese on Islay during the winter, 1957-58 to 1966-67. Only winters in which at least three independent counts were made are included here.

pendent measure of the losses suffered by this stock is available. It is known that the kill on Islay itself is small, because the owners of most of the land used by the geese allow very few geese to be shot. A preliminary impression of mortality suffered by the population may be gained by using the first-winter ratios in conjunction with the seasonal means (Table V). These suggest that from 1959 to 1966 the losses of full-grown birds averaged scarcely 10% annually, an unusually low rate for geese. From the published recoveries of Barnacle Geese ringed in Greenland in 1955, 1961 and 1963 the average annual mortality rate of full-grown geese is calculated to have been about 20% in the years 1955-64. Several of the Greenland-ringed geese were reported shot, and many seen, on Islay. The discrepancy between the mortality rate of marked geese and the apparent rate for those visiting Islay suggests that the true rate of mortality of Islay-visitors has been masked by extensive immigration unless mortality in other places is vastly greater. Thus it is of particular interest to compare changes in the numbers on Islay with changes in other parts of the wintering range.

Changes in numbers in other regions

Table VI and Figure 4 summarize the data given in Table I in forms which make it easier to compare the observed changes in different parts of the Hebrides and in Ireland. It appears that a decrease occurred nearly everywhere between February 1957 and November 1959 while gains were general thereafter. The geese on the islands off the Sutherland coast may not have shared in this prosperity, though the lack of aerial inspections of the islands along the north coast before 1961 makes the extent of the decline between 1959 and 1962 uncertain. That is unfortunate, because of the special interest attaching to the geese in Sutherland as the only ones nominally afforded full protection since 1955. What seems certain is that the extra protection has not led to an exceptional rate of increase. The most likely reasons are the very limited number of suitable feeding places in Sutherland, and that on the bigger islands,

Table IV. Breeding success of Barnacle Geese wintering on Islay, as shown by observed proportions of first-winter birds and average brood-sizes, 1958-67.
Data obtained by H. Boyd, 1958-63 and Mar. 1966, and M. A. Ogilvie, 1964-67.

Year	*Proportion first-winter birds*		*Mean brood-size*	
	sample	*% 1st w.*	*sample*	*mean*
1959	721	14.1	20	2.5
1960	1500	9.7	20	1.9
1961	1900	10.7	14	2.1
1962	1088	7.6	21	2.5
1963	320	30.6	13	2.8
1964	580	7.5		
1965	798	11.2	24	1.7
1966	660	13.0	20	1.4
1967	550	17.1	32	1.8

In 1963 observations were made on 23rd October, before majority of geese had arrived.

Table V. Estimates of recruitment to and losses from the population of Barnacle Geese wintering on Islay, 1959-66.
Data from Tables II and III.

Year	*Population*	*1st winter*	*Older*	*Losses since previous winter*
1959	6000	846	5154	—
1960	5700	555	5145	855
1961	6300	674	5626	74
1962	7400	562	6838	(538 gain)
1963	10400	3192	7208	192
1964	8300	623	7677	2723
1965	8800	1100	7700	600
1966	8500	1105	7395	1405

$$\text{mean rate of recruitment} = \frac{\Sigma\ (\text{1st winter})}{\Sigma\ (\text{older})} = 16.4\%\ \text{annually}$$

$$\text{mean rate of loss} = \frac{\Sigma\ [\text{losses } (-\ \text{gains})]}{\Sigma\ \text{population}} = 10.1\%\ \text{annually}$$

Table VI. Numbers of Barnacle Geese found in different regions of the Hebrides and in Ireland during aerial surveys, 1957 to 1966.

Region	*1957*	*1959*	*1961*	*1962*	*1965*	*1966*	*mean*
Islay	3000	2800	5500	4800	*8300*	8500	5500
other Argyll	800	500	1000	1300	*1200*	1700	1100
Skye and Wester Ross	700	300	400	700	1100	1000	700
Outer Hebrides	2100	1400	2300	2400	2600	3300	2400
Sutherland	*800*	*1000*	600	400	*700*	700	700
total Hebrides	7400	6000	9800	9600	13900	15200	10300
Ireland	4400	2800	4100	4400	—	4800	4100
total	11800	8800	13900	14000		20000	14400

Notes: Hebridean records from Table I, group totals rounded to nearest hundred, with some adjustments for incomplete searches. Irish records for 1959 by H. Boyd, for 1961, 1962 and 1966 by H. Boyd, D. B. Cabot and J. D. H. Radford; no survey in Ireland in 1957, the total given being the sum of the average numbers in each locality recorded by Ruttledge and Hall Watt (1958).

Islay figure for 1965 from ground counts in November and January. Argyll and Sutherland figures for 1965 and Sutherland figures for 1957 and 1959 include estimates for unvisited sites.

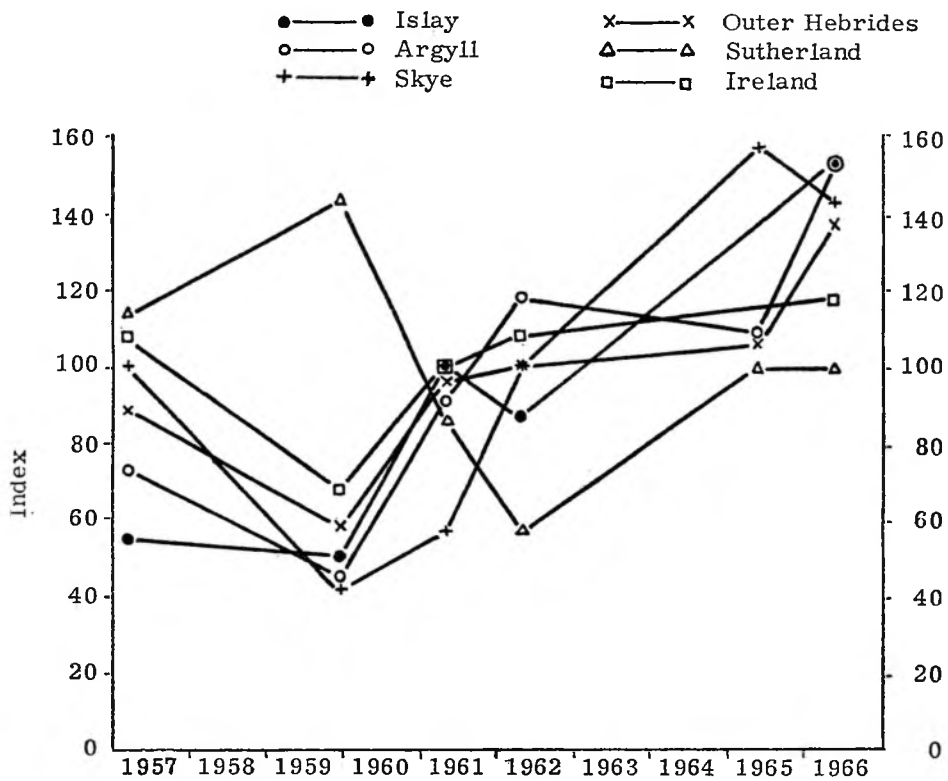

Figure 4. Changes in numbers of Barnacle Geese found during aerial surveys in different regions of the Hebrides, and in Ireland, 1957-66. Index numbers based on mean = 100 for each region.

such as Handa and Eilean nan Ron, the geese are competing with relatively large numbers of sheep and are more disturbed by shepherds and other human visitors than on most small Hebridean islands.

Despite important shifts in distribution within Ireland, the total strength there appears to have altered little in the last decade. The Irish total in November-December 1959 was probably depressed by under-estimates of the large flocks on the Inishkeas, islands off Co. Mayo, where Cabot (1963) found 2,200 ± 100 resident during his visit from 19th March to 22nd April 1961, and 2,500 from 10th to 18th March 1962, compared with estimates from the air of 1,580 on 11th March 1959, 1,200 on 5th December 1959, 1,010 on 23rd March 1961 and 1,570 on 6th April 1962 (all by H. Boyd). The species was given full protection in Ireland in 1962.

Nearly all the 'natural groups' of geese on adjacent islands have increased in the same way as the total population. Two exceptions may be noted in the Outer Hebrides: on the islands south of Barra the numbers seen on the last four visits have fluctuated between 430 in 1961 and 360 in 1966; a reduction in numbers and frequency of occurrence of Barnacle Geese near Loch Bee on South Uist has been confirmed by many observers. The change is presumably due to the construction of a rocket-firing base in the area, but has been more than offset by increases on the Monach Isles some twelve miles to the north-west. The Monach Isles were declared a National Nature Reserve on 1st December 1966, primarily for the benefit of the geese.

Some of the outermost of the Hebridean islands—the St. Kilda group, North Rona and the Flannan Isles—have not been included in the aerial surveys, apart from a visit to the Flannans on 19th February 1957 during the first survey. Though Barnacle Geese and other geese have frequently been reported flying over these remote islands on passage in the spring and autumn and have occasionally alighted on them, they are not probably regular haunts during the winter.

Discussion

The general increase in the number of Barnacle Geese in the Hebrides and Ireland is pleasing. While the causes have not been established, there are indications that the geese wintering on Islay have benefited from very low annual mortalities. There are few records of age-ratios among the geese elsewhere in the Hebrides but such as there are, and data collected in Ireland, chiefly by Mr. D. B. Cabot, suggest that the proportions of young birds in different places in the same year resemble each other. Thus it is quite likely that low mortality has characterised much of the Greenland-breeding population of Barnacle Geese during the last decade.

There are differences between the behaviour of Barnacle Geese on Islay and elsewhere. On Islay they feed inland, as well as close to the sea, and they often occur in large flocks. The rate of increase on Islay seems to have been somewhat greater than among the geese scattered on small islands. One result has been that, while in February 1957 Islay apparently held 40% of the Barnacle Geese in the Hebrides and 25% of the entire Greenland stock, by April 1966 the proportions were 56% and 43%. The increase on Islay began at least forty years ago (Berry 1939). Its long continuation is due in large part to the special protection afforded to the geese by landowners. Their success has led to growing complaints by farmers that the geese now take too large a proportion of the grazing on the island. Should a change in circumstances lead to measures against the geese there is little doubt that large numbers could be killed and the survivors find it necessary to move off the farmed land. In that event there might well be strong competition for space and food on other Barnacle Goose haunts, perhaps far removed from Islay.

This investigation was prompted by concern about the survival of the Barnacle Goose. There are perhaps twice as many Barnacle Geese now as there were ten years ago, for those wintering on the Solway Firth and in the Netherlands have also increased. Does this mean that the anxiety was ill-founded and unnecessary? Or that the additional protection afforded to the species has been effective? Could that protection safely be relaxed?

The criterion applied by the U.S. Federal Government is that any species less than 100,000 strong is so scarce that it should be protected from hunting as far as possible. The group breeding in Spitsbergen and wintering on the Solway Firth is so very small and its breeding and wintering grounds are so limited that it should always be given special care. The geese wintering in the Netherlands are threatened by the loss of large parts of their feeding grounds (Lebret 1965). The Barnacle Geese of the Hebrides and Ireland are less vulnerable. The breeding places available in east Greenland are relatively extensive. In winter, many of

their haunts are at present little disturbed, either by local residents seeking them for food or by visiting sportsmen.

There is a final question of great interest to the biologist, which is also fundamental to sound conservation. Should an attempt be made to follow up this study by finding out how many Barnacle Geese could live on the habitat available in the Hebrides, on the supposition that no further increase in their numbers on the improved grasslands of Islay can be accepted by the farmers? The recent declaration of the Monach Isles as a National Nature Reserve, though welcome as providing the first sanctuary for Barnacle Geese in the Hebrides, may deflect attention from the real problems associated with the welfare of these exciting birds. At a time when funds for research are contracting, it is especially easy to choose problems that are merely urgent, instead of others of greater long-term importance. It would be regrettable if the transitory well-being of the Barnacle Goose were to diminish the interest shown in it in Britain.

Acknowledgements

This study was supported, financially and practically, by the Nature Conservancy and the Wildfowl Trust. I am grateful to Mr. E. M. Nicholson, formerly Director-General of the Nature Conservancy, to Dr. J. Berry, formerly Director of the Nature Conservancy, Scotland, and to Mr. Peter Scott, Hon. Director of the Wildfowl Trust, for their encouragement.

Such success as was attained in the aerial surveys was very largely due to the skill and enthusiasm of Mr. J. D. H. Radford, as pilot, photographer and student of geese. I am also indebted to Dr. S. K. Eltringham and to Mr. Arthur Wignall for flying the aircraft used briefly in 1958 and more extensively in 1959. Mr. D. B. Cabot acted as an observer in one of the Hebridean and several of the Irish surveys.

The counts of geese on Islay would have been much less plentiful and informative without the contributions of the gentlemen listed in Table III. Many of them, like me, are indebted to the directors of Islay Estates Limited, and especially also to Mr. J. H. Cranston, O.B.E., until recently their factor, for permission to move over their land and for assistance of various kinds. Mr. M. A. Ogilvie, by continuing the annual series of observations on the numbers and age-composition of the Islay flocks, has added greatly to their value.

Summary

Five aerial surveys of the Barnacle Geese wintering on islands off the west and north-west coasts of Scotland were made between February 1957 and April 1966. The practical problems of the aerial survey of geese dispersed in small groups on islands are discussed. Supplemented by counts made from the ground on Islay, much the most important haunt, the surveys show that the Hebridean population has increased substantially from about 7,400 in February 1957 to 15,200 in April 1966. Numbers in different regions of the Hebrides have varied in rather similar ways. The gradual increase on Islay up to 1966 may have been due to low adult mortality. A massive increase there in 1967 must have involved immigration. The geese in Sutherland, and in Ireland, afforded full protection since 1955 and 1962 respectively, have increased less than in the Hebrides, where shooting is permitted in the months of December and January.

The present healthy state of the Hebridean population could be drastically altered if their competition with agriculture on Islay leads to countermeasures.

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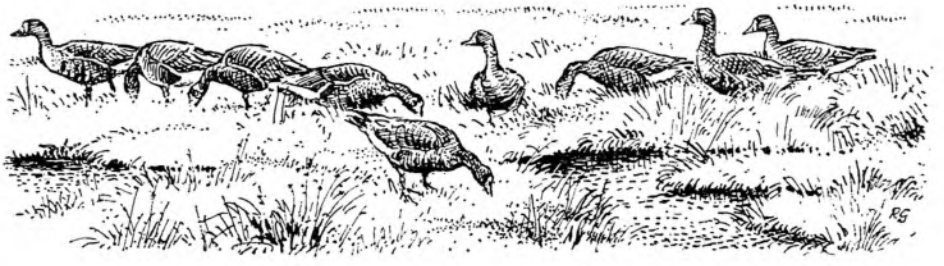

A preliminary study of the feeding of the Greenland White-fronted Goose *Anser albifrons flavirostris* in Cardiganshire

D. F. W. POLLARD and P. WALTERS-DAVIES

Introduction

The Greenland White-fronted Goose *Anser albifrons flavirostris* occurs principally in the western and northern areas of the British Isles. The main concentration is in Ireland, where perhaps three-quarters of the population overwinter. The remainder inhabit remote districts of west Scotland, from Kirkcudbright through Argyll to the Outer Hebrides, apart from smaller groups in Lancashire and Wales (Atkinson-Willes 1963). The race is not as well documented as the European White-fronted Goose *A. a. albifrons* on account of the inaccessibility of many of its haunts.

The British population of *A. a. albifrons* represents between 12 and 20 per cent of the race, whereas that of *A. a. flavirostris* (including the Irish component) comprises essentially the entire population of the race. It is most important, therefore, that knowledge of its ecology is adequate for a sound conservation policy.

Until recently, a population of about 500 Greenland Whitefronts overwintered at Cors Tregaron National Nature Reserve in Cardiganshire. Numbers declined markedly during the severe winter of 1962-63, and have rarely exceeded 100 in subsequent years. Under the direction of the Regional Office of the Nature Conservancy, a preliminary study of geese on the reserve was carried out during winter 1964-65. In collaboration with the Wildfowl Trust, the investigation was intensified with a survey of vegetation in summer 1966, based on existing knowledge of feeding habits of the geese, and was followed by a feeding study in winter 1966-67. The summer work was supplemented by surveys of upland bogs in the vicinity of Cors Tregaron N.N.R. which were known to have been frequented by Greenland Whitefronts in previous years. For comparative purposes, the proposed nature reserve at Borth Bog, used as a feeding area by a small population of White-fronted Geese

J. D. H. Radford

Plate IX. (a) A Dragon Rapide after a (routine) landing on the sands of Barra, Outer Hebrides, during an aerial survey of Barnacle Geese. (See p. 97).
(b) Roanish Island, typical winter haunt of Barnacle Geese.

J. D. H. Radford

Philippa Scott

Plate X. Inside the new Tropical House at Slimbridge. (a) The general view towards the waterfall pond, which is shown (b) in close-up. (See p. 169)

J. A. Middleton

reported as *A. a. albifrons*, was also investigated.

The first part of this paper deals with the various surveys carried out in Cardiganshire in summer 1966. In the second part, results are presented for the preliminary feeding study of 1964-65 and a food analysis scheme developed in 1966-67. Results are discussed in relation to the summer investigations.

PART I. Survey of vegetation at Cors Tregaron N.N.R. and other sites in Cardiganshire.

Study sites

Cors Tregaron N.N.R. occupies an area of 1,898 acres (769 hectares) in mid-Cardiganshire about 12 miles (19.3 km.) from the sea, at an altitude of about 500 ft. (162 m.) a.s.l. The reserve is surrounded by hills up to 1,000 ft. (352 m.) a.s.l. and is centred on three adjacent raised bogs, known as the Western, North-east and South-east Bogs. The bogs are separated from each other by promontories of rising land and by streams flowing through the reserve. These include the River Teifi and its tributaries the Camddwr and the Ffluv. These watercourses have developed narrow river terraces.

A full description of Cors Tregaron may be found in Godwin and Conway (1939). In brief, each bog is characterized by purple moor-grass *Molinia caerulea* at its higher levels, giving way to deer - grass *Trichophorum cespitosum*, pool and hummock areas (bog-moss *Sphagnum* spp. and cotton-grass *Eriophorum* spp.) and heather *Calluna vulgaris*. The development of these associations varies considerably according to area, and to the extent of previous peat extraction. A peripheral zone known as the Rand may separate the bog from river terrace. To the north, river terraces are broad and are characterized by rush *Juncus* and marsh willow *Salix* swamp. To the south, *Juncus* diminishes to pasture close to the river. The pasture is grazed by sheep and ponies.

In contrast to Cors Tregaron, Borth Bog lies almost at sea level, covering an area of 1,352 acres (547 hectares) close to the Dovey Estuary in north-west Cardiganshire. This proposed reserve is centred on a single raised bog which is surrounded by reed *Phragmites communis* swamp and *Juncus* marsh. Drainage channels include the River Leri, now in canalised form, and the Pwll Ddu.

Other sites investigated include small upland bogs of Llyn Eiddwen, Llyn Fanod, Llyn Garn Fach and Pwll-yr-uch. These bogs lie a few miles to the west of Cors Tregaron.

Methods

A small number of plant species have been previously recorded as food sources for *A. a. flavirostris*. These include deer-grass *Tricophorum cespitosum* which was reported by Campbell (1947) from Whitefronts shot in North Uist, and common cotton - grass *Eriophorum angustifolium* and white beak-sedge *Rhyncospora alba* which were found in Whitefronts shot near Cors Tregaron (Cadman 1953, 1956). Special attention was paid to these plants in each part of the summer survey.

The region of particular interest at Cors Tregaron was the pool and hummock area of the Western Bog, since it was here that geese had been most frequently observed during the preliminary survey of 1964-65. Frequency distribution of plant species in this area was determined using 30 cm. × 30 cm. random quadrats. A similar analysis was carried out in the *Trichophorum* zone of the Western Bog, and in the pool and hummock area of Borth Bog.

Surveys of the smaller bogs were limited to the compiling of plant species lists and general description of vegetation.

The location of food parts of *Rhynchospora* and other recognised food plants at Cors Tregaron was considered in terms of depth within the substratum and its hardness. Usually, depth of foodstuff could be measured after pulling entire plants from the peat. Hardness of the peat was determined using a 34 cm. spear, weighing 73 g. The spear was prepared from 5 mm. steel rod, with a filed point and metal flights to ensure a vertical drop. Graduations of 1 cm. were marked along its length. The spear was dropped into sample areas from a height of 50 cm. (from the flights); penetration was recorded for 10 drops in each of 20 quadrats. Percentage cover was estimated by eye for each plant species within quadrats.

Results

(a) Comparison of vegetation within Cors Tregaron and Borth Bog.

Frequency of species is given in Figure 1. The most pronounced difference between pool and hummock areas of the two raised bogs occurred in the distribution of bog myrtle *Myrica gale*. This species was a prominent feature of Borth Bog but was not observed at Cors Tre-

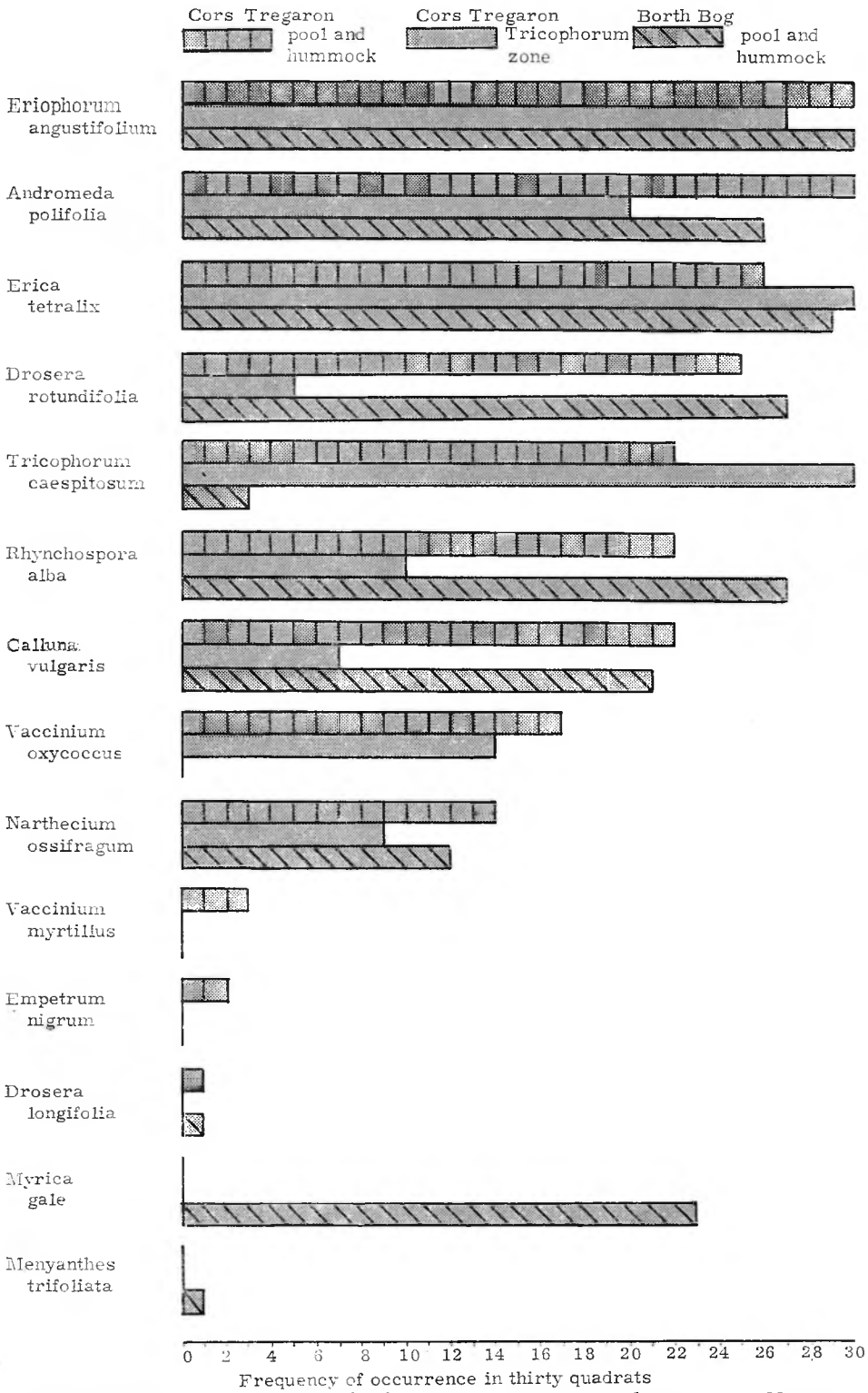

Figure 1. Frequency of plant species in 30 cm. × 30 cm. quadrats at Cors Tregaron and Borth Bog.

garon. *Trichophorum* was more abundant at Cors Tregaron but there were no marked differences in distribution of other food plant species.

The *Trichophorum* zone of Cors Tregaron is characterized by a decline in every species other than *Trichophorum* and cross-leaved heath *Erica tetralix*. These changes reflect the drier soil conditions as compared with pool and hummock areas.

(b) Upland bogs in the vicinity of Cors Tregaron.

Prior to winter 1962-63, *A. a. albifrons* inhabited some of the smaller bogs and lakes near Cors Tregaron. Of these, Llyn Eiddwen was one of the more frequently used. The lake is about 500 m. long by 250 m. wide. A small bog, extensively cut for peat in the past, exists at the south end. *Eriophorum* was very abundant, with a little *Trichophorum*. *Rhynchospora* was absent. Observations by one of the authors (Pollard) in November and December 1962 showed that this bog was certainly used for feeding by geese.

Llyn Fanod lies about two miles (3.2 km.) south of Eiddwen; although similarly free from disturbance, Llyn Fanod is not known to have been used by geese. This is possibly explained by the fact that the adjacent bog comprised essentially *Juncus* marsh, in contrast to the artificial pools and hummocks in the peat-cutting area of Eiddwen.

Llyn Garn Fach is a very small and exposed hill tarn, on which geese are reported to have roosted occasionally. The surrounding bog comprised mainly *Juncus*, but there was also pool and hummock development.

Pwll-yr-uch has no permanent water but comprises about 10 acres of bog, much of it 'quaking'. *Eriophorum* was very abundant. The bog was used by geese particularly when disturbed on Llyn Eiddwen.

(c) Depth of foodstuffs in substratum.

As shown in Table I, depth of foodstuffs varied appreciably. The most readily accessible appeared to be *Rhynchospora* bulbils; these were often located above the peat surface, with roots penetrating *Sphagnum* before entering the peat.

Depth of *Eriophorum* roots varied according to site. Only 10-15% could be extracted with roots attached by hand-pulling and the force required to lift intact plants was considerable. It seems likely that this food must be at least partly excavated by the geese—a difficult process under freezing conditions—before being eaten.

Depth of *Trichophorum* shoot bases varied according to the age of tussocks. Whilst generally quite shallow, shoots of this species also were difficult to extract, owing to the formation of a tough mat of fibrous roots in the tussock.

(d) Hardness of substratum.

Plant cover is presented diagramatically in Figure 2 for each of four classes of peat hardness, as indicated by mean depth of penetration of the spear described above.

Certain species showed a distinct correlation with hardness of substrate. Thus, *Sphagnum* species were considerably more abundant in softer areas. *Rhynchospora* appeared to grow mainly in areas of

Table I. Depth of shoot base in various plant species on Cors Tregaron.

