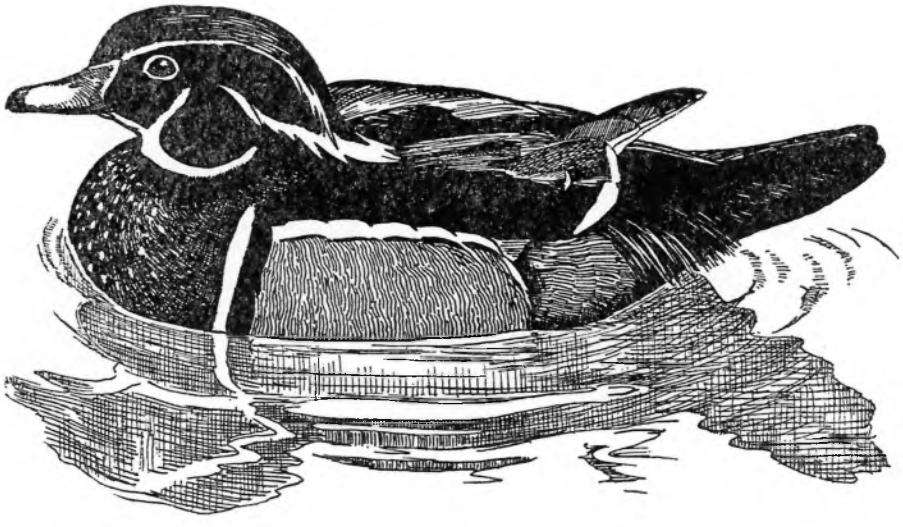

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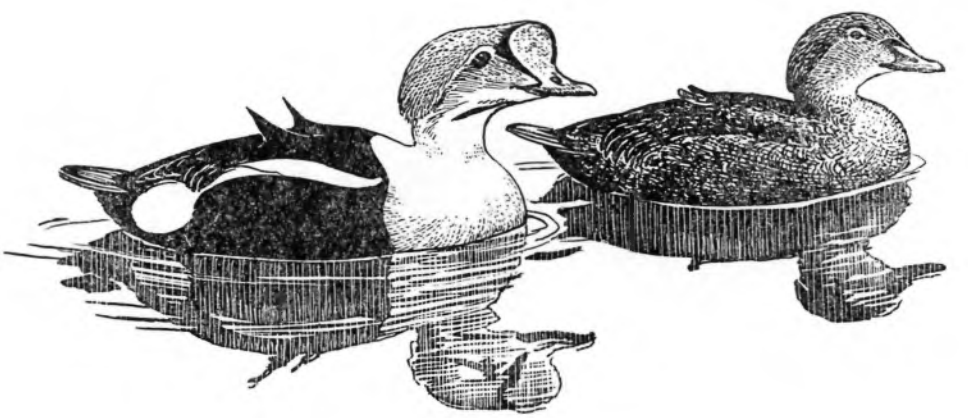

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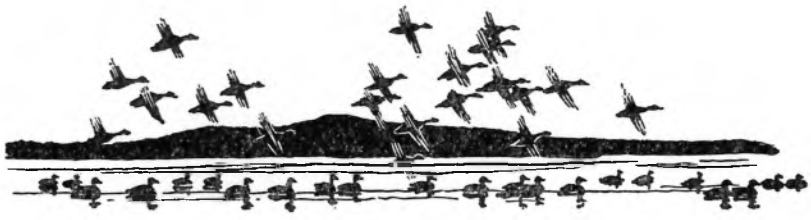

Waterfowl wintering, resting and breeding areas of the south-west Caspian lowlands

DAVID A. FERGUSON

Introduction

The South Caspian region of Iran has received considerable ornithological attention as compared with other sections of the country. Misonne (1953), Schüz (1959), Passburg (1959), Nielsen and Speyer (1967), Nielsen (1969), and Feeny *et al.* (1968), to name only a few of the more recent investigators, have all added to the knowledge of this area. Most of these workers, however, were only able to devote relatively short periods of time to the region and therefore concentrated on migrational aspects. Others described local movements, occurrence and abundance. Emphasis was almost always on the passerines.

This paper describes the results of an intensive study of the waterfowl and wetlands in the south-west Caspian lowlands. Investigation of the area was instigated through the interest of the Iran Game and Fish Department. The entire South Caspian region was recognised as an important wintering ground for Palaearctic waterfowl which provided an abundant supply of food for a well-established wildfowling industry (Savage 1963). However, little information was available on the kinds and abundance of species, the number, size, and type of habitats, effects of hunting, as well as many other aspects that would affect the status of the population as a whole. The Department was primarily interested in the factors affecting management of the waterfowl, but were also concerned with the overall ecology of the region.

The author of this paper, while employed as an advisor to the Iran Game and Fish Department and later as the Chief of the Migratory Waterfowl Unit, Division of Research and Development in the Department, collected data on an irregular time basis for the area from January 1967 to April 1970. Most observations were carried out during the winter months, but in December 1968 a month-by-month survey was initiated at the Pahlavi lagoon and marsh situated in the centre of the region. Visits were made over two or three day periods at approximately the same time each month until April 1970.

A total of 332 observations was made on over 100 areas throughout the south-west Caspian lowlands. Some areas were only visited once or twice to locate, study and evaluate them. Others, which were usually larger and determined to be more important, were visited several times to see how the situation changed from month to month. Due to the number of areas and observations the information in this paper is necessarily summarised.

The area of study consists of the south-west Caspian lowlands extending from the border in the north with the U.S.S.R. at Astara, south and east to an arbitrary point near the present town of Rudsar where the plain narrows between the Alborz Mountains and the Caspian Sea (Figure 1). The arbitrary demarcation was due in the north to political boundaries and in the south-east to physical limits of extensive wetland habitat other than the shore of the Caspian itself.

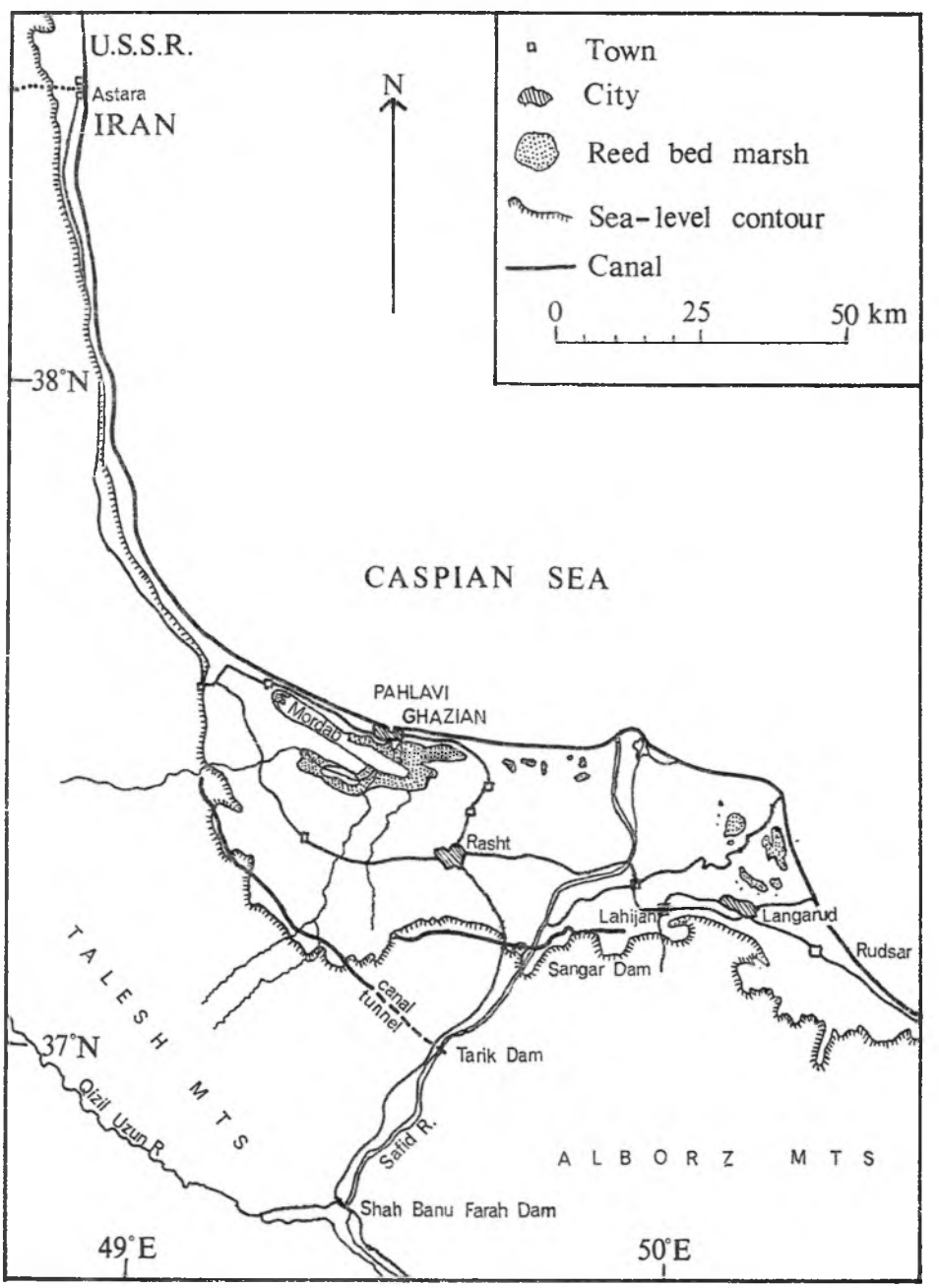

Figure 1. The south-west Caspian lowlands.

AREA AND STRUCTURE

Physical geography, geology and geomorphology

1 Caspian Sea

The Alborz Mountains (the western portion is known as the Talesh section) extend eastward from the border with the U.S.S.R. in the north-west, in a shallow arc (maximum width of 130 km. and an average of under 95 km.) along the southern end of the Caspian Sea for over 1,000 km. Included in this chain, and lying approximately in the centre, is the volcanic cone of Mount Demavand (5,774 metres) which is higher than any peak to the west of it in Asia or Europe. Because of its restricted width, the system is extremely steep, especially the northern slopes. These rise directly from the below sea level coastal plain of the Caspian.

Water runoff has furrowed these slopes with deeply-cut valleys and deposited the debris in the forelands in great alluvial fans and wide deltas. However, drainage to the South Caspian is by no means restricted to the northern slopes of the Talesh and Alborz Mountains.

The outwash and deposition of sediments from erosion of the northern uplands, accompanied by a lowering of the level of the Caspian, has succeeded in creating a narrow coastal plain some 650 kilometres in overall length but varying in width from 30 kilometres to less than two.

According to Zenkevitch (1963) the lowering of the Caspian is characteristic of the whole Quaternary Period. Savage (1958) indicates that since the area is in a great earthquake region, following any movement of the earth's crust there must be some settlement in the great depth of unconsolidated gravels which are known to underlie the Caspian. He also suggests that the climate is getting warmer in that part of Asia, and evaporation is therefore increasing.

Other investigators, including Zenkevitch (1963), report that changes in the level of the Caspian are the results of the fluctuations in the amounts of fresh water received from the rivers and from rainfall minus evaporation. Zenkevitch points out that over the last century (1830-1946) the level of the Caspian has averaged 25.45 metres below ocean level but that there has been considerable year to year as well as seasonal variation. The highest level was recorded in 1896 but since then the level has continued to drop. By 1929 it had decreased by 42 cm., and in the next 17 years fell rather uniformly another 187 cm. (there was an exception in 1942 when a minor rise was experienced, but this was followed by a greater fall in 1944). Zenkevitch further reports that the conformity between fluctuations of the Caspian Sea level and those of the inflow of the Volga River which supplies about 75.6% of the total water supply of all the rivers, is so close that direct influence has been established. He states that the great drop in the Caspian level from 1930 to 1943 was caused by the considerable decrease of river inflow, particularly the Volga, but that this has now been stabilised.

Almost all the reports since then indicate the contrary; that the Caspian continues to fall. However, the same reports give values for the level of the sea which lead to a great deal of confusion. For example, Vladykov (1964) states that the level of the Caspian in 1955 was about 28 metres below the level of the Atlantic Ocean (in effect, a further drop from 1946). Savage (1958) reports this level for 1956-57. Fisher (1968a), on the other hand, writes: 'The Caspian Sea at present is some 85 feet (25.91 m.) below mean sea level, and is slowly shrinking in size, with an average annual fall in level of about 8 inches (20.32 cm.)'. If all the readings were correct it would mean a drop from 1946 to 1957, and then a two metre rise from 1957 to 1968! It is doubtful that such is the case.

It is known, however, that the Caspian shows great seasonal fluctuation with highest levels occurring during the first half of summer, after floods, the lowest levels at the beginning of winter. There are no real tides, but sporadic *seiche* movements are produced as a result of sustained wind action. Definite currents exist; mainly from west to east, as regards the southern end. The sea has no outlet but is less saline than open oceans. The salt content is only about one-third of the average major ocean (12-13%) and one-fifth to one-fourth of that prevailing in the Mediterranean and Red Sea (Zenkevitch 1957).

2 The south-west lowlands

The present coastline of the south Caspian, produced as it is by shrinkage of the water surface, appears generally straight or only slightly curved and without any prominent headlands or cliffs. It is characterised by a sequence of sand beaches, dunes, spits and bars, bordered by a series of low-lying brackish and freshwater lagoons and marshes. A slightly higher and generally drier terrace zone fronts a piedmont zone marking the

beginning of the Alborz and Talesh foothills.

The south-west Caspian lowlands consist essentially of the delta of the Safid River which has built out a plain north and north-east into the Caspian and, hence, extended the width of the coastal plain to about 30 kilometres. The Safid River is the second largest in Iran and has a catchment basin of over 54,000 square kilometres and a natural flood discharge of 3,400 to 4,200 cubic metres per second which dwindles to a minimum flow of 19.6 cubic metres per second (Oberlander 1968). With such intermittent flow the Safid, and to a certain extent most of the Caspian rivers, divided into several distributary channels which frequently shifted and changed course. Many small lagoons, marshes and inundated areas were created along the seaward side of the plain and some were closed off by developing sand spits; hence, the name Mord-ab (dead water).

3 The Pahlavi Mordab

A large lagoon (now known as the Pahlavi Mordab) developed on the western flank of the Safid delta. Its exact origin is not known, but obviously underwent fluctuations in size and salinity, and may even have been inundated as a direct result of the changes in level of the Caspian. Presently, it is composed of a shallow, 26 km. long and 2 to 3.5 km. wide strip of water surrounded by reed beds and aquatic vegetation, which extend its eastern limits another 7 km., and lies in a north-west—south-east plane very close to the Caspian (Figure 2). Adjacent to this lagoon to the south and probably once a part of the lagoon is the extensive reed-bed marsh called Siahkesheem (12 km. long by 4.5 km. wide).

Several small perennial streams emanating in the nearby Talesh Mountains feed into this large lagoon-marsh complex, chief of which are the Bohambar, Chakoor and Siahdarveshan. Other shorter streams from runoff and irrigation from the Safid River also terminate in this area. The entire marsh and lagoon complex drain into the deep-water harbour of Bandar Pahlavi from several short channels at the north-east end of the lagoon.

4 Other mordabs

There are a few other open-water mordabs in the south-west Caspian lowlands worthy of note. Bandar Farahnaz (formerly Hassan Keyadeh) is a 3.75 km. long by 1.5 km. wide, shallow, freshwater lagoon 1.5 km. east of the present mouth of the main channel of the Safid River. It has formed relatively recently in the delta area and is separated from the Caspian by a sand spit that varies from 60 to 250 metres wide. An extensive reed marsh of 140 hectares covers the western end.

The open, but reed-rimmed, freshwater Shal Kol Mordab (also called Sheikh Ali Kol and Amirkelayeh) is situated on the eastern end of the Safid River delta about two kilometres from the Caspian. It lies in a north-south plane and is 4.5 km. long and 1,700 metres wide at the north end narrowing to about 700 metres in the south. Diverging northwesterly from the south end and lying nearly parallel to Shal Kol is the Hassan Aliadeh reed marsh (4 km. by 1 km.). These areas drain from the north-west end of Shal Kol into a channel of the Safid River that flows northward 1.5 km. away. Whether this channel created the mordabs originally is hard to say for it now appears they are entirely spring-fed. Shal Kol is extremely clear with depths of up to six metres and rich growths of underwater vegetation.

Several other mordabs are present in the lowlands. They vary in size from about 35 hectares up to nearly 900, and most of them occur on the east edge of the Safid delta in the vicinity of Shal Kol. They are nearly all full of aquatic and emergent vegetation and many are being reclaimed for agricultural use.

A complete list of mordabs, Abbandans and other wetlands in the area, 65 in all, with their size, location, status and present use, has been deposited with the Iranian Game and Fish Department, and with the headquarters of the International Waterfowl Research Bureau.

Climate

Although Iran has not had any long-term climatic observations, the Iranian Meteorological Department has been keeping records since World War II and has published an annual meteorological yearbook from 1956. From these synoptic and climatological data and Ganji (1968), the following account has been compiled.

1 Winter

During the winter months a high pressure system builds up over the interior of Asia due to the cooling of this vast continent. It is highest over Siberia but decreases outward. Portions of it extend over the north Caspian region into Europe, as well as over the interior of

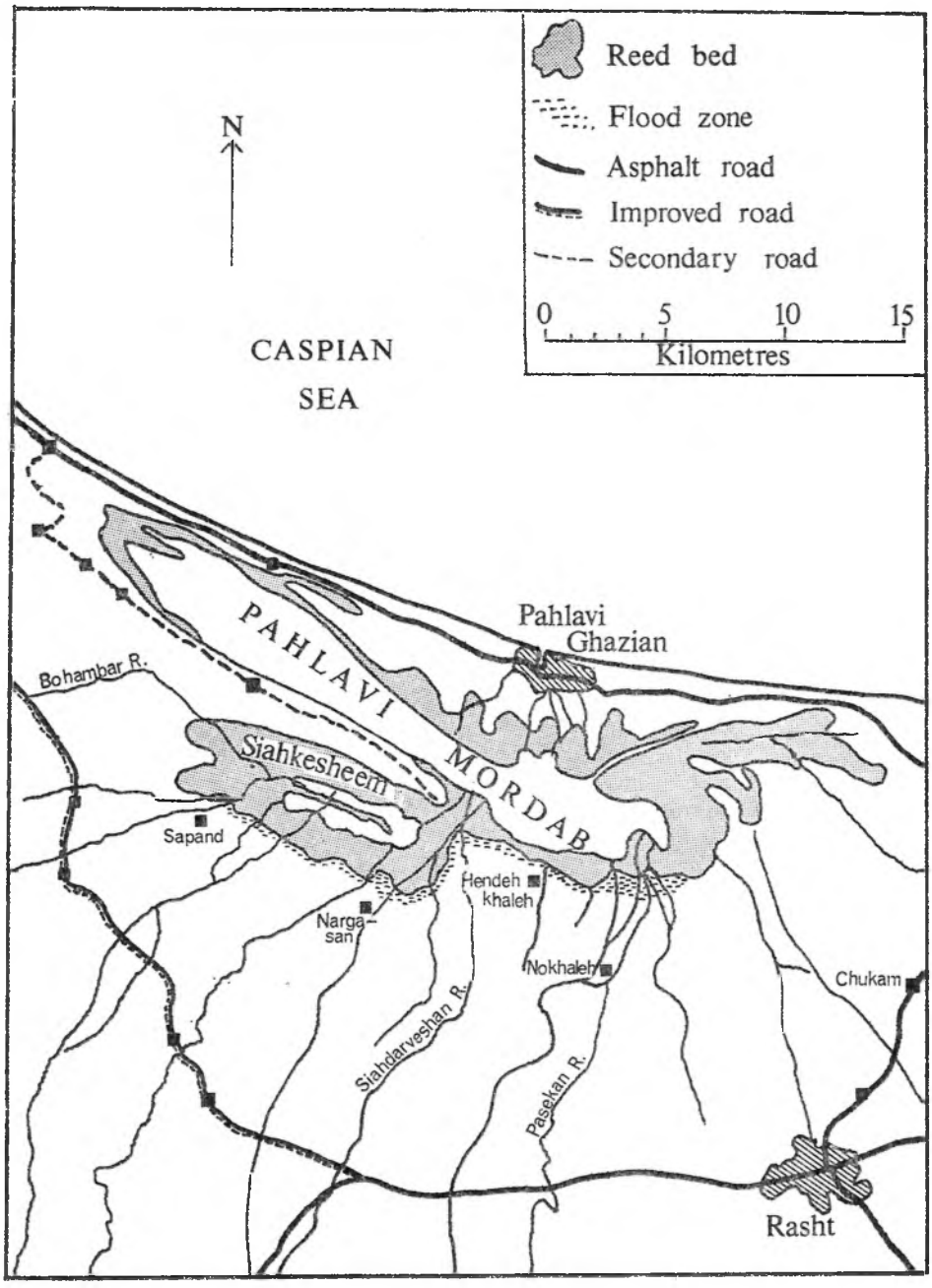

Figure 2. Pahlavi Mordab and Siahkesheem Marsh.

Iran. However, there is a relatively low centre over the warm waters of the Caspian itself bringing counter-clockwise winds from the north and west. Ganji (1968) states that the pressure field for northern Iran in winter (January) is 1,020 to 1,018 millibars mean sea level pressure and declines in intensity southward. Depressions formed over the Mediterranean bring almost all of the rain that occurs over the region during this time. Although winter is generally the rainy season for the rest of the country and the Caspian area receives the most precipitation, it is actually less than 25% of its annual total. Falls of 40-80 mm. of precipitation per day are frequent along the Caspian with up to 100 mm. per day in the south-west lowlands. Precipitation decreases from west to east.

2 Spring and summer

In spring and summer the interior of the country warms up rapidly, but cooler air over the Caspian causes a relatively high pressure field over the northern part of the country. The Mediterranean depressions retreat rapidly and as the temperature rises, a great deal of instability is created causing convectional rain and thunderstorms to arise in the north and west. Rainfall in the spring falls to 10% of its annual total along the Caspian, but the region still remains the wettest part of the country.

The summer months bring local winds primarily orographic in origin which are extremely variable and greatly influenced by topography over the Alborz and Talesh Mountains. Narrow valleys provide channels between the pressure system of the interior and that of the Caspian producing strong winds; a good example of which occurs in the Safid River valley at Manjil. Upward flows in the day and downward flows at night are common. Land and sea breezes are prevalent over the coastal area and bring in moisture from the large surface area of the Caspian. The steep, high Talesh and Alborz Mountains lie at right angles to these air movements and greatly facilitate condensation. Precipitation is heavy with almost daily rains, and the south-west lowlands again receive the greatest amount.

3 Autumn

After the autumnal equinox the Mediterranean depressions begin to re-establish themselves over the Middle East. The high pressure over Asia begins to form and the Caspian region draws in north-easterly and easterly winds that pick up a good deal of moisture as they move across the Caspian. Cyclonic activity is considerable all across the north Caspian coming in from the west. Local land and sea breezes continue. The combination of all these processes brings tremendous rain and shower activity. The south-west Caspian receives 50% of its annual rainfall during this time.

At all times the main annual precipitation is much higher along the Caspian with the south-west averaging 1,950 mm. roughly five times the average for the country as a whole. Relative humidity averages 80-85% yearly with highest readings during spring and autumn.

Temperature distribution is highly influenced by latitude and elevation. The Caspian zone is characterised by a low annual range of temperatures with relatively high values in winter and lower ones in summer. Low temperatures occur in February (mean around 6°C.) and the highs in August (maximum near 25°C.), due to the retarding influence of the sea. Minimum temperatures occur in January throughout the rest of the country with maxima in July.

Sub-zero readings are occasionally recorded but snow is relatively rare along the Caspian plain due to the warming effects of the sea. However, storms in January/February 1969 dumped up to a metre of snow on the lowlands including those in the south-west.

Soils and vegetation

1 Alluvial soils

The bulk of the soils in the south-west lowlands are fine-textured alluvials and continually or intermittently wet hydromorphic soils. They range from silt loam to silty-clay loam, clay loam and even clay in the surface (Dewan and Famouri 1961). The Safid River delta is composed mainly of these soils which are usually medium to heavy textured, calcareous, and good to fairly well drained.

2 Hydromorphic soils

The hydromorphic soils are a variety of low-humic, humic gley, and half bog, pseudo-gley, and gley; generally formed from sediments in the Caspian and converted into land with the recession of the sea (Dewan and Famouri 1961). These soils contain the remains of mussel shells which are broken down to chalk. Gradual lowering of the ground water and removal of the salts makes these soils very fertile. They are, however, very poorly drained.

3 Other soils

Other soils, of the piedmont and foothill zone, are the podzols, lithosols, and the brown forest types.

4 Vegetation

Zohary (1963) indicates that the south Caspian, due to its particular local climate, was one of the few refugia during the glacials of the Pleistocene to retain part of the temperate mesic flora of Europe which was virtually exterminated from the northern parts of its range. The lowland vegetation falls into several associations according to local conditions.

Sand Dune Vegetation—along most of the present south Caspian shore extends a line of dunes from 10 to 20 metres high and at various distances from the water's edge, but no more than 600 metres. A loose group of communities of coarse plants, including grasses, bushes and scrub, are confined to the non-mobile sands of the spray zone. According to Zohary (1963) the most characteristic species are: *Agriophyllum latifolium, Crepis foetida, Convolvulus persicus, Tournefortia arguzia, Daucus littoralis, Salsola kali.*

Swamp Vegetation—the rich hydrophytic flora is widespread all over the Caspian lowlands in the mordabs, small marshes, and virtually every impoundment of still or slow moving water. However, widescale drainage, filling, and agricultural practices have reduced this group's range.

The underwater aquatics are comprised of a long series of characteristic plants such as *Nuphar luteum, Nymphaea alba, Lemna* sp., *Limnanthemum nymphoides, L. indicum, Potamogeton crispus, P. pectinatus, P. nodosus, Myriophyllum spicatum, Ceratophyllum demersum, Salvinia natans.*

The emergent vegetation is represented by a series of plant communities dominated by: *Phragmites communis, Arundo donax, Erianthus ravennae, Saccharum spontaneum* var. *aegyptiacum, Cyperus longus, C. laevigatus, C. globosus, C. fuscus, Carex* sp., *Heleocharis palustris, H. pauciflora, Juncus lampocarpus, J. bufonius, J. conglomeratus, Alisma plantago-aquatica, Butomus umbellatus, Sparganium erectum, Iris pseudocorus, Typha australis, T. minima.*

The Hyrcanian Forest—this vegetation is similar to a tropical forest in its vigorous growth, tall trees and several storied structure. The liana, the fast regenerative abilities, and the number of species of trees and shrubs it contains (Bobek (1968) cites about 50 and 60 respectively), add to this effect. Individual communities are difficult to delineate owing to the effect Man has had on the ecological boundaries and species makeup through excessive cutting and unrational use of certain species. This has caused a large-scale altitudinal shifting. Clearing of the lowlands, particularly during the last 50 years, has left only small patches of the former forest, and agricultural and cultivated zones now predominate.

RESULTS AND CONCLUSIONS

Wintering

Habitat and food conditions of the south-west Caspian lowlands for waterfowl are near ideal and the region serves as one of the most important wintering areas in Iran for Palaearctic waterfowl, particularly dabbling species.

The area of land at or below sea level is about 3,800 sq. km. and a good portion of this is under rice cultivation. Although rice is planted in April and assiduously harvested by October, the paddies are full of stubble and seeds throughout the winter months. The abundance of precipitation in the autumn and winter turns the paddies into one large feeding table. In addition there are over 200 sq. km. of inland marshes, ab-bandans and mordabs which provide places to rest and hide. They are also filled with rich amounts of aquatic vegetation providing additional food. The great expanse of the Caspian, with its 250 km. of shoreline, serves as a resting area during the day for many species which fly inland at night to feed. Diving species may winter here throughout the season.

1 The Pahlavi Mordab

The most important area in the region is the Pahlavi Mordab and its adjacent reed beds and flood zones covering a contiguous area of nearly 15,000 hectares or three-quarters of the inland habitat of the region. The Mordab itself comprises nearly 11,000 hectares with about 7,000 hectares of open water, 3,300 hectares of *Phragmites communis* and emergent vegetation, and the rest flood plain. The adjacent Siahkesheem Marsh covers over 3,600 hectares, most of it *Phragmites* and emergent vegetation (2,400 hectares) with 900 hectares of open water and about 350 hectares of flood plain.

Maximum precipitation occurs in the autumn and as this is also the end of the growing season, runoff is allowed to flow unimpeded. The Pahlavi Mordab receives its greatest quantities of water at this

season and most of the southern sides are flooded, with water level rises of one metre or more not uncommon. This great mass of water seems to be slowed and dissipated by the reeds and there is rarely any flooding along the north side or at the drainage channels to the Caspian.

Precipitation in the winter is not as intense as in the autumn and water levels in the Mordab are much lower. Flood zones on the south side may be covered with 50 cm. of water down to practically none. This creates ideal conditions for dabbling ducks such as Mallard *Anas platyrhynchos*, Pintail *Anas acuta*, Teal *Anas crecca*, Shoveler *Anas clypeata*, Wigeon *Anas penelope* and Gadwall *Anas strepera*, as well as the Greylag Goose *Anser anser* and the White-fronted Goose *Anser albifrons* and the Mute Swan *Cygnus olor*, Whooper Swan *Cygnus cygnus* and Bewick's Swan *Cygnus columbianus bewickii*. The White Pelican *Pelecanus onocrotalus*, Dalmatian Pelican *Pelecanus crispus* and even the Greater Flamingo *Phoenicopterus ruber* occasionally use the area, but not in large numbers.

Disturbance is minimal even with a relatively high human population close by because the local inhabitants rigorously protect these areas which they have turned into ab-bandans, to trap ducks (see Savage 1963). The protection as well as the improvement by diking, reed cutting, and grazing enhances the value of the ab-bandans to waterfowl.

The three most important areas, in order of numbers wintering, are situated between the towns of Nokhaleh-Hendehkhaleh (90 hectares called Selkeh), Hendehkhaleh-Nargasan (100 hectares called Nargasan), and Nargasan-Sapand (60 hectares called Esfand) (see Figure 2). The entire southern flood plain is estimated at a little over 1,000 hectares. Concentrations of waterfowl occur at the previously mentioned locations throughout the winter because of the protection afforded them. Other parts of the flood zone are utilized but not to any great extent.