Species and parts eaten	*Site*	*Av. depth (cm.)*	*Standard error*	*Substratum level*
White beak-sedge (bulbils) *Rhynchospora alba*	Shallow pools	2.02	0.10	Peat surface
	Wet *Sphagnum*	3.13	0.26	*Sphagnum*, upper surface
	Calluna/Erica assoc.	0.90	0.09	Peat surface
Common cotton-grass (roots) *Eriophorum angustifolium*	Shallow pools	7.97	0.35	Peat surface
	Wet *Sphagnum*	13.16	0.46	*Sphagnum*, upper surface
	Drier *Sphagnum*	7.60	0.37	*Sphagnum*, upper surface
	Calluna/Erica assoc.	9.27	0.56	Peat surface
Deer-grass (bulbils) *Trichophorum cespitosum*	Old tussocks	4.60	0.36	Tussock surface
	Young tussocks	1.51	0.09	Tussock surface

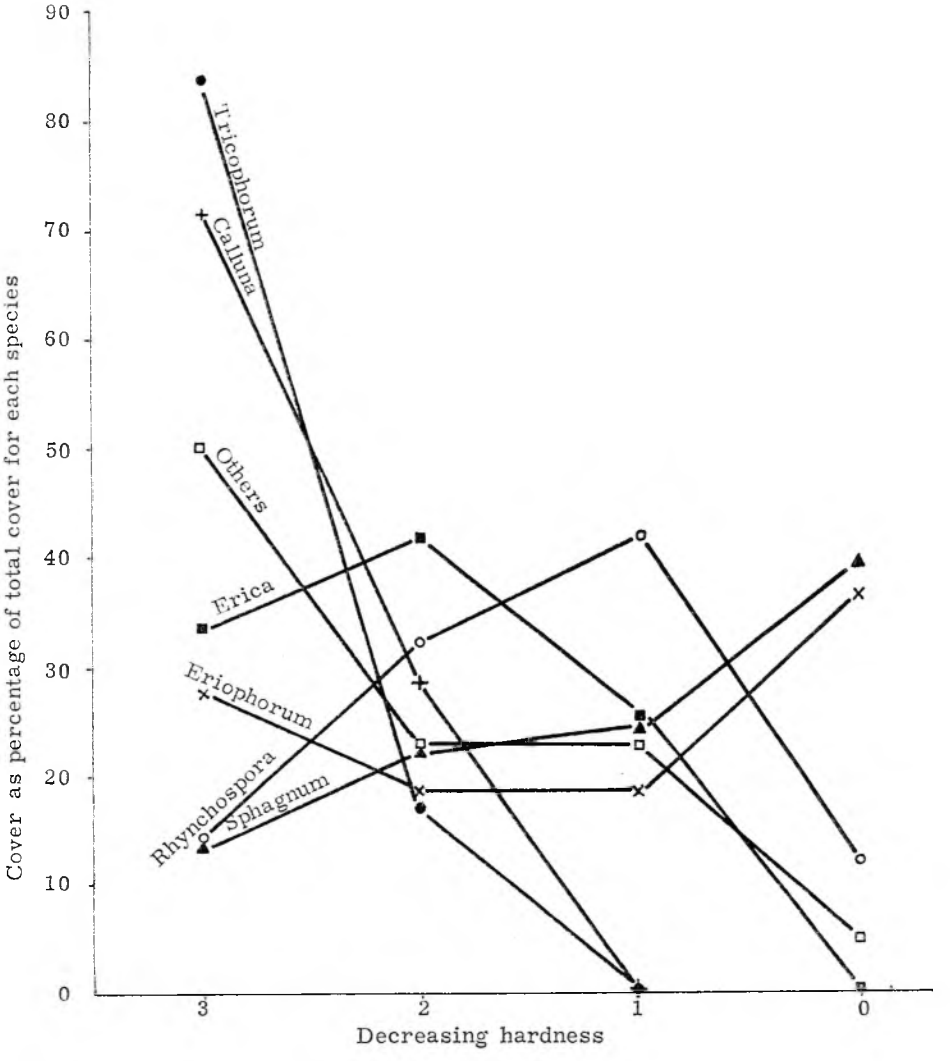

Figure 2. Plant cover in relation to hardness of substratum.

intermediate hardness, not tolerating the very soft ooze in pools. (At Borth Bog it was abundant in firm and comparatively dry peat of old peat-cutting and fire zones. Apparently this species, a coloniser of pools on the raised bog, tolerates harder peat in the absence of strong competition from species such as *Calluna, Erica* and white fork moss *Leucobryum glaucum.*) *Eriophorum* showed a broad tolerance range; *Trichophorum* was confined mainly to firmer areas. Resistance to penetration in tussocks was comparable to that of hard-packed peat.

PART II. Studies in feeding habits of Greenland White-fronted Geese in Cardiganshire.

Background

The fact that *A. a. flavirostris* was not recognised as distinct from *A. a. albifrons* until comparatively recently (Dalgety and Scott 1948) complicates evaluation of earlier feeding studies on White-fronted Geese. Campbell (1947) reported two instances of bulbils of *Trichophorum* found in the crops of Greenland Whitefronts shot in North Uist. The only other records are in Cadman (1953, 1956) who found roots of *Eriophorum* and young

shoots of *Rhynchospora* in viscera of geese shot in the vicinity of Cors Tregaron. Each of these records refer to material collected through viscera analysis of shot birds. The technique of viscera analysis for investigation of wildfowl feeding habits has been described by Harrison (1960) and has been used extensively in studies of several species of duck, e.g. Olney (1964). Generally, however, viscera analysis may be used only for quarry species, since the researcher is usually dependent on wildfowlers for the supply of study material. Whilst *A. a. flavirostris* is on the shooting list, its distribution is such that much of the British population is afforded protection through remoteness or preservation of its wintering areas. In addition to difficulties in obtaining material from such locations, it is undesirable that further reduction of a small population should occur through such sampling techniques.

An alternative approach to wildfowl food analysis was adopted by Ranwell and Downing (1959) in a study of feeding pattern in Brent Geese *Branta bernicla.* Faeces of this species were found to be suitable for food determination through microscopic examination of plant remains. This technique had already found application in feeding studies of rabbits (Dusi 1949) and has been frequently employed in investigations of range habits of herbivores (Stewart 1967). Faeces analysis offers the special advantage in wildfowl feeding studies that the size, number and frequency of samples is limited only by the amount of disturbance imposed on the birds in collecting material. It is therefore very suitable in situations where conservation of the local population is of special importance, and where access is fully controlled. For this reason, faeces analysis was employed for the 1966-67 feeding study of *A. a. flavirostris* at Cors Tregaron National Nature Reserve.

Methods

The preliminary study of 1964-65 was based on direct observations by the previous Warden-Naturalist, Mr. P. J. Panting. On each of 23 occasions, a nine mile (14 km.) transect about 400 yards (370 m.) wide was surveyed. Date of observation and location of groups of feeding birds were recorded on a large-scale map of the reserve.

In preparation for the feeding study of 1966-67, samples of known food plant parts, and material of associated plant species, were gathered in late autumn 1966. Permanent mounts of sections showing diagnostic features within the upper and lower epidermal surfaces were prepared by the method outlined by Metcalfe (1960), for reference purposes in subsequent microscopic examination of faeces. The reference collection was supplemented by material gathered during winter 1966-67.

Collection of faeces commenced immediately after the arrival of geese in October 1966. Thirty faeces were collected by the Warden-Naturalist, Mr. P. Davis, at approximately three-week intervals, and were immediately despatched to the Wildfowl Trust for analysis. Upon arrival, six were randomly selected from the sample and sealed individually in tubes containing formal acetic acid (FAA). The frequency of sampling was increased in March 1967 when changes in composition of the droppings were observed. Collection and subsampling procedures were such that it could be reasonably assumed that each dropping originated from a different bird.

Faeces were prepared for analysis by crushing in FAA a few days after fixing. Separation of plant fragments was found to be facilitated by the fixing procedure. Ten portions of slurry from each faeces were examined for component plant species. Presence or absence only was resorted to after attempts to quantify the occurrence of each species proved unsatisfactory.

Results

(a) Preliminary survey 1964-65.

Locations of feeding geese during 1964-65 are shown in Figure 3(i) in relation to minimum ground temperature as recorded for the preceding 24 hours at Swyddffynon meteorological station on the edge of Cors Tregaron N.N.R. In a total of 23 observations, geese were feeding on raised bog on 19 occasions, and on pasture (mainly river terrace) on 13 occasions. Birds were seen in both areas on 10 days, indicating movement or splitting of the flock. There was an increase in use of pasture after November; in general, feeding station did not appear to be associated with temperature.

(b) Droppings analysis and direct observations, 1966-67.

Faeces analyses resulted in strikingly few species being identified as food plants and for much of the winter feeding appeared to be confined to bulbils of *Rhynchospora alba.* It should be noted, however, that geese and fresh droppings could not always be located within the reserve (hence the irregularity of

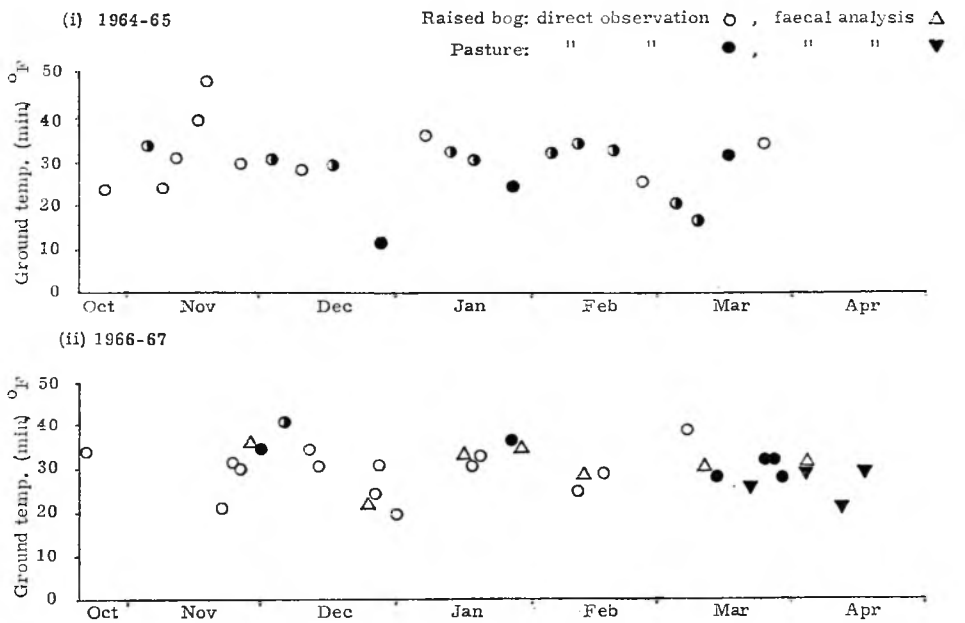

Figure 3. Location of feeding geese in relation to ground temperature, Cors Tregaron, 1964-65 and 1966-67.

samples); since *Rhynchospora* appeared to be confined to Cors Tregaron in that particular region, it is most unlikely that the diet of geese was as unvaried as is suggested.

Not until the middle of March did sample droppings contain species other than *Rhynchospora.* In every case, identifiable droppings contents reflected those species occurring in the area from which the sample was collected. In late March and April, the most common material in droppings was foliage of common bent-grass *Agrostis tenuis.* This was also the most abundant species in the turf of river terraces. Reed-grass *Glyceria* spp., common in wetter sections of terraces, was detected. Tufted hair-grass *Deschampsia cespitosa* was taken frequently towards the time of departure of the geese (18th April 1967), and in two instances comprised over 50% of droppings material. Dicotyledonous foliage occasionally formed a substantial proportion of droppings from river terraces, but could not be identified further.

Direct observations on feeding geese for winter 1966-67 are shown in Figure 3(ii). Prior to mid-March, birds were observed feeding on pasture on only three occasions; there was no indication of a temperature effect on feeding station. Direct observation supported the evidence from droppings analysis of a change in feeding habits in mid-March. In 1964-65, pasture grazing was frequent throughout the winter. Feeding pattern in late March and April of that year could not be observed due to earlier departure of the geese.

Discussion

There is little doubt that the drastic decline in the population of *A. a. flavirostris* at Cors Tregaron in winter 1962-63 was associated with the very severe conditions at that time. Markgren and Mathiasson (1963) concluded that premature departure from feeding grounds under adverse conditions reflected limited food supplies rather than a direct response to the weather. However, the reduction in numbers at Cors Tregaron was permanent, and is believed to have resulted from the combined effects of starvation and shooting. In 1967-68 no geese were observed on the area (P. Davis, pers. com.).

By virtue of its status as a National Nature Reserve, Cors Tregaron affords complete protection of its fauna and flora (section 16, National Parks and Access to the Countryside Act 1949). In the case of a quarry species such as *A. a. flavirostris*, however, protection is limited to the scheduled area of the reserve. Under normal conditions, the species fed within this area for much of the winter, as in-

dicated by observations in 1964-65 and 1966-67, although visits to remote upland bogs were not unusual in previous years. However, in 1962-63 geese moved out of the reserve into agricultural areas, presumably in search of food, and in consequence were subject to unusual shooting pressure.

According to observations reported in this and other papers (see above) the food plants of *A. a. flavirostris* include *Eriophorum angustifolium, Rhynchospora alba, Trichophorum cespitosum* and a number of grasses of which *Agrostis tenuis, Deschampsia cespitosa,* Yorkshire fog *Holcus lanatus* and *Glyceria* spp. appear to be important. Study of distribution of the first three foodstuffs in peat at Cors Tregaron suggested that *Eriophorum* roots would be the least available under severe conditions. *Deschampsia* bulbils would probably be available even with deep snow cover, but there are no records of these being consumed by geese in Cardiganshire. *Rhynchospora* bulbils occur at very shallow levels and are often developed within the overlying *Sphagnum.* Even under very cold conditions, this food would still be available, and could be readily obtained during periods of snow cover. Cadman (1956) reached similar conclusions.

In 1966-67, and probably in 1964-65 also, *Rhynchospora* was an important food from the time of arrival of the geese until shortly before their departure in spring. *Eriophorum* was not detected in any droppings samples analysed. Both droppings analysis and direct observations made on the reserve also indicated that pasture was an important source of food. There is also a substantial unknown element in the winter nutrition of these geese. There appears to be no reliable information on the location and feeding habits of the birds when not within the confines of Cors Tregaron N.N.R., apart from observations made on the larger population prior to 1963-64 (Cadman 1953, 1956). There was a pronounced change in feeding pattern shortly before departure of geese in April 1967, when feeding took place predominantly on grasses (river terrace) instead of *Rhynchospora* (raised bog). (It is interesting to note that geese were claimed by local farmers to be of considerable nuisance on early pasture grass and winter wheat when the population numbered several hundred.)

The reasons for this change are obscure. Possibly changes occurred in the nutritive value of either food items, for example, a lower protein content in rapidly-expanding *Rhynchospora* bulbils, or an increasing protein level in grasses. In an investigation of *A. a. albifrons* at Slimbridge, Gloucestershire, Kear and Pollard (unpublished) found substantial increases in protein levels in the early spring of 1966, not only in grass foliage extracted from viscera, but also in droppings and random clips from the feeding area.

A similar increase in the use of uncultivated grassland in early spring was observed by Markgren and Mathiasson (1963) in a study of Bean Geese *Anser fabalis.* These authors also found *Deschampsia cespitosa* to be an important food plant of this species in some localities. The increasing frequency of *Deschampsia* utilization at Cors Tregaron towards the time of departure in 1967 is especially interesting, since it is generally regarded as being a poor source of food for herbivores.

The only known major sources of *Rhynchospora* in north-west Cardiganshire are Cors Tregaron and Borth Bog. Feeding areas and habits of the population of *A. a. albifrons* at Borth Bog have not been fully investigated, but most reports suggest that feeding occurs in the *Trichophorum* and peat-cutting zones at the south end. However, these geese have also been observed feeding on grazed pasture in January and March 1967 and, somewhat surprisingly, on mud within the tidal zone of the Dovey estuary, which was later shown to hold quantities of crustaceans *Gammarus* sp. and molluscs *Hydrobia* sp. Despite the similarities between available feeding grounds at Borth Bog and Cors Tregaron—as shown from the summer surveys of 1966—there has been no indication that geese from the latter site use Borth Bog as an alternative feeding area.

Acknowledgements

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The 1966 summer survey and 1966-67

feeding investigation was carried out under the auspices of the Wildfowl Trust, and was grant-aided by the Natural Environment Research Council.

Summary

An investigation of feeding habits of Greenland White-fronted Geese *Anser albifrons flavirostris* in Cardiganshire was commenced in winter 1964-65, following a drastic decline in the population in 1962-63. A survey of feeding grounds was made in summer 1966, followed by an intensive study of feeding habits in winter 1966-67, in which the technique of faeces analysis was employed. During much of the winter the preferred food plant species taken at Cors Tregaron was white beak-sedge *Rhynchospora alba.* Various grass species were also taken, particularly in spring. Temperature did not appear to be an important factor of feeding pattern, although there were indications that certain foodstuffs would not be readily available under severe conditions.

The technique of faeces analysis is discussed in relation to research into feeding habits of disturbance-sensitive species.

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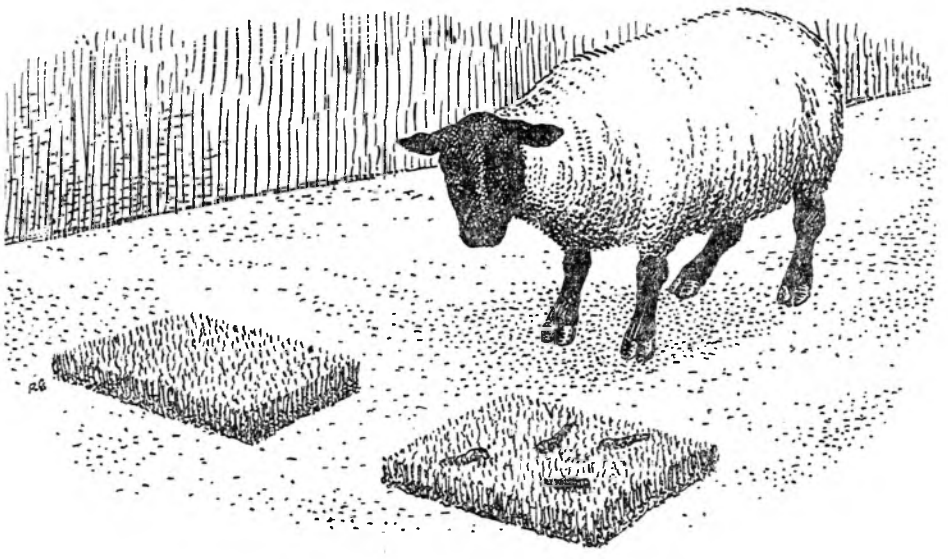

A trial to investigate the reactions of sheep to goose droppings on grass

J. B. A. ROCHARD and JANET KEAR

Any study of the interaction of wildfowl and agriculture is likely to encounter the farmers' complaint that cattle and sheep actively avoid land fouled by goose droppings. Kear (1963) reviewed what was then known on the subject: that grazing stock certainly avoid their own faeces and those of other mammals, but that there was no experimental evidence that showed the same reaction to the droppings of birds which look, smell and taste (to humans) quite different. Indeed, a few reports from farmers had indicated a totally different response, that domestic animals sometimes eat goose droppings selectively. It was suggested by Kear (1963) that these cases might have the factor of soil mineral deficiency in common and occur only in areas where soil and vegetation are short of some element which is obtained by the geese as grit elsewhere. Two examples from parts of Scotland where phosphate levels are known, or assumed, to be low were mentioned and since 1963 three others have been reported. A farmer interviewed in Iceland recalled that he had seen sheep eat Greylag Goose *Anser anser* droppings on poor ground. Another farmer on Islay (P. D. Pearce, *in litt.*), an island notoriously short of phosphate, reported that 80% of his cattle herd were picking up Greylag and Barnacle Goose *Branta leucopsis* droppings between January and April. Cabot (in prep.), in a study concerned with Barnacle populations on the Inishkeas, islands off Ireland, stated that cattle and donkeys eagerly devoured droppings there, the cattle picking them up at an average rate of 100 droppings every five minutes.

There seemed no doubt, however, that these instances of coprophagia were unusual and that the animals involved were to some degree suffering from a pathological condition. A study was required that would investigate in a precise manner the reactions of 'naive' but normal stock to goose-contaminated turf. Therefore a trial was designed (by J.K.) to test these reactions and the factors that might be involved if avoidance occurred.

Method

The work was carried out (by J.B.A.R.) at the research station of the Department of Agriculture and Fisheries for Scotland at East Craigs, Edinburgh.

Four yearling Blackface sheep (two castrate males and two females) were housed individually in 10 feet × 7 feet pens in a hay shed with an earth floor, and with the east side open. The only fresh grass offered to the sheep was that used in the tests; hay and water were continuously available, and a concentrated dry feed was given after each day's trial had been completed.

Grassy turves, measuring 12 inches × 18 inches, were cut fresh each day, and a uniform sward of about 3 inches depth was maintained by clipping with shears. Turves were treated before being offered to the sheep in one of four ways:

A. Left plain (untreated).
B. Four imitation goose droppings were spaced approximately evenly over the surface.
C. Four real goose droppings were placed as in B.
D. Four goose droppings were smeared over the grass and then removed.

It can be seen that turf C had visual and any chemical (taste and smell) elements of fouling, turf B had visual signs only, and turf D chemical components alone. It is also possible that tactile stimuli were involved in B and C. The spacing of the droppings was equivalent to the highest density of fresh droppings (three per square foot) found on a natural pasture grazed by geese.

Greylag droppings were obtained initially from the feral flock at Lochinch, Wigtownshire, but, as these deteriorated somewhat in the post, the majority were collected fresh in Holyrood Park, and stored in a deep-freeze until required. The imitation droppings were made to a recipe of two parts by weight of flour to one of plaster of paris, with finely chopped sisal being added to give a fibrous nature. The mixture was worked to a clayey consistence with water, moulded to shape, and allowed to dry before painting with Reeves 'Co-polymer' paint to simulate the green vegetable and white urate elements of the real droppings. This paint is more durable than poster paints, and does not leave the smell of the oil-based kinds. Imitation droppings were re-used after washing in plain water.

In the choice tests, each sheep was presented, once a day, with a pair of turves and its preference noted. The four turf treatments gave six paired combinations which were presented in a randomised sequence of 24 tests. Position preference was controlled by offering each turf type an equal number of times to the left and right. Tests were run consecutively so that the choice of one sheep did not affect that of its neighbour. Ideally the 24 tests would have been presented on consecutive days; however, staff and weather problems intervened and seven isolated days were missed. The breaks in routine had no obvious effect on the sheep at the resumption of tests.

The two turves were placed one foot apart at the east end of the pen and, at the beginning of the experiment, the time a sheep spent on each during ten minutes of feeding, was noted. The turf with the greatest aggregate time was then scored as 'first choice'. However, as it soon became obvious that a sheep could graze the grass from its first choice very rapidly and spend the greater part of its ten minutes grazing more hesitantly on the second choice, the total time was reduced to five minutes. In practice the choice was usually obvious from the comparative appearance of the turves or the sheep's behaviour, and the timing test was relied on only in case of doubt. One turf might be repeatedly sampled and rejected, the sheep returning to graze the alternative until it was quite bare, while the rejected turf remained green.

Results and discussion

The results obtained are set out in Table I. A chi-square test indicated that there were no significant differences in the performances of individual sheep; similarly no bias to left or right was found. However, the data indicate that significant differences did exist in the number of times different turf types were chosen. Turves without any contamination by real droppings were preferred and A and B were not discriminated ($P = 0.5$). Turf C, with the real droppings, was first choice significantly less often than A ($P = 0.02$) and turf D was the least attractive ($P = 0.001$). It seems therefore that goose droppings do repel sheep and that the repellent factor is mainly chemical, either taste or smell, but that the sight of strange objects alone (the imitation droppings) does not deter. The sheep used were unfamiliar with goose fouling at the start of the experiment and tests showed that they did not acquire experience during its course; that is, they did not avoid more at the end than at the beginning.

On turf C the real droppings were never eaten, but were often grazed around. Imitation droppings on turf B were nosed aside and frequently found on the ground after the test. Turf D was contaminated over its whole surface and had no clean grass, but even this obviously most repellent turf was usually grazed after the alternative had been stripped bare. The sheep would sample very delicately the tips of the blades of grass, quartering the whole surface to find clean grass in a manner which suggested extreme dis-

Table I. The preference of sheep for various pasture treatments.

Sheep No.	*Turf A* *untreated*	*Turf B with imitation droppings present*	*Turf C with goose droppings present*	*Turf D smeared with goose droppings*
1	11	6	5	2
2	10	10	4	0
3	8	9	5	2
4	7	10	5	2
Total first choices	36	35	19	6

taste, but normal grazing usually followed. Of course, the conditions of turf D are not found in the wild, but they may not be altogether different from pasture frequented by large numbers of geese over a long period (for example on a roost where the density of droppings may also be higher than that used here).

Although the results strongly suggest reduced palatability of fouled pasture, it cannot be assumed that such grass is 'lost'. The repellent factor may be unstable and soluble and disappear rapidly in normal weather conditions. Further experiments to investigate this, and the reactions of unpenned stock are required; possibly the severely limited supply encouraged the penned sheep to consume grass which would have been unacceptable in the field.

Summary

A trial is described that investigates the validity of farmers' contentions that stock will not graze on pasture fouled by geese. 'Choice tests' on penned sheep, with turves treated in various ways to simulate the properties of pasture contaminated with goose droppings, indicated that palatability is lowered by fouling, but that fouled pasture may still be grazed in some circumstances. Either smell or taste, or both, appeared to be the repellent factors involved; no response to the visual component of goose droppings could be detected.

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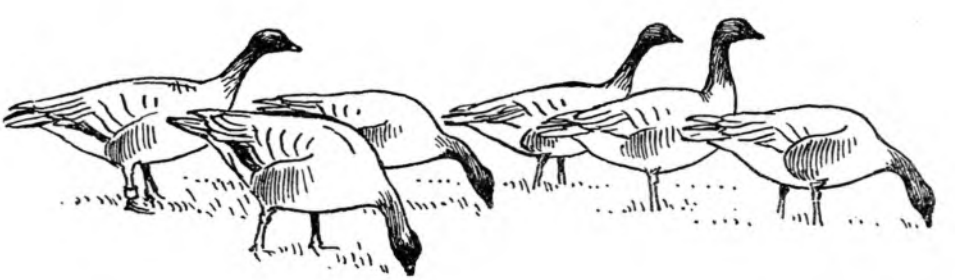

The attempted rehabilitation of oiled sea birds

J. V. BEER

Introduction

Water birds nowadays risk pollution by crude oil, oily wastes and oil products. Böös (1964) estimated that the number of birds oiled each year ran into millions. Although in recent years some progress has been made towards controlling the discharge of oil at sea (Barclay-Smith 1967) the problem is still enormous, part of Man's attrition of the natural environment.

Marine birds are the most affected, and especially the auks. For instance, Tuck (in McCallum 1964) reports that an estimated 250,000 auks have been lost in two years from one important colony off Newfoundland and he considers it will be wiped out in a few years if pollution continues at the same rate. The numbers of auks in the southern parts of the British Isles have markedly declined during the last 20-30 years (Boyd 1956, Parslow 1967) and oiling was already thought of as an important factor before the Torrey Canyon disaster killed an estimated 30,000 birds, nearly all auks, off England and France (Bourne *et al* 1967). Divers are also frequent victims and among wildfowl, eiders *Somateria* spp., scoters *Melanitta* spp. and the Long-tailed Duck *Clangula hyemalis* have suffered losses in tens of thousands in some incidents (McCallum 1964; Harrison 1967). In March 1968, 1,300 Common Eiders and scoters were found oiled in the Firth of Tay in Scotland (J. J. D. Greenwood, pers. com.). In May 1968 in South Africa colonies of penguins were seriously affected by oil (D. Hey, pers. com.). The Canvasback *Aythya vallisneria* and the Mute Swan *Cygnus olor* provide examples of freshwater birds which often suffer destruction from oiling.

The world demand for oil is still increasing and tankers are already carrying more than the 119,000 tons in the 'Torrey Canyon'. International codes and legislation may reduce the amount of oil deliberately discharged, but massive accidental pollutions will occasionally occur and cause heavy damage. Thus pollution will be with us for some long time yet. Many people have attempted to rehabilitate oiled birds, but the success rate has almost invariably been very low. Looking after these birds is very expensive in terms of effort, time and money and it has been suggested that most if not all oiled birds should be humanely killed (Rook 1967).

The 'Torrey Canyon', carrying sour Kuwait crude oil, grounded on the Seven Stones reef off Land's End on 18th March 1967 and within days numerous oiled birds, many of them migrants, were found on the Cornish beaches. By 17th April over 8,000 birds had been picked up alive and taken to centres run by the R.S.P.C.A. and R.S.P.B. Over 2,000 were moribund, leaving 5,811 which were cleaned (R.S.P.C.A. 1967).

Although very little hope could be held out for these birds, the Wildfowl Trust offered to take some from the overcrowded centres in Cornwall and attempt to rehabilitate them, gleaning as much information as possible from their day to day management and treatment. In particular, post-mortem and pathological studies were to be carried out to determine the causes of death.

Cleaning

Some of the materials and methods used for cleaning at the various centres proved to be unsuitable for emaciated and highly stressed birds. The process took far too long, the detergents caused irritation, and often oil stains were still left. Towards

the end of the rescue operation Tremalon B, a cosmetic cleaning agent (mascara remover), became available. It was easier to use, removed all oil stains and did not affect the eyes or cause dermatitis. However the cleaning process was still too long and again left the bird without waterproofing.

Another method was to leave the bird to clean itself. This is probably not advisable since Hartung and Hunt (1966) have shown that a bird can quickly remove and ingest sufficient oil to cause serious internal damage. A variation was to coat the bird with cleansing agent and then prevent it from preening by enclosing its body in a sack. This also rests the bird and reduces stress. J. A. Griswold (pers. com.) has cleaned scoters by immersion in water through which ultrasonic vibrations were passed. This takes only a few minutes but as before the birds end up without waterproofing and there are some dangers to birds and operators to be guarded against. Odham (1968) has recently formulated a three-component cleaning agent, Larodan 127, which is said to clean and re-waterproof in one operation. The indications are that it is an improvement on previous materials.

After cleaning, the birds were partly dried with absorbent materials and then placed in a small pen with a hot air fan. When completely dry they were transferred to a larger pen. Sprats or in some cases sand-eels were used for food, often after initial force-feeding.

Two batches of cleaned birds were brought the 200 miles to Slimbridge by lorry: 13 Guillemots *Uria aalge* and 4 Razorbills *Alca torda* on 28th March, and 75 Guillemots, 2 Razorbills and 3 Shags *Phalacrocorax aristotelis* on 2nd April. A single Razorbill, also a 'Torrey Canyon' victim, came from another source on 1st June.

General management

Many species of water bird are difficult to keep in captivity and auks, healthy and oiled, have only survived in zoos for an average of two months and a maximum of 11 months (J. Yealland, pers. com.). Auks brought in for rehabilitation are usually already in poor condition. They preen and ingest oil which damages the gut, the effect being worsened by the surfactants used to disperse the oil. Waterproofing and insulation is largely lost and the body temperature tends to fall. To maintain their temperature the birds should increase their food intake but instead they spend a disproportionate amount of time preening (Hawkes 1961). They therefore become emaciated, as were the Tay Eiders. Hartung (1967) has shown experimentally that the energy metabolism of oiled ducks does increase markedly to make up for the extra heat loss. As this would require twice the normal food intake to maintain, their body fats are used up instead. Only if internal damage is not severe and body fats are still present may a bird survive. Hartung and Hunt (1966) also showed that many internal organs were affected by oil. His birds had enlarged adrenals, indicative of stress conditions. The lethal dosage of oil was lower for birds further stressed by overcrowding and by cold.

Eighty-seven of the 97 birds arrived alive and were put in four concrete pens with a covered heated area with a raised wire-mesh floor. Outside, the birds had a small freshwater pond in which to bathe. Washing and preening often had to be stimulated by giving the birds showers on the warmer days. The floors were regularly hosed down and periodically disinfected with 'Erasan 125' a disinfectant with a very low avian toxicity. At first the birds were shut in at night but as their condition improved this restriction was gradually removed, completely so by the end of May.

In June the survivors were transferred to a much larger grassed pen with a covered heated area with a raised floor of P.V.C. coated Weldmesh ($\frac{1}{2}''$ square). In the open part there was an oval freshwater pond (12′ × 8′ × 20″ deep) fed by tapwater. Artificial cliffs were constructed of blocks, covered in soft-board and polythene sheeting to reduce leg and wing abrasion.

Diet

Initially the birds were fed sliced coley fish but after two weeks they were given thawed deep-frozen sprats, in a $3\frac{1}{2}\%$ weight to volume solution of sea-salt. Every effort was made to keep the food fresh, for even hungry birds would refuse tainted fish. The two surviving Shags ate sprats for three weeks but ignored them once they became used to taking live eels from the pond. In the late summer sprats were no longer available and small chopped eels were alternated with coley fish.

Supplements were added to the food to compensate for probable deficiences in the diet. Vitamins A and D (Scott's Emulsion), B (in Abidec) and B_{12} (Cytacon) were initially added to the fish. Later it was found easier to give the additives in

a capsule placed inside a sprat: each bird was thus given daily ¾ gm. of 'Bloom', a multivitamin and mineral food supplement, with additional vitamins B_1, B_2 and B_{12}.

Mortality and Pathology

The pattern of mortality and post-mortem findings are described in detail elsewhere (Beer 1968). The rate of loss of the auks followed approximately an exponential curve and can be divided into four phases.

Phase 1 (94 live birds, 14 deaths, mean mortality rate 20% per day) was the day of the journey from the Cornish centres. The additional stresses of a long journey, handling and new quarters, acting on birds that were already very sick, probably caused this high mortality rate.

Phase 2 (80 live birds, 33 deaths, 13% per day) lasted from arrival at Slimbridge to the 4th day, by which time half the original birds were dead. In general the post-mortem picture was similar in phases 1 and 2. The birds were emaciated, weighing at death an average of 640 gm. compared with a fat, rehabilitated bird of between 800 and 1,000 gm. The gut was severely affected by enteritis, with coagulative necrosis and haemorrhage in many cases. The lungs were often congested and the air-sacs clouded. Gross renal changes were more frequent in phase 2.

Phase 3 (47 live birds, 11 deaths, 1.4% per day) lasted from the 4th day until 3 weeks and was characterised by a transition from the acute conditions of phases 1 and 2 to the chronic conditions of phase 4.

Phase 4 (36 live birds, 25 deaths, 0.4% per day) started at 3 weeks and was terminated at 28 weeks, when most of the survivors were released. The acute enteric conditions were no longer important but aspergillosis, a secondary condition frequently found in stressed and debilitated birds, predominated. Another serious disease was infective arthritis. The feet and 'ankles' of auks are not adapted to long periods on land. The skin becomes calloused and cracked by contact with a hard surface while the joint develops arthritis, often becoming infected with *Staphylococcus* and other organisms. Renal disease was common, reflecting stress and the early toxic effects of oil and detergents.

Treatment

Infra-red heating was provided to reduce chilling and resultant respiratory conditions. Scott's Emulsion was given for six weeks to ameliorate toxic effects of oil and detergents on the gut, and Neomycin liquid was given for one week to control bacterial invasion of the gut wall (100 cc. and 10 cc./3 kg. fish respectively). At one station an intestinal disinfectant, Dianimal, was used (J. Hughes, pers. com.).

Aspergillosis cannot at present be successfully treated. Pimaricin (Royal Dutch Fermentation Industries) has been used in man with some response but preference was given to an experimental drug. Injected intramuscularly, the drug did not stop the deaths but the lesions were small and the form of the mycelium suggested some inhibition of the fungus. Griseofulvin was used at one centre but there is no evidence that it is of any value against *Aspergillus fumigatus*. The use of Erasan 125 or Polysan as general disinfectants or in aerosol form can do much to reduce the number of fungal spores in the bird's environment and thus improve the chances of its avoiding the disease.

Prevention of arthritis poses a serious problem and it is evident that an ideal type of flooring for maintaining large numbers of auks has yet to be devised. Possibly the best at the moment is Weldmesh with a soft plastic coating. This also lets the droppings through and avoids contamination of the feathers. Had this been used from the start, it is possible that the incidence of arthritis in our birds would have been lower. If, despite general hygienic measures, the ankle joints became infected, Ampcillin, ½ ml. 2 days, was injected intramuscularly. If tests showed the staphylococci to be resistant, streptomycin (Dimycin) was also used. When the webs became involved antibiotic powders and antiseptic creams were rubbed into the lesions. Even bland creams may help by keeping the foot supple.

Restoration of waterproofing

The rapid restoration of waterproofing is the crux of the whole problem of rehabilitation. Experience to date shows that birds have to be kept for many months before this is achieved and they can be returned to the sea.

When the birds arrived at Slimbridge their feathers were mostly oil-stained, sticky, disarranged and no longer waterproof. It was felt that the additional stress involved did not warrant removal of this staining by further cleaning. The amount of oil that the bird could still ingest by preening was too small to cause significant additional internal damage. The survivors were in fact free of oil stain in

about two months but were still not fully waterproof.

For a feather to be waterproof its components must have a regular structure (Elder 1954) of certain dimensions (Rijke 1968) and a water-repellent surface. It is possible that, as in some plants, a micro-rough surface is needed for strong water repellency (Amsden and Lewins 1966). Oiling, handling and cleaning disarrange the feathers and probably damage their fine structure. The bird's attempts to preen its feathers back into their normal form may cause further damage. Little is known about the rate of preening in wild auks, but the captives readily accepted opportunities to bathe and preen. Large pools are preferable in this connection to trays of water.

Even if a bird is able to preen its feathers back into a reasonable shape they are not fully waterproof until the water-repellent substances in or on the keratin of the feathers are replaced. The preen gland produces secretions which contain a great variety of ester waxes (Odham 1967). These compounds are spread, by preening, on to the feathers. Besides increasing water-repellency they probably keep the feathers more pliable and generally in better shape. Commercial ester waxes (Purcellin) sprayed in aerosol form on to the feathers improved waterproofing temporarily. Too large a dose clogs the feathers and the value of the waxes is then largely lost.

Despite cleaning, bathing, preening, and the application of waxes, in many cases full waterproofing is not regained until a new set of feathers has been grown. This may not be for a long time and meanwhile the birds die of secondary conditions. Thus anything that hastens moult would be of considerable value. Changing daylength is thought to be one factor controlling moulting. Our birds were therefore given artificial light at night, to simulate a 24 hr. day, until mid-June when the day was reduced by one hour per week until the end of July. Comparison with birds at one centre which did not use any artificial light suggested that the Slimbridge birds' moult was but slightly advanced. Another possible future approach might be to use hormones or drugs such as the commercial product I.C.I. 33828 which precipitates and shortens the moult period of female chickens (Sykes 1964).

Release

In mid-October 5 Guillemots, 3 Razorbills and 2 Shags, all considered to have regained good condition, were ringed and released on the north Somerset coast. Four birds were held back because of their poor plumage condition and arthritis. One of these died at 44 weeks of renal failure. The other three are alive after 18 months in captivity but their condition does not yet warrant their release. Of those birds which were released, long-term survival is not proven. Two were recovered within $2\frac{1}{2}$ weeks. Conder (1968) reports that of 60 birds ringed and released 16 were found dead within a month. Obviously success is only really achieved when the bird returns to a colony and breeds. Watching a bird out to sea for an hour or two and noting that it is still buoyant is not a very adequate measure.

Conclusion

Regretfully it must be concluded that it is better to kill humanely all but the lightly oiled birds, at least until improved rehabilitation techniques are available. The knowledge we have gained from our attempt, particularly with regard to mortality factors and restoration of waterproofing, may serve as a beginning to the research needed into all aspects of the problem. This should cover the toxicology of oils and detergents, the causes, effects and control of emaciation, stress and relevant acute and chronic diseases; the mechanism of waterproofing and methods of restoring it; nutrition; aspects of behaviour and the general management of the species most frequently oiled.

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Summary

Following the Torrey Canyon oiling disaster a number of sea birds, mostly auks, were cared for at Slimbridge. Methods of cleaning, management and feeding are described. The acute and chronic diseases developing in captivity were investigated, as were methods of treatment. The rapid restoration of waterproofing is considered the crux of the problem. Despite much effort, few birds could be returned to the sea and their long-term survival is in doubt. More research is needed before attempted rehabilitation can be considered a satisfactory alternative to humane destruction.

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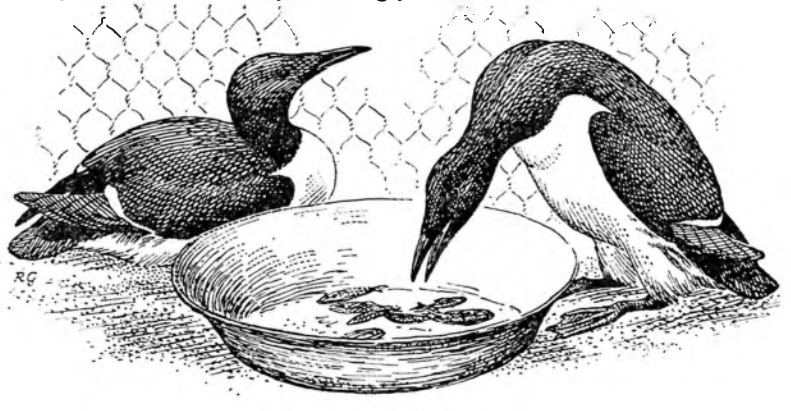


Philippa Scott

Plate XI. (a) Part of the new Wildfowl Trust Reserve at Welney Washes, Norfolk, viewed from one of its high retaining banks, across the New Bedford River.
(b) Shallow winter flood on the grazed pastures of the Reserve provides ideal feeding grounds for wildfowl. (See p. 130)

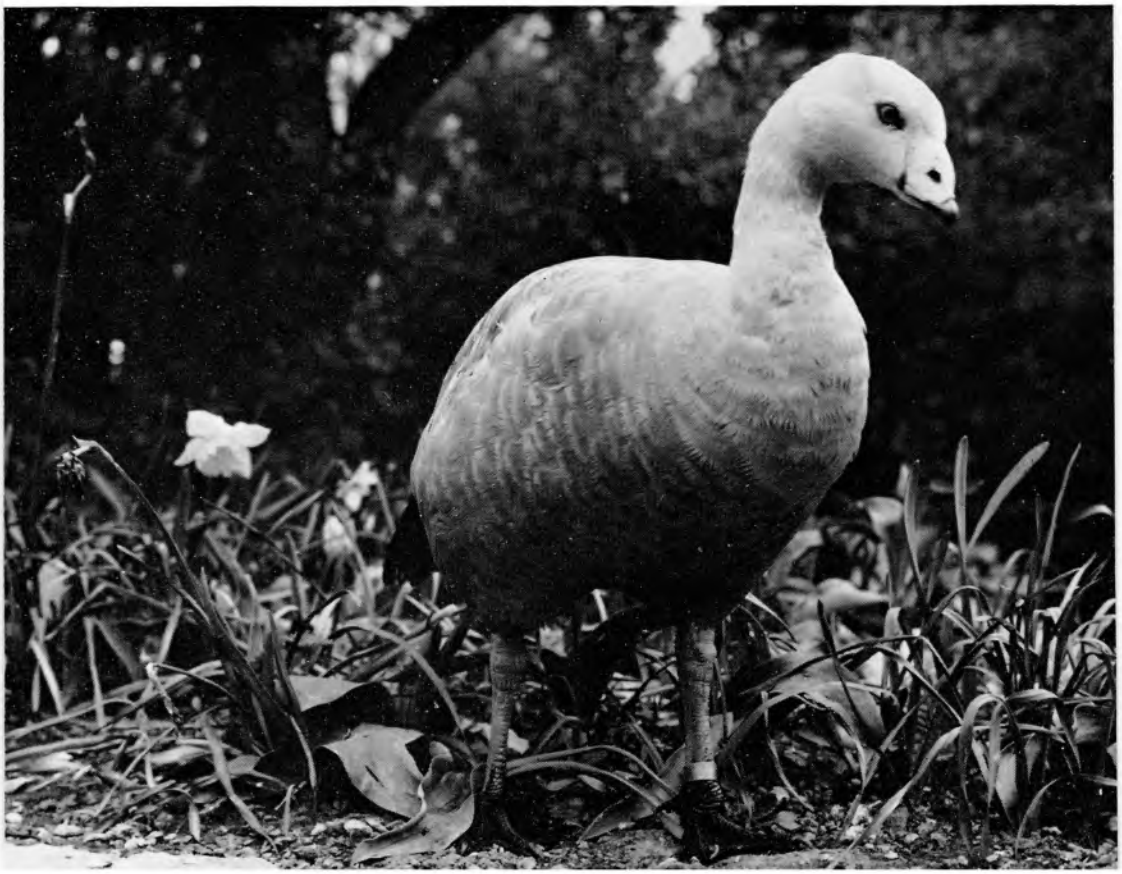
E. E. Jackson

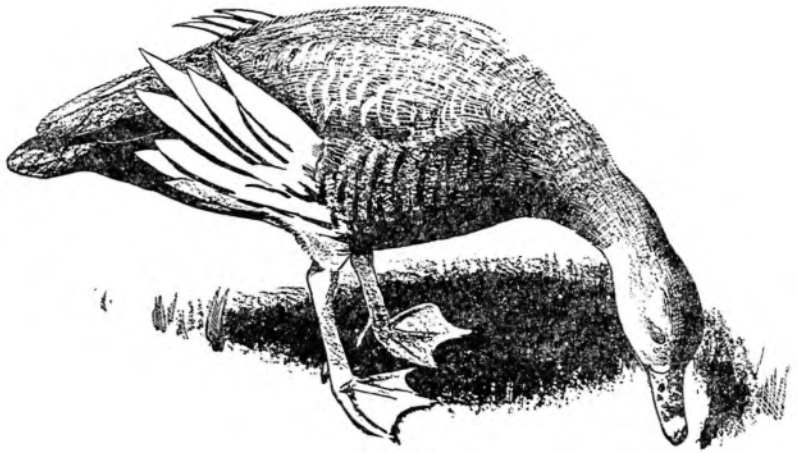
Philippa Scott

Plate XII. (a) A pair of Lesser White-fronted Geese *Anser erythropus*. The presence of this species amongst the wintering goose flock was a deciding factor in the establishment of the Wildfowl Trust at Slimbridge in 1946.

(b) A Cereopsis Goose *Cereopsis novæ-hollandiæ*, one of the rarest geese (about 6,000 survive in the wild) and, taxonomically, one of the most puzzling.

J. A. Middleton





The Slimbridge Collection—the first 21 years

S. T. JOHNSTONE

When the Wildfowl Trust started in late 1946, the aftermath of war made the acquisition of waterfowl extremely difficult and it was due to the kindness of Gavin Maxwell, who loaned to the Trust his private collection, that we were able to show our early visitors a fairly representative selection of swans, geese and ducks of some sixty-five different kinds.

During the succeeding twenty-one years, this nucleus has been built up into the largest and most comprehensive collection of the Anatidae in the world. Of the 247 species and races of waterfowl, 185 have been represented at Slimbridge, 142 have nested and 137 have been reared. Fourteen of these were the first breeding recorded in captivity. At the present time there are some 2,000 birds of 171 different kinds.

The Magpie Goose has done well at Slimbridge. The original female that came with the Monreith collection, a pre-war wild-caught bird, was paired to a wild male from Australia. When she was at least eighteen years old she commenced breeding and did so for the succeeding ten years until her death this year. The only other recorded case of Magpie Geese breeding in captivity was at San Diego Zoo.

All the whistling ducks have been established at Slimbridge and all have nested, although as yet we have not reared the Eyton's or Javan. We reared the Wandering Whistling Duck on two occasions, but sad to relate the species is no longer represented in the collection, and until such time as birds are again exported from Indonesia, it is unlikely that we shall be able to acquire new specimens.

Slimbridge has a comprehensive collection of swans and although they are perforce kept in rather small pens all have bred with the exception of the Whistling Swan. The nearest this form got to breeding was when the female died from an impaction of the oviduct when laying her first egg. We have the only breeding Bewick's Swans in captivity. The female, a wild bird caught in Holland, started to lay after being at Slimbridge for eight years. Her mate was a juvenile, caught in the Rushy Pen in 1947 which, after several years of breeding, died in the autumn of 1962. Subsequent efforts to find a satisfactory new mate for the

female proved unsuccessful until in 1966 she became enamoured of one of her sons and in 1967 again produced two fine cygnets.

There are forty kinds of geese and sheldgeese in the collection, the Kelp Goose being the only species that we have failed to establish at the New Grounds. Three attempts have been made to accomplish this: first by the collection of adult birds on the Falkland Islands by Dr. W. Sladen; secondly by the purchase of adult birds from Dutch dealers; thirdly by hand-rearing goslings on the islands with turkey starter crumbs and bringing the juvenile birds back. In each case the birds eventually succumbed to aspergillosis. This was particularly sad in the case of the last project; Peter Gladstone and Charles Martell on their expedition hand-reared some 17 Kelp Geese on the Falklands and brought them back to Slimbridge; but all had died within twelve months (see p. 25).

Our principal success in the goose field has been with the Hawaiian Goose or Ne-ne. In the sixteen years that we have been breeding this rare bird, 226 have been reared from the original two females that were sent to us in 1950 and a further 130 birds in other collections to which we have loaned breeding pairs.

Among the surface-feeding ducks, three kinds unique to our collection are the Salvadori's Duck, the New Zealand Blue or Mountain Duck and the Galapagos Pintail. Rare species that we have hand-reared and provided stock for world collections include Bronze-winged Duck, Kerguelen Pintail, New Zealand Brown Duck, Laysan Teal, Cape Shoveler, New Zealand Shoveler and Ringed Teal.

During the past year we have had seven of the eight forms of eiders in the collection. A pair of Pacific Eiders were reared from eggs collected in the Yukon but unfortunately they died last autumn. We have, however, two drake and four duck Spectacled Eiders which came as juveniles and have now joined our adult drake in the Rushy Pen. We have been breeding King Eiders for a number of years and have found that the females are much more robust than the males. None of the hand-reared males have survived for more than two years. It would appear that fast-flowing, and cold, water is essential to eiders' well-being; birds that we have kept on our Waterfall pond have fared much better than those put on ponds more remote from the source of supply. It is proposed to build a special pond for the eiders and other sea ducks for, although we have kept a Longtail drake for nine years, Harlequins for five, and Common Scoters for seven years, it is felt that the new pond might facilitate the breeding of these attractive ducks. So far we have only bred the Common and Barrow's Goldeneyes.

All species of pochard are kept at the New Grounds and all breed regularly with the exception of the Ring-necked Duck which has nested, but its young have not been reared.

Among the perching ducks it is some years since we had a White-winged Wood Duck in the collection, and in spite of considerable efforts we have been unable to obtain new specimens. Our Hartlaub's Ducks were the first to breed in captivity and from these a hand-reared stock has been established in other collections where they are now breeding. We have managed to keep African and Indian Pygmy Geese going in fairly unsatisfactory conditions during the last ten years. Now we have a fine Tropical House where they are duly installed and we hope will breed.

All the European sawbills have been reared at Slimbridge and the hand-reared birds did very well for a number of years. But subsequently the Goosanders and Red-breasted Mergansers developed tuberculosis, and a large number were lost. The disease so far has not affected the Smew which breed regularly. This may be because they are not really mergansers but more closely related to the goldeneyes. The first Hooded Mergansers to be reared at Slimbridge were from chipping eggs collected in the United States and flown over in special boxes, hatching a few days after arrival.

Of the stiff-tails, four species have been kept successfully — North American Ruddy Duck, Peruvian Ruddy Duck, Maccoa and White-headed Duck, also the more doubtfully related species, White-backed Duck and Black-headed Duck. Of these, the North American Ruddy has bred consistently and reared its young successfully by itself. The White-backed Ducks have laid for the last three years but so far we have not managed to rear any of the young that have hatched.

A list of kinds of waterfowl that have been represented at Slimbridge follows. Against those present at the end of 1967 is set the number of individuals. Forms which have been reared are marked (+), or (*) if we were the first to breed them in captivity.