It is important to mention that the flood zones are tied in very closely with the adjacent low, emergent marsh vegetation and there is a lot of movement of waterfowl back and forth. Generally, these emergent zones are narrow and give way to tall, thick *Phragmites* which seem to serve merely as escape cover. If the approximately 5,000 hectares of reeds covering the entire area was one solid block, it would be virtually lost as waterfowl habitat. Fortunately it is spread out and the larger blocks are all interlaced with canals, streams and openings. The reeds are utilized by the local people for building materials, mats, etc., and thus many are cut each year. Duck hunters clear series of channels through the large reed blocks creating openings which attract waterfowl. These activities have definitely improved the reed bed areas for waterfowl.

The large, open, shallow-water area of the Mordab proper has lost much of its former importance for waterfowl mainly from almost constant disturbance even though it is potentially a good area for diving species. Pochard *Aythya ferina* and Tufted Duck *Aythya fuligula* still occur in fairly large numbers and float in large rafts near the west central portion.

Coots *Fulica atra* still use the area in large numbers and often occur near the reeds at the west end. However, waterfowl hunters, using firearms, keep all the birds moving. It is illegal to hunt from a motor boat but hunters working in pairs can get around this measure by using one man in the boat to keep the birds moving while the other sits in a blind surrounded by decoys. The disturbance effect of this method by a hundred hunters with no bag limits can be considerable. This water area is also the traditional route to the market at Bandar Pahlavi and boat activity transporting goods to and from the small villages and towns surrounding the Mordab is quite considerable. Many birds fly out to the Caspian during the day.

2 *Ab-bandans and smaller mordabs*

The remaining inland ab-bandans, marshes, mordabs, and small reservoirs make up an important part of the winter wetland complex. The degree of protection afforded these areas or their remoteness seem to be the most deciding factors in their welfare. Many areas of relatively small size such as Amir Abad Ab-bandan just west of the Pahlavi Mordab, get tremendous numbers of waterfowl. Others, many times larger but lacking protection, have but a fraction of the population, or even none at all. Many birds probably return to the same areas year after year but there is also considerable local movement in the whole population. Ducks ringed at ab-bandans near the Pahlavi Mordab have been recovered a few days later in areas 20-30 km. west and south. Movement may be random or from stress. Nevertheless, the numbers of sanctuaries and proximity to each other are undoubtedly important factors in the quality of the region as a whole. Waterfowl rest in these areas and forage out in

the surrounding rice paddies in the evenings and early mornings.

3 Caspian Sea

The Caspian is a key element in the suitability of the adjacent land area for waterfowl. As noted previously, its surface salinity is only 12-13% and according to Vladykov (1964) the salts consist mainly of carbonates and sulphates which approaches the situation in fresh water. Because of this, many freshwater fish can survive in the Caspian and in its rivers. Although not as rich faunistically or floristically as other large seas, the Caspian, nevertheless, provides abundant food for many species of waterfowl. It also serves as a haven of rest. Ducks such as the Tufted Duck and Pochard in good numbers as well as a few Goldeneye *Bucephala clangula* can be seen riding the waves in long lines 100 to 300 metres offshore all winter. Concentrations are often seen at the mouths of rivers.

Surface-feeding species, such as Mallard, Shoveler and Teal can often be seen in the Caspian opposite the Pahlavi Mordab. Except for severe storms, birds on the Caspian are fairly safe from disturbance and danger. Unfortunately, there has never been any attempt to fly over the Caspian to see how far from shore waterfowl occur, mainly because of the proximity of the U.S.S.R. border and the political implications.

Passage movement

There is little doubt that the south-west Caspian lowlands serve as an important resting area for bird migrants travelling to and from their more northern breeding grounds and their more southern wintering grounds. However, there is sometimes a problem in sorting out the status of waterfowl in the region since it is also a vast wintering ground and early arrivals or late departures of overwintering birds may be mistaken for migrants. Some species such as the Garganey *Anas querquedula* are obviously passing through since they do not winter there. Others, like the Pochard, which do winter in the region, probably also have numbers moving through.

1 Ringing results

A ringing programme was established by the Iran Game and Fish Department in early 1966 to follow duck movements as well as to learn something about the origins of the waterfowl visiting Iran. By 1970, 1,279 individuals of 14 species of ducks and coot had been ringed in the south-west Caspian lowlands, with 42 recoveries of eight species (Cornwallis and Ferguson 1971). Of these recoveries, 26 were in Iran within 100 km. of the place of ringing and most of them (17 Mallard, 3 Teal, 1 Ferruginous Duck *Aythya nyroca* and 1 Coot) during the same winter. However, four of these (2 Mallard, 1 Teal and 1 Tufted Duck) were recovered the following winter.

The remaining sixteen birds (9 Mallard, 1 Teal, 1 Pintail, 1 Garganey, 1 Pochard, 2 Tufted Duck and 1 Coot), were all recovered in the U.S.S.R. Most of the birds were captured within nine months on their nesting grounds during the late spring or early autumn. Three Mallard were recovered the second year after ringing. The recovery localities lie in an ellipse aligned in a north-east direction from the south-west Caspian wintering grounds and the moulting grounds in the Volga Delta and extend into North and West Siberia between the Urals and the Upper Ob River.

2 West Siberian-Caspian-Nile population

The above information is included since it lends support to Isakov and Shevareva's (1968) postulate that the large geographical population of ducks and geese which they call the 'West Siberian-Caspian-Nile' group winters near the shores of the Caspian Sea, in western Turkey, in the countries of the eastern Mediterranean, in the Nile Delta, as well as the valley of the Euphrates, on the Persian Gulf, in Ethiopia and in the Sudan. This population, which they contend emanates from breeding grounds within the drainage systems of the Pechora, Kama and Vyatka rivers to the west of the Urals and in the north and west of West Siberia along the Lower Ob, North Sos'va, Tavda, Ishim and Tobol rivers, migrates principally along the valleys of the Lower Ob, the Irtysh and the Tobol through which they emerge over the Urals, the Emba River and the Volga delta. Here, Isakov and Shevareva say a number of flyways join together with a section of birds moving west towards the Balkans and the Mediterranean while the majority proceeds southerly along the west shore of the Caspian to Azerbaijan and Iran. They go on to state that a considerable number of these birds continue still further to the valley of the Euphrates and the Persian Gulf. From there they may pass to the Upper Nile, Ethiopia and the Sudan.

3 Effects of weather

Weather, of course, has quite an effect on migration, both on arrival and departure times as well as on the routes taken. Using Isakov and Shevareva's (1968) contention of the route of waterfowl coming to the south-west Caspian, if fair weather and good conditions are prevalent on the Volga delta during migration, it is conceivable that many birds might linger there longer than normal, thus delaying flights to Iran. Mild winters in the north Caspian region could entice many birds from journeying further south.

The autumn and winter of 1969-70 may have been a good example of this. Unfortunately, official weather records are not yet available for Europe, the U.S.S.R. and the Middle East for this period and hence it is only possible to speculate. Unofficially, northern Iran experienced a mild winter. The general consensus of hunters and farmers in the south-west Caspian lowlands on the arrival of waterfowl in the region is that Garganey usually arrive first in late August to late September. Occasionally Pintail, Shoveler and Teal arrive at nearly the same time. Mallard are said to arrive from mid-October to mid-November, geese in mid-November and the bulk of the ducks are in by mid-December.

A visit to the Pahlavi Mordab area in the second week of September 1969 indicated that, at least for waders and raptors, autumn migration was well under way. However, the Caspian was void of waterfowl as were the open waters of the Pahlavi Mordab, Bandar Farahnaz, and Shal Kol. The only place waterfowl were seen in numbers was the Safid River, especially at the Sangar Dam reservoir, 42 km. south of the Safid mouth, where 200 Garganey and 12 Shoveler rested.

The following month from the 13th to the 15th, the wader-raptor migration appeared to be tapering off, but waterfowl had not made an appearance except for a few thousand ducks on Selkeh (mostly Pintail, with a few Mallard and Shoveler).

The next visit to the area in the first week in November found 15,000 ducks of 10 species and 30,000 Coot on the Pahlavi Mordab area. About 100 geese (11 Greylag and 90 White-fronted) were also observed. Only a few birds were seen on the Caspian with about 500 ducks on Bandar Farahnaz and none on Shal Kol. There was no activity in any of the smaller ab-bandans and queries to the local inhabitants revealed that there had not been any.

Checking the same localities during the second week of December (11th-14th) resulted in counts of a little over 29,000 ducks of 11 species and 6,300 Coot on the Pahlavi area. The numbers of Coot, Pochard and Tufted Duck had dropped off drastically from the previous month suggesting that many birds were passing through. The Caspian Sea, Bandar Farahnaz and Shal Kol showed an increase in both numbers and species. Waterfowl were present in most of the smaller ab-bandans and hunting methods throughout the area were well under way indicating that wintering birds had established themselves. However, gun hunters on the Pahlavi Mordab were all complaining that there were not many birds this year.

This fact seemed to be borne out by mid-winter counts in January and February 1970 which totalled only 86,000 ducks in the Pahlavi Mordab area; and counts were fairly complete. Mid-winter counts for the two previous years which were only 50-80% complete turned up 144,000 and 101,000 ducks respectively for the area. Naturally, there are probably other reasons for these differences and it will be interesting to see what develops in the coming years.

4 Spring migration

The south-west Caspian is a staging or resting area in the spring for returning migrants. The local inhabitants say that the wintering population of waterfowl normally leaves the region in late March and early April with the geese departing a bit earlier in mid-March. Counts in late March (14th and 25th) 1969 indicated that at least for that year, this theory was correct. With 12 cm. of snow on the ground, the open water of the Pahlavi Mordab held only 600 ducks of four species (Pochard, Tufted Duck, Mallard and Shoveler, in order of abundance) and 3,100 Coot. The small ab-bandans around the area were essentially empty of waterfowl, but about 350 ducks (Mallard, Tufted Duck, Teal and Goldeneye) were seen in the Caspian area opposite the Mordab. In addition, the flooded abandoned airfield area east of Ghazian-Pahlavi had about 500 ducks (Pintail, Teal and Shoveler). Five flamingos and six Mute Swans were seen, at different times, flying low over the Mordab toward the Caspian. Ten Whooper Swans were seen on the west end of the Mordab and 28 more were observed feeding on a flooded zone at the east end of the Mordab.

One month later (26th April-1st May) observations along the Caspian from Bandar Pahlavi to Astara revealed no

waterfowl. On 27th April, 1 Ruddy Shelduck *Tadorna ferruginea* at Selkeh, 6 Mute Swans (2 immature) at Nargasan, 5 Mute Swans with 100 ducks and 2 Coot on the Pahlavi Mordab, were recorded.

The 1970 spring, which followed a mild winter with low numbers of waterfowl, saw the birds leaving perhaps earlier than usual. Counts from 3rd-9th March indicated a few thousand ducks present on the Pahlavi Mordab (Mallard, Teal, Pochard, Tufted Duck and 3 Ferruginous Duck). However, a report from Selkeh on 23rd April listed a concentration of over 700 Pintail, 500 Pochard, 350 Teal, 150 Wigeon and over 100 Shoveler. These were, no doubt, migrants from further south.

One further set of records from 1967 has some bearing here. On 29th April and 5th May visits to Selkeh revealed no waterfowl, but on 8th May at Bandar Farahnaz, the Safid River mouth and the adjacent Caspian, a total of over 400 ducks (135 Shoveler, 100 Garganey, 90 Mallard, 40 Wigeon, 20 Gadwall, 15 Tufted Duck, 9 Pintail and 8 Pochard) with a pair of Mute Swans were noted. Most of the birds were on the Bandar Farahnaz Mordab.

5 Routes of migration

The route taken by migrants when they leave the south-west Caspian to travel further south seems to follow the Safid River upstream across the Alborz Mountains on to the inner plateau. Here there probably is a divergence of birds with some moving south-eastward along the east-facing slopes of the Zagros Mountains to the salt lakes and marshes of south-west Iran around Shiraz. Another route probably turns south-west across the low Northern Zagros and follows the west-facing slopes southward to Iraq and the Persian Gulf.

Whether waterfowl returning to their northern breeding grounds in the spring follow the same routes as in the autumn is not known. Many more continuous month-by-month observations plus recovery data from ringed birds will be necessary before any conclusions can be drawn.

Breeding and nesting

The only waterfowl found to be nesting in the south-west Caspian lowlands were Mallard, Teal and Coot. Activity seems to be restricted to the heavily vegetated portions of the Pahlavi Mordab and adjacent Siahkesheem Marsh.

1 Food and habitat conditions

Physical conditions appear to be satisfactory for supporting nesting of fairly large numbers of waterfowl. It is estimated that there are over 300 kilometres of major emergent-to-open water and emergent-to-land edge, plus probably three times that amount created by openings.

Khavari-Nejad (1968) lists 37 species of plants in the Pahlavi Mordab (14 emergents, 14 floating-leaf aquatics, and 9 submerged aquatics) (Table I). Unfortunately, he makes no estimate of quantity of any of the species. From personal observation, however, the most dominant emergent, by far, is *Phragmites communis* which has little cover and no food value to waterfowl. This means that the bulk of the 5,000 hectares of reed bed is relatively unused.

Nevertheless, openings, and especially shallow water areas around the Siahkesheem Marsh and along the north and at the east end of the Mordab proper, show a zonation of plants which include fair to excellent cover and food species. Floating leaf and submerged aquatics are the species that provide the bulk of the food in the marsh areas. The open water in the centre of Siahkesheem is particularly rich in submerged aquatics such as *Potamogeton* sp., *Elodea* sp., and *Ceratophyllum* sp. *Lemna* sp. and *Spirodella* sp. cover the water in protected areas. Profuse growths of filamentous algae appear in the shallows and stagnant areas.

Vegetation growth, as mentioned earlier, is fast-growing and lush due to the favourable climate. Some areas would soon become a solid mass of plants were it not for the activities of Man. Still, some species such as *Trapa natans* are overwhelming in their capacity to reproduce. Fully one-third of the open water area of the Pahlavi Mordab at the east end (about 2,000 hectares) is completely covered with leaves of this plant by July every year. Although edible by waterfowl, it is not utilized as much as it could be because the area of growth coincides with the area of most intense boat activity.

Aquatic animal life in the Mordab area is abundant also. The late spring and early summer waters contain a wealth of invertebrate and insect fauna. Tadpoles of frogs and toads abound as do small molluscs and millions of tiny fish fingerlings in very shallow water cling to vegetation. Walczak and Ralonde (1971) report at least 11 species of resident, 8 migratory, and 1 semi-migratory fish in the Mordab. They mention that all the migratory species come into the area in the spring with *Silurus glanis* generally migrating in

Table I. Plant species in the Pahlavi Mordab (from Khavari-Nejad 1968).