Anatidae represented at Slimbridge, 1946-67	*Present at end of 1967*	*Breeding record 1946-67*
Magpie Goose *Anseranas semipalmata*	6	+
Spotted Whistling Duck *Dendrocygna guttata*	1	*
Eyton's Whistling Duck *D. eytoni*	14	
Wandering Whistling Duck *D. arcuata*		+
Fulvous Whistling Duck *D. bicolor*	15	+
Cuban Whistling Duck *D. arborea*	8	+
Javan Whistling Duck *D. javanica*	20	
White-faced Whistling Duck *D. viduata*	30	+
Northern Red-billed Whistling Duck *D. a. autumnalis*	25	+
Southern Red-billed Whistling Duck *D. a. discolor*	25	+
Coscoroba Swan *Coscoroba coscoroba*	6	+
Black Swan *Cygnus atratus*	4	+
Mute Swan *C. olor*		+
Black-necked Swan *C. melanocoryphus*	5	+
Whistling Swan *C. c. columbianus*	4	
Bewick's Swan *C. c. bewickii*	6	*
Jankowski's Swan *C. c. jankowskii*	1	
Whooper Swan *C. c. cygnus*	6	+
Trumpeter Swan *C. c. buccinator*	17	+
Swan Goose *Anser cygnoides*	9	+
Western Bean Goose *A. f. fabalis*	9	+
Russian Bean Goose *A. f. rossicus*	5	*
Thick-billed Bean Goose *A. f. serroriostris*	3	
Pink-footed Goose *A. brachyrhynchus*	16	+
European White-fronted Goose *A. a. albifrons*	14	+
Pacific White-fronted Goose *A. a. frontalis*	9	
Greenland White-fronted Goose *A. a. flavirostris*	15	+
Lesser White-fronted Goose *A. erythropus*	19	+
Western Greylag Goose *A. a. anser*	20	+
Eastern Greylag Goose *A. a. rubrirostris*	5	+
Bar-headed Goose *A. indicus*	9	+
Emperor Goose *A. canagicus*	23	+
Lesser Snow Goose *A. c. caerulescens*	10	+
Greater Snow Goose *A. c. atlanticus*	24	+
Ross's Snow Goose *A. rossii*	28	+
Atlantic Canada Goose *Branta c. canadensis*	2	+
Moffitt's Canada Goose *B. c. moffitti*	4	+
Giant Canada Goose *B. c. maxima*	2	+
Taverner's Canada Goose *B. c. taverneri*	6	+
Dusky Canada Goose *B. c. occidentalis*	6	+
Vancouver Canada Goose *B. c. fulva*	2	+
Aleutian Canada Goose *B. c. leucopareia*	2	
Richardson's Canada Goose *B. c. hutchinsii*	3	
Cackling Canada Goose *B. c. minima*	8	+
Hawaiian Goose *B. sandvicensis*	101	+
Barnacle Goose *B. leucopsis*	30	+
Dark-bellied Brent Goose *B. b. bernicla*	6	
Light-bellied Brent Goose *B. b. hrota*		
Black Brant *B. b. orientalis*	15	*
Red-breasted Goose *B. ruficollis*	31	+
Ruddy Shelduck *Tadorna ferruginea*	6	+
Cape Shelduck *T. cana*	4	+
Australian Shelduck *T. tadornoides*	3	
Paradise Shelduck *T. variegata*	6	+
Moluccan Radjah Shelduck *T. r. radjah*	6	
Australian Radjah Shelduck *T. r. rufitergum*	4	+
Common Shelduck *T. tadorna*	5	+
Egyptian Goose *Alopochen ægyptiacus*	4	+
Orinoco Goose *Neochen jubatus*	1	+
Abyssinian Blue-winged Goose *Cyanochen cyanopterus*	6	+
Andean Goose *Chloëphaga melanoptera*	15	+
Ashy-headed Goose *C. poliocephala*	4	+
Ruddy-headed Goose *C. rubidiceps*	4	+
Lesser Magellan Goose *C. p. picta*	6	+
Greater Magellan Goose *C. p. leucoptera*	6	+
Greater Kelp Goose *C. hybrida malvinarum*		
Cereopsis Goose *Cereopsis novæ-hollandiæ*	5	+
Falkland Flightless Steamer Duck *Tachyeres brachypterus*	3	

	Present at end of 1967	*Breeding record 1946-67*
Patagonian Crested Duck *Lophonetta s. specularioides*	10	*
Andean Crested Duck *L. s. alticola*	10	+
Marbled Teal *Marmaronetta angustirostris*	15	+
Bronze-winged Duck *Anas specularis*	8	*
Salvadori's Duck *A. waigiuensis*	1	
Cape Teal *A. capensis*	20	+
Hottentot Teal *A. punctata*	11	+
Northern Versicolor Teal *A. v. versicolor*	16	+
Puna Teal *A. v. puna*	17	+
Red-billed Pintail *A. erythrorynchа*	18	+
Southern Bahama Pintail *A. bahamensis rubrirostris*	22	+
Galapagos Pintail *A. b. galapagensis*	1	
South Georgian Teal *A. g. georgica*	1	
Chilean Pintail *A. g. spinicauda*	12	+
Northern Pintail *A. a. acuta*	12	+
Kerguelen Pintail *A. a. eatoni*	6	*
Chilean Teal *A. f. flavirostris*	20	+
Sharp-winged Teal *A. f. oxyptera*	5	+
European Green-winged Teal *A. c. crecca*	8	+
American Green-winged Teal *A. c. carolinensis*		+
Baikal Teal *A. formosa*	20	+
Falcated Teal *A. falcata*	20	+
Australian Grey Teal *A. gibberifrons gracilis*	10	+
Chestnut-breasted Teal *A. castanea*	15	+
Auckland Island Flightless Teal *A. a. aucklandica*		
New Zealand Brown Teal *A. a. chlorotis*	8	*
Mallard *A. p. platyrhynchos*		+
Greenland Mallard *A. p. conboschas*	2	+
Hawaiian Duck *A. p. wyvilliana*	6	+
Laysan Teal *A. p. laysanensis*	20	*
Florida Duck *A. p. fulvigula*	6	+
Mexican Duck *A. p. diazi*	1	
North American Black Duck *A. rubripes*	8	+
Indian Spotbill *A. p. pœcilorhyncha*	4	+
Chinese Spotbill *A. p. zonorhyncha*	8	+
New Zealand Grey Duck *A. s. superciliosa*	10	+
Pelew Island Grey Duck *A. s. pelewensis*	4	
Australian Black Duck *A. s. rogersi*	2	+
Philippine Duck *A. luzonica*	20	+
African Yellowbill *A. u. undulata*	20	+
Abyssinian Yellowbill *A. u. ruppelli*	10	+
African Black Duck *A. s. sparsa*	7	+
Abyssinian Black Duck *A. s. leucostigma*		
Gadwall *A. s. strepera*	6	+
European Wigeon *A. penelope*	20	+
American Wigeon *A. americana*	10	+
Chiloe Wigeon *A. sibilatrix*	12	+
Blue-winged Teal *A. discors*	12	+
Argentine Cinnamon Teal *A. c. cyanoptera*		+
Northern Cinnamon Teal *A. c. septentrionalium*	12	+
Garganey *A. querquedula*	8	+
Argentine Red Shoveler *A. platalea*	10	+
Cape Shoveler *A. smithi*	8	*
New Zealand Shoveler *A. rhynchotis variegata*	12	+
Common Shoveler *A. clypeata*	12	+
Ringed Teal *A. leucophrys*	30	+
Blue Duck *Hymenolaimus malacorhynchos*	1	
European Eider *Somateria m. mollissima*	24	+
Pacific Eider *S. m. v-nigra*		
Northern Eider *S. m. borealis*	2	
American Eider *S. m. dresseri*	3	
King Eider *S. spectabilis*	9	*
Spectacled Eider *S. fischeri*	7	
Steller's Eider *Polysticta stelleri*	3	
Red-crested Pochard *Netta rufina*	24	+
Rosy-bill *N. peposaca*	19	+
South American Pochard *N. e. erythrophthalma*	3	+
African Pochard *N. e. brunnea*	16	+

	Present at end of 1967	*Breeding record 1946-67*
European Pochard *A. ferina*	12	+
Redhead *A. americana*	12	+
Canvasback *Aythya vallisneria*	6	+
Madagascar White-eye *A. innotata*		
Common White-eye *A. nyroca*	16	+
Baer's Pochard *A. baeri*	20	+
Australian White-eye *A. a. australis*	10	+
New Zealand Scaup *A. novæ-seelandiæ*	20	*
Ring-necked Duck *A. collaris*	6	
Tufted Duck *A. fuligula*	12	+
Lesser Scaup *A. affinis*	12	+
European Greater Scaup *A. m. marila*	12	+
Lesser Brazilian Teal *Amazonetta b. brasiliensis*	10	+
Greater Brazilian Teal *A. b. ipecutiri*		+
Maned Goose *Chenonetta jubata*	10	+
Mandarin Duck *Aix galericulata*	50	+
North American Wood Duck *A. sponsa*	50	+
African Pygmy Goose *Nettapus auritus*	4	
Indian Pygmy Goose *N. c. coromandelianus*	12	
Comb Duck *Sarkidiornis m. melanotus*	24	+
South American Comb Duck *S. m. carunculatus*	6	+
Hartlaub's Duck *Cairina hartlaubi*	8	*
White-winged Wood Duck *C. scutulata*		
Muscovy Duck *C. moschata*	10	+
Spur-winged Goose *Plectropterus g. gambensis*	2	
Black Spur-winged Goose *P. g. niger*	1	
Common Scoter *Melanitta n. nigra*	3	
Velvet Scoter *M. f. fusca*	1	
Atlantic Harlequin Duck *Histrionicus h. histrionicus*	12	
Long-tailed Duck *Clangula hyemalis*		
Barrow's Goldeneye *Bucephala islandica*	7	+
European Goldeneye *B. c. clangula*	14	+
American Goldeneye *B. c. americana*	4	
Bufflehead *B. albeola*	7	
Smew *Mergus albellus*	10	+
Hooded Merganser *M. cucullatus*	5	+
Red-breasted Merganser *M. s. serrator*	4	+
Goosander *M. m. merganser*		*
American Merganser *M. m. americanus*	1	
White-headed Duck *Oxyura leucocephala*	6	
North American Ruddy Duck *O. j. jamaicensis*	30	+
Peruvian Ruddy Duck *O. j. ferruginea*	1	
African Maccoa Duck *O. maccoa*		
African White-backed Duck *Thalassornis l. leuconotus*	7	
Black-headed Duck *Heteronetta atricapilla*		
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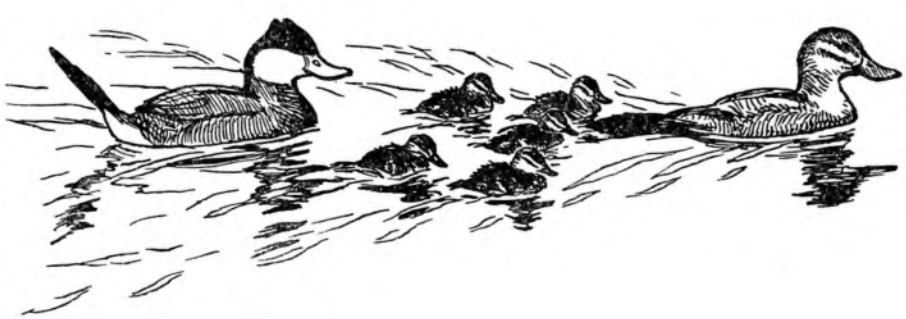


Welney Washes, 1967

PETER SCOTT

The Place (Plate XI *a* and *b*, facing p. 124)

The Welney Washes lie across the map of the Great Fens like a ruler, stretching from Earith in Cambridgeshire north-eastwards for 21 miles to Denver Sluice in west Norfolk. They are an amazing feat of engineering laid out at the beginning of the 19th century, designed as a short cut for the winding River Great Ouse and also as a safety valve when the river system is already full and more rain falls. Water from the Great Ouse basin is diverted so as to spread out over the grass fields of the Washes and confined by 20 foot high barrier banks which run, half a mile apart, dead straight for mile after mile across the fens.

The water in the bordering Old and New Bedford Rivers and on the flooded meadows is far above the level of the surrounding country which was always low and has sunk further as a result of drainage. All this country is now under the plough, and the only grassland in the fens is the water meadows of the Washes, which are relatively dry in summer and grazed by cattle. The present ornithological interest of the area is entirely based on the summer grazing regime. In winter the floods may begin in October, or even earlier, but in dry years there may be no flooding until after Christmas.

The flat landscape may not appear beautiful to every eye, but it has a peculiar fascination. The brown fields, divided by ditches, stretch away into the distance, the roads run straight with sharp angular bends to conform with the drainage channels. Away to the east the tower and lantern of Ely cathedral break the horizon where the land rises almost imperceptibly to form 'the isle of Ely'. Between the vast green retaining banks the grass fields are open, broken only by occasional willow or thorn trees, a few carefully nurtured osier beds (their produce essential to the engineering and maintenance of the drainage) and the gates and gateposts on the droves which give access to the cattle in summer. When the floods are out fingers of dry land stretch into the shallow water along the sides of the ditches where a hundred and fifty years of cleaning them out has raised a low bank on either side.

There is a small number of shepherds who are key men in the economy and management of the Washes. Each deals with a stretch of some six or seven miles. The shepherd has in the past been given the shooting rights (which let at about £1 per acre) by the landowner in return for work on maintenance of the ditches. In addition he receives payment which may be £1 per acre from the farmer who rents the grazing (nowadays at £2-£2 10s. per acre though formerly up to £9 per acre) in exchange for care of the cattle using the grazing.

Thirty years ago it was widely but erroneously believed that the tidal nature of the New Bedford River conferred public shooting rights on the whole area of the Washes. Recently this has been shown not to be so, and the shooting rights have been let, on some land at £1 per acre. The difficulty of getting within shot of birds in an area with a variable shore line and very little natural cover has meant small bags; the birds flight

over the open water and at enormous height. General disturbance has come from large numbers of small areas being under separate ownership with widely varying degrees of keepering, and extensive poaching. The situation had become completely out of hand and resulted in a few syndicates being formed to try to take over the rights on larger blocks of land. Gradually opinion mounted, among wildfowlers as well as naturalists, that some form of refuge should be available in the Washes.

The Welney Washes are included in Category A of the MAR list of European Wetlands drawn up by the International Wildfowl Research Bureau in collaboration with the International Union for Conservation of Nature and the International Council for Bird Preservation. They were also included as a possible Nature Reserve in H.M. Government's Command Paper 7122 of 1947.

The Birds

My notes on the bird life of the Washes go back to 1927, but it was not till 1950-51 that regular wildfowl counts were established there. Monthly figures are therefore available for 17 winters, and these show striking fluctuations, as would be expected with an area so intimately influenced by floodwaters.

Wigeon are the most numerous species with a high count of 19,300 in 1954-55; the highest figure for Mallard is 4,880. The 1954-55 season also produced the highest peak of Teal (4,200) and Pintail (5,000). Over 2,200 Pochard have been present during recent winters, and over the years no less than 26 species of Anatidae have been recorded—including Garganey, Gadwall, Shoveler, Scaup, Tufted Duck, Goldeneye, Velvet and Common Scoter, Red-breasted Merganser, Goosander, Smew, Shelduck, Greylag, White-front, Bean, Pinkfoot, Brent and Canada Geese, Mute, Whooper and Bewick's Swans. The Bewick's in particular have shown a striking pattern of increase, though with many fluctuations, from 17 in 1950-51, and 7 in 1951-52 to 855 in 1966-67.

In all, during the 1966-67 winter the flooded Washes carried, at peak, 24,000 wildfowl. The Bewick's Swans and Pintail were by far the largest concentrations of these species in the country.

At least 10 species of Anatidae have definitely bred in the Washes, as well as Great Crested Grebe and a number of waders including some very rare ones.

Because of the disturbance during the shooting season the best views of the wildfowl have been after the end of the season on 1st February. With a refuge of adequate size it should be possible to observe them all through the season, with a corresponding addition to ornithological knowledge and bird watchers' enjoyment.

The fact that the axis of the Washes lies virtually parallel with the migration routes of so many European birds, undoubtedly makes it a landmark which they follow regularly both in autumn and spring, and there is little doubt that a constant watch on this route will produce very interesting results.

The Refuge

When, therefore, an anonymous donor presented the Wildfowl Trust with 102 acres of the Washes north of Welney in February 1967, Council had little hesitation in deciding what course to follow. By establishing an effective refuge the Wildfowl Trust would be making its most important single contribution to conservation. In the fields of research and education too the area has great possibilities arising from the Trust's special knowledge and experience of showing wild birds to people at close range without disturbing the birds. The educational advantages of such facilities are obvious. From a scientific point of view there are two particular studies of importance to the Trust. One is the Bewick's Swan study which requires opportunity to see the birds at close enough range to identify individuals. The other is a long cherished plan to study the effects of controlled flooding on grassland with a view to attracting water birds at times when floods are few and far between.

The first hundred acres was clearly much too small an area to be an effective refuge. The Trust therefore embarked on a vigorous campaign to acquire land on either side. It was essential that there should be a solid block of land free from shooting. Owners of potential enclaves not unnaturally concluded that the market value of their land had suddenly increased. A great deal of money was required, but friends rose nobly to the occasion. Arthur Guinness, Son & Co. (Park Royal) Ltd. made a most generous interest-free loan of £24,000 for the period of a year. This enabled us to press ahead with acquisitions while seeking to gather donations sufficient to repay the loan. The World Wildlife Fund proved a tower of strength. Through its American National Appeal a substantial grant was promised if it could be matched by the

British National Appeal. And it was, despite incidental difficulties such as devaluation. Through many people's generosity we are now in full possession of 400 acres and have acquired the shooting rights on an adjacent 100 acres. Our rights extend to the high barrier banks belonging to the Great Ouse River Authority. Shooting on the land outside, and below, these banks is muffled to birds on the Washes, so we have now an effective Refuge, on whose central portion the wildfowl should be free from disturbance. The cost of this achievement was £33,000.

The Future

Before the Wildfowl Trust came on the scene, the Royal Society for the Protection of Birds and the Cambridgeshire and Isle of Ely Naturalists' Trust had been acquiring land on the Washes further upstream and mostly beyond the railway viaduct. As they were primarily concerned with protecting summer breeding areas, they were able to purchase piecemeal at normal prices. But over several years their purchases had aggregated into substantial blocks. Together with the Trust's purchase, the naturalists' bodies have become the largest landowners in the Washes, holding over a fifth of the total area. This fact played an important part in averting one major threat, a proposal to improve the drainage of the Washes and convert them to arable farming. Hardly had the drainage proposal sunk from sight when the reverse threat emerged, to convert the Washes into a freshwater reservoir. From an agricultural point of view it makes more sense to drown low-grade grassland rather than good agricultural land. And it requires some effort to convince the planners that twenty miles of deep permanent water is no substitute, as far as wildfowl are concerned, for great areas of temporary shallow floods. A feasibility study is being made and a report is expected shortly. Fortunately the indications are that the engineering requirements will be prohibitive, and that we shall be able to breathe again.

However, we have not been wholly successful on all fronts. As if to demonstrate how modern technology is continually throwing up new threats against our few remaining wild places, the National Research Development Council now propose to set up an experimental hover-train monorail track along the length of the Washes! Again from their point of view this is an ideal site on which to test their vehicles up to 300 m.p.h. — twenty miles in a straight line with relatively few road crossings. It would be absolutely disastrous if the track were to run on the Washes themselves. But, fortunately, the idea is to build it on the outside of the NW. barrier bank between the Old Bedford River and the River Delph. The three naturalists' organisations, together with representatives of the Nature Conservancy, have co-ordinated their actions through an *ad hoc* committee, and have pressed for the experimental vehicle to be kept out of sight of the birds on the Washes during its whole run. We feel that if this is done the noise of its progress (even though it may be equivalent to a Comet jet at take off!) will not be unduly disturbing to the birds. Indeed, as a small crumb of comfort, the existence of the test track may effectively seal off one boundary of the Washes and so increase their security.

Be that as it may, it is quite obvious that it is going to become increasingly difficult to keep any large area of land in southern England in a wild state, just for the birds and a fortunate few. We believe that the only hope for the long-term future is to develop our area discreetly, so that large numbers of people can experience for themselves the thrill of seeing masses of wildfowl at close quarters. With our experience at Slimbridge we know that this can be done without spoiling the essential wildness of the scene. Then the Washes will have the status of a recreational amenity as well as a wildfowl refuge and it will be much easier to withstand pressure from other kinds of land-use development. Many people shudder at the thought of interfering with the natural scene—though the Washes were wholly artificial in their origin. In an attempt to reassure such people, and to indicate how the development might take shape, I wrote a letter purporting to be from one enthusiastic naturalist to another in 1975, seven years after the initial land purchase, when I hope all our plans will be realised. This was circulated in support of our campaign for funds, and it is appended herewith (slightly shortened and modified where events have already caught up with the prophet).

Letter to a friend

15th January 1975

Dear George,

I thought you might be interested to hear of a rather fabulous day we spent yesterday at the Wildfowl Trust's place

at Welney. We checked in at one of the local inns the night before and got out to the Washes just at first light. The Head Warden, a splendid marshman who's lived all his life on and around the Washes, met us where we left the car at the foot of the steep barrier bank of the New Bedford River. A pilot light at the top of the bank lit us up a ramp to the footbridge high over the river. It's screened on the Venetian blind principle so that people crossing can't be seen by the birds out in front—the first example of the fantastic attention to detail in the planning of this Observatory. As we got to the far side of the bridge we heard a burst of calling from the wild swans—Bewick's, which, as you know, are a special feature of the place.

The only exit from the bridge is into a building which is in part Wardens' house and in part a Members' Room. A great picture window looks out over the marsh, with a pool almost in front of it, covered with ducks, just visible in the half light, and more arriving all the time —mostly Mallard and Shoveler. I think Mary would have liked to stay in the warmth of the Members' Room, which, incidentally, being 10 or 15 feet above the marsh, had a wonderful view right across it. The floods were out on the far side of the Washes—which are about half a mile wide here, and we could just see the water stretching across in front. But we weren't allowed to stay indoors. We were to be taken up the Washes to look at the geese, and we'd have to hurry if we wanted to see them flight in. Down a flight of steps and we were on a path running along behind a 7 foot bank and parallel with the river. It took about 10 minutes to walk to the hide, and every now and again we heard the geese calling over on the far side of the Washes.

After a while the path turned sharp right and we walked with a ditch immediately on our left and high banks on both sides of us. We passed at least three observation huts and eventually we went very quietly up some steps into the fourth hut. It was a characteristic Slimbridge-type hide capable of holding about a dozen people, but we had it to ourselves. From the shuttered slits the view was fantastically beautiful. In front of us was a shallow flash of water in a grass field. We were looking out north-eastwards and the water came round on our right to reflect a most gorgeous orange dawn sky. Silhouetted against the reflection were a mass of Wigeon whose calls we had been hearing as we approached and now the volume of sound was astonishing.

I suppose we'd been perched on the seats in the hide for about ten minutes, by which time it was getting pretty light, when we suddenly heard geese—White-fronts—above the noise of the Wigeon. There were eight geese in the first bunch, flying very low and almost at once they landed about 100 yards away at the edge of the shallow water. Immediately they began to feed. Then six more came, then a dozen, and following them a continuous flight. Most of them were crossing close in front, and you felt you could almost reach out and touch them as they passed. One bunch of about 30, probably Pink-feet, passed over gaining height and went on out towards Littleport.

I was doing a count when I noticed a single Barnacle amongst them. There were 418 Whitefronts and the Barnacle. They were all feeding and walking to the left and slightly towards us, and suddenly I noticed a very prominent high white front. And there was a beautiful adult Lesser Whitefront, the first recorded on the Washes.

Down the steps again and out along the central path beside a wider ditch, navigable but still between high banks, towards the main Observatory building which spans the waterway; a boathouse with rooms above. As we approached we could hear the calling of the Bewick's Swans and again the sound of Wigeon, Teal, Pintail and Mallard. You walk into one side of the boathouse and then up a flight of stairs into the living rooms, which is also kitchen and dining room. At the other end of the building is the observation room, with mounted telescopes and telephoto lenses, which Peter Scott also uses as a studio when he comes here for a week or so two or three times a year. Between these two large rooms are three quite small double bedrooms, each with a shower and a loo. All the windows are landscape-shaped—longer than they are high, and leaning outward, to protect them from bird droppings and rain.

The view was best from the observation room with the morning sun behind us and a perfectly fabulous array of birds all around. Within 100 yards there were probably 2,000 birds and they stretched away along the edge of the flood-water as far as the eye could reach—perhaps 20,000 ducks. The foreground was dominated by about 300 swans—a quarter of them Mutes, the rest mostly Bewick's, but one family of Whoopers with four cygnets. Some were feeding almost

directly below the windows—on wheat thrown for them by an ingenious scattering hopper.

The banks, which hid our approach, continue on either side of the waterway (which is about 15 feet wide) until they gradually disappear into the flood. This double promontory was densely covered with Wigeon and Pintail all sleeping in the sun. Then at right angles to the right and to the left the edge of the flood stretched away — black with birds — including a great many Teal. Out in the deeper water were rafts of Tufted and Pochard, and masses of Coot and gulls. Through the binocular telescope we looked at an immature Long-tailed Duck and, far out in the deeper water, a dozen Goldeneye, 7 Goosander, 2 brown-headed Smew and one beautiful white drake.

Most astonishing was the tameness of the Wigeon, Shoveler, Teal and swans. We were in full view through the window above them, but provided we did not move suddenly the birds paid no attention to us. For an hour or more we took photographs of this incredible assembly. Then far away to the south we saw the ducks rising in clouds from the edge of the floodwater. Soon we saw the cause —a Marsh Harrier was flying along the shore looking, no doubt, for disabled birds. Gradually he worked his way towards us. The Teal would lift like mosquitos and flush out on to deeper water. Some would circle back and land behind the Harrier. Surprising to find him still here in mid-winter. Of course the season has been very mild until these last few days. And even now there's scarcely any ice except just at the edges.

We were shown the swan portrait books and the data processing techniques which Peter Scott and his daughter have been working on, and which allows all the details to be stored in a computer at Cambridge. His wife has built up an amazing collection of photographic portraits of the individual swans, which is the basis of a long-term behaviour study. It was all begun at Slimbridge of course, but the Bewick's families pass through the Welney Refuge on their way there and a surprising amount of movement takes place between the two places even in mid-winter. Some of the birds first appeared at Slimbridge 12 years ago. We actually saw Bill and Catherine and Master and Mary, long known at Slimbridge, and Porgy and Bess who had been at Slimbridge this season for ten days in December, and then returned here. Kon and Tiki come here each spring on their way back to the Russian Arctic, and can confidently be expected again this March as they've been at Slimbridge since October. It has evidently been a very good breeding year for Bewick's as there were plenty of grey cygnets. Many were carrying large coloured plastic rings with easily readable numbers.

I suppose with the flood level right—as it was yesterday—the view from the observation room at Welney must be the most impressive bird spectacle to be seen anywhere in Britain. In the context of birds it is certainly reminiscent of the African National Parks, an 'avian Serengeti'. Members can spend the night out at the Central Observatory among all these floodlit birds; we didn't know this, but we plan to do so next time we come. We feel this will be a supreme thrill comparable in some ways to 'Tree Tops'.

As we left we were shown the hinged poles which swing flight nets up behind the floodlights for catching swans in certain wind directions. About 800 have been ringed in this way.

Back in the Members' Room near what is called the Cradge Bank, we collected sandwiches and with the Assistant Warden embarked in a Norfolk punt which he poled along the ditch to the NE. We were on our way to a special mudflat which the Trust maintains for waders by an elaborate system of flooding and draining so as to make artificial tides. The banks were lower in this area, so that the observation huts at this state of the flood could only be approached unseen by boat. The ditch we followed passed right *under* the hides. We did not stop at the first two, but at the third we disembarked on steps which led up up through the floor of the hide. In front was what looked for all the world like a couple of acres of tidal mudflats. The water, reinforced with manure and fertilizer, is run over the area at dusk and run off again at dawn. There were quite a lot of Teal and a few Mallard, but the most surprising thing was a party of 20 Bar-tailed Godwit, and 3 Little Stint. There was also a pretty fruity pong from the manure, especially with the east wind. There were two wader traps which this morning had caught four Redshank, one of them ringed here two years ago. Just as we were leaving a Short-eared Owl came flopping by and then glided along one of the nearly submerged banks looking for flooded-out voles.

The mudflat area was not very far out from the Cradge Bank and the Warden explained that this side of the Washes are a good deal higher (and therefore less liable to floods) and the Trust had built up here a system of ditches and dams (locally called slackers) which enabled almost every field to be flooded and drained at will—except of course that they can't be drained if the flood is up to their level. This deliberate flooding, for variable periods, has led to one of the Trust's most important researches, dealing with the agricultural and conservational effects of all kinds of flooding, with corresponding blue-prints to produce the desired effects both for pasture and for wildlife.

I must say I've been a bit suspicious of the Wildfowl Trust, building its empire, new branches, Parkinsoning itself up, and getting progressively more institutionalised and impersonal, but I'm bound to say the whole of this Welney thing has been so superbly well done that I've felt like doing a little word-eating since yesterday. It really is a striking achievement.

On the way back we passed some pens in which a few pinioned wildfowl were kept. Originally the Trust hadn't intended to keep any here, but almost at once they had been required to provide a home for pricked birds picked up on the Washes, and this has led to a rather nice small collection of purely British species. They also have a row of pens with all the world's swans—swans being a speciality because of the Bewick's.

Later we set off again from the Members' Room past the turning to the hide where we had been at first light in the morning. Ahead of us was a patch of alder carr and willows and we turned off into a narrow path leading to a hide which overlooked the three-pipe duck decoy, the only new one to be built in Britain in this century. It is extremely cunningly laid out so that wherever the wind is, one of two rather high observation huts is accessible and from them there is a view into all three pipes. Two of the pipes serve the SW. wind and one the NE. The Warden said he'd taken 28 ducks (including 10 Teal) in the east pipe in the morning. There must have been about 600 ducks on the 1½ acres of the pool. The problem has been to get Teal, Wigeon and Pintail into it, rather than Mallard. (Teal are specially important because of the continued decline of the western European stocks.) There was little to attract the smaller ducks away from the floodwaters so nearby. However, experiments with millet seed—expensive though it is—have produced promising results. We had a very good view of a Water Rail in the west pipe just in front of us, feeding at the edge of a group of Moorhen. I reckon it's rather unusual to see the two together.

The decoy looks rather new, the great cry being to have materials which don't need maintenance. So the screens are of

concrete panelling, the hoops of metal and the nets of plastic. The landings are coated with rough concrete to avoid erosion. The catch looks like being about 2,000 in this first season. They've been operating six or seven duck traps here fairly successfully for several years, and also catching ducks from a boat with a hand-net, a flare and a gong, in the Persian style, so that some useful data have been amassed during the last seven years.

The light was beginning to go as we left the decoy. We headed south-westward, towards the sunset, and had nearly reached another observation hide when there was a burst of distant shots. Evidently they were up beyond the Causeway across the Washes, outside the Refuge, but we heard at once that they had put the geese up. We nipped quickly up into the hide in time to see the whole skein stretched across the sunset coming down the Washes. It was a memorable sight, for the sky was humming with ducks too, which had risen far up beyond the road and were moving into the sanctuary. The geese planed down to land very much where they must have been before they flighted in in the morning; evidently their standard roosting area.

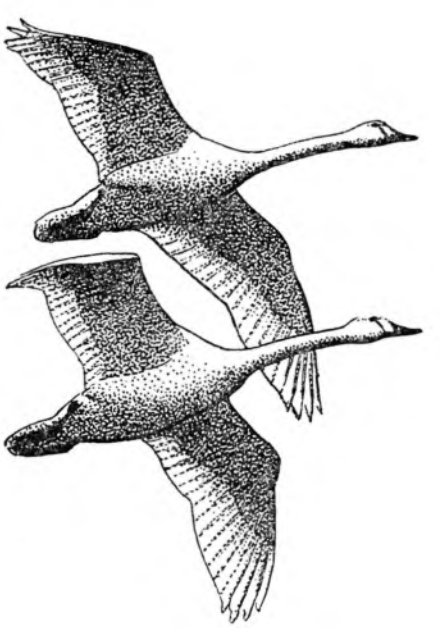
As dusk fell there was a good deal of shooting at both ends of the Refuge, but it was surprising how little notice the birds seemed to take of it. Soon the air was full of Wigeon, quantities of them pouring down into the field directly in front of the hide we were in. There was something very romantic and stirring about these Wigeon whistling and churring and sweeping round, and suddenly dropping down to land with a swish and a splash within 20 yards of us.

As we withdrew from the hide, leaving the birds totally unaware of our presence and therefore totally undisturbed, I was conscious of a tremendous feeling of satisfaction. For a day we had been in amongst the birds, yet few of them had seen us. We had watched them intimately for long hours without harming them or even frightening them. Somehow this was a proper relationship between man and animal, and the way in which this refuge has been planned and laid out to maintain and foster this relationship seemed infinitely imaginative and splendid.

There was tea in the Members' Room with the glow of the floodlights far out in front and a white line of swans lit by them. Mallard quacked overhead as we returned across the 100 foot river and down the steep bank to the car. It had really been a superlative day — you absolutely *must* go there.

Yours,

Bill.



The Slimbridge observation hides

C. J. BEALE and F. S. WRIGHT

It is now seventeen years since the Trust published specifications of a permanent hide suitable for watching wildfowl. Increased public interest in bird watching, together with the desire of local authorities, water boards, and other bodies to provide recreational facilities with a good degree of control, has resulted in many enquiries being received for details of the construction of observation hides. As our ideas as to the ' perfect hide ' have evolved very considerably, we are publishing our current designs which aim at permanence, minimum maintenance and maximum use by a controlled public, i.e. the design is *not* vandal-proof.

The hides are particularly suited for building into banks of earth such as seawalls (on the approach side, of course). A little altitude helps the view and is necessary if the surrounding land is liable to flood. Whatever the site, hides should if possible be placed so that the sun is behind the observer for much of the day, not shining in his eyes. A concealed approach is another essential. The more natural the cover afforded, the better. Best, on the grounds of permanence, is a high earth bank which, when covered with grass and occasional shrubs, will merge into almost any landscape. Otherwise a thick hedge or solid fence will be required. Any gaps in the natural cover must be made good with brushwood, timber or hessian on a post and rail fence. In some cases it may be necessary to prevent one's presence being detected by over-flying geese. This has been satisfactorily achieved at Slimbridge by a ' ceiling ' of camouflage-netting.

In general, hides constructed 5 ft. 6 in. wide inside, in multiples of 6 ft. in length, seem the most satisfactory and economical. The accompanying drawings, which have proved acceptable to our local planning authority, show the basic 6 ft. unit replicated twice to give a hide capable of comfortably holding eight adults bulkily dressed and with optical accessories. This is a useful minimum size. For an entire school party of, say, 40 pupils a hide 36 ft. long would be needed.

A wide range of materials and designs is possible depending on position, degree of permanence, usage and cost.

Walls in wet sites, for building into banks or for permanence, are perhaps best built of 4 in. concrete blocks (or 4½ in. brickwork) on a suitable foundation — see type A. The somewhat displeasing appearance can be eliminated by nailing weather boarding on to the outside, or disguised by rendering the outside with a sand/cement slurry, or paint, or by planting suitable shrubs and creepers. The all-timber hide — type B — has 3 in. × 3 in. posts creosoted at the foot and set 2 ft. into the ground. The framework is covered with treated weatherboard.

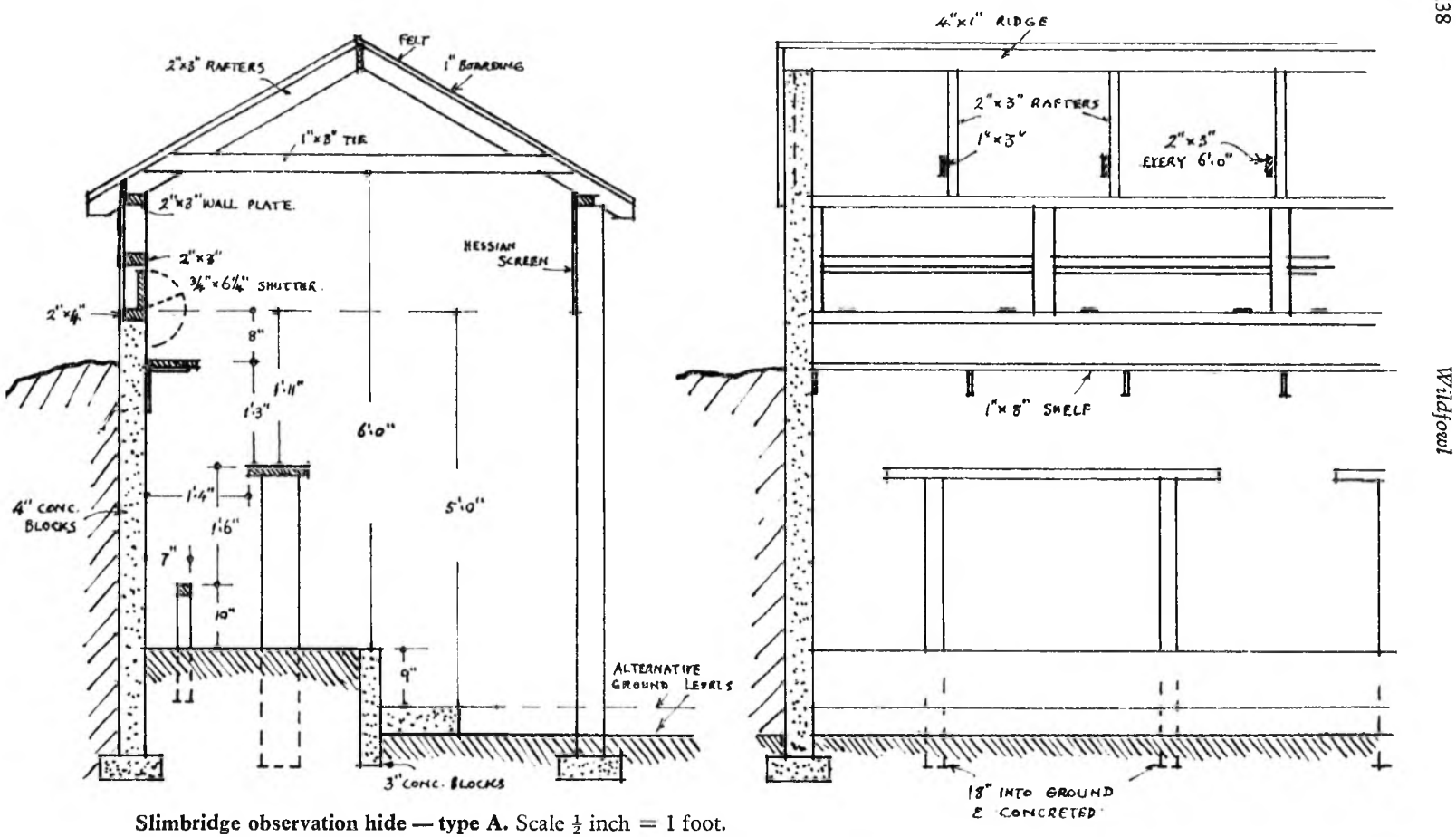
By choosing the right kind and treating it correctly, wood can be made to last almost indefinitely. If the permanence of the hide is of prime importance then vacuum-pressure impregnation with either creosote or one of the copper-chrome-arsenic preservatives is undoubtedly best. No subsequent treatment is necessary and this may eventually warrant the extra initial cost of between 1s. 6d. and 2s. per cubic foot.

A useful substitute if expense is of primary importance is to steep in preservative the bottom ends of all uprights to a height of 1 ft. above eventual soil level. The depth of penetration is, in part, governed by viscosity, so when creosote is used heat the steeping vessel to just below 200°F.

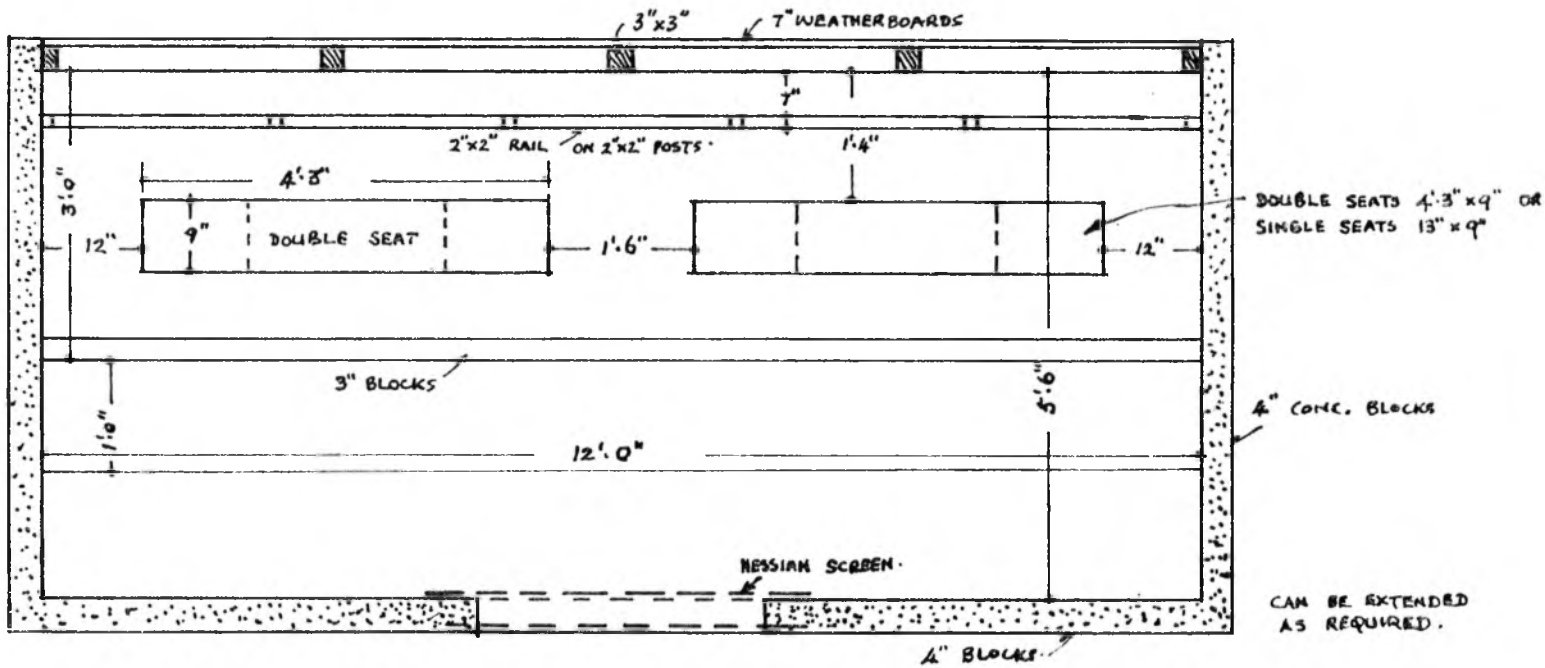
For the upper walls, roof and interior fittings, brush or spray treatment, using creosote or an organic solvent-based preservative, can provide a useful degree of protection. This is little more than skin-deep and retreatment of exterior surfaces particularly will be required every year or so. Both treatments are best done in summer when the timber is in a drier and more absorbent condition.

There is much to be said for a hybrid design between types A and B. Three courses of concrete blocks above ground level helps to reduce rot where rank grass and undergrowth produce damp conditions. It also stops any reverberation or damage that may result from observers kicking the walls.

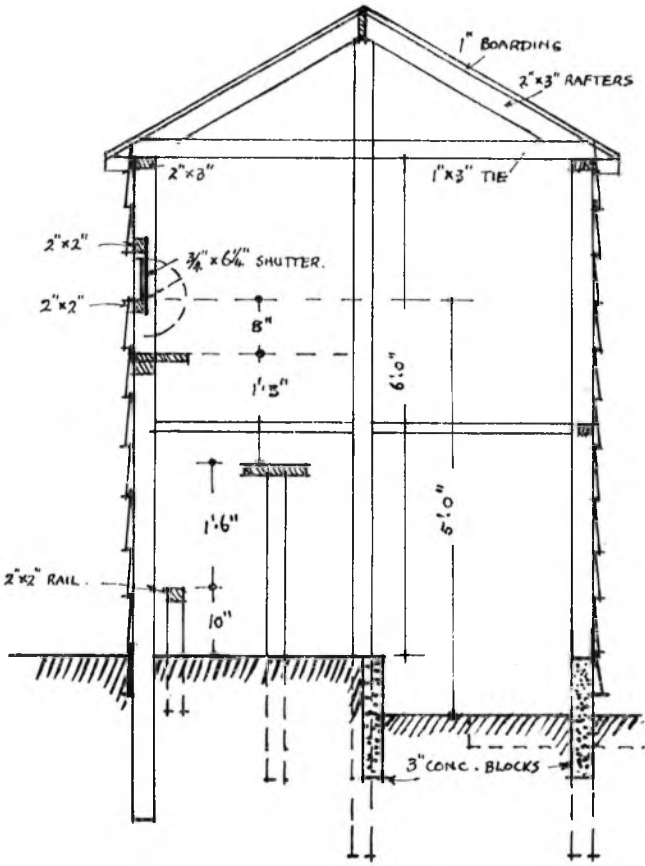
Corrugated asbestos is unsuitable for walls due to its extreme brittleness but can serve as a useful roof covering if attached to 2 in.×2 in. battens on the 2 in.×3 in. rafters. Other roofing materials include weatherboarding on felt or 1 in. close boarding each on 2 in.×3 in. rafters. If slates or tiles are used then the number of rafters should be increased to one every 18 in. to take the increased weight. If thatched or covered with wooden shingles



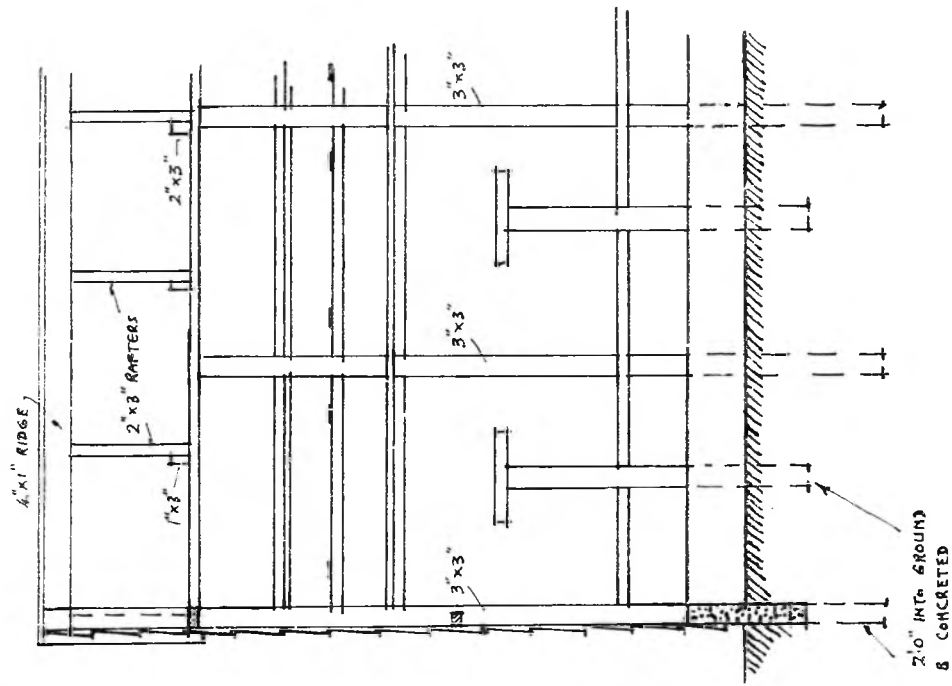
Slimbridge observation hide — type A. Scale $\frac{1}{2}$ inch = 1 foot.



Slimbridge observation hide — type A. Scale $\frac{1}{2}$ inch = 1 foot.



Slimbridge observation hide — type B. Scale $\frac{1}{2}$ inch = 1 foot.


4"x1" RIDGE
2"x3"
2"x3" RAFTERS
1"x3"
3"x3"
3"x3"
3"x3"
2'0" INTo GROUND & CONCRETED

Philippa Scott

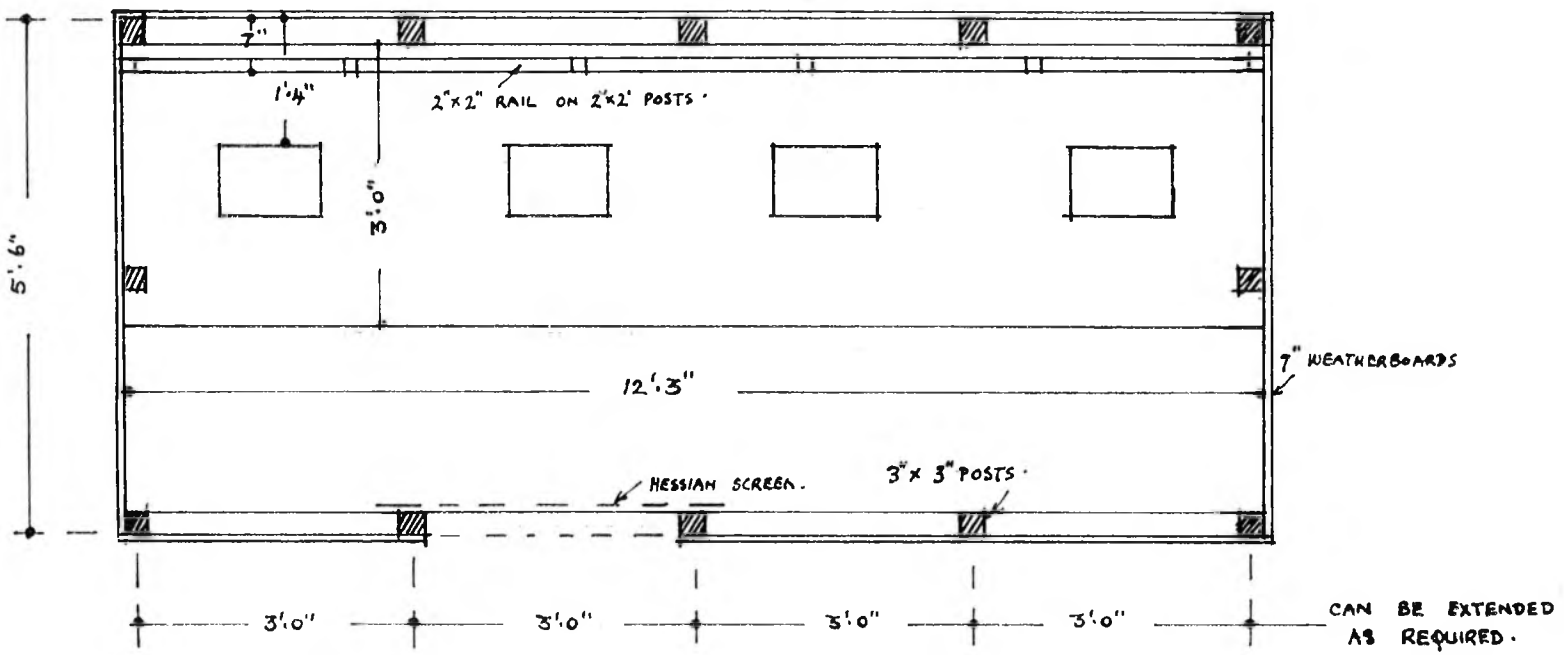
Plate XIII. South American ducks typically show little sexual dimorphism, a point well illustrated by (a) Chilean Teal *Anas f. flavirostris* and (b) Northern Versicolor Teal *Anas v. versicolor*.

E. E. Jackson

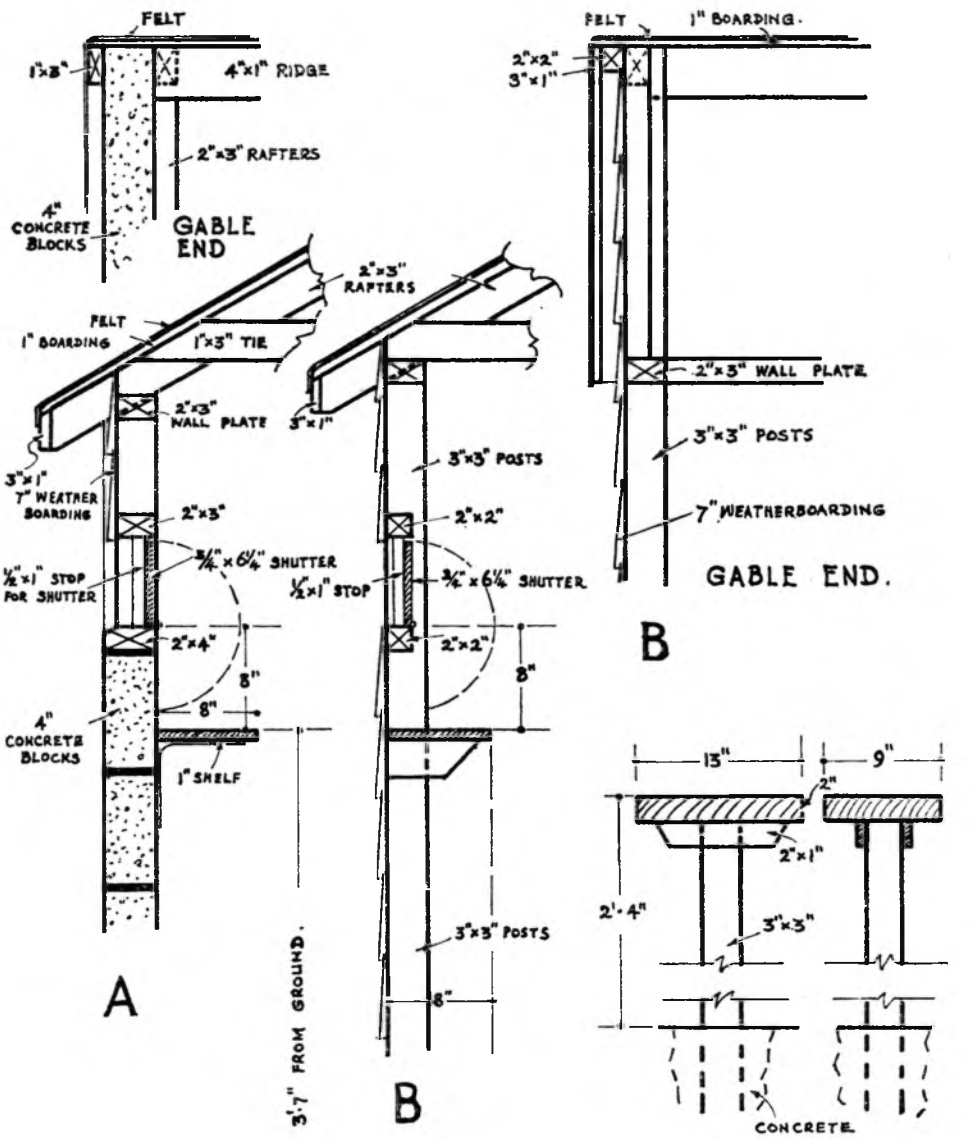
Philippa Scott

Plate XIV. Stiff-tails are notably difficult to establish in captivity. The male Peruvian Ruddy Duck *Oxyura jamaicensis ferruginea* (a) has been at Slimbridge for two years. Recently males of the White-headed Duck *Oxyura leucocephala* (b) have been obtained for the two long-resident females.

J. A. Middleton



Slimbridge observation hide — type B. Scale $\frac{1}{2}$ inch = 1 foot.



Slimbridge observation hides, details of construction.

then the appropriate battens will be needed across the 2 in. × 3 in. rafters.

When a long hide of type B is erected in an exposed windy situation it is necessary to fix cross ties joining the wall plates — as shown — every 6 ft. between the end walls. This eliminates any tendency for the wooden walls to bow outwards.

Although the drawings illustrate hides with ridged roofs, a 'lean-to' type is possible where headroom allows. If the latter style is chosen then the slope of the roof allows rain to drain off away from the observation windows.

A flap of hessian should be tacked above the entrance so that it hangs down in the doorway below the level of the observation windows. This prevents the birds from spotting any movement within the hide silhouetted against the sky beyond.

Over the years the variety of hides constructed at Slimbridge has enabled us to try various positions for seats, elbow rests, etc., resulting in a series of dimensions that will suit the majority of people. An elbow rest too far below the observation opening becomes exceedingly tiring after half an hour of intensive viewing. Thus we cannot emphasise too strongly the importance of dimensions adjusted to the observers, whether seated or standing.

These critical dimensions involve:

The elbow rest: a 1 in. planed board placed 8 in. below the bottom of the observation opening and extending 8 in. out from the wall face at foot level.

The seats: with planed upper surfaces and uprights set in concrete, are 1 ft. 11 in. below the bottom of the opening and 1 ft. 4 in. from the wall face at foot level. For prolonged study the individual stool seats are preferable but where observations are of a less serious nature the 'double' version will adequately seat three children.

The foot rail: a valuable asset if positioned as shown.

Finally for people standing behind those who are seated it is best to provide two floor levels as illustrated for type A — one 5 ft. 4 in. below the bottom of the observation opening for tall people and one 5 ft. below for those who are shorter.

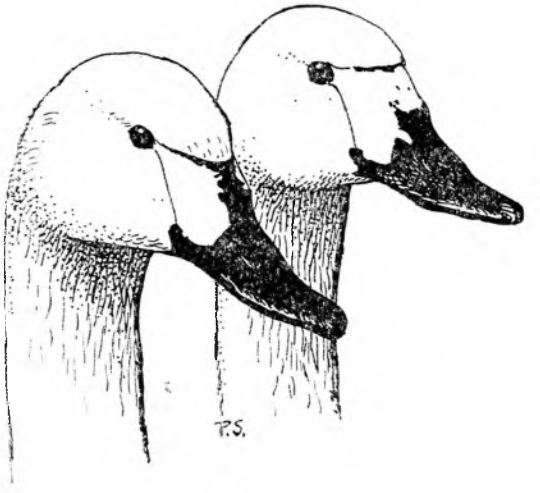
The 7 in. observation opening is closed by means of a $6\frac{1}{4}$ in. shutter hinged at the bottom so as to open downwards through 180°. The $\frac{3}{4}$ in. slit above the closed shutter allows the observer a preliminary view before opening. A simple turn-button secures the closed shutter while a 14 in. length of chain (with $1\frac{1}{2}$ in. links) stapled to the frame above the shutter allows variable opening when required, the selected link being slipped over a screw-hook on the shutter.

Photographers usually require an observation opening below elbow rest level so that focussing and shutter settings (on the camera) can be operated conveniently without disturbance. It might be thought worthwhile to dispense with part of the elbow rest and one single seat to allow floor room for a tripod.

In view of the wide fluctuations in labour and transport costs it is impossible to give a meaningful total costing for the two styles of hide mentioned above. Instead we offer the retail prices of materials only for a 12 ft. hide. These costs are based on figures obtained in December 1967 and include a small allowance for cutting and waste.

Type A: Cost of gravel sand, cement, blocks, timber, roofing felt, ironmongery and nails	£33 per 12 ft. run
Type B: (ditto)	£47 „ „ „

The Trust has also had some experience of multistorey hides. The big problem has been one of resonance caused by many people walking on wooden stairways and floors and in future reinforced concrete floors will be used although considerably more expensive. For a three-storey hide of base area 30 ft. × 10 ft. the cost (with concrete floors) of labour and materials would be somewhere round £2,000.