Plant species	*Value to waterfowl* food	cover
Emergents:		
Phragmites communis		++
Sparganium sp.	++	
Typha latifolia		+++
Echinochloa crus-galli	+++	+++
Glyceria luitans	?	?
Scirpus palustris	++++	++++
Cyperus sp.	++++	++++
Sium angustifolium	?	?
Nasturtium amphibium	?	?
Sagitteria sagittaefolia	++	
Alisma plantigo-aquatica	?	?
Butomus umbellatus	?	?
Equisetum sp.	+	
Nelumbium caspicum	?	?
Floating-leaf aquatics:		
Utricularia vulgaris	++	
Salvinia natans	?	
Hydrocharis morsus-ranae	?	
Hydrocotyle vulgaris	?	
Lemna minor	+++	
Lemna trisulca	+++	
Lemna polyrhiza	+++	
Trapa natans	++	
Lymnanthemum nymphoides	++	
Polygonum lapathifolium	++++	
Polygonum amphibium	++++	
Polygonum natans	++++	
Spirodella polyrhiza	+++	
Riccia sp.	?	
Submerged aquatics:		
Myriophyllum verticillatum	+	
Myriophyllum spicatum	+	
Ceratophyllum submercum	+	
Ceratophyllum demersum	+	
Hydrilla verticillata	?	
Potamogeton pectinatus	++++	
Potamogeton crispus	++++	
Elodea nutallii	+	
Ranunculus divaricatus	+	

Value ratings: + = slight; ++ = fair; +++ = good; ++++ = excellent; ? = unknown.

the spring to coincide with the hatching of the young cyprinids.

One of the more obvious of invertebrate organisms inhabiting the Mordab area and virtually all standing and slow-moving waters including rice paddies and the smaller streams are the leeches. There seem to be two species present: a large blood-sucking leech, tentatively identified as *Hirudo medicinalis*, which preys on fish, turtles, waterfowl and mammals including Man, and is extremely widespread on the south-west Caspian lowlands; the other species is probably *Glossosiphonia* sp., a smaller member of flat leeches and less abundant, which inhabits the vegetation of standing waters and calm rivers and feeds on the blood of molluscs and small invertebrates.

The larger leech, which is still used for medicinal purposes in the U.S.S.R., is a pest to the rice farmers of Northern Iran who call it 'zagi' and know it well. The leeches become active as soon as the water warms sufficiently in the spring and persist into November. Their abundance and habits may be detrimental to young waterfowl by weakening them, although there is no evidence to support this theory.

2 *Predation*

Potential predators of waterfowl inhabiting the area include avian, terrestrial and

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Plate I. (Above) Low tide at Fox Bay East, West Falkland Islands, with a pair of Kelp Geese *Choëphaga hybrida malvinarum* feeding on rock outcrops. (See p. 25.) (Below) Female Falkland Island Flightless Steamer Duck *Tachyeres brachypterus* with nine young, swimming amongst kelp, Falkland Islands.

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Plate II. Kelp Geese feeding in Fox Bay East, West Falkland Islands. The male (above) is eating a natural food, sea lettuce *Ulva* sp., while the female (below) prefers Man's offerings from the sewer outlet.

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aquatic. Of these, the Jackal *Canis aureus* poses the biggest threat to nesting and juvenile waterfowl. Jackals range all over the lowlands, especially along the sea coast, marshes, and villages where they search for carrion. They have been observed at all times of the year and do not hesitate to venture into shallow water.

Of the avian predators, the most common during the breeding and nesting period is the Marsh Harrier *Circus aeruginosus* and although it may take a few young birds and eggs, it is doubtful that it is a limiting factor. Black Kites *Milvus nigrans* and White-tailed Eagles *Haliaeetus albicilla* frequent the area but generally confine themselves to the sea coast where there is always an abundance of dead fish and carrion.

3 Disturbance

Most of the flood zones on the south side of the Pahlavi Mordab and Siahkesheem Marsh dry up during the summer months. Domestic livestock, mostly water buffaloes and horses but some cattle also, are allowed to graze this area as soon as green shoots appear (about early April). These animals have adapted themselves to the aquatic environment and will forage into water one metre or more deep in search of the marsh plants. There is little danger of overgrazing and the effect of cropping the vegetation is probably beneficial in setting back succession. It is doubtful that they are detrimental to nesting waterfowl.

Boat activity continues but generally stays on the open waterways and seldom ventures into the surrounding vegetation.

4 Breeding data

All conditions would seem to point to a favourable waterfowl breeding and nesting habitat. However, courtship and breeding behaviour was observed only once even though there was obviously much more: on 28th April 1967 at Gulegha on the north side of the Pahlavi Mordab. Three pairs of Garganey were sitting together in open water with the males dropping their heads to the water and bobbing and swimming in front of the females. All would suddenly leap into the air and, flapping their wings, turn in a clockwise semi-circular path back into the water. This was repeated several times. Then all circled the area in the air and finally disappeared into the nearby *Phragmites* reeds, picking up a fourth pair along the way.

Reports from local inhabitants indicated that Mallard, Teal, Shoveler and Ferruginous Duck nested at the east end of the Pahlavi Mordab and some in Siahkesheem. Coot were reputed to nest in hundreds near Selkeh. Investigation in late April and early May 1969 revealed the presence of Coot, Mallard, Teal and Garganey but none in large numbers and no indication of nesting.

Visits from 8th-10th July 1969 found 15 Coot nests in the reeds near the Nargasan River (south side of Siahkesheem) and one Coot with three recently hatched young. Several adult Coot were seen nearby but no more young. Pygmy Cormorants *Phalacrocorax pygmeus* were nesting in the reeds in the same vicinity and six nests were found, all containing 3-5 eggs. The lateness of these suggests they may have been second nests.

Farther west along the south side of Siahkesheem near the village of Sapand a female Teal was seen sitting on a nest in the marsh vegetation alongside an earthen dike. Six adult Mallard were observed over the centre of Siahkesheem one evening.

On the evening of 4th August 1967, 17 Teal in eclipse plumage with a pair of Garganey were feeding at the edge of Siahkesheem near the mouth of the Siahdarveshan River. Later, 40 unidentified ducks were seen flying east in two groups over the Caspian opposite the Mordab.

Despite the fact that so few waterfowl nest in the region several other species of water birds do. Sightings in the summer of 1969 confirm that the following water birds nest in the marsh vegetation of the Pahlavi Mordab and Siahkesheem: Great Crested Grebe *Podiceps cristatus*, Squacco Heron *Ardeola ralloides*, Cattle Egret *Bubulcus ibis*, Great Egret *Egretta alba*, Little Egret *E. garzetta*, Grey Heron *Ardea cinerea*, Water Rail *Rallus aquaticus* and Purple Gallinule *Porphyrio porphyrio*.

Anthropogenic effects

1 Historic

The first real effect Man had on the region was probably during the Mongol invasion of the thirteenth century. The following account is from Savage (1958) who reported that before the tenth century the level of the Caspian Sea was only about 10 metres below sea level. The Mongols diverted the ancient River Oxus (now called Amu-Dar'ya) which used to flow into the south-east corner of the Caspian at Krasnovodsk and the Turkmensk Inlets in the U.S.S.R. For a short period the sea fell rapidly until it reached

an equilibrium at about 33 metres below sea level. Later, during their second invasion of the region, the Mongols diverted the River Oxus back to its old channel to drown a city built over its previous course. The water level in the Caspian rose to a little above its former level where it remained for about another two centuries when the Oxus was once again diverted to the Aral Sea. There it has been used for irrigation and other purposes ever since. How much of the South Caspian lowlands were inundated and altered by these events is not known.

The lowlands were still sparsely settled and according to DePlanhol (1968) only by individuals and detribalised peoples forced into the area from south of the Alborz. Fisher (1968b) speaks of early populations leading patriarchal lives, with pastoralism a principal element, preying on travellers for extractions and conducting local trade as an important supplement. These predatory and often turbulent actions of the inhabitants led Shah Abbas in 1593 to order a general massacre of the people in the south-west Caspian region. Ultimately, the Qajar rulers south of the Alborz in the capital city of Tehran brought in numbers of people from other regions in the eighteenth century. Significant colonisation took place soon after.

2 *Population*

The south-west Caspian lowlands are part of the administrative province of Gilan (named in 1937) with the city of Rasht as the political capital and communications centre. Rasht lies about 20 kilometres from the Caspian Sea on the Safid River delta and dates from the end of the thirteenth century (DePlanhol 1968).

With the construction of all-weather roads, Rasht has developed considerably and is now the largest town of the Caspian provinces. Besides its function as the regional agricultural market and capital, it handles a large portion of the trans-Caspian trade through the port of Pahlavi. A 1966 census (Anon. 1970) established the population of Rasht as 143,557.

Gilan is one of the most densely peopled areas of Iran with an average of 47.9 persons per sq. km. (1966 census) and nearly half of the population are under 20 years of age. Oberlander (1968) states that the south Caspian plain: "supports the greatest concentrations of humanity between the Black Sea and the Indus Valley".

This great influx of people shows no sign of diminishing; rather as more and more areas are cleared of forest, there are increased opportunities for settlement. The soils under the Mordabs are particularly fertile so wetlands are being drained and reclaimed. In many places cultivation now extends over the entire zone between the sea and the Talesh foothills.

3 *Water*

The Safid River is now controlled by the 106 metre high Shahbanu Farah Dam, 60 kilometres south of Rasht and completed in 1963 for flood control, irrigation and electric power. This has essentially eliminated any further building out of the Safid delta, but it has created a large reservoir that varies in size from 3,000 to 5,600 hectares. The reservoir is silting up very rapidly which may render it practically useless in 20 years or so.

Two smaller water control structures on the Safid, the Tarik Pasikhan Dam and the Shakharaz (Sangar) Dam, between the large dam and the Caspian were completed in the late 1960's for irrigation purposes. A system of canals from these two smaller dams will eventually provide sufficient water to most of the south-west Caspian plain to eliminate the need for the private ab-bandans, the small reservoir-like impoundments constructed all over the lowlands for irrigation.

Rice is the major crop grown in the area and requires a great deal of water during its growing season. Thus, as land was cleared and planted, the small streams from the mountains were diverted into the paddies and small earthen reservoirs were constructed to provide an adequate supply of water through the summer. Some of the smaller mordabs were improved for similar purposes. These reservoirs or ab-bandans are fairly shallow and vary in size from a few hectares to several hundred. The favourable climatic conditions encouraged abundant growth of hydrophytic flora in the ab-bandans and the owners quickly found that these areas attracted large numbers of waterfowl in the winter months. For centuries through his clearing practices Man has destroyed a great deal of wetland habitat. Unknowingly, he produced suitable habitat with his ab-bandans.

It probably did not take the Gilan farmer long to realise that he had a ready supply of meat from late autumn to early spring if he kept his ab-bandans filled with water and protected. Thereafter a series of waterfowl catching methods evolved (see Scott (1939) and Savage

(1963) for discussion of the more important methods). The role of these ab-bandans in wetland conservation is stressed by Savage (1963) and Firouz (1968).

The future demand for more land and the availability of irrigation water from the larger dams will probably preclude the need for ab-bandans. Thus, the farmers will require added incentive to retain these structures merely for waterfowl during a short period of the year.

4 Pahlavi Mordab

Several large projects in Gilan in the past few years have greatly affected the Pahlavi Mordab area and threaten its well-being. New roads are being pushed into many areas formerly served only by foot trail or by boat, particularly on the south side of the Mordab. Other roads are being asphalted. An airport has been constructed north of Rasht. The harbour facilities at Bandar Pahlavi are being expanded. An industrial site is planned for the south side of the Mordab. These projects have opened up new areas and increased the flow of people which makes more of a demand for available land.

A section of the 1,100 km., 101-106 cm. Iran-U.S.S.R. gas line runs about 6 kilometres south of the Mordab and Siahkesheem area. Farther west it turns toward the sea coast and follows it up into the U.S.S.R. at Astara. Although the pipe is underground, a 30-50 m. wide right-of-way has been cleared on the ground surface which cuts across marsh-land and agricultural areas alike.

A 2 km. long 20 m. wide drainage canal, from the north-west end of the Mordab (8 kilometres east of Bandar Pahlavi) into the Caspian, is presently under construction. Its purpose is to reclaim some 5,000 hectares of reed marsh for agriculture. What effect drainage of this area will have on the rest of the Mordab ecosystem is not known.

The forests of Iran were nationalised in January 1963 to protect them against indiscriminate burning for charcoal. In October 1967 the Ministry of Natural Resources was created and took over the administration of the forests from the Ministry of Agriculture. As part of their overall management of the northern forests a law was passed to allow cutting of all timber below 100 metres elevation so that the land could be converted to agriculture. This will essentially wipe out the remaining forests of the south-west Caspian lowlands.

5 Hunting

It has been mentioned previously that the Gilan farmers use their irrigation ab-bandans to catch waterfowl during the winter months. Savage (1963) estimated that nearly a million ducks were harvested in Gilan in this manner in 1959, while Firouz (1968) indicated that the number had dropped to about 20% of this by 1967. The reasons for the decline are many. The amount of suitable habitat has obviously been decreasing. The Iran Game and Fish Department, which had its beginnings in 1956, required all duck hunters to obtain a licence and ab-bandan owners were forced to purchase permits for their areas, the price being dependent on the size, quality, and number of birds taken. Some ab-bandan owners felt the permit price was too high and simply ceased activities.

Gun hunters in Gilan accounted for 82,500 ducks in 1959, according to Savage (1963), while the number taken by them in 1967 was down to about 15,000 (Firouz 1968). Game and Fish Department records indicate that the number of bird licences sold in Gilan (about 90% are for waterfowl) dropped by nearly half from 4,673 to 2,991 in the period 1966 to 1969. Evidently, many hunters are not finding it profitable to purchase licences. Still, the effect of gun hunters on the disturbance of waterfowl, mostly on the Pahlavi Mordab, is considerable.

The netting methods are silent and rely on protection of the areas to attract waterfowl. The most efficient method is carried out at night and disturbance is minimal. Few birds are maimed or lost and the birds rarely connect Man with the operation. On the other hand, shooting is not only more noisy, but losses from crippling and the ingestion of lead shot are a real threat.

In February 1969 two Whooper Swans which were unable to fly, were captured on the south side of the Pahlavi Mordab. They later died and examination of the gut revealed the presence of a considerable amount of lead shot in both gizzards. In November of the same year at Selkeh, 3 Coot and 1 Great Egret were found dead. All had been shot, but had evidently managed to fly off before dying.

Gun hunters, pursuing their quarry in boats or from blinds, keep the birds constantly moving with little chance for rest, hence, many birds fly out to the Caspian during daylight hours.

6 Protection

The importance of the south-west Caspian lowlands for waterfowl seems to be

determined by the number, proximity, and diverseness of the habitats. Some ab-bandans are as small as two hectares but are located close to other areas and attract hundreds of waterfowl. A good 40 hectare ab-bandan lies near Astara but there are no other wetland areas nearby except for the Caspian, and waterfowl are subject to gun hunting, so few birds utilise the area. The same goes for a similar area 70 kilometres farther south. The first area of any importance lies a few kilometres west of the Pahlavi Mordab and from that point south and east for about 120 kilometres stretches a network of good to excellent waterfowl habitat. The size of this complex, however, has been decreasing steadily over the years and is at a critical point now. Further diminution of the complex, especially the Pahlavi Mordab area, coupled with increased disturbance, will spell doom to the entire region as an important wintering ground for waterfowl.

The ages-old protection of waterfowl by the protection of ab-bandans has already been briefly mentioned. However, as this system is gradually fading out, the Iran Game and Fish Department has taken steps to set aside the more important areas as Protected Regions (described by Firouz *et al.* 1970). Most of the Siahkesheem Marsh, totalling 3,515 hectares, was declared a Protected Region in August 1967. About 85 hectares of important flood zone and adjacent marsh vegetation at Selkeh became a Protected Region in September 1970. The 519 hectare Shal Kol Mordab and the 40 hectare Jocandan Ab-bandan 85 kilometres north-west of Bandar Pahlavi are being considered for such status. Hunting and fishing, grazing and reed cutting are controlled on these areas and can be immediately banned if the necessity arises.