Current Reports

Wildfowl Survey in south-west Asia : progress in 1967

Introduction

Renewal of the World Wildlife Fund grant referred to last year permitted further expansion and consolidation of the survey as outlined in previous reports. Plans for a regional conference on wildfowl for which the Government of Iran had kindly offered to be host had to be amalgamated with those of the I.U.C.N. Ecology Commission in a meeting on Middle Eastern wetlands which was held in Ankara and Istambul from 9th-16th October. The after effects of the June war unfortunately prevented many countries from being represented, but the conference nevertheless proved extremely stimulating to all interested in wildfowl and wetland conservation in south-west Asia.

Plans for 1968 include co-ordination of the mid-winter census, co-operation with the Pakistan Wildlife Committee in reviewing the status of wildlife in Pakistan and participation in the 3rd International Wildfowl Conference at Leningrad in September.

Progress and prospects in the region can best be summarized country by country.

Egypt (U.A.R.)

The first International Festival of Duck Shooting referred to last year was apparently so successful that a second International Festival was arranged in 1967-68 from 25th November to 'late in January'. According to the Egyptian Gazette of 21st November this was to be attended by thirty Lebanese, one American and the Ambassadors of the Soviet Union, Japan and Indonesia. In view of the obvious governmental interest in the tourist attraction of wildlife in the U.A.R. and the international importance of the Nile delta wetlands, every effort is being made to ensure representation of the U.A.R. at the forthcoming conference in Leningrad.

The Smithsonian Institution research programme in the Nile Delta was unfortunately interrupted by the June war and cannot be continued for the time being. In the meantime however any wildfowlers or ornithologists visiting Egypt in winter on business or on holiday can make valuable contributions to knowledge by counting and recording wildfowl seen on the principal delta lakes around Alexandria and Port Said.

Jordan

For the first time records have been made of wintering wildfowl at Azraq Oasis through Ainsworth Harrison of the British Embassy, Amman. In spite of the great interest of this area to ornithologists in recent years it has not previously been studied in winter. Observations to date indicate that it is an area of the first importance and that it deserves as much detailed attention in winter as it has had during spring and summer.

Iraq

A mid-winter expedition was made by staff of the Iraq Natural History Museum as a contribution to the 1967 International Wildfowl Census and a further expedition is in hand for the 1968 Census in collaboration with Monsieur Jacques Vielliard of the I.W.R.B. Apart from this, field work had unfortunately to be curtailed due to the severe economic effects of the June war.

Nevertheless some valuable observations are being made in the Diwaniyah area by Ir. Van't Leven who is a temporary resident.

Iran

Thanks to the enthusiastic interest of the Department of Game and Fisheries a reconnaissance survey was made in the south-west Caspian region as a contribution to the 1967 Census, and a more detailed survey is in hand for the 1968 Census. Some more ringing has been done which has already resulted in a few recoveries from the U.S.S.R., and an important part of the Pahlavi Mordab has been set aside as a wildfowl sanctuary.

With the help and encouragement of the Pahlavi University at Shiraz, Lindon Cornwallis has been able to intensify his studies on a group of wetlands of outstanding interest and importance. As a result of these studies the whole of Lake Neiriz and the surrounding hills is being scheduled as a National Park and another area is likely to follow which includes Lake Perishan (Famur). These areas provide wintering grounds for tens of thousands of wildfowl including a fair number of geese; breeding grounds of flamingos, pelicans, and Marbled Teal *Marmaronetta angustirostris*, as well as small numbers of Palaearctic ducks and waders. A semi-detailed winter survey was made in collaboration with the Department of Game and Fisheries and plans are in hand for detailed studies under the International Biological Programme. Some useful studies in the Caspian area were recorded during the year by Nielsen and Speyer (1967) who continue their interest in other parts of Iran.

Bad news from Iran however was that the Seistan lowlands (Savage 1965) have very largely dried out as the result of increased irrigation water usage in Afghanistan and that many of the human as well as wildfowl inhabitants are having to leave the district. The Hamun-e-Helmand and Hamun-e Sabari were until quite recently wetlands of international importance particularly in late winter and during spring passage. Also, though not satisfactorily recorded, they are known to have been breeding grounds for several species including the White-headed Duck *Oxyura leucocephala*, Marbled Teal and Ruddy Shelduck *Tadorna ferruginea* amongst others. Only Hamun-e Puzak (wholly in Afghanistan) apparently remains viable and even this is so reduced in size that the margins now largely consist of mudflats instead of the former reed beds.

Afghanistan

In June the writer made a short reconnaissance expedition to Lake Ab-e Istadah (about 170 miles south of Kabul) in order to determine whether or not the Common Shelduck *Tadorna tadorna* and Greater Flamingo *Phoenicopterus r. ruber* were breeding there since both these species occur every winter in the northern Punjab of West Pakistan and this seemed to be the most likely breeding ground. Over sixty Shelduck were seen, mostly in pairs, and one brood of downy young. Although the connection is not proven there is every reason to believe that these are the same birds which appear in West Pakistan every winter in similar numbers.

In the case of the flamingos however there was no evidence of them breeding in 1967 though they are known to have bred there in recent years, and only a small number of non-breeding birds was found. At the same time there was depressing and ample evidence of heavy disturbance by shooters from Kabul for whom the lake is now readily accessible by the new American-built motor road which passes only twenty miles to the west of it.

Some valuable observations on wildfowl round Kabul were published last year by G. and J. Niethammer (1967a, b). These include the first record of Indian Pygmy Goose *Nettapus c. coromandelianus*, in Afghanistan, and of breeding of

Black-necked Grebe *Podiceps caspicus*. Both these observations tie up with recent changes in distribution of these species in West Pakistan. The Pygmy Goose is now found in the Salt Range lakes in summer and early winter, and the Black-necked Grebe is now a common winter visitor. Neither species were previously recorded in spite of intensive observations over the last forty years.

Pakistan

A second expedition from the World Wildlife Fund, led by Guy Mountfort, visited Pakistan in October-December as the guests of the Pakistan Government to complete their preliminary investigations into the problems of wildlife conservation in Pakistan which were begun last year. Their itinerary included a visit to the mouth of the Indus which is a notable wetland area for wildfowl in winter and in summer as a breeding place of ibises and storks. They also visited the Sundarbans (Ganges/Brahmaputra delta) which was disappointing for waterfowl, but above all the *haors* of Sylhet. The *haors* are large areas of permanent flooding and now attract very large numbers of wildfowl presumably because the burgeoning human population elsewhere in East Pakistan is causing increasing disturbance to the areas they formerly frequented. During the expedition's visit the ducks on Hail *Haor* amounted to over forty thousand and on a small part of Hakaluki *Haor* there were over twenty thousand. A great part of these numbers were made up of whistling ducks of which about 80% were Javan Whistling Duck *Dendrocygna javanica* (called locally Indian Whistling Teal) and the remaining 20% Fulvous Whistling Duck *Dendrocygna bicolor* (Greater Whistling Teal). The latter had not been recorded in India for over ten years and was believed to be extinct. Recent information from Assam however is that the Greater Whistling Teal breed in numbers in below Gauhati in the Brahmaputra valley, and the Indian Whistling Teal in larger numbers further upstream. Neither species is found there at other times of the year. This again provides an interesting correlation between populations as the Whistling Teal do not breed in Sylhet in significant numbers.

The proposed Wildlife Commission was not set up during the year but a Wildlife Committee is however being appointed to implement the recommendations of the Mountfort expedition, and the Wildfowl Survey will be assisting this committee during 1968.

As reported last year, Khabbaki Lake (32° 37′ N, 72° 14′ E) is now a wildfowl sanctuary. Enforcement however proved difficult during the 1966-67 season, but there has been a great improvement in the 1967-68 season. Wildlife management is now in the hands of the Forest Department who are discharging their responsibilities with greater zeal than the former Game Department could with their limited resources. As a result, the numbers of duck wintering on Khabbaki in 1967-68 have been exceptional, including over 1,000 White-headed Ducks.

India

There was a particularly good response from observers in India during the 1967 Wildfowl Census and though many of the most important wetlands are still not covered much valuable information came to light. Moreover a reconnaisance was made to Chilka Lake to weigh up the possibilities of conducting ringing activities there and greatly increased efforts are being made at the Keoladeo Ghana in Bharatpur where the Bombay Natural History Society/W.H.O. ringing camp has been operating throughout the winter, and is still in the field.

One of the most interesting discoveries during the year was the enormous concentration of Garganey *Anas querquedula* at Vandal Swamp near Point Calimere, Madras State, numbering around 125,000. Large numbers were also found in Ceylon where the species is much more numerous than previously. These taken together may well prove to be the principle wintering grounds of this species in Asia today.

Ceylon

Extremely thorough observations were returned during the 1967 Wildfowl Census. With the help of these and with the advice of Mr. C. E. Norris and others it was possible to compile a comprehensive working paper on the wildfowl and wetlands of Ceylon within a matter of only three months. This included a review of the literature and brought to light the remarkable increase of Garganey, and Pintail *Anas acuta*, referred to above. It is also typical of what we hope to achieve in this survey by taking area by area, and reviewing the present status of wildfowl and wetlands in the light of previous literature, and with the co-operation and advice of local inhabitants.

Turkish Meeting on Wetlands in the Middle East

The technical meeting of the I.U.C.N. Commission on Ecology held in October, and attended by 40 specialists from 14 countries, provided the first opportunity for a semi-detailed review of the wildfowl and wetland situation in south-west Asia. General reviews had already been submitted to the 2nd European Meeting on Wildfowl at Noordwijk, Holland, and the I.W.R.B. Meeting on International Co-operation in Wildfowl Research at Jablonna, Poland, in 1966, but here it was possible to consider the situation species by species and also to include tentative proposals for a MAR list for south-west Asia.

The conference was extremely well arranged by our Turkish hosts and brilliantly administered by Sir Hugh Elliott of the I.U.C.N. as evidenced by the fact that, through the co-operation of I.U.C.N., and the assistance of George Atkinson-Willes at Slimbridge, he has been able to get the proceedings to press within four months of the conference — which must be a record—and there is no doubt that the stimulus to further research and activity given by this conference will be greatly enhanced by prompt distribution of the proceedings particularly when so many national delegates were unable to attend.

CHRISTOPHER SAVAGE

References

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Wildfowl Ringing in Britain

The statistics of wildfowl ringing, mainly carried out at stations operated by or in collaboration with the Wildfowl Trust, have hitherto been presented in 'seasons' running from 1st August to 31st July. These originated as reflections of the main periods of activity in duck decoys (early autumn and winter). They have less relevance to stations which operate the year round as at Abberton, Essex, or mainly in the summer months as at Loch Leven, Kinross. Borough Fen Decoy, Northamptonshire, has also for some time been making substantial catches in July. Attempts to erect a natural 'season' coinciding with one duck generation invariably fail owing to the different breeding periods of the various species. A final, administrative, objection was that the 'season' ended after the time that the printers required copy for our journal, published in the early autumn. The statistics published were thus some eighteen months out of date.

For all these reasons we will in future present the ringing data according to the calendar year, giving in this volume those for 1966 and for 1967. The former overlap only slightly (because most duck ringing is done before the turn of the year) with those published for 1965-66 in the 18th Annual Report.

1966

Swans

This year saw the end of the Wildfowl Trust's financial encouragement of the widespread ringing of Mute Swans by amateur workers. The 1,576 birds ringed brought the total since the beginning of 1960 to 14,921. Support for special studies of this species is being continued. Eighteen Bewick's Swans were caught and ringed at Slimbridge, and six Whooper Swans were ringed, two at Loch Leven and four at Wards Farm.

Geese

Details were given in the 18th Annual Report of the 315 geese ringed in 1966.

Ducks

The table gives the details of the 5,265 ducks caught and ringed by the Trust and its helpers during 1966. It was not a particularly distinguished year with only Borough Fen Decoy producing anything like its normal catch. Major General C. B. Wainwright had a distinctly poor year at Abberton Reservoir with very low catches of both Teal and Mallard. The numbers of Shoveler and Tufted Duck ringed there provide the only bright spots. Reports on 1966 at Borough Fen Decoy by Mr. W. A. Cook, and at Dersingham Decoy by Mr. R. Berry, appeared in the 18th Annual Report. Small numbers of Mallard and Teal were ringed at Orielton Decoy (Mr. P. Stuttard), Wards Farm, Dunbarton (Mr. R. Shaw), Ludham, Norfolk (R. S. Smithson), Valley, Anglesey (Mr. R. Palethorpe), and at Abbotsbury Decoy, Dorset (Mr. F. Lexster), where the catch also included 18 Pintail. We are very grateful to all these gentlemen for their continuing help. At Deeping Lake, where Mr. Cook operates a cage trap by kind permission of Messrs. Dandridge, useful numbers of Pochard and Tufted Duck were included in the catch of 257. Finally our research workers at Loch Leven, Kinross, caught 88 adult Tufted Ducks and 61 ducklings in their total of 294.

1967

Swans

The Mute Swan continued to receive attention, with the Trust supplying rings and other support for a number of studies. Twenty-five Bewick's Swans were caught and ringed at Slimbridge.

Geese

Greatly increased attention was paid to Canada Geese and ringing with Trust support was carried out in three areas. In Yorkshire Mr. A. F. G. Walker organised a number of round-ups resulting in the capture of 305 birds. In the west Midlands 237 geese were caught by Dr. C. D. T. Minton and his team in Staffordshire and Warwickshire, while further west at Ellesmere the Shropshire Ornithological Society caught and ringed 237 in a single round-up.

Ducks ringed, 1966.

Species	*Abberton*	*Borough Fen*	*Deeping*	*Dersingham*	*Slimbridge*	*Loch Leven*	*Other stations*	*Totals 1966*
Shelduck	38					2		40
Pintail			8				18	26
Teal	408	450	28	110	1	2	64	1063
Mallard	563	2089	137	165	453	69	174	3650
Gadwall	7			4		45		56
Wigeon	5		9		1	25		40
Garganey	3							3
Shoveler	32	11	5		6	2		56
Pochard	15		27		1			43
Tufted Duck	95		43			149		287
Goldeneye	1							1
Totals	1167	2550	257	279	462	294	256	5265

Ducks

The total of ducks ringed by the Trust and by helpers supplied with rings was 10,880, the highest number ever achieved in a year. The details are shown in the table and short reports from the major ringing stations follow. It is sufficient here to mention that at Abberton Reservoir the catches of Teal and Mallard were considerable improvements over those of the last year or two and that Borough Fen and Dersingham Decoys and Deeping Lake all had their best year's catch. One new ringing station started operation in 1967 in a very spectacular manner. Nacton Decoy, Suffolk, was converted to ringing in September 1967 with the kind co-operation of Mr. G. M. T. Pretyman, and the decoyman, Mr. Tom Baker. Its catch by the end of the year included 426 Pintail, which compares with a grand total of 910 marked in this country since ringing began in 1909. We are hopeful that the Trust can achieve a permanent status at Nacton. If this is so, an account of the history of this fascinating decoy will be published in the next volume of WILDFOWL.

Useful numbers of Teal and Mallard were ringed at Orielton Decoy (Mr. P. Stuttard), Valley, Anglesey (Mr. R. Palethorpe), and Abbotsbury Decoy, Dorset (Mr. F. Lexster). We thank these people for their support.

Ducks ringed, 1967.

Species	*Abberton*	*Nacton*	*Borough Fen*	*Deeping*	*Dersingham*	*Slimbridge*	*Loch Leven*	*Other stations*	*Totals 1967*
Shelduck	12				1				13
Pintail	3	426	6	1		6			442
Teal	1090	248	465	8	479			99	2389
Mallard	1227	844	2669	427	977	973	109	181	7407
Gadwall	1			2	16	8	11		38
Wigeon	26	121	2	4	4		7	4	168
Garganey	25		2		2				29
Shoveler	36		6	4		7	1		54
Pochard	19			17					36
Tufted Duck	87			69			146		302
Goldeneye				1					1
Goosander	1								1
Totals	2527	1639	3150	533	1479	994	274	284	10880

M. A. OGILVIE

Abberton Reservoir, 1967

The first part of the year produced rather few ducks in the traps with Teal, in particular, in short supply. Useful numbers of Tufted Duck and Pochard were caught during April, May and June, and in July I caught 25 Shoveler and 8 Garganey.

Trapping improved in August and September and though it was a poor Teal year by the standards of a few years ago, at least I was catching more than in 1966 which was a very bad year. I caught just under 900 Teal from August to the end of the year compared with 408 in the whole of 1966, but also compared with over 2,000 in both 1961 and 1962. For the third year running I caught more Mallard than Teal which is a complete reversal of the situation in past years.

Despite the improvement this year I am still convinced that Teal numbers are declining, the reason for which remains a major problem. Two questions, without answers as yet, have been raised by my Teal ringing. Firstly where is the breeding area for the regular influx of young birds that we get each December? Secondly what is the wintering area of the birds we catch each spring in a small trap set in a splash at the side of a field? We have had several retraps of these birds in the same trap at the same time of year.

The height of the water in the reservoir greatly affects the numbers of birds on and about it, and therefore the numbers that can be ringed. This especially applies to the ducks and other water birds as well as waders. The main supply for the reservoir is pumped through two 36-inch pipes, eleven miles from the River Stour, though only when there is sufficient flow in the river. Rainfall on and around the reservoir does little but compensate for evaporation through the year. In a wet year the flow is sufficient to keep the reservoir reasonably full, i.e. near 'Top Level', when it holds some five thousand million gallons. Several million gallons are pumped out daily, filtered and then pumped on to meet the ever-increasing requirements of the population and industry of south Essex.

In a dry year no water can be pumped in and the level starts to fall. In a very dry year the level may reach 5 feet below top level by July and an island of about 11 acres then appears 400 yards out from the south-west corner of the reservoir, as well as an area of mud round the 120 acre middle reservoir. When the level falls another 3 feet a fringe of mud appears round part of the edge of the main reservoir, and a further 2 foot fall (ten feet below top level) produces mud round most of the edge of the 1,000 acre main reservoir.

Only three times in the last nineteen years has the island been uncovered in the spring. As well as ducks and waders, colonies of Black-headed Gulls, Common and Little Terns have nested there, and in 1950 a pair of Gull-billed Terns, still the only breeding record for this species in Britain. As soon as the island appears, ducks and waders gather there, as it is surrounded by at least 400 yards of water and entirely free from normal disturbance. The short daily visit that I make to inspect my traps does not keep them away for long. The traps are floated over to the island on empty ten-gallon drums and as soon as they are installed some really adequate ringing, especially of Teal, can begin.

The breeding success of many birds, particularly Great Crested Grebes, Shelducks and Mute Swans, is almost entirely dependent on the height of the water. Great Crested Grebes require only a gradual fall from April to the beginning of June. A quick rise floods the nests while a fast fall leaves them high and dry and the nestlings are unable to reach the water. The heavy rain in the second week of April this year caused the water level to rise a foot. At one time 140 million gallons in a day poured in from the stream entering the head of the reservoir. The Grebes were flooded out and they did not attempt to re-nest.

Both Shelducks and Mute Swans do best when there is some mud round the margins at the time when their young hatch. This requires a drop of at least five feet by June, which very seldom happens. The young can then feed in shallow water and come out to rest on the bank. Mute Swans are also affected at the time of their moult. When the water is very high in July and August the underwater weed is too deep for the swans to reach. The herd of swans which comes to the reservoir to moult, having shed their flight feathers, are then caught out and soon lose condition. Some wander off across country, others we manage to catch and transfer to the tidal rivers where they can pick up a living round grain mills and wharfs. At one time this moulting herd reached over 500 but after the disaster of 1958 when I found no less than 50 dead, they have learned the advan-

tages of the Rivers Stour at Mistley and Blackwater at Maldon as places to moult.

The following table shows how the height of the water has affected the breeding of the Great Crested Grebes, Shelducks and Mute Swans, and also the moulting herd of swans in the same period.

Effects of water level at Abberton Reservoir.

Year	*Month*	*Height of water below top level in feet*	*Results*
1958		Never below 2½	Breeding: very bad for Mute Swans Ringing: bad
1963	July	1 - 3	Breeding: very bad for Shelducks and Mute Swans
	August	3 - 4½	
	Oct.-Nov.	7	Ringing: good
1964	July	2	Breeding: poor
	Sep.-Dec.	5 - 12	Ringing: good
1965	Jan.-Nov.	12 - 5	Ringing: very fair Breeding: bad for Grebes—only 7 young from 7 nests; best ever for Shelducks—12 broods, 60 young
1966	whole year	Never below 2	Ringing: bad
	(Apr.-Jun.)	Only 1″ - 10″	Breeding: best ever Grebes—25 successful pairs; very bad Shelducks and Mute Swans
1967	Jan.-Jul.	Less than 1	Breeding: bad for all species
	Sep.-Oct.	Below 5	Ringing: only fair, fall too late

Moulting was disastrous in 1958 and 1963, and conditions were bad in 1966 and 1967.

C. B. WAINWRIGHT

Borough Fen Decoy, 1967

After being ice-free for the first few days of the New Year, the Decoy pond was frozen until 18th January. It then remained clear of ice for the rest of the month. The total catch of ducks was 144, of which over a third were taken with the aid of Piper, the Decoy dog; this is a very high proportion for winter catches. With no frosts in February there was a good take of 184 ducks, only 28 of these following the dog which is closer to the winter average. The clear fine weather at this time enabled me to carry out some orientation releases involving 152 Mallard. This has considerably boosted the combined total of releases for this month of the year.

At the beginning of March I set my sights on a season's total of 3,000 before the season closed at the end of the month. However the weather stayed good and probably helped to induce the mass exodus of ducks on the 6th. I fell nine short of my target, the March catch of 61 bringing my season's total to 2,991.

A few early passerine nests were recorded in March, the first being a Song Thrush's with four eggs on 21st. Two Blackbird's nests with eggs were located on 27th. After several Woodpigeons had been picked up dead in the Decoy wood, the Ministry of Agriculture was informed and eight corpses out of a total of 30 found were taken away for analysis. Spring migrants were generally late arriving this year and it was not until 18th April that the first Willow Warbler was heard. It was closely followed by a Swallow seen the same afternoon.

With the departure of the last few ducks on about 6th April, the annual maintenance work began. A number of dangerously large willows were felled and many elders were cut back to encourage them to shoot new growth and so provide the thick low cover essential to a decoy wood. Seventy nests were found by the end of April and the first nestlings—four Song Thrushes — were ringed on 19th. Turtle Doves were early this year, arriving on 29th, beating the first Cuckoo by three days. Swifts appeared over the Decoy on 2nd April followed by a Nightingale which unfortunately did not stay to breed.

The annual Open Weekend was held on 20th and 21st May. It was a pity that it rained heavily from 13th to 19th as this

spoilt the paths and probably kept some people away. The total number of visitors, 51 including 16 Members, was well down on last year.

The greater part of May was spent in replacing netting on the pipes; nearly all that required renewing had been in place since 1959. Eight years seems to be the longest one can expect it to last and it is hoped that a rota can be established of renewing one pipe each year from now on. During June maintenance continued apace with the usual rush to complete it before the start of the catching season. Vegetation encroaching on the perimeter track was cut back to allow a vehicle to be used to transport grain, potatoes and other food to the East, South-east and South pipes. Elders and willows were trimmed hard back to improve the view from the hides.

During May and June the number of passerine nests recorded rose to 180 and a large number of nestlings were ringed. After 15th June nest-searching dropped off as no visits were made to the margin of the pond or to the reed bed so as not to spoil the early lead of ducks which began to develop. Eleven Mallard were caught while feeding in the West pipe on 26th and 28th June, and there was a good lead by early July. During this month 95 Mallard and seven Teal were caught of which 37 were inveigled into the pipes by Piper. Only seven of the Mallard were adults and three of these were actually flightless.

August opened with an abundance of wildfowl on the pond, a happy state of affairs which was to continue to the end of the year. The month's total of 374 was managed in only 19 days catching as I took a week's leave from 19th to 26th. As is usual at this time of year the greater part of the catch was made with Piper, 221 ducks falling victim to his charms. Some late passerine nests were found during August, including a Greenfinch's which was found newly-built on 1st and with three eggs in it on 8th. A Linnet's nest with one egg was found on 5th. The first excursion of the season, flight-netting on the Wash, was made on 10th when 63 waders and gulls were caught.

September was the peak month of the year. Many young ducks were present, easy to catch and very ready to follow the dog, and unlike 1966 there were no farming activities close by to disturb the pond. During the first week 476 ducks were caught. The month's catch in the Decoy was 1,361, compared with the previous best month's catch of 1,129 in September 1959. Then 480 (42%) of the catch was dogged, this year 739 (54%). The Decoy was worked on 25 days in the month, the best being 2nd and 4th when respectively 102 and 111 ducks were caught. Despite there being little time available for ringing birds other than ducks, 133 were caught this month.

During October 763 ducks were caught in 22 catching days, 205 being dogged. I netted for waders on the Wash again catching 50, including some gulls, as well as a lone Wigeon. The non-duck ringing totals this month rose to 234 including a very late Spotted Flycatcher on 2nd. The first frosts in November signalled the beginning of winter and the ducks, standing around on the ice, became much more wary and less inclined to follow the dog. This is clearly shown by the low proportion (10%) dogged of the month's catch of 538. There was a good day on 9th November when 83 ducks were caught. The area had been shrouded in thick fog for two days and the birds, presumably unable to find any feeding grounds, were forced by their hunger to feed well inside the pipes. Among other birds ringed were the first winter migrants, four Redwings.

December was a month of very changeable weather, commencing with fog and frost, and the pond had two inches of ice on it by 7th. A heavy snowfall on 8th brought in a big flock of thrushes feeding under vegetation and also high in the white poplars. Despite early morning ice-breaking only four ducks were caught between 7th and 15th. All things considered, the catch of 246 this month was very satisfactory. No birds were caught as a result of Piper's efforts although a great many came to within six feet of the

Monthly totals of ducks caught at Borough Fen Decoy and Deeping Lake, 1967.

	Borough Fen Decoy		*Deeping Lake*
	Catch	*% dogged*	*Catch*
Jan	144	*36*	6
Feb	184	*15*	42
Mar	61	*6*	68
Apr	—		12
May	—		—
Jun	11	*18*	—
Jul	102	*36*	95
Aug	374	*63*	170
Sep	1361	*54*	200
Oct	763	*26*	66
Nov	568	*10*	48
Dec	246	*0*	12
Totals	3814	*36*	719

pipe mouth, obviously aware of the limit of safety.

My ringing totals for the year will be found in the wildfowl ringing table on p. 149 and in the table for other species on p. 154. During the year I continued to co-operate with research workers from the Medical Research Institute and from the Institute of Laryngology and Otology, University of London. Five hundred and sixty-four blood smears were taken, bringing the grand total up to 3,813.

By kind permission of the owners, Messrs. Dandridge, I was able to continue operating a cage trap on nearby Deeping Lake. Trapping was re-started here in 1966 after a break of four years. For the first part of the year it caught steadily, though in small numbers, until trapping ceased in April. I started to bait the trap again in July and after a slow start over 100 ducks were caught in both August and September. The site's past reputation for catching diving ducks was re-affirmed with totals this year of 69 Tufted Duck and 17 Pochard. Over 400 Mallard were also caught and many of these were used in orientation releases. Other species of birds are also taken in the trap and these are included in the table of ringing totals on p. 154. Useful numbers of Herons, Great Crested Grebes, Coots and various gulls were caught and ringed.

W. A. COOK

Dersingham Decoy, 1967

At the start of the year the Decoy pond was frozen over, but the water in the single pipe was kept open and fed heavily, and a flight of Mallard came in regularly. However, the Teal left during the cold weather and did not return even after the thaw. Forty-seven ducks were caught and ringed during January but only a handful in the next two months, after which the Decoy was closed for the season with a total catch of 343.

Small numbers of Mallard and two Gadwall were caught at this time in the two cage traps which had been removed from the Decoy pond and re-built in Coldens Creek, which comes to within a quarter of a mile of the Decoy, to the north. It is about three-quarters of a mile long and never more than 40 feet wide, twisting and turning through a thick growth of reed. In 1966 over 200 wildfowl were regularly flighting into the creek during August and September, whereas the numbers using the Decoy pond never exceeded 100. It was therefore hoped that by moving the traps the total catch could be increased.

During February work got under way on restoring another pipe. The North-west pipe was selected as this would enable the Decoy, with its existing South pipe, to be operated on the maximum number of days in the prevailing westerly winds. The ducks also show a preference for loafing on this side of the pond which gets a lot of sun. The pipe did not require a great deal of clearing, just some hawthorn and alder scrub removing and the tail end digging out and re-aligning. The work was completed by the middle of July in time for the start of the catching season.

A wildfowl breeding survey was conducted during the summer in the area of the Decoy and Coldens Creek. At least 26 pairs of Mallard bred, possibly as many as 36, together with two pairs of Shelduck and single pairs of Teal, Shoveler and Mute Swan.

With two pipes now in working order and good numbers of birds in the area it was hoped that a catch of 1,000 might be possible during the 1967-68 season. In fact the 1,000 mark was passed on 20th November, a red-letter day in the history of the Decoy. This is the first time for over 100 years that 1,000 ducks had been caught, the great difference being that this time they were ringed and released, not killed for the market as in the past.

The Decoy was short of water in July and August and many waders came and fed on the mud which was exposed in the pipes and around the edge. Despite this the duck came in readily and 132 were caught in August, half of which were Teal. A small number of Gadwall started using the pond in late July and these built up to 25 by 5th August. Before they departed in September, 11 had been caught, six of them in the newly-completed pipe.

The number of Teal flighting into the pond rose to over 300 by the end of September but dropped to around 100 after the stubble fields in the area had

been ploughed. Eighty-three Teal were caught in September and 182 in October. The number of Mallard coming in remained at about 100 during both months but the birds must have been constantly changing as 107 were ringed in September and 203 in October. The best day in the year was 30th October when 29 Mallard and 14 Teal were ringed.

After a sharp frost on 17th November which froze the pond, the number of Teal dropped again to about 50, but the Mallard increased to around 200 and stayed at this level to the end of the year. The catch in November was 402. On several days in December the pond was frozen over. The North-west pipe and the creek by the two traps were kept open by daily ice-breaking. This effort was rewarded with catches of over 20 on three separate days.

The total number of ducks ringed during 1967 was 1,479. The monthly breakdown will be found in the accompanying table. The totals for other species ringed are given in full in the table below. All the catches were made by "showing blind" to duck feeding up a pipe. A dog is most effective in early autumn (as shown in the Borough Fen report) so, if plans to acquire and train one materialise, the catch may be considerably boosted.

Monthly totals of ducks caught and ringed in Dersingham Decoy and Coldens Creek, 1967.

	Mallard	*Teal*	*Others*	*Totals*
Jan	37	10	—	47
Feb	15	—	2	17
Mar	17	—	—	17
Apr	—	—	—	—
May	—	—	—	—
Jun	—	—	—	—
Jul	12	3	3	18
Aug	64	66	3	133
Sep	107	83	8	198
Oct	213	182	1	396
Nov	266	131	5	402
Dec	246	4	1	251
Totals	977	479	23	1479

R. BERRY

Numbers of birds, other than ducks and swans, ringed at Abberton Reservoir, Borough Fen Decoy and Deeping Lake, and Dersingham Decoy, 1967.

Species	*Abberton Reservoir*	*Borough Fen Decoy and Deeping Lake*	*Dersingham Decoy*
Great Crested Grebe	1	8	
Little Grebe	10		
Heron		21	2
Water Rail	17	2	7
Moorhen	19	70	81
Coot	52	97	
Oystercatcher			3
Lapwing	5		
Snipe	110		3
Jack Snipe	5		
Green Sandpiper			8
Common Sandpiper	46		2
Redshank	3		1
Icelandic Redshank	3		
Dunlin	12		
Northern Dunlin	21		
Ruff	3		
Great Black-backed Gull		3	
Herring Gull		9	
Common Gull		42	4
Little Gull	1		
Black-headed Gull	6	92	5
Wood Pigeon		41	4
Turtle Dove	9	6	3
Cuckoo		1	
Kingfisher	1		
Skylark	6		
Swallow	3		17
Sand Martin	1		38
Great Tit	16	11	5

Species	*Abberton Reservoir*	*Borough Fen Decoy and Deeping Lake*	*Dersingham Decoy*
Blue Tit	13	24	42
Marsh Tit	1		
Willow Tit		2	4
Long-tailed Tit	4	21	10
Bearded Tit			5
Tree Creeper	1		2
Wren	31	8	1
Mistle Thrush	4	2	10
Fieldfare		1	61
Song Thrush	45	108	119
Redwing		53	23
Blackbird	77	159	187
Wheatear	1		1
Greenland Wheatear	2		
Whinchat	2		
Redstart	1		1
Nightingale	1	1	
Robin	35	23	19
Reed Warbler	44	9	39
Sedge Warbler	212	3	20
Blackcap	6	23	20
Garden Warbler		3	2
Whitethroat	86	9	6
Lesser Whitethroat	74		
Willow Warbler	31	6	9
Chiffchaff	16	5	2
Goldcrest	1	11	3
Spotted Flycatcher	2	7	11
Dunnock	90	53	47
Meadow Pipit	33		
Rock Pipit	8		
Pied Wagtail	75		4
White Wagtail	2		
Grey Wagtail	2		1
Yellow Wagtail	422		
Sykes Wagtail	1		
Starling	218	8	18
Greenfinch	61	116	66
Goldfinch	1	53	18
Linnet	46	65	14
Redpoll			11
Bullfinch	24	42	7
Chaffinch	51	19	39
Brambling		16	95
Yellowhammer	2	2	21
Corn Bunting	1		
Reed Bunting	76	3	17
House Sparrow		1	
Tree Sparrow	1	106	38
	2154	1365	1172

In addition Mr. W. A. Cook caught the following birds on the Wash: Oystercatcher 8; Grey Plover 1; Turnstone 7; Curlew 3; Bar-tailed Godwit 4; Redshank 8; Knot 18; Dunlin 55; Arctic Tern 1.

Wildfowl censuses and counts in Britain

An important part of the research work of the Wildfowl Trust is the monitoring of wildfowl populations by means of censuses and sample counts. We have not hitherto published the immediate results of this work other than as information sheets to the many hundreds of amateur counters on whose help we rely so heavily. Analyses in depth are, of course, published at intervals. We feel, however, that the results of our running checks on the numbers of British wildfowl could usefully be given a wider dissemination.

1966-67

Goose censuses

Not only do many of the geese wintering in Britain form discrete populations, they also tend to congregate in large flocks to roost at relatively few places. It is therefore realistic to attempt complete censuses at certain seasons, with the aid of over a hundred amateur counters. A further useful feature is that the juvenile geese can be distinguished from adults in the field and this, together with the persistence of the family bond, enables much useful information on the composition of the populations to be gathered. The percentage of young birds found in the various goose populations during the winter, together with the average brood-size of the family parties, are given where available. The two figures give a very good indication of the breeding success attained the previous summer. Due to the exigencies of the weather in the Arctic, where nearly all our wintering geese breed, considerable annual variations can occur in the number of young birds produced. These may range from a virtually complete failure to breed, with less than 1% of young birds in the flocks and few broods of more than one, to an excellent breeding year when there will be over 40% of young birds and many broods of four or more.

Pink-footed Goose *Anser brachyrhynchus*. A census of this species was carried out in Britain on 5th/6th November 1966. 76,000 birds were counted, an increase of 9,000 on November 1965. Ringing has shown that the British wintering population of Pinkfeet comprises the entire breeding stock from Iceland and Greenland. Age-counts in November revealed that 1966 had been only a moderate breeding season (22.3% young birds; average brood-size 2.4).

European White-fronted Goose *Anser albifrons albifrons*. On 15th January 1967 there were about 5,000 European Whitefronts in Britain. At the time of the second census, held on 19th February, the total was 6,800. Using intermediate counts it was calculated that there was a peak in numbers of 7,300 during the second week of February. The European Whitefronts that come to Britain are part of a large (60-70,000) population that breeds in Arctic Russia and has its main wintering headquarters in Holland. Weather conditions in the latter country can affect the timing and numbers of visitors to British haunts. Breeding success was good in 1966 (31.5% young were found in December; average brood-size 2.6).

Greenland White-fronted Goose *Anser albifrons flavirostris*. No census was made of this race, indeed its scattered distribution, often in areas difficult of access, has so far made this impracticable. However age-counts were made in November at one of its Scottish wintering areas and showed a fairly good breeding year (26.1% young; average brood-size 2.6). This population breeds in west Greenland and winters almost entirely in Scotland, Wales and Ireland. It is thought to number about 12,000 birds.

Greylag Goose *Anser anser*. The Icelandic breeding population of this species, which winters entirely in Britain, was censused on 5th and 6th November 1966 when there were 60,000 birds present. This represents a considerable increase over the previous year. Breeding success was nevertheless only fair (19.6% young; average brood-size 2.5 in November).

Barnacle Goose *Branta leucopsis*. Two populations of this species winter in Britain. The Spitsbergen breeding stock winters on the Solway where the maximum count reached 3,000. In most winters part of the population, up to another 1,000 birds, probably does not come further than Norway. Breeding success was rather poor in 1966 (13.3% young; average brood-size 2.4).

The Barnacle Geese breeding in east Greenland winter exclusively in west Scotland and Ireland. No census was made as this involves an aerial survey and can only be carried out every four or five years. Counts in November at the major wintering place, Islay in the Inner Hebrides, were well up to normal despite a poor breeding year (13.0% young; average brood-size 1.5). The population probably numbers 18-20,000.

Light-bellied Brent Goose *Branta ber-*

Philippa Scott

Plate XV. A Whistling Swan *Cygnus c. columbianus* portrayed to contrast with the many pictures of Bewick's Swans we have published in recent years.

E. E. Jackson

Plate XVI. (a) 'Ditty', a wild Bewick's Swan *Cygnus columbianus bewickii* at Slimbridge, recognisable by the large numerals on her plastic leg ring, although the face pattern is hidden. (See p. 162).

(b) Anyone can take photographs with these modern cameras! We welcome them for publication in WILDFOWL.

R. Besant

nicla hrota. The small flock at Lindisfarne, part of the Spitsbergen population, reached 500 this winter. Weather conditions in Denmark, where the majority of the 2-3,000 birds winter, affect the numbers coming to Britain.

Censuses, organised by the Irish Wildfowl Conservancy, of the Greenland stock of Brent Geese, which winter virtually exclusively in Ireland, showed that there were about 8,000 birds present in mid-November 1966 and 6,200 in mid-February 1967. The numbers are a little higher than comparable counts in 1965-66, but still well below the 12,000 found in the Novembers of 1960 and 1961. Breeding success was better than in the two previous years (16% young).

Dark-bellied Brent Goose *Branta bernicla bernicla.* The peak count this winter was in mid-December and reached 15,600. This is slightly above the previous year and represents just over half the world population of this race (which breeds in Arctic Russia), the remainder wintering in France and Holland. Breeding success was very good (40.0% young).

M. A. OGILVIE

Duck counts

Most of the ducks wintering in Britain are not discrete populations and are widely distributed. Complete censuses are not therefore attempted, but since 1948 extensive sample counts have been made with the assistance of hundreds of amateur counters. The common species are now counted each winter on the middle Sunday of each month from September to March on some five hundred waters. For a selected 'priority' sample of about 120 of the main waters the counts are compared with similar counts made in previous years and an index of abundance for the season is calculated, related to a base line of 100 taken for the winter 1959-60 (called the 'Master' season). The figures are given in the table and discussed by species below.

Shelduck *Tadorna tadorna.* Although the indices may be affected by the timing of the arrival in Britain of the flocks returning from the Helgoland Bight moulting area, it is thought that there has been a genuine increase in numbers in Britain.

Teal *Anas crecca.* The autumn numbers were the lowest since 1958 but from January onwards there was some improvement and the seasonal index was the same as last year. However the north-west European wintering population of Teal, of which Britain holds a major share in mid-winter, remains at a low ebb.

Mallard *Anas platyrhynchos.* This was the best season yet and in nearly all months the counts were well above average, and in November and March were the highest on record.

Wigeon *Anas penelope.* Large numbers were reported in all months except December and the season as a whole was the best since 1961-62. No trends are apparent over the full period for which seasonal indices are available. This species has always been prone to short-term fluctuations in numbers visiting Britain each winter.

Pochard *Aythya ferina.* The record level reached last year has been maintained, and it seems that the pattern of previous increases is being repeated. This is the third time in 19 years that the population has shown a sharp increase after a period of comparative stability. The first occurred between 1952 and 1954, the second in 1960 and the third in 1965. To some extent these increases reflect the earlier arrival of winter migrants but they also show a substantial increase in total numbers.

Tufted Duck *Aythya fuligula.* The index for this winter is somewhat suspect because records were lacking from some important haunts. After a steady increase during the 1950s the population became stable and appears to have remained so, except for a slight drop in 1964.

Seasonal indices of ducks in Britain.

	Av. Index		*Master season*	*Av. Index*		
	1948-53	*1954-58*	*1959-60*	*1960-64*	*1965-66*	*1966-67*
Shelduck	47	74	100	90	103	106
Teal	49	62	100	67	47	47
Mallard	74	79	100	92	106	113
Wigeon	95	102	100	96	106	113
Pochard	73	95	100	129	194	195
Tufted Duck	63	90	100	97	120	97

International wildfowl census

An important development in this field was the organisation of a single mid-winter count carried out nearly simultaneously in many countries of Europe, Asia and Africa. From the results it is not only hoped to learn much more about wildfowl distribution but also to arrive at some idea of total stocks. At the very least the wide coverage will form a better background against which to judge the results of more intensive studies in small areas, such as Britain. In particular we should know whether our increases and decreases are due to variations in local conditions or reflect changes in the total numbers of the whole population of a species.

The first such international wildfowl census was held in January 1967, based on the 15th of the month with counts admitted for a week on either side. The response in Britain exceeded all expectations, with counts being received from over 1,500 places. This is three times the number of sites normally counted. A summary of these results appears below:

Shelduck	36295
Pintail	7725
Teal	32890
Mallard	156993
Gadwall	236
Wigeon	144694
Shoveler	2245
Eider	12230
Red-crested Pochard	9
Pochard	32586
Tufted Duck	26133
Scaup	16269
Common Scoter	5898
Velvet Scoter	9
Long-tailed Duck	165
Goldeneye	6942
Smew	88
Red-breasted Merganser	805
Goosander	958
Total	483170

In addition counts from 29 countries, covering 3,570 sites and a total of 2,528,330 ducks, were received at Slimbridge for analysis. The U.S.S.R. reported another 3,405,700 ducks from a large number of sites.

G. L. ATKINSON-WILLES
C. J. BEALE

1967-68

Goose censuses

Pink-footed Goose *Anser brachyrhynchus*. At the time of the annual November census there were 65,000 Pinkfeet in Britain. This represents a fall of about 15% in the population since the previous year. A main cause of this drop was the poor breeding season experienced (10.8% young; average brood-size 1.3).

European White-fronted Goose *Anser albifrons albifrons*. A census was carried out on 3rd and 4th February 1968 when 10,400 Whitefronts were present in the country. This already high total rose to a record 12,000 in the period 10th to 15th February. The previous highest peak was 10,500 in 1946-47, the first winter for which we have adequate records. One of the factors which had a favourable effect on the numbers of this species in Britain this winter was the reduction in disturbance and shooting during the epidemic of foot-and-mouth disease. The geese had another in a series of good breeding seasons in 1967 (33.9% young counted in December; average brood-size 2.3).

Greenland White-fronted Goose *Anser albifrons flavirostris*. Increased numbers were present at some Scottish haunts in November 1967, though breeding success was only fair (16.0% young; average brood-size 1.7).

Greylag Goose *Anser anser*. The annual census of this species held on 4th/5th November 1967 showed a fall in numbers from last year, to 53,000. Like the Pinkfeet the main reason appeared to have been a poor breeding summer (11.0% young; average brood-size 1.7).

Barnacle Goose *Branta leucopsis*. The Spitsbergen population wintering on the Solway reached a peak of 2,700. The breeding success was better than is usual for this population (27.1% young; average brood-size 2.6).

The Greenland stock was not censused though there were 16,500 birds, or over 80% of the probable total, concentrated on Islay in early November 1967. Age-counts at this time showed that the breeding season had been a moderately good one (17.1% young; average brood-size 1.8).

Light-bellied Brent Goose *Branta bernicla hrota*. 700 was the peak count of the Spitsbergen stock made at Lindisfarne during the winter. Full results of the censuses of the Greenland population in Ireland are not yet to hand but there appears to have been a slight increase over last year.

Dark-bellied Brent Goose *Branta bernicla bernicla*. There was a peak in Britain of 16,000 on 17th February 1968, slightly higher than last winter. However the total population of this race probably declined somewhat in the same interval as shown by counts from the other wintering areas

in France and Holland. The main reason was the poor breeding success in 1967 (6.0% young).

M. A. OGILVIE

Duck counts

Because of the foot-and-mouth epidemic, the counts for the peak months of November, December and January were seriously disrupted, especially in the Midlands. The seasonal indices should therefore be regarded with some caution. The only results which are not suspect are those for coastal species, i.e. Shelduck and Wigeon.

Seasonal indices, 1967-68.

Shelduck	105	Wigeon	115
Teal	42	Pochard	196
Mallard	103	Tufted Duck	93

Shelduck *Tadorna tadorna.* The population of this species has remained stable over the last three seasons at a level slightly above that of the early 1960s. As usual the numbers in the early part of the season were small, but by December, and again in February, they were recorded in very large numbers.

Teal *Anas crecca.* In general this species appears to have been slightly less numerous than in 1966-67, but the index cannot be regarded as very accurate and probably errs on the low side.

Mallard *Anas platyrhynchos.* A successful breeding season in 1967 meant that Mallard were exceptionally plentiful in September but later in the winter numbers were below those for previous years.

Wigeon *Anas penelope.* The seasonal index is the highest for five years. The species was very numerous throughout the autumn and winter, the counts in October and January being the highest on record for the time of year.

Pochard *Aythya ferina.* The index is probably too high but would still seem well above the level in the early 1960s.

Tufted Duck *Aythya fuligula.* This species appears to have been scarcer with the counts at the beginning and end of the season being noticeably smaller than usual.

International wildfowl census

The second international wildfowl census was held in mid-January 1968. The foot-and-mouth epidemic caused a fall in the number of returns from Britain, where 1,038 sites were counted producing the following numbers of duck:

Shelduck	33756
Pintail	8126
Teal	25932
Mallard	121437
Gadwall	280
Wigeon	151661
Shoveler	2009
Eider	9202
Pochard	23618
Tufted Duck	23600
Scaup	22808
Common Scoter	7436
Velvet Scoter	2959
Long-tailed Duck	548
Goldeneye	7008
Smew	115
Red-breasted Merganser	955
Goosander	699
Total	442149

In addition counts have already been received from 33 other countries covering 4,000 sites and a total of 5,306,983 ducks.

G. L. ATKINSON-WILLES
C. J. BEALE

Loch Leven, 1967

Despite the departure of Hugh Boyd to Canada in May and the necessity for the writer to act as the Warden of the National Nature Reserve pending a replacement by the Nature Conservancy, it still proved possible to carry on with the main study of breeding ducks. A temporary assistant, Gavin Dallmeyer, was employed for the four months of greatest necessity.

The work largely consisted of a repetition of last season's, but beginning earlier so that the start of the Mallard nesting season was covered. It was also possible to be more systematic, following the erection of posts dividing the main breeding area on St. Serf's Island into a grid of eighty 50 × 50 m. squares. A vegetation map of the Island was also prepared. Successive areas of the Island were searched for nests once a week, the other islands, and certain sections of the mainland, once a fortnight. The totals of nests found in this way are shown in Table I.

To check on the efficiency of the nest-searching, and to get some idea of the absolute total of nests, a post-season check was carried out on the advice of Dr. N. Morgan of the Nature Conservancy and Dr. R. Cormack of the Depart-

ment of Statistics, Edinburgh University. Fifty-five transects, each 55 yards long and 2 yards wide, were laid out in the *Deschampsia* and *Phalaris* zones on St. Serf's Island. These were minutely searched with the aid of 12 people from the Nature Conservancy, and the number of nests not found during the season were noted. The general conclusion was that our searching methods had revealed 90% of the nests present. The number of Tufted Duck nests found, also showed a good correlation with the numbers of females observed in the pre-nesting sex-ratio counts round the Loch.

Despite the intensification of effort, the number of nests known to have been deserted remained very low, about 3%. The hatching success of the Mallard was lower than last season, but that of the Tufted Duck was higher. Table II shows the nests divided according to the type of cover in which they were placed.

The successful association with the nesting gulls is to be noted. The Black-headed Gull colony had increased markedly, and a Nature Conservancy team found no less than 9,000 nests (including re-nests). This year an increase in the predation rate coincident with the fledging of the young Jackdaws was not found, though they certainly could not be absolved from a share in the predation.

Only 120 duckling broods were observed, including many presumed re-sightings. It begins to appear that the Loch, most of whose perimeter is inhospitable to young ducks, may not be a good production area, however favourable the nesting conditions on St. Serf's. This problem will be one of the main ones to be tackled in the succeeding years.

The technique of catching sitting females by the use of a hand-net was further refined and resulted in 212 ducks of five species being ringed, or recaptured with rings put on in 1966. Tufted Ducks and Gadwall caught in this way were equipped with coloured plastic patagial tags, for recognition at a distance. A second diving-duck trap was built and operated from 1st August. The two traps secured 83 Tufted Duck, mostly juveniles, which were also given patagial tags. Another ringing effort was directed against the Mute Swans moulting on the Loch, 85 of the 96 present being caught.

The main winter's work was the detailed observation and recording of the field feeding habits of Pink-footed and Greylag Geese in a study area surrounding the Loch. This was carried forward into a second season.

Table I. Totals of ducks' nests found at Loch Leven, 1967.

Species	*St. Serf's*	*Other islands*	*Mainland*	*Total*
Mallard	557	20	32	609
Tufted	452	75	1	528
Gadwall	47	—	1	48
Wigeon	35	—	1	36
Teal	4	—	—	4
Shoveler	10	—	—	10
Shelduck	1	—	—	1
	1106	95	35	1236

Table II. Types of nesting cover used by Mallard and Tufted Duck on St. Serf's Island.

Cover type	*Mallard*		*Tufted Duck*	
	No. of Nests	*Hatched (%)*	*No. of Nests*	*Hatched (%)*
Deschampsia	296	*50*	117	*38*
Phalaris	62	*39*	125	*43*
Salix	145	*40*	54	*50*
Gullery	54	*61*	149	*53*
Pasture	—	—	7	*14*
	557	*44*	452	*45*

C. R. G. CAMPBELL

Wild Geese at the New Grounds, 1966-67

European White-fronted Goose *Anser albifrons albifrons*

Three birds arrived on 30th September, about the normal time, but the build-up of numbers was very slow during October and November, and there were still only 131 birds by 25th November. Influxes during December brought the flock up to 1,000 by 25th and to about 1,300 by 30th. January was almost over before 3,000 was reached, on 27th, and then a further increase in early February took the total to 4,100 on 8th. The peak was reached on 18th February when 4,200 were present. The peak was not maintained, however, and departures began almost at once. Numbers dropped rapidly with counts of 3,000 on 25th February, 2,750 on 1st March and only 500 on 5th. The last birds seen, 51 of them, departed on 10th. The peak count was about normal but the period when more than 3,000 birds were present was much shorter than usual.

For the third season running the breeding season was a good one; the proportion of young birds in the early part of the winter was 31.3% and the average brood-size was 2.6. In January it fell a little, as is usual, to 28.2%, average brood-size 2.5, and at the time of the peak count in the middle of February it had dropped further to 26.5%, average brood-size 2.4.

Lesser White-fronted Goose *Anser erythropus*

A first-winter bird was present for some weeks, being first recorded on 29th January and last seen on 4th March. This was the only definite record but the presence of a second bird was suspected during February.

Bean Goose *Anser fabalis*

A first-winter bird, probably of the western race *fabalis*, was seen on several dates between 26th January and 26th February.

Pink-footed Goose *Anser brachyrhynchus*

Two birds were seen on 15th January, an adult and a first-winter, and what was probably the latter bird was seen many times during the rest of January, and on many dates in February.

Dark-bellied Brent Goose *Branta bernicla bernicla*

A first-winter bird was seen almost every day between 10th and 18th February.

Red-breasted Goose *Branta ruficollis*

Great interest was aroused among bird watchers visiting Slimbridge by the presence of two birds during the winter. A first-winter bird was first seen on 5th January and stayed until 15th. What may have been the same bird turned up a few days later among some Whitefronts wintering in Hampshire. On 4th February an adult was seen at Slimbridge and this bird stayed until the end of the month. These are the fifth and sixth records for the New Grounds.

M. A. OGILVIE

Wild Geese at the New Grounds, 1967-68

We are publishing this winter's observations as well as those for the previous winter (above) as part of our policy for making the Current Reports section as up-to-date as possible.

European White-fronted Goose *Anser albifrons albifrons*

This season began with the latest ever arrival of the geese at Slimbridge, yet before it ended the peak had reached an all-time high and much larger numbers had spent longer at the New Grounds than usual.

It was 18th November before the first Whitefront arrived, the previous latest date being 23rd October 1963. During the past few years there has been a gradual slowing of the autumn build-up and it is logical that this should also show in time in late arrival dates. Once the first birds had come the pattern was much as in other years with 200 recorded on 10th December and then influxes during the rest of the month coinciding with the brief periods of cold weather. On 12th December 1,220 were counted and 2,800 on the 27th. It was during the second half of January that things really began to happen. On the 15th 4,200 were counted and then a large influx took the total to 5,450 on the 21st. Numbers stayed above 5,000 for the next six weeks, the peak rising to a massive 6,700 on 13th February. The previous highest count for the New Grounds was 5,500 in February 1966, and on that occasion and in the few other seasons when numbers have

reached 5,000 such a level has only been maintained for a very small number of days. This season a special circumstance almost certainly contributed to this unusual state of affairs. Restrictions imposed because of a disastrous foot-and-mouth epidemic (which did not, however, reach the Slimbridge area) meant that the geese were much less disturbed by farm workers and bird watchers than usual and they were able to feed extensively on fields, including some outside the reserve area, which are normally denied to them. Thus these large numbers of geese were probably able to stay because more food was available to them. In the past we have indeed hazarded a guess that availability of food might be limiting the numbers of geese spending the second half of the winter at Slimbridge.

Departures began in early March coinciding with the end of a week of cold, overcast weather. From over 5,000 on 3rd March, numbers dropped to 2,400 on 4th and dropped again to 630 on 5th. The last geese were seen on 11th March.

The geese continued a series of good breeding seasons, the proportion of young birds being very close to that in the last three years. Age-counts in December showed 33.9% young with an average brood-size of 2.3. During January there were 30.0% young birds on the 12th, average brood-size 2.5, and 27.5% on the 26th, average brood-size 2.1. The only satisfactory sample count in February, on the 11th, showed 27.8% young birds, average brood-size 1.9.

Lesser White-fronted Goose *Anser erythropus*

An adult was first seen on 3rd February and on many dates thereafter until the end of the month.

Bean Goose *Anser fabalis*

There was a single record of an adult 'yellow-billed' bird on 26th January.

Pink-footed Goose *Anser brachyrhynchus*

Five Pinkfeet were seen on 24th January and seven on 26th. These were together in a little bunch and consisted of a pair with a single young and two other pairs. They were all seen on several dates during February, the last time on 24th.

Barnacle Goose *Branta leucopsis*

A single adult was present from 14th January until at least 27th February.

Dark-bellied Brent Goose *Branta bernicla bernicla*

A first-winter bird was first seen on 28th December and was last recorded on 28th February.