Systematic list

The following list of waterfowl includes only those species seen during the study period. Some species observed in previous years by other investigators may have been overlooked, but it can be assumed they were vagrants and not very important in the overall picture.

Greater Flamingo *Phoenicopterus ruber*

A passage migrant in small numbers both in the spring and autumn. Two Flamingos ringed in July at Tengiz Lake near Tselinograd, U.S.S.R., were recovered in Iran: one near Lake Rezaiyeh in north-west Iran six months later in December of the same year, the other at Gorgan Bay in the south-east Caspian during March of the following spring (Cornwallis and Ferguson 1971). On 12th November 1966, 56 Flamingos were observed flying west over the South Central Caspian near Chalus, Iran. A dead Flamingo was recovered at the mouth of the Shalmon River near Langarud, Gilan, in late December 1968. One was seen at Bandar Farahnaz at the mouth of the Safid River in early February 1970. During the hard winter of 1968-69, 124 were recorded from Selkeh and Nargasan in early February 1969. Twelve were seen in the same locality early the following month. Fifteen Flamingos rested in the same locality for four days in mid-October 1969. Wintering populations are known from Lake Rezaiyeh and Gorgan Bay and it can be theorised that they are of the same Russian origin. Movement may be along the South Caspian shore to Pahlavi, then over the Talesh Mountains to Rezaiyeh, perhaps via the Safid and Qizil Uzun Rivers.

Mute Swan *Cygnus olor*

Mainly a vagrant in winter although a few are observed every year. In late January 1969 during a blinding snowstorm, eight were seen flying south along the Caspian at Astara. Early the following month, four were recorded on Shal Kol and 13 on the south side of Siahkesheem. Six were seen on the north side of Siahkesheem late in March of the same year and again in the same place at the end of April. Five more were on the south side of Siahkesheem at the end of April.

The only other record is for a pair on Bandar Farahnaz in early May 1967.

Bewick's Swan *Cygnus columbianus bewickii*

An irregular winter visitor generally occurring with Whooper Swans and geese on the flood zones south of Siahkesheem and Pahlavi Mordab. Records include 20 in late December 1968, 843 in early February 1969, 16 in early January 1970 and 20 in early February 1970.

Whooper Swan *Cygnus cygnus*

A regular winter visitor to the region in small numbers, normally occurring with the geese on the flood zones south of Pahlavi Mordab and Siahkesheem. They have also been recorded from Sangar Dam on the Safid River, Shal Kol, Bandar Farahnaz, the north side of Siahkesheem,

in the Pahlavi Mordab, and on the Caspian opposite the Mordab. Arrival time appears to be in mid to late December with departure in February. However, they have been recorded in late March (1969). The average number of wintering birds is about 50, although 1,361 were recorded in early February 1969.

White-fronted Goose *Anser albifrons*

Similar to the Greylag as a regular winter visitor in the flood zones and rice paddies south of the Pahlavi Mordab and Siahkesheem but in smaller numbers. The highest number recorded was 800 in November 1969 and some of these may have been passage migrants. Arrives and departs about the same as the Greylag.

Greylag Goose *Anser anser*

Winters regularly on the south side of Pahlavi Mordab and Siahkesheem in numbers from 1,000 to 2,000. They usually arrive in late November to early December with a few seen in early November and depart from mid-February to March. Occasionally they appear on the Pahlavi Mordab and Farahnaz in small numbers. In the harsh winter of 1968-69, 4,500 were recorded for the south side of Siahkesheem.

Ruddy Shelduck *Tadorna ferruginea*

Only two records and both from Selkeh: one was seen in late April 1969 and the other in early February 1970. The April bird was alone while the February one occurred with thousands of geese, swans and ducks. This species is known to winter in the Lake Rezaiyeh area and also farther south in the interior of Iran.

Common Shelduck *Tadorna tadorna*

Another winter vagrant with only three records: one bird at Bandar Farahnaz in mid-January 1968, two at Selkeh in mid-December 1969, and three flying near the Caspian opposite the Pahlavi Mordab in early January 1970.

Marbled Teal *Marmaronetta angustirostris*

Little information on this species which is a passage migrant in small numbers. Recorded from Shal Kol in November 1969. Probably occurs with Garganey and may go unnoticed.

Pintail *Anas acuta*

A common but not widespread species with major concentrations at Selkeh where mid-winter surveys count 11,000 to 40,000 birds. Arrivals and departures are about the same as Mallard and Teal. Occurs in Ab-bandans and on the Caspian in small numbers; Bandar Farahnaz and Pahlavi Mordab in somewhat larger flocks.

May be a passage migrant. Nine were recorded at Bandar Farahnaz in early May 1967, two were seen there in mid-September 1969, 1,000 were observed at Selkeh in mid-October 1969, and 730 were seen there in late April 1970.

It is taken by hunters in fair numbers.

Teal *Anas crecca*

Winters in the region in populations counted as high as 46,500. The Teal is probably second to the Mallard in numbers taken by hunters annually in the region. It too frequents the ab-abandans but occurs most abundantly in large concentrations in the flood zones south of Pahlavi Mordab and Siahkesheem. Flocks of 19,000 to 25,000 have been counted annually at Selkeh in mid-winters 1967-68 to 1969-70. It occurs throughout the Safid delta lowlands but is rarely seen on the Caspian or at Shal Kol. Arrivals and departures are about the same as for Mallard.

Some birds of this species probably use the region as a resting place during migration further south. In late September 1968, 550 were seen in the Pahlavi Mordab, 800 in mid-October 1969 at Selkeh and 350 at Selkeh in late April 1970. In mid-March 1969, 64 were seen in the Safid River below the Shahbanu Farah Dam.

Breeding of this species was confirmed in Siahkesheem in the summer of 1969, but total numbers are, no doubt, quite small.

Mallard *Anas platyrhynchos*

One of the most common and widespread species wintering in the south-west Caspian lowlands, the Mallard seems to prefer the ab-bandans, reed bed peripheries, and flood zones and is rarely recorded in large numbers on the open water of the Pahlavi Mordab. However, it often uses the Caspian surface for a resting place during the day. This species is the mainstay of the wildfowling industry in the region, occurring in flocks of thousands. Wintering populations of 30,000 have been counted and it is estimated that numbers may go as high as 50,000.

Evidence suggests that there are few passage migrants through the region. Some birds are seen before November

but the bulk of the population does not arrive until December and then most are gone by March. Ringing returns indicate the population originates in West Siberia and North Kazakhstan, U.S.S.R.

A few birds have been seen in mid-summer in Siahkesheem and it is suspected that some breed in the region but not significantly.

Gadwall *Anas strepera*

A regular, but not common, winter visitor. Small numbers mix with large flocks of other dabbling ducks and it may often go unnoticed. An exception occurred in January 1970 when two flocks of 1,000 birds each were recorded from Selkeh and Nargasan. They were in company with large concentrations of other ducks.

Probably arrives and departs with Mallard and Teal, but 230 were seen at Selkeh with some other ducks in late April 1970 indicating that some birds may be passage migrants.

A small number are taken by waterfowl hunters each year.

Wigeon *Anas penelope*

Winters commonly in the region, particularly in large concentrations in Nargasan and at Selkeh where 14,000 were recorded in December 1968. Occurs throughout the Safid delta lowlands in small numbers and can often be found sitting on the Caspian.

Arrivals and departures coincide with Mallard and Teal. There may be some passage migrants as 41 were seen on Bandar Farahnaz in early May 1967 and 140 were observed at Selkeh in late April 1970.

A small number are taken by waterfowl hunters.

Garganey *Anas querquedula*

A regular early autumn and late spring passage migrant moving through the region in early September and October and back again in late April/early May. They have been recorded from Esfand where about 250 of them stayed about 25 days in late September and early October 1969, Bandar Farahnaz, Shal Kol, Gulegha, and Sangar Dam where about 200 were recorded in mid-September 1969.

Breeding by a few birds probably occurs, although no confirmed nests or young have been found. Three pairs were observed in courtship behaviour at Gulegha in late April 1967 and a pair were recorded at the north side of Siahkesheem in early August 1969.

Shoveler *Anas clypeata*

A regular winter visitor in fair numbers with habits much like the Mallard. Occurs in most ab-bandans in the Safid delta region with the largest concentrations at Selkeh and Nargasan (1,500 in Selkeh, early February 1970).

May also be a passage migrant as 135 were observed at Bandar Farahnaz in early May 1967, 12 were seen at the Sangar Dam in mid-September 1969, about 40 at Siahkesheem in mid-October 1969, and 117 at Selkeh in late April 1970.

Taken in small numbers by hunters.

Red-crested Pochard *Netta rufina*

A regular winter visitor in small numbers and not very widespread. Recorded at Abbas Abad Ab-bandan near Astara, the Pahlavi Mordab, Bandar Farahnaz, and Shal Kol. By far the largest concentration occurred in early February 1969 at Shal Kol when 2,300 were recorded. At the same time 1,275 were observed in Siahkesheem.

Rarely taken by hunters.

Pochard *Aythya ferina*

Vies with the Tufted Duck as the most common winter diving duck with mid-winter counts of 8,000 to 12,000 in the region. It is widespread and common in large concentrations on the Pahlavi Mordab from December through February. It also occurs on Shal Kol and the Caspian; occasionally some of the smaller ab-bandans.

Probably a passage migrant. Eleven were recorded near Bandar Farahnaz in early May 1967 and 500 at Selkeh in late April 1970. Large concentrations of 2,200 and 2,400 were seen at Selkeh and Nargasan in early November 1969 but disappeared by early the following month.

Taken in good numbers by hunters.

Ferruginous Duck *Aythya nyroca*

Seemingly an irregular winter visitor in small numbers. In the mid-winter census of 1966-67, 450 were counted, with 10 seen the following year, and none the next. The census of 1969-70 picked up nearly 100. They occur in the Pahlavi Mordab, Gulegha, Selkeh, Nargasan, Shal Kol and a few ab-bandans.

There may be irregular passage migrants also as 5 were seen at the north side of Siahkesheem in mid-October 1969,

and nearly 70 at Selkeh and Nargasan early the next month, with 210 at Shal Kol in late November.

Rarely taken by hunters.

Tufted Duck *Aythya fuligula*

A regular and widespread winter visitor and the most common diving duck in the Caspian. Occurs in large numbers at Bandar Farahnaz and with the Pochard on the Pahlavi Mordab. Also shows up regularly at Shal Kol and ab-bandans throughout the region. It seems to be a winter resident only, arriving in November and leaving in February to March.

Taken in good numbers by hunters.

Scaup *Aythya marila*

A winter visitor in very small numbers, this species has only been recorded once in four years at Gulegha in early January 1970. It is probably often overlooked or counted in with Tufted Duck at sea. They are occasionally picked up by hunters from Shal Kol and the Pahlavi Mordab.

Goldeneye *Bucephala clangula*

Regularly winters in small numbers all along the Caspian and ventures inland to suitable waters nearby. Recorded from Abbas Abad at Astara, Pahlavi Mordab (100 in early February 1970), Bandar Farahnaz, and Shal Kol.

Rarely taken by hunters.

Smew *Mergus albellus*

Winters in the south Caspian in small numbers and appears in the south-west region only in January and February when it generally confines itself to the sea. Occasionally comes in to the Pahlavi Mordab and 100 were recorded there in early February 1970.

Red-breasted Merganser *Mergus serrator*

Two were recorded at Bandar Farahnaz in early January and again in early February 1970. These were probably vagrants from farther east where large numbers are regularly observed in the winter.

Coot *Fulica atra*

A regular winter resident occupying virtually every wetland habitat throughout the region except the Safid River. Large numbers generally arrive in late September and early November and do not leave before March. They are common on the Pahlavi Mordab (12,000 recorded in early December 1969) and often are the only waterfowl present there when large numbers of hunters are active. Concentrations seem to move about and are not confined to one place for long but 21,000 were counted at Esfand in late December 1969.

This species provides the bulk of the birds taken by the gun hunters in the Pahlavi Mordab. There may be much movement by this species into and out of the region during the winter. One Coot ringed at Shal Kol in November was recovered a few days later near Lenkoran, 300 kilometres north in the U.S.S.R. Another ringed at the same time and place was recovered a little over a month later 300 kilometres east.

A few birds stay all year round and nest, confirmed by a report of 10 Coot, one of which had three young at Nargasan in early August 1969. Others of this species may nest throughout the region in small numbers.

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Summary

The waterfowl and wetlands of the south-west Caspian lowlands were intensively surveyed over a period of three years from January 1967 through April 1970. Factors affecting management of the waterfowl and the overall ecology of the region are discussed. It is concluded that a number of species use the area as a refuelling ground during passage migration and a few remain to nest in small numbers. The importance of the region as a wintering ground is dependent on the number, proximity to others, and degree of protection afforded the individual wetland habitats, and the entire area is severely threatened by man-caused disturbance and development projects.

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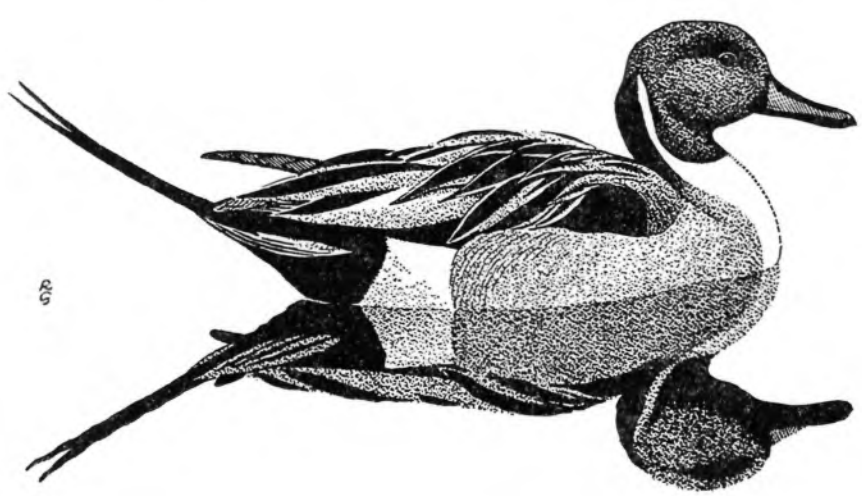

Ecological studies of Falkland Islands' waterfowl

MILTON W. WELLER*

As part of a study of the waterfowl of isolated southern hemisphere islands, October 1970 to mid-January 1971 was spent on the Falkland Islands. Additional field work was done during week-long visits in early November and late December 1971. Full time was devoted to the study of the more common waterfowl on two study areas on East Falkland Island with subsequent observations at several other islands for comparison. The chief objectives of the study were (1) to relate feeding habits, territory selection and brood behaviour to available freshwater and marine habitats, and (2) to appraise diversity in relation to ecological niches. (See also Plates I, II and V.)

The Falkland Islands are located about 550 kilometres east of the tip of South America between latitude 51° and 52°S. and longitude 58° to 61°W. They are a British colony of about 2,500 people whose activity is sheep farming for wool. Ranches are large, and under 30 landholders manage the total of about 1,200,000 hectares (Cawkell *et al.* 1960). The islands tend to be gently sloping with mountains reaching a maximum of 700 metres, but the southern portion of East Falkland (Lafonia) is low and level, rarely exceeding 90 metres.

Climate is cold-temperate (Murphy 1936) with recorded extremes during 1951-1970 being −8°C. to 25°C., with an annual mean of 5.6°C. Freezing temperatures are uncommon during summer days although nocturnal lows are near freezing. Long-term mean wind velocity was 26.4 km.p.h. Annual rainfall varies from about 635 mm. on the eastern islands to less than 405 mm. on the West Falklands (Moore 1968). Data on temperature and rainfall shown in Table I indicate the general mildness of the period of this study.

As a result of the low temperatures, decomposition is very slow and soil is mostly peat. Deep peat beds are most common on the wetter East Falkland. The islands are treeless and introduced trees succeed only where protected and watered. The dominant vegetation is white-grass *Cortaderia pilosa*, with the low bush, diddle-dee *Empetrum rubrum* dominating drier sites. The tall and dense tussock grass *Poa flabellata* covers small islands and shorelines which sheep cannot reach (names from Moore (1968)).

Study areas

Two major study areas were selected primarily because of their known waterfowl use and habitat diversity, but accessibility and distance are important considerations in an area with no all-weather roads. Most observations were made at the basal portion of Cow Point, where the settlement of Fitzroy is located. The Stanley Commons and Stanley Harbour formed a check area that had the same habitat diversity and exposures, but waterfowl there were more disturbed by human activities.

Additional observations were made at Seal Point, south-west of Stanley; at Kidney Island, north-east of Stanley; at Port San Carlos on the northern extreme of East Falkland; at Fox Bay East on the south-east corner of West Falkland; and at West Point Island.

Methods

Five species were selected for study whose abundance reflected successful adaptation to the area and permitted collection without harming populations,

Table I. Standard climatic measurements at Stanley, East Falkland.
(Data from Daniel Borland of the Falkland Island Meteorological Station.)

	Mean temp.°C.	*Range temp.°C.*	*Rainfall in mm.*	*Nights of frost*	*Mean humidity*	*Mean wind*
1970-1971						
Oct.	5.9	1-16	32.9	7	83.4	15.8
Nov.	7.9	2-18	13.2	6	77.9	12.8
Dec.	8.5	2-22	74.6	4	80.8	15.4
Jan.	8.3	1-19	133.5	8	82.9	14.7
1970 Mean	5.8	−5-22	651.8	—	86.4	15.3

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which represented all major habitats, and provided meaningful amounts of data (Table II). Observations were made regularly on the study areas to record the positions of pairs, flocks and broods in relation to habitat. Broods were classified by standard plumage categories to assess growth in the absence of more precise age estimates. Observations were recorded on field maps and correlated with habitat descriptions of lake type, vegetation and coastal topography. Territorial behaviour and interspecific interactions were noted. Little time was devoted to searching for nests.

Major effort was devoted to recording feeding behaviour, foods and feeding sites. When collected, most waterfowl had been observed feeding intensively for at least 15 minutes. Birds were dissected immediately after collection to avoid post-mortem digestion. Contents of the oesophagus and proventriculus were more easily identified and food estimates were less influenced by the hard, residual objects that remain in the gizzard (Bartonek and Hickey 1969).

At aquatic feeding sites, bottom samples were taken with an aquatic sweep net, 12 in. wide × 3 in. high (30.5 cm. × 7.6 cm.), having 20 meshes to the inch. This allowed both surface and bottom sweeps of 12 in. × 12 in. on most substrates except large boulders. Hydrogen-ion readings were taken with a pHydrion paper; a Secchi disc was used to record turbidity; and water depths were measured at each sampling site. Vertical photographs were taken of each feeding site when water clarity permitted. Terrestrial grazing areas were sampled by collecting representative plants and taking random close-up photographs in those areas where birds were collected. Because of the frequent grazing of short growing plants, mature seedheads were obtained by excluding sheep from field sites or by taking the sod samples indoors.

Waterfowl diversity and abundance

The eleven species observed are listed in Table II. Regular breeding birds include one swan, three southern sheldgeese of the genus *Chloëphaga* and the monotypic Crested Duck *Lophonetta specularioides*, two unique diving ducks of the genus *Tachyeres* and four species of the widespread genus *Anas*. All these species occur in Patagonia and Tierra del Fuego (Olrog 1968) except the Falkland Flightless Steamer Duck *Tachyeres brachypterus*, considered endemic, although a Continental form differs mainly in colour and size (Murphy 1936). Numerous accidentals have been reported (Bennett 1926; Cawkell and Hamilton 1961).

In an effort to estimate relative abundance of species, censuses from three areas were summarized (Table II). Counting only adults, their combined numbers indicate that two herbivores, Upland (or Greater Magellan) Goose *Chloëphaga picta leucoptera* and Kelp Goose *Chloëphaga hybrida malvinarum* were commonest, followed closely by a carnivore, the Falkland Flightless Steamer Duck.

There were several conspicuous differences in populations on the three areas. Only nine species were observed at

Table II. Waterfowl observed at two census areas on East Falkland and one (Fox Bay East) on West Falkland. Number of counts in parenthesis. Br = pairs with broods; Pr = pair only; Ind = individuals and flocks. Rank is based on adults only.

Species	*Fitzroy (8-11)* Br	Pr	Ind	*Stanley (4-5)* Br	Pr	Ind	*Fox Bay (2-3)* Br	Pr	Ind	*Total adults*	*% of total*	*Combined rank*
Black-necked Swan *Cygnus melanocoryphus*	0	0	71	0	0	0	0	0	0	71	4.8	7
Ruddy-headed Goose *Chloëphaga rubidiceps*	4	3	0	0	1	0	8	10	39	91	6.1	6
*Upland Goose *Chloëphaga picta leucoptera*	24	3	250	0	0	0	16	5	122	468	31.5	1
*Kelp Goose *Chloëphaga hybrida malvinarum*	11	2	7	0	4	12	1	51	137	294	19.8	2
*Crested Duck *Lophonetta s. specularioides*	9	4	36	0	2	0	3	6	21	105	7.1	4
*Falkland Flightless Steamer Duck *Tachyeres brachypterus*	24	6	31	1	2	27	9	9	112	272	18.3	3
Flying Steamer Duck *Tachyeres patachonicus*	3	0	0	0	1	0	1	2	0	14	0.9	11
*Chilean Teal *Anas f. flavirostris*	11	0	50	2	1	0	2	4	4	94	6.3	5
Chiloe Wigeon *Anas sibilatrix*	2	2	9	0	1	3	0	3	1	29	1.9	8
Brown Pintail *Anas georgica spinicauda*	1	0	13	0	2	4	0	0	1	24	1.6	9
Versicolor Teal *Anas versicolor fretensis*	2	2	7	1	2	1	0	0	0	22	1.5	10

* Study species

Stanley and Fox Bay, but eleven species occurred at the more diversified and less disturbed Fitzroy area. At Stanley there were no Upland Geese on the census area although three were seen nearby.

The frequency of Black-necked Swans *Cygnus melanocoryphus* at Fitzroy was biased because of a concentration on one area, whereas no concentrations of this magnitude were seen elsewhere in the Islands. The second largest group, about 40, was at Swan Inlet, East Falkland.

There was an abundance of non-breeding Kelp Geese at Fox Bay East, but observations at the tip of Cow Point, at Seal Point and elsewhere indicate that this species may very well be the most abundant anatid.

Diversity of waterfowl habitats

Upland vegetation

Natural and cultivated upland grass communities important to sheldgeese were roughly mapped. The most dominant and widespread plant species is the coarse white-grass, which varies from 15 to 30 cm. in height and forms tussocks, especially when grazed. Dry growth of previous years remains and gives a general tan colour to grasslands, even in mid-summer. Finer grasses, such as meadow-grass *Poa annua* and *P. pratensis*, pigvine *Gunnera magellanica*, sedges *Carex* spp. and native rush *Juncus scheuzeroides* often grow between the tussocks of white-grass. These smaller plants are dominants on the well-sloped drainages where light green patches, 'green valleys', are conspicuous in the general tan colour of the white-grass or the dark green heath (Davies 1939). Such swards were often on steep slopes, boggy from subsoil water, but showing little surface drainage. Drier sites, such as fence corners or gate areas intensively trampled by livestock, and abandoned rookeries of Gentoo Penguins *Pygoscelis papua* also tend to be dominated by meadow-grasses and low herbs.

Cereal grains are rarely planted, but pasture grasses such as Yorkshire fog *Holcus lanatus* are cultivated near settlements on drier soils. Roto-tilling is used to level the soil and to eliminate native species and often results in wind erosion, particularly on the drier western islands.

Freshwater habitats

Streams are common and vary from small brooks a metre or two wide to so-called rivers, small by northern hemisphere standards. Pools commonly contain native waterweed *Myriophyllum elatinoides*, rich in aquatic crustaceans attractive to certain ducks. Even small brooks may have complex meanders resulting in wide valleys. The streams are highly acid (pH 4.0-4.5) and run through and even under the deep peat where overgrown holes are dangerous to man and livestock.

Shallow bodies of fresh water are abundant in some areas. Even the large ones did not exceed one metre in depth, unless formed as barrier ponds in a steep walled drainage. Deeper ponds, however, have been reported by Vallentin (1924). Such waters are termed ponds on the Falklands even though they may exceed 400 hectares in size; the term 'lake' tends to be used for very large saline areas currently or recently connected to the sea by a narrow channel. An excellent series of government maps (Directorate of Overseas Surveys 1962) prepared from aerial photos shows the distribution of ponds of even a few hectares. The map also reflects limnological characters, the ponds being shown in light and dark blue according to the water colour that appeared on the aerial photographs. Ponds coloured dark blue on the map were peat-bottomed and had brown water, whereas light blue ponds were sand basins with clear water or clay basins with light grey water.

Ponds with peat or clay bottoms are turbid, with Secchi disc readings of 5 to 12 cm. during windy periods. Both tend to have abrupt peat banks because of wave action against the tightly bound soil. Sand-bottomed ponds with sloping shores generally are at low elevations, often near the coast, and tend to be clear. However, water turbidity varies with the nature of the soil of the banks. All ponds are acid, and 19 had pH readings between 4.0 and 5.3. Only one, sand-bottomed, pond reached pH 6.0.

The clay- and sand-bottomed ponds are richest in submergents such as native waterweed and, more rarely, the large, branched algae *Nitella* sp. Sand ponds have marginal stands of the emergent spikerush *Eleocharis melanostachys*, and Vallentin (1924) reported ponds on West Falkland with rushes *'Scirpus lacustris'*.

On both main islands there is some snow on the highlands during winter and sufficient moisture for sizeable ponds to occur in mountain valleys. Extensive peat beds form at elevations about 150 metres, where ridge peat ponds form from cracks produced by soil slippage, and enlarged by wave action and possibly wind erosion during the arid summer months. Sometimes their drainage and erosion on rock bases exposes small 'stone runs' of the

type unique to the mountains of the islands, the origin of which geologists still debate (Cawkell *et al.* 1960). With their vertical shorelines, inadequate shallow feeding sites and scarcity of invertebrates, the ponds are generally unattractive to ducks.

Small oxbow ponds formed in stream valleys are excellent sites for the growth of the succulent emergent plants such as *Lilaeopsis macloviana* and *Caltha sagittata* or submergents such as native waterweed.

The Fitzroy study area had a group of over 200 small ponds in peat on the ridge north-west of the settlement. The character of the larger and richer Cow Point ponds were from west to east: Fitzroy Pond—vertical peat shore, but clay- or, rarely, sand-bottomed; North and South Twin Ponds—peat shores and bottoms; Swan Pond—sand- to clay-bottomed with mostly sloping shores and with a relatively shallow peat layer surrounding. Although Fiztroy Pond had some native waterweed, Swan Pond had extensive beds of waterweed, emergent spikerush, submerged algae *Nitella* and mud plantain *Heteranthera* sp.

The ponds on the Stanley Commons were in heavy peat beds, except for two of three barrier ponds near the sea. One of these was deep, rocky and unattractive to waterfowl. The second was shallow, sand-bottomed and rich in native waterweed and very attractive to ducks.

Marine shoreline habitats

Abrupt shores are created by the erosion of the highly angled sedimentary strata on windward shores, but more gradual slopes are characteristic of protected areas. Both the Fitzroy and Stanley study areas had cliff-like or rocky southern shores relatively unprotected from southern storms. Northern exposures of the study areas were better protected and had gentle, gravel-covered slopes. Usually on the exposed shores, but occasionally on the sloping shore, waterworn strata formed shelves exposed at low tide, ideal for marine algae attractive to certain waterfowl. In areas of low topography and soft rock strata, windward shores may be of extensive white sand of key importance to Gentoo Penguins, but are not attractive to waterfowl because of the severe surf action.

Bays resulting from erosion by small drainages or springs were usually covered with sand, fine gravel or small stones. Extensive beds of sand characterise major creeks that sometimes are wholly or partially closed by barrier ridges to form sand-bottomed ponds. Such creeks were suitable for wigeon grass *Ruppia* sp. Older barrier ponds tended to become more turbid and densely populated by native waterweed.

All marine shores, save those dropping abruptly into extremely deep water, are ringed by beds of Leafy Kelp *Macrocystis pyrifera.* In some places these beds are only a metre or two wide, but shallow bays and inter-island areas may be completely covered with the floating leaves. Kelp beds reduce wave action and are rich in snails, limpets and other potential waterfowl foods.

Waterfowl habitat utilization

Census data were classified according to major habitat types to demonstrate general species-habitat associations. On the Fitzroy study area waterfowl distribution was correlated still more specifically with habitat types. Emphasis was placed on pairs or pairs with broods because their food was the likely limiting factor in reproductive success. However, flock use of an area obviously reflected an abundance of food, and such groupings were recorded regularly.

Terrestrial habitats

Upland Geese are completely terrestrial except when flightless or with broods. During the nesting period their foods are taken from well-drained green valleys and other green grass areas created by grazing or farming. Waiting males, or pairs with broods, were isolated one per valley along the shores of lake or sea in relation to distribution of green swards. Green patches along streams and a small green island in Swan Pond were territorial and brood-rearing sites. Larger green areas, especially those some distance from water, were used by flocks of non-breeding birds (probably yearlings) during the breeding season. Pre-moulting birds moved to green areas near the sea which they could subsequently use for escape when flightless (Figure 1).

At Fox Bay East and Port San Carlos green *Poa* slopes, produced as a successional stage following an intensive, but usually single season, use of a vegetated area by Gentoo Penguins, were favoured feeding areas of Upland Geese. Areas in which Magellanic Penguins *Spheniscus magellanicus* burrowed also tended to be rich in meadow-grasses and were grazed by livestock and Upland Geese. Occasionally, Kelp Geese grazed in these areas.

Freshwater habitats

Chilean (or Speckled) Teal *Anas f. flavirostris* and Crested Duck are the major waterfowl frequenting freshwater areas. The former is the major anatid of small upland streams, favouring small pools in streams or shallow ponds rich in waterweed, and most broods were reared in such areas (Figure 2). Teal were the only species that occasionally used steep-sided bog ponds in both uplands and lowlands.

Crested Duck used large sand- or clay-bottomed lakes with gradually sloping shores rich in food. At Fitzroy, Seal Point and Stanley, these ponds were near the sea, but a large inland pond at Fox Bay East also had a pair.

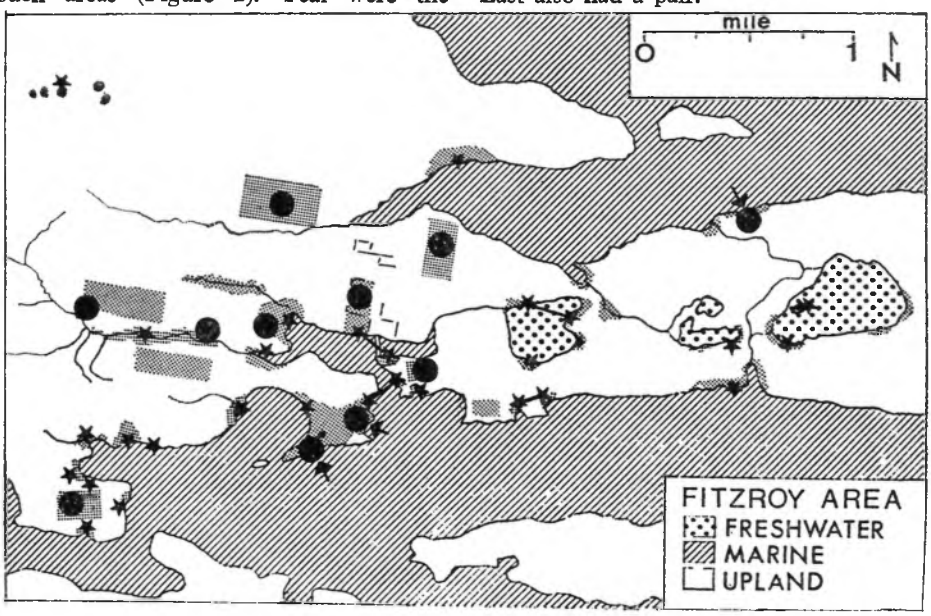


Figure 1. Distribution of broods (stars) and flocks (dots) of Upland Geese in relation to green valleys and cultivated pastures (stippled areas) at Fitzroy.

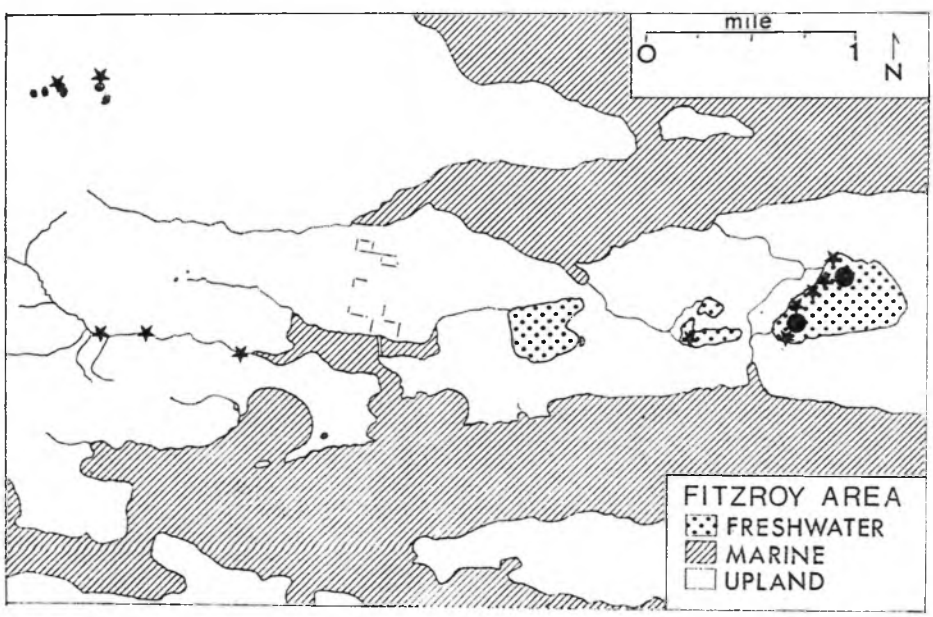


Figure 2. Distribution of broods (stars) and flocks (dots) of Chilean Teal in relation to freshwater ponds and streams at Fitzroy.

Marine habitats

Crested Ducks were the only species studied that regularly established territories and reared broods in both fresh and marine areas, but they were more abundant on the seashore. Pairs were isolated in coves and were strongly associated with gravel shores, but they often fed on algae-covered rocks at low tide. Flocks of non-breeding birds also favoured extensive gravel or silt shores not normally used by breeding pairs (Figure 3). One flock of some 45 birds used a boulder-covered shore where rotting leafy kelp had accumulated.

Falkland Flightless Steamer Ducks are strictly marine and use all types of shorelines where loafing sites occur. However, breeding pairs usually selected territories with well-sloped gravel shores (in which their very young broods fed), probably because they must walk to their nest sites. Flocks of non-breeding immatures frequented more abrupt rocky shores and cliffs. Brackish creeks dominated by silt were also used. Rarely, in storms, adults moved to freshwater barrier ponds along the southern coast.

The Kelp Goose is perhaps the most specialised marine herbivore among anatids and is rarely seen feeding on gravel areas. It frequents rocky shelves or boulders exposed at low tide where certain species of marine algae grow (Figure 4). Flocks of non-breeders feed in extensive rocky areas, but they sometimes loafed on sand or gravel areas sheltered from the wind. Pairs on territory or with broods were regularly associated with coves where there were freshwater seeps, which both adults and young used. Kelp Geese also drank from sewers in settlements as do Falkland Flightless Steamer Ducks (Pettingill 1965; Cawkell and Hamilton 1961) (Plate IIa, p. 17).

At Seal Point, across the bay to the south-east of Stanley, Kelp Geese nested in coarse grasses by freshwater lakes less than a kilometre from the sea. These nests were adjacent to meadows where Magellanic Penguins nested and where meadow-grasses and diddle-dee bushes occurred. A brood was observed on 30th December 1971 feeding on *Poa* sp. near one of these freshwater ponds, and they used the pond as escape cover.

Feeding behaviour and foods

Upland Geese

Leaf tips and seed heads were usually taken, rather than large, mature leaves and stems. There was little variation between the food of young and adults. Five of the nine young and two of the four adults contained *Poa* spp. (Table III). One young contained a small *Juncus* (probably *J. scheuzeriodes*), two contained native carrot *Oreomyrrhis andicola*, and one adult and three nearly full-grown young collected at a sedge meadow

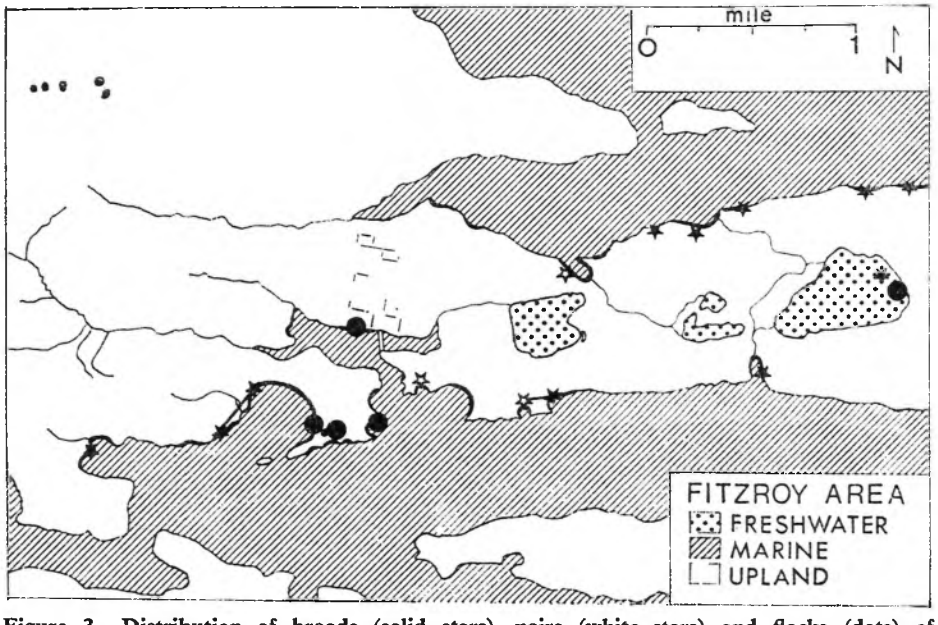


Figure 3. Distribution of broods (solid stars), pairs (white stars) and flocks (dots) of Crested Ducks in relation to gravel shorelines (heavy lines) at Fitzroy.

at Port San Carlos contained mostly tips and berries of brown swamp grass *Roskovia magellanica* and tips of *Carex* sp. Two young collected at Fitzroy contained berries of diddle-dee, and the droppings of all adults in that area showed a dominance of diddle-dee in the diet from mid-December, when the berries started to ripen, until at least mid-January. Information from residents indicates considerable use of this plant by the geese throughout the winter. No animal foods

Table III. Some summer foods of Upland Geese on the Falkland Islands.

	Young (9)		*Adults (4)*	
Food	*% Mean Volume*	*% Frequency*	*% Mean Volume*	*% Frequency*
OESOPHAGUS AND PROVENTRICULUS CONTENTS				
Meadow-grass leaves	28.0	55	46.2	50
Meadow-grass seeds and heads	1.6	44	1.8	50
White-grass leaves	.3	11		
White-grass seedheads	1.0	33		
Yorkshire Fog leaves			24.5	25
Carex sp. stems	.2	22	1.0	25
Carex sp. seedheads	5.4	33	20.0	25
Roskovia magellanica stems	30.7	44	1.5	50
Roskovia magellanica seeds and seedheads	12.1	55	4.0	25
Native Rush stems	1.1	11		
Native Rush seedheads	.3	11		
Native Carrot	7.2	22	1.5	25
Daisy leaves *Bellis perennis*	.5	22	.2	25
Unidentified plant	.1	11		
GIZZARD CONTENTS	*Young (6)*		*Adults (3)*	
Meadow-grass leaves	68.0	100	64.7	66.7
Meadow-grass seedheads	2.7	50	1.0	33.3
White-grass leaves	2.3	16.7		
Yorkshire Fog leaves			33.3	33.3
Roskovia stems	4.8	16.7	.3	33.3
Roskovia seeds and heads	4.5	16.7		
Juncus sp. stems	2.5	33.3		
Native Carrot	1.8		.3	16.7
Daisy leaves			.3	33.3
Diddle-dee seeds	1.3	16.7		

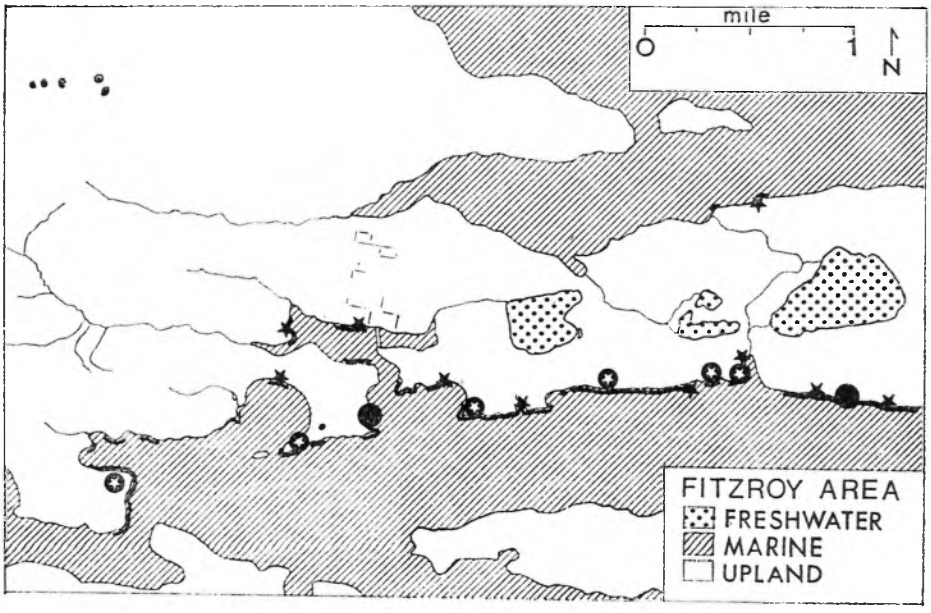


Figure 4. Distribution of broods (stars), nests (circle-stars) and flocks (dots) of Kelp Geese in relation to rock strata (heavy lines) exposed at low tide.

were found even in very young Upland Geese, nor did observations suggest any feeding on insects.

Chilean Teal

These fed on smaller prey items than any other anatid species (Table IV). One adult and several young contained mostly microscopic cladocerans of the genus *Bosmina* and some minute cyclopoid crustaceans, *Cyclops* sp. Other Teal examined regardless of age contained amphipods, midge larvae (Chironomididae), insects, fish eggs and, rarely, pigvine seeds. Broods were accompanied by the female (sometimes by the male as well) and tended to remain isolated from flocks on ponds or on streams. The attractiveness of rich sand ponds filled with native waterweed such as the largest pond, Swan Pond, at Fitzroy was very marked (Figure 2). Such areas had an abundance of bottom organisms such as midge larvae, and amphipods in the waterweed. Flocks of 40 to 45 Teal gathered at Swan Pond late in the breeding season.

This was one of few species that ever used steep-sided bog ponds. Such ponds usually lacked vegetation but bottom sampling always produced a few amphipods and midge larvae. Teal were seen diving for food in two such ponds and a brood was seen feeding by diving in a peat-rimmed, sand-bottomed pond. Two young collected in bog ponds had food contents similar to those of other areas, namely insect larvae and amphipods.

On one occasion late in the breeding season, two adult Chilean Teal were seen on a south shore of Cow Point where leafy kelp had been washed ashore and was rotting. Possibly the Teal were attracted to fly larvae therein which may be a source of food in winter. At two sites Teal were feeding at the mouths of freshwater streams where rotting kelp had been stranded. Local residents indicated that flocks of Teal gather in barrier ponds and creeks and on the seashore in winter and, because lowland ponds rarely freeze, could feed there all year.

Crested Ducks

Because of the scarcity of Crested Ducks on freshwater areas, only two were collected at Seal Point in a rich pond surrounded by burrows of Magellanic Penguins. It was one of the richest ponds sampled, with an invertebrate fauna of small crustaceans, such as cladocerans and amphipods, and insect larvae. Crested Ducks there used these items (Table V).

In general, broods of Crested Ducks were reared in marine situations and clearly favoured areas with extensive growths of green, filamentous algae. These commonly occurred at freshwater seeps in gravel beds or on rock strata exposed at low tide.

Both adults and young of all ages selected marine isopods and amphipods, invertebrate larvae and minute clams (Table V), dabbling with the bill barely submerged. Both adults and young often came ashore to feed in pools a centimetre

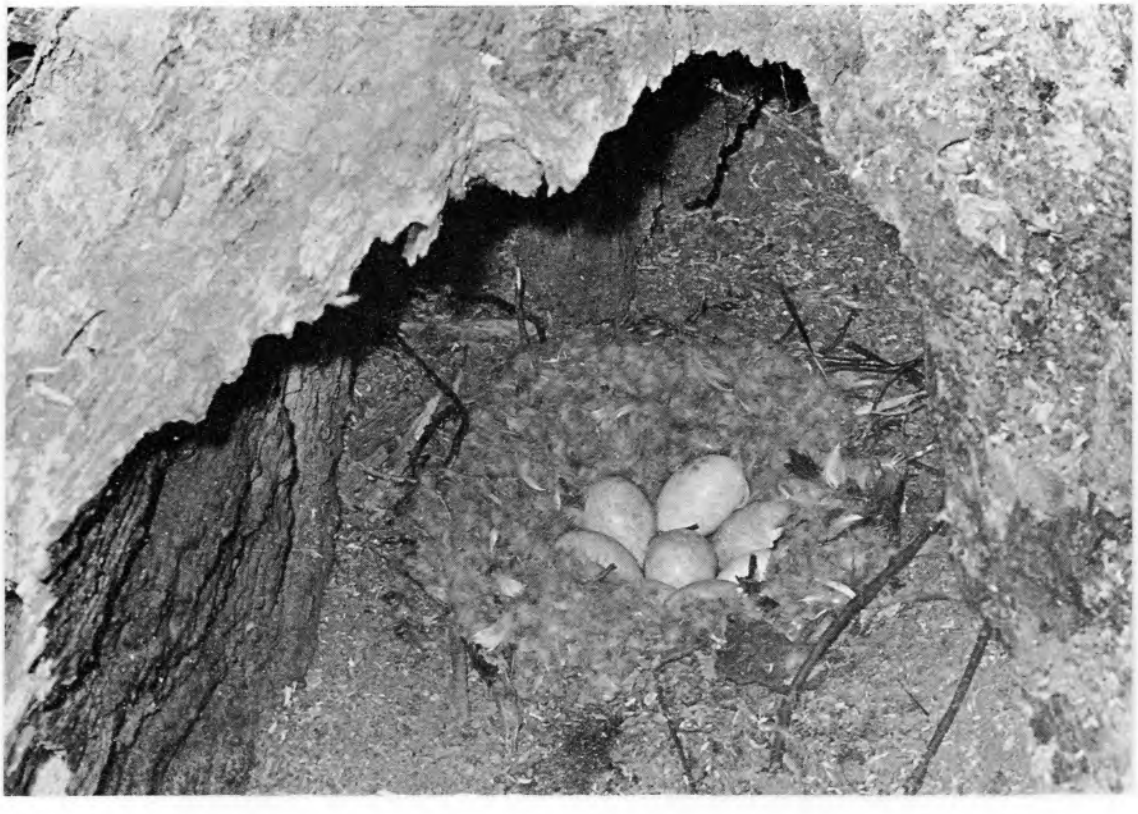
Table IV. Some summer foods of Chilean Teal, Falkland Islands.

	Young (6)		*Adults (3)*	
Food	*% Mean Volume*	*% Frequency*	*% Mean Volume*	*% Frequency*
OESOPHAGUS AND PROVENTRICULUS CONTENTS				
Cladocera (*Bosmina*)			29.3	33.3
Cyclopeida (*Cyclops*)			2.3	66.7
Amphipoda	1.2	16.7	1.0	33.3
Trichoptera	23.2	33.3		
Chironomidae (larvae and pupae)			50.0	66.7
Diptera (Helcomyzidae)			1.0	33.3
Osteichthyes (eggs)	8.3	16.7		
Diddle-dee seeds	.5	16.7	1.0	66.7
Unknown plant	16.7	16.7	16.0	33.3
Pigvine	.2	16.7		
GIZZARD CONTENTS				
Cladocera (*Bosmina*)			25.0	33.3
Cyclopeida (*Cyclops*)			4.0	33.3
Amphipoda	4.2	16.7		
Trichoptera	4.2	16.7		
Chironomidae (larvae and pupae)			30.7	33.3
Osteichthyes (eggs)	13.3	16.7		
Diddle-dee seeds	30.5	83.3	4.0	66.7
Pigvine seeds	12.3	50.0	1.3	33.3
Roskovia seeds	6.3	16.7		
Unknown seeds	22.2	50.0	8.0	100.0
Unknown plant material	6.8	16.7		

J. F. Young

Plate III. Feral Greylags *Anser anser* nesting in Galloway (p. 83) mostly choose sites with some cover, such as fallen branches (above), though occasionally the base of a hollow tree will be used (below).

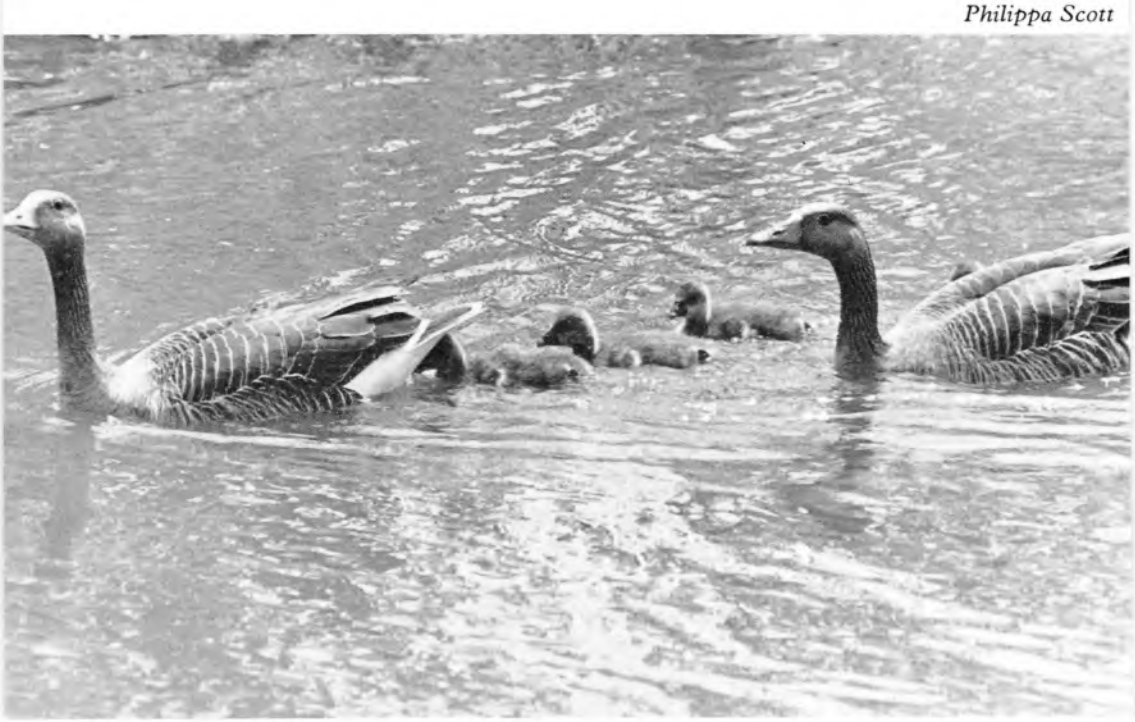
J. F. Young



Philippa Scott

Plate IV. Feral Greylags at Slimbridge. (Above) Coming into land; (below) a family party. The flock is now some 50 birds strong.

Philippa Scott



deep or less. Occasionally they fed in deeper water with head and neck submerged. Some very tiny, probably newly hatched young fed by picking; some older (Class II) birds fed by diving in a creek and also dabbled in algae on the boards of a structure exposed at low tide.

The most spectacular response of Crested Ducks to a food source was demonstrated by a flock of about 45 birds feeding on larvae and pupae of shore flies (Helcomyzidae) in rotting leafy kelp. A flightless adult male and one young of its brood were collected and found filled with these larvae. Occasionally bits of filamentous algae are found in digestive tracts, but this seems accidental.

Crested Ducks are said to feed on the offal of slaughter houses (Johnson 1965), but whether they seek the decaying meat or the invertebrates associated with the offal has not been established.

Thus, it seems that Crested Ducks are almost entirely carnivorous and seek larger organisms than do Chilean Teal.

Falkland Flightless Steamer Duck

When actively feeding, it dives in deep water or feeds with head under water in gravel or kelp. Its association with kelp has misled people into believing that it feeds directly on the plant.

Foods were exclusively marine invertebrates (Table VI) as would be expected from the adaptations for diving and as found by Murphy (1936), Humphrey *et al.* (1970) and Johnson (1965) for the closely related mainland species, the Magellanic Flightless Steamer Duck *T. pteneres*. Mussels *Mytilus* spp. have been reported as a major food but, despite their great density, there was only a trace of them in these summer specimens. Cobb (1933) reported one female with 450 mussels and a male with three crabs and some other bivalves. Brooks (1917) noted large pieces of crabs taken, as well as limpets, chitons, mussels, gastropods and shrimps. Murphy (1936) reported limpets, crustaceans and 'small bugs'. Vallentin (1924) observed 'loggerheads' eating the echinoderm *Hamiaster philippii*.

Downy young of less than two days old mostly fed by dabbling in gravel in shallow water. Diving started at this age, however, and the percentages of time spent diving increased as did the duration of dives. Adults feeding in the same depths stayed under water only a little longer than ducklings, and submergence

Table V. Some summer foods of Crested Ducks, Falkland Islands.

	Young (8)		*Adults (3)*	
Food	*% Mean Volume*	*% Frequency*	*% Mean Volume*	*% Frequency*
OESOPHAGUS AND PROVENTRICULUS CONTENTS				
Gastropoda	.1	12.5	6.7	33.3
Pelecypoda	1.2	12.5		
Cladocera (*Daphnia*)	6.2	12.5		
Isopoda	25.0	62.5	23.3	66.7
Amphipoda	23.8	50.0	23.3	66.7
Diptera				
Helcomyzidae (larva)	1.4	12.5		
Helcomyzidae (pupa)	10.8	12.5		
Helcomyzidae (adult)	.2	25.0	33.3	33.3
Empididae (adult)	.1	12.5		
Ephydridae (adult)	.1	12.5		
Coleoptera	6.2	12.5		
Filimentous algae	12.5	12.5		
Unidentified algae			6.3	33.3
Unidentified plant material			6.3	33.3
GIZZARD CONTENTS	*Young (7)*		*Adults (3)*	
Gastropoda	3.3	14.3	3.0	33.3
Pelecypoda	4.7	14.3		
Isopoda	16.0	42.9	34.3	66.7
Amphipoda	10.4	42.9	22.7	66.7
Diptera				
Chironomidae (larva)	7.1	14.3		
Helcomyzidae (larva)	4.1	14.3	33.0	33.3
Helcomyzidae (pupa)	8.1	14.3		
Helcomyzidae (adult)	2.0	14.3	.3	33.3
Filimentous algae	7.1	14.3		
Diddle-dee (seed)	23.7	57.2	.3	33.3
Pigvine (seed)	10.9	28.6		
Unidentified algae			3.0	33.3
Unidentified plant material	3.1	28.6		

seemed generally related to estimated water depth (Table VII). Young also probed in surface kelp and presumably pulled off snails and occasionally limpets. Feeding in gravel was common when parents were loafing near shore, however, and it was obvious that young spent considerably more time feeding than did adults.

Young birds fed mainly on marine amphipods, isopods, bottom-dwelling snails and kelp snails. Birds of three weeks old or more differed little from adults and favoured kelp snails and limpets. One consumed bits of crabs dropped by an adult in the process of breaking up the shell.

Large marine crayfish *Munida gregaria* were swallowed whole by adults and were taken in water deeper than kelp beds—probably over 9 metres. One adult taken in a creek was full of soft-shelled clams and fish eggs; another held several small fish. Of the waterfowl studied, Falkland Flightless Steamer Duck ate the largest prey items and also had the largest gravel in the gizzard (Figure 5).

In summary, the Falkland Flightless Steamer Duck shows versatility in food selection by dabbling, probing or diving. Benthos samples suggest great richness and diversity in shallow marine waters where these birds spend most of their time. The foods of young clearly overlap with those of Crested Ducks for the first two weeks of life but the Steamer Ducks were never observed feeding in algae-covered gravel or rock strata. Steamer

Table VI. Some summer foods of Falkland Flightless Steamer Ducks.

	Young (4)		*Adults (6)*	
Food	*% Mean Volume*	*% Frequency*	*% Mean Volume*	*% Frequency*
OESOPHAGUS AND PROVENTRICULUS CONTENTS				
Gastropoda	28.5	50.0	2.2	33.3
Smooth-shell Limpet			.3	16.7
Rough-shell Limpet			.2	16.7
Pelecypoda (soft-shell)			14.0	16.7
Isopoda	41.0	100.0	3.2	16.7
Amphipoda	27.5	50.0	.2	16.7
Decapoda (*Munida* sp.)			45.3	66.7
Decapoda (Hermit Crab)			5.0	16.7
Osteichthyes			13.2	16.7
Unidentified green algae	2.5	25.0		
Unidentified algae			.2	16.7
GIZZARD CONTENTS				
Gastropoda	48.8	75.0	22.3	66.7
Gastropoda (cores and shells)	8.5	25.0	20.2	83.3
Pelecypoda (soft-shelled)			9.2	16.7
Pelecypoda (small)			.8	50.0
Mytilus shell			1.2	33.3
Isopoda	13.0	75.0	.5	16.7
Amphipoda	16.5	75.0		
Decapoda (*Munida* sp.)	10.0	25.0	32.5	66.7
Decapoda (Hermit Crab)			1.5	16.7
Osteichthyes			.5	16.7
Osteichthyes (eggs)			7.5	16.7
Unidentified algae			.5	16.7
Unidentified plant	2.5	25.0		

Table VII. Duration of dives of Falkland Flightless Steamer Ducks.

YOUNG				
Age in days	*Number of dives*	*Range in minutes*	*Mean in minutes*	*Standard deviation*
1-2	6	.04-.27	.137	±.099
21-22	6	.11-.24	.197	±.046
27-28	28	.17-.27	.218	±.127
34-35	11	.20-.29	.252	±.031
ADULTS				
Depth	*Number of dives*	*Range in minutes*	*Mean in minutes*	*Standard deviation*
60 cm.	15	.16-.34	.231	±.054
60-90 cm.	12	.05-.49	.243	±.133
90 cm.	13	.12-.48	.322	±.123
110 cm.	7	.27-.55	.429	±.103

Ducks dabble in gravel, but they tend to select larger food at an earlier age than do Crested Ducks (Tables V and VI).

These birds spend considerable time loafing on shore, often sunning or drying with semi-spread wings. Waiting males, non-breeding but territorial pairs, and flocks of unpaired, non-breeding immatures had specific loafing sites. One, used by over 100 birds, was white-washed with droppings. Presumably, such loafing sites were used overnight as well because there are few terrestrial predators.

Kelp Geese (Plate II, p. 17).

Intensive feeding was on rocky outcrops, shelves or boulders where algae were abundant on the tidal zone. These included an olive leafy algae *Porphyra* sp. (probably *umbilicalis*) that grows on vertical and horizontal surfaces; a pale green filamentous algae *Enteromorpha* sp. on the gravel areas and rocky substrates; and green sea lettuce *Ulva* sp., barely exposed on horizontal rock or gravel at low tide and often taken as drift. All adults collected had fed on these species (Table VIII), and in numerous cases only one food was taken. Large flocks of non-breeding and moulting Kelp Geese occurred only on extensive rocky areas where lush growths of algae occurred. Flocks of 28 and 42 were seen at the tip of Cow Point, the basal portion of

Table VIII. Some summer foods of Kelp Geese on the Falkland Islands.

	Young (3)		*Adults (5)*	
Food	*% Mean Volume*	*% Frequency*	*% Mean Volume*	*% Frequency*
OESOPHAGUS AND PROVENTRICULUS CONTENTS				
Amphipoda			.2	20.0
Arthropoda (mites)	3.0	33.3		
Filimentous algae	12.0	33.3		
Porphyra sp.	84.6	100.0	19.8	20.0
Sea Lettuce (*Ulva* sp.)			40.0	40.0
Diddle-dee seeds			39.8	40.0
Diddle