M. A. OGILVIE

The Bewick's Swans, 1967-68

The fifth successive year of the Bewick's Swan study at Slimbridge started somewhat later than usual. Indeed there was some anxiety as to whether any swans would be on view at our 21st Birthday celebrations. However 9th November saw the arrival of three birds hatched in 1966. They were first seen about half-past three in the afternoon flying over the Enclosures. They disappeared in the direction of the Moors, an area of wet fields a mile away and were found grazing there at four o'clock. Within another half-hour however, they were back over the Trust and came into land on Swan Lake. As it was about tea-time they were promptly named Jammy, Honey and Butter.

The next day brought some old friends, a breeding pair, Kon and Tiki. This year they had no young, our first indication that it had been a poor breeding season. There were, however, two, and later three, second-year birds with them, distinguished from the full adult by the odd grey feather, particularly on the head and neck. These were almost certainly their young from the previous year which had either stayed with their parents right through the summer, or, more probably, had joined up with them again before or during the autumn migration. Suitable Polynesian names were chosen, and Kama, Kura and Ku remained with Kon and Tiki throughout the winter. Pineo and Pinafore also arrived on 10th November. They were hatched in 1965 as young of Pink and Rebecca.

The next arrivals were 16 swans on 17th November. These included Rebecca with a single youngster, but, alas, no Pink. This pair had been among the original 24 birds to be identified by their face patterns in February 1964. In the three succeeding winters they had returned to Slimbridge bringing first 2, then 3, and last winter 4 young with them. The

young of the previous years, together with their mates, often associated with their parents at Slimbridge and at times there were 15 swans in the family party. Pink never turned up during this winter and it must be assumed that he is dead. Although there are cases of swans missing a winter at Slimbridge and then returning it is unlikely that this will happen with Pink as they concerned immature and unpaired birds. There were four cases this winter, all first recorded in 1965-66, and missing 1966-67. One of these, Sparrow, was caught and ringed as a cygnet in 1965-66 and thus it was possible to check its identity this year although the bill pattern had changed from its juvenile pink and grey to adult yellow and black. Sparrow is still easily the smallest Bewick's Swan that has been seen at Slimbridge, and its name refers to this feature not to any resemblance to the Controller.

It has been suspected that the bill patterns can change slightly even when they have become yellow and black, but a surprisingly large change occurred during this winter in one bird. James, a second-year swan, arrived on 26th November and, fortunately as it turned out, was caught and ringed two days later. At that date he was a 'yellowneb', the yellow continuous across the top of the bill, with the patches on either side. During the winter the yellow on the top of the bill was seen to be turning white and for a time it looked just as if he had a 'frostbitten' nose. However, gradually the white disappeared and was replaced by black. So James then became a 'darky' with black running up the front of the bill to the feathering between the eyes. The change took about three months, its cause remaining a complete mystery.

Last winter some metal leg-rings were tried out which were stamped with large figures which could be read at a distance and thus help to check the identity of each swan, especially young birds. They were particularly useful when a swan was up-ending for food and the bill was out of sight. Thirty-three swans were marked with these rings in 1966-67 and several of the birds returned. This year rather better rings were developed, of plastic instead of metal and with even larger numerals, half an inch high, engraved in a contrasting colour. In addition it is possible to add a colour code to indicate the age of the swan. Only twenty birds were caught and ringed in this way during the winter, but the rings proved extremely visible and cause the birds no discomfort. (Plate XVI *a*, facing p. 157).

Until this winter all the swans ringed caught themselves by landing in the side-pens and other confined spaces. There were two probable reasons why fewer birds were caught in this manner in 1967-68, some of the trees which obstructed their flight paths were removed and there were rather few young birds. These are less good flyers than adults, though there are some duffers amongst the latter. One, Rebel, caught on 19th November 1967 was recaptured on 13th January 1968, both times making false landings. In the interval it had increased its weight from 5,019 gm. to 7,357 gm., a tribute to our feeding, at least. Deliberate attempts were made this winter to catch the swans as they flew out of the pen at night and after two abortive attempts six were caught at the third try. Visitors to the Trust during the winter may have seen some curious constructions in the back of the Rushy Pen. Looking like ballistas or other antique military engines, they were actually three pivoted poles, 45 feet high, which could be raised to the vertical with a large-mesh flight net suspended between them. The birds do not tangle in the net but drop down on to a further net spread horizontally underneath to break their fall. The apparatus can only be used on very dark nights with a light wind from one general direction. Reflection from the floodlights also caused difficulties. However it is a promising technique. There is a lot more that could be learnt about the swans if they are marked so as to be recognisable at greater distances than is possible with their bill patterns. For example it should be possible to identify the birds when they visit other resorts where they do not approach as close to the observer as at Slimbridge.

Bewick's Swans from Slimbridge were first recognised elsewhere when six known birds were seen about 16 miles north on floodwater beside the River Severn on 30th December. It seems that some birds were commuting regularly between the two places.

The total number of individual Bewick's Swans seen this winter was 344, very slightly more than last winter. The highest total on Swan Lake on any one day was 199, compared with 222. In each of the past winters the numbers have successively doubled, but this halt to the increase was almost certainly due to the very poor breeding season. Only 26 young birds appeared during the winter, 7.5% of the total. This compares with about 30% in each of the two previous winters. Not only did rather few pairs of adults

bring young with them, but the size of the families was small as well, the largest only having three. The swans breed in Arctic Russia where weather conditions can cause a partial or even complete breeding failure in some years. A period of very bad weather when the adults are laying or especially when the cygnets are just hatched, can cause very heavy mortality and this is probably what happened in 1967. By contrast the European White-fronted Geese wintering at Slimbridge had a good breeding season. We know they breed around Novaya Zemlya, and thus it is probable that the Bewick's Swans' breeding grounds are elsewhere, perhaps further east on the Yamal peninsula. The Brent Geese coming from that region also had a poor season. Eventually ringing recoveries will give us the clue and perhaps it will even be possible to see and identify 'our' birds at the nest.

Departures for Russia started on 2nd March when a spell of fine weather followed a week of rain and high winds. Thirty birds went that day and further 86 the next. More left on 9th but, curiously, four birds arrived that day, and stayed a little while. It is probable that they had wintered further west and were using Slimbridge as a staging post on their return migration. The last bird to leave was a cygnet which had come by itself late in the winter and stayed on after all the other swans had departed. It finally left on 17th April.

M. A. OGILVIE

Breeding results 1967: Slimbridge Collection

		Incubated by bantams		*Incubated by parents*		
	Date of first egg	*eggs*	*hatched*	*reared*	*Hatched artificially*	*and reared by parents*	*Total reared*
Eyton's Whistling Duck		10					
Fulvous Whistling Duck	10.3	86	25	23			23
Cuban Whistling Duck	20.6	11	0				
White-faced Whistling Duck	24.5	20	17	17			17
N. Red-billed Whistling Duck	15.5	13	11	11			11
S. Red-billed Whistling Duck	20.3	31	20	19			19
Black Swan	9.2					3	3
Black-necked Swan	3.2					3	3
Bewick's Swan	9.5					2	2
Trumpeter Swan	6.4	13	8	8		1	9
Swan Goose	30.3	6	3	3		2	5
Western Bean Goose	27.4	7	4	4			4
Russian Bean Goose	27.4	7	2	1			1
Pink-footed Goose	23.4	8	5	4			4
European White-fronted Goose	16.5	6	1	1			1
Greenland White-fronted Goose	23.4	16	8	5			5
Lesser White-fronted Goose	21.4	23	12	11			11
Western Greylag Goose	2.4					14	14
Eastern Greylag Goose	16.3						
Bar-headed Goose	21.4	22	4	3		2	5
Emperor Goose	21.4	34	17	14			14
Lesser and Blue Snow Goose	28.4					14	14
Greater Snow Goose	26.4	6	4	4		5	9
Atlantic Canada Goose	20.3					2	2
Moffitt's Canada Goose	28.3	9	3	1			1
Giant Canada Goose	25.3					9	9
Taverner's Canada Goose	20.4		1	0		2	2
Cackling Canada Goose	27.5	4	0				
Hawaiian Goose	11.2	123	40	35			35
Barnacle Goose	27.4					27	27
Black Brant	19.5	9	6	3			3
Ruddy Shelduck	4.5	9	2	0			
Cape Shelduck	18.3	5	4	3			3
Egyptian Goose	16.2					7	7
Abyssinian Blue-winged Goose	28.4	4					
Andean Goose	16.5					9	9
Ashy-headed Goose	4.4	12	2	1		2	3
Ruddy-headed Goose	18.4	4	4	3		4	7
Lesser Magellan Goose	2.4	10	9	5		2	7
Greater Magellan Goose	21.4	5	1	1			1
Cereopsis Goose	3.1					1	1
Patagonian Crested Duck	18.2	5	5	5		9	14

		Incubated by bantams			*Incubated by parents*		
					Hatched and reared		
	Date of first egg	*eggs*	*hatched*	*reared*	*artificially*	*by parents*	*Total reared*
Andean Crested Duck	12.3	3	1	1			1
Marbled Teal	21.4	13	12	8	12		20
Bronze-winged Duck	3.3	13	1	1			1
Cape Teal	12.3				10	8	18
Hottentot Teal	8.7	6	6	6			6
Versicolor Teal	25.4	19	8	2			2
Puna Teal	12.5	8	0				
Bahama Pintail	20.5	20	6	6	24		30
Chilean Pintail	8.4				20		20
Northern Pintail					10	5	15
Kerguelen Pintail	20.4	10	3	3			3
Chilean Teal	15.4				15	2	17
Falcated Teal	22.5	31	2	1			1
Australian Grey Teal	23.5	8	1	1			1
Chestnut-breasted Teal	20.2					6	6
New Zealand Brown Teal	12.2					5	5
Greenland Mallard	1.7	6	0				
Hawaiian Duck	27.4						
Laysan Teal	25.4	23	19	17			17
Florida Duck	12.5	7	7	1			1
North American Black Duck		4	0				
Indian Spotbill	19.5	9	1	1			1
Chinese Spotbill	19.5				1		1
New Zealand Grey Duck	25.3				12		12
Philippine Duck	10.5	34	19	18			18
African Yellowbill	20.2				15		15
Abyssinian Yellowbill	30.3				12		12
African Black Duck	30.3	4	2	0			
Gadwall					25	20	45
European Wigeon	25.5	10	4	4	6		10
American Wigeon	25.5				8		8
Chiloe Wigeon	5.5	42	26	20	2		22
Blue-winged Teal	12.5	33	16	10			10
N. Cinnamon Teal	29.5	6	1	1			1
Cape Shoveler	22.4	16	9	2			2
New Zealand Shoveler	25.4	7	3	2			2
Common Shoveler	30.4	10	0				
Ringed Teal	18.4	37	16	14		3	17
European Eider	18.5	11	6	5			5
King Eider	4.6	4	3	2			2
Red-crested Pochard	25.3	25	21	20			20
Rosy-bill	15.5	13	3	3	4		7
African Pochard	3.3	4	2	2			2
European Pochard	12.5	14	10	8			8
Redhead	26.4	18	9	8			8
Common White-eye	15.4				6		6
Baer's Pochard	22.6	8	8	7			7
Australian White-eye	12.3				3		3
New Zealand Scaup	5.6				11		11
Lesser Scaup	11.6				5		5
European Greater Scaup	25.6	9	6	4			4
Brazilian Teal	23.5						
Mandarin Duck	6.4				30	2	32
North American Wood Duck	12.3				61	4	65
Comb Duck	15.6	32	27	16			16
Hartlaub's Duck	12.7					6	6
Muscovy Duck	15.5					8	8
Spur-winged Goose	4.4	8	0				
European Goldeneye	20.4	3	1	1			1
American Goldeneye	28.4						
Smew	18.5	7	1	0			
Hooded Merganser							
Red-breasted Merganser	1.6	6	1	0			
North American Ruddy Duck	28.5	6	4	1		15	16
African White-backed Duck	6.6	10	1	0			
Crested Screamer						2	2

Breeding Results 1967: Peakirk Collection

	Date of first egg	*Eggs incubated*	*Eggs hatched*	*Young reared*
Black Swan	23.2	5	5	4
Black-necked Swan	7.2	10	4	2
Swan Goose	7.4	27	8	5
Pink-footed Goose	1.5	10	4	3
Greenland White-fronted Goose	7.5	6	0	
Lesser White-fronted Goose	11.5	3	1	0
Western Greylag Goose	2.4	18	17	12
Emperor Goose	13.6	3	0	
Lesser Snow Goose (Blue)	26.4	5	3	3
Taverner's Canada Goose	6.5	5	1	1
Cackling Canada Goose	22.4	10	4	3
Hawaiian Goose	18.3	1	0	
Barnacle Goose	3.5	11	0	
Red-breasted Goose	12.6	5	4	4
Ruddy Shelduck	25.4	6	2	2
Cape Shelduck	11.3	11	3	1
Common Shelduck	28.4	11	5	5
Greater Magellan Goose	3.4	16	11	9
Patagonian Crested Duck	27.3	11	8	3
Andean Crested Duck	16.4	10	1	1
Marbled Teal	17.5	40	35	26
Cape Teal	5.4	14	14	11
Versicolor Teal	19.4	6	2	0
Bahama Pintail	14.5	60	30	17
Chilean Pintail	6.4	19	19	10
Northern Pintail	24.4	24	4	4
Chilean Teal	28.3	19	14	11
Falcated Teal	7.6	8	5	0
Chestnut-breasted Teal	16.4	22	7	7
Laysan Teal	24.4	24	14	11
North American Black Duck	17.5	8	5	4
Chinese Spotbill	9.5	14	4	3
African Yellowbill	24.5	10	4	3
African Black Duck	6.4	10	1	1
Gadwall	17.5	21	15	10
European Wigeon	29.4	50	27	20
American Wigeon	15.6	9	5	3
Common Shoveler	11.5	24	4	0
Ringed Teal	8.6	5	0	
European Eider	27.5	4	0	
Red-crested Pochard	4.4	44	13	8
Rosy-bill	31.5	11	0	
African Pochard	23.5	6	0	
European Pochard	9.5	6	2	1
Common White-eye	5.5	26	18	9
Baer's Pochard	11.6	9	6	3
Australian White-eye	15.5	22	17	8
New Zealand Scaup	12.5	15	8	7
Tufted Duck	11.5	39	27	22
European Greater Scaup	15.6	4	3	3
Brazilian Teal	21.4	17	5	4
Mandarin Duck	8.4	14	10	6
North American Wood Duck	25.3	45	15	1
North American Ruddy Duck	25.5	42	17	8

S. T. JOHNSTONE
P. B. VARDY

The Annual Report of the Wildfowl Trust, 1967

The Wildfowl Trust

Patron HER MAJESTY THE QUEEN

President His Grace the Duke of Norfolk, K.G., P.C., G.C.V.O.

Vice-Presidents Captain R. G. W. Berkeley
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Hon. Director Peter Scott, C.B.E., D.S.C., LL.D.

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C. Braby
Dr. Bruce Campbell
Peter Conder
J. O. Death
Professor J. E. Harris, C.B.E., F.R.S.
Dr. J. G. Harrison
Professor G. M. Hughes
G. A. J. Jamieson
Miss P. Talbot-Ponsonby
Major General C. B. Wainwright, C.B.
The Hon. Vincent Weir

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G. M. Jolliffe, F.L.A.S.
E. G. Kleinwort
R. E. M. Pilcher, F.R.C.S.
J. P. Williams

Invited to attend meetings ex-officio Miss Emilie Davies, H.M.I. *(Ministry of Education Assessor)*

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R. C. P. Hollond
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Professor E. W. Yemm

Trust Activities, Development and Finance

The Officers, Council and Committees of the Trust as at 31st December 1967 are listed on page 167. The Council met in the Headquarters of the Nature Conservancy in London on 4th April and 6th July and the Finance Committee on 14th March, 19th July and 20th December. The Scientific Advisory Committee met in the Department of Zoology, Bristol University, on 22nd March.

The Nineteenth Annual General Meeting was held at the Royal Geographical Society, London, on 16th May. The Annual Dinner was at the Hyde Park Hotel the same day. The Hon. Director presided and the speakers were Sir Stanley Rous, Mr. Max Nicholson, Sir Milner Holland and Mr. Laurens van der Post.

To mark the 21st anniversary of its foundation the Trust held a luncheon party at the New Grounds on 11th November 1967, which was attended by 272 Members. The health of the Trust was proposed by Mr. James Fisher and the Hon. Director replied. Visitors were conducted round the grounds and showings of Wild Wings were arranged.

There was an increase in overall membership of 507 over 1966. Thus:

	1966	*1967*
Life	326	317
Full	4238	4581
Associate	1638	1643
Parish	217	254
Junior Compounded	15	13
Gosling	626	751
Corporate	92	99
Contributors	31	32
	7183	7690

The Council has learned with regret of the death of 72 Members and Associates since March 1967.

Twenty-three Members of the Trust kindly opened their collections to fellow Members on various dates in 1967. These were C. J. and A. J. Bird, Arthur Cadman, T. Curtis, J. O. Death, A. W. E. Fletcher, Major I. Grahame, B. E. Greenwell, R. Law, Miss E. Manasseh, E. A. Maxwell, A. McLean, Mrs. B. Michell, Lt.-Col. R. B. Moseley, George Newman, F. W. Perowne, R. E. M. Pilcher, G. R. Pryor, Peter Short, Shrewsbury School, E. O. Squire, Mrs. P. V. Upton, J. Williams, D. Wintle.

The sixth annual Wildfowl Identification Competition for Schools was held on 18th March. Leighton Park were the winners in Groups A and B and Beaudesert Park in Group C.

Borough Fen Decoy was opened to the public on 20th and 21st May.

The Gosling Party fixed for 23rd December 1967 was cancelled on account of foot-and-mouth disease.

To help defray the considerable costs of harbouring, feeding and studying the growing herd of Bewick's Swans wintering at the New Grounds and frequenting the Rushy Pen, Members were invited to become Swan Supporters at an annual subscription of £5. By the end of the year 135 enthusiastic and generous Members had enrolled. They are each allocated a named swan and receive a coloured portrait of their bird. Its subsequent arrivals and departures, details of its breeding record and other personal information are passed to its Supporter at intervals.

The two main developments in 1967, the acquisition of the Welney Washes Reserve and the completion of the Tropical House, are described in detail elsewhere (pp. 130 and 169). The latter was opened for the 21st Birthday Party as was the new glassed-in Swan Observatory adjoining the Hostel building overlooking the Rushy Pen. This is for the use of Members and Swan Supporters only. The latter may reserve places therein by notifying the Trust before the day of their visit.

The grounds at Peakirk were once more expanded by an additional 2½ acres, again through the generosity of Mr. W. R. Neaverson. Mrs. Annie Williams kindly gave the Trust a pair of cottages next to the Goshams, which will make an excellent house for staff.

The accounts, which have been circulated to Members, showed that income exceeded expenditure in 1967 by £2,781. In addition, £5,053 received in special donations and legacies were credited direct to General Reserve. As a result it was possible to increase the Special Reserve to £7,500 and to carry forward a general reserve of £10,964 available for further development.

By 10th November all the private loans which had been advanced to help finance its early development had been repaid and the Trust came of age clear of debt and with the above reserves totalling £18,464 in hand.

In addition, by the end of the year £21,772 had been raised towards the total

of some £33,000 needed for purchase of the Welney Wildfowl Refuge.

As a precaution against the spread of foot-and-mouth disease the grounds at Slimbridge were closed from 25th November to 26th December 1967 and the gardens at Peakirk from 30th November 1967 to 6th January 1968. Nevertheless there was a record number of visitors to Slimbridge and a second best total at Peakirk:

	1963	*1964*	*1965*	*1966*	*1967*
Slimbridge	130143	151180	141841	200231	209243
Peakirk	29434	43678	42735	46514	46181
	159577	194858	184576	246745	255424

C. E. H. SPARROW

1967 Breeding Season

The 1967 breeding season was not particularly outstanding and a number of species which usually lay did not do so. We did, however, have our best year with the Ne-nes, forty goslings were hatched of which thirty-five were reared. Mr. Jack Williams reared another fifteen, bringing the total in this country to fifty. Nine Trumpeter Swans were raised, eight by hand and one by the parents. Hottentot Teal were reared for the first time at the New Grounds. Large numbers of the commoner species of duck were allowed to incubate their own eggs as a measure to keep the production of ducklings down to practical numbers (by avoiding repeat clutches). Incubators were then used to hatch out these eggs. The young were reared firstly in the indoor unit and subsequently under infrared lamps in our brooders.

The Tropical House

The building of our Tropical House was made possible by the munificent anonymous gift of £5,000. We have to thank two of our members, Mr. Len Hill and Mr. Harry Horswell, for their help in building the main structure, and the Royal Botanical Gardens, Kew, for their advice in planting up and for a fine collection of plants. We are indebted to Mr. Ian MacVicker for his help with the heating and ventilation system.

The building covers an area of some 3,600 square feet, and half of this is water. There are three ponds at different levels connected by waterfalls and cascades. The surface of the highest pond is at eye level and the lowest at that of the external water. (Plate X *a* and *b*, facing p. 109).

The water is circulated by an electric pump from the lowest to the highest pond which it enters over a twelve-foot waterfall and thence back to the low pond. Incorporated in the pumping system is an arrangement for producing a rainstorm for dampening the vegetation. The temperature is maintained in winter at 70°F by two Wanson Thermobloc hot air heaters which are oil-fired and electrically controlled. Oil is pumped from the main entrance through a pipe line to a tank on the site, adjoining the African Pen. The possibility of electric power failure is taken care of by a Lister generator which starts automatically in that event. In summer the heating unit is used to blow cool air into the building and warm air is removed by six extractor fans.

There are at the moment twenty-six ducks of the following species in the house: Spotted Whistling Duck, Eyton's Whistling Duck, Javan Whistling Duck, Hottentot Teal, Galapagos Pintail, African and Indian Pygmy Geese, and African White-backed Duck. The upper air space is utilised by seven kinds of tanager, two of humming bird, and some Robinchats. The African and Indian Pygmy Geese seem to be benefiting greatly from their salubrious surroundings. We hope these will encourage them to multiply exceedingly.

S. T. JOHNSTONE

Conservation, Research and Education, 1967

The main conservation achievement of the year was the securing of 500 acres of the Welney Washes, Norfolk, as a Wildfowl refuge (p. 130). On the international front the first continental mid-winter sample census of wildfowl was carried out, the results, other than those from the U.S.S.R., being collated at Slimbridge by Mr. Atkinson-Willes and Mr. Beale. More than 4,500 sites were covered and six million wildfowl counted (p. 157). Mr. Atkinson-Willes attended the Technical Meeting of the International Union for the Conservation of Nature at Ankara, in November, aimed at stimulating the conservation of wetlands in the Near East. He was also present at the annual meeting of the International Wildfowl Research Bureau at Morges, Switzerland, as was Dr. Matthews. The latter was returning from an advisory visit to the University of Pisa, Italy, and shortly afterwards was chairman of a group of visiting experts advising the Government of Northern Ireland on the conservation of their main wetlands. Together with Dr. Kear he also attended the International Ethological Conference in Stockholm. The Survival Service Commission of the I.U.C.N. met at Slimbridge under the chairmanship of Mr. Scott.

The widespread foot-and-mouth restrictions interfered somewhat with the monthly duck counts, but fortunately did not greatly impinge on the goose censuses, now organized by Mr. Ogilvie (p. 156). The extensive survey of the breeding distribution of ducks in Britain was continued, as was the intensive study of breeding biology at Loch Leven (p. 159).

After 18 years with the Trust Mr. Hugh Boyd departed to take up the post of Research Supervisor, Eastern Region, Canadian Wildlife Service. Our very best wishes go with him, together with our gratitude for all that he has done for the Trust's research programme. He would be the first to be embarrassed by fulsome tributes, with their air of termination. On the contrary, we look forward to years of linked activity, slightly tinged with envy at the research funds he now has at his disposal! The Nature Conservancy had offered Mr. Boyd a permanent post with them in Scotland, to ensure that research on geese, and in particular their relation to agriculture, could go forward on a long-term basis. They appointed Dr. I. Newton, formerly of the Edward Grey Institute, Oxford, to fill this post in October. The Trust's contribution to the joint team was strengthened by the appointment in September of Mr. I. K. Marshall to work at Loch Leven. He had been carrying out a Ph.D. study on the breeding biology of the Common Eider on the Farne Islands. Another new appointment to the research staff was that of a botanist, Dr M. Owen. He obtained his Ph.D. at Leeds University and succeeded, in October, Dr. Pollard who had also joined the Brain Drain to Canada. Dr. Owen is being concerned primarily with the feeding ecology of geese and, on the new Welney Refuge, with the ecological aspects of transitory flooding of grassland.

The ringing programme (p. 147) continued at the three long-established centres, Slimbridge, Abberton and Borough Fen Decoy. In addition ringing with Trust assistance was carried out at Dersingham Decoy, Norfolk, and the former market-decoy at Nacton, Suffolk, was also used for ringing. Negotiations for a long-term lease of this decoy are in progress. Large numbers of Canada Geese were ringed with our support, and long-term studies of the Mute Swan, particularly that of Dr. C. D. T. Minton (p. 41), continued.

Advice was given, and supporting research carried out, on many projects concerning the management of wetland areas. These ranged from the restoration of habitat after opencast mining to the assessment of conflicting recreational usages. The integration of wildfowl with agricultural requirements is an important aspect of management, and Dr. Kear rounded off a long series of grazing trials with penned geese on winter crops by two runs of 'spot' checks in Scotland. She continued to advise the Department of Agriculture on further researches such as the effects of goose droppings on pasture usage by farm animals (p. 117). Further studies were made on the innate behavioural factors concerned in food selection.

Dr. Kear was also concerned with research into the breeding periods, clutch sizes, egg weights and so forth, for all the wildfowl, coupled with an intensive study of the Hawaiian Goose at Slimbridge. Nutritional aspects of infertility were investigated by a programme of differential feeding. A more direct approach, by the examination of sperm production, was begun by a veterinarian, Mr. P. N. Humphreys, who hopes to develop this into a full scale study.

Post-mortem examinations were made as usual by Dr. Beer on all birds dying at Slimbridge, and a start has been made on the analysis of the past ten years' records on pathology. The reference collection of skins and skeletal material expanded further. An extra burden was assumed in attempts to rehabilitate some of the unfortunate victims of the *Torrey Canyon* oiling disaster (p. 120).

The long-term investigations of the orientation of wildfowl were continued. Dr. S. Miles reversed the Brain Drain and returned to Britain from Canada to work on orientation at Slimbridge for a year. His main interest was the orientation of eels, which are plentiful in the Severn, both the adults and the young elvers. Our other acquisition from North America, Maya Scull, married an Englishman and therefore had to be replaced, by Mr. T. Pitcairn, for the continuing study of the Bewick's Swan visitors to Slimbridge (p. 162).

Besides research studies by its own staff, the Trust continued to supply materials and provide facilities to workers in other institutes. These included the National Agricultural Advisory Service, Poultry Research Station, Medical Research Council, Institute of Laryngology and Royal Radar Establishment. Similar research links were maintained with the Universities of Bristol, Bath, Oxford, Cambridge, Liverpool and Reading.

On the educational front, courses of lectures were given at the Universities of Bristol and Cardiff, while students also came for day courses from London and Manchester. A most significant development for the future was the allocation of sufficient funds by the Carnegie Foundation and the Dulverton Trust for the Youth Hostels Association to establish a Field Studies Hostel at Slimbridge. Its 50 beds will solve the present problems of accommodating students and schoolchildren for more than day-courses; it is hoped it will be ready in 1969. A most successful four-day course for schoolteachers was organized in conjunction with the Department of Education, Bristol. Some 770 parties of children were given conducted tours of the grounds and a start made on a more instructive 'nature-trail' method of using their time here. A new Guidebook for the Trust grounds was completed and published. Displays were mounted at the Exhibitions of the Royal Horticultural Society, the Game Fair, the Harrogate Festival and the School Boys' and Girls' Exhibition.

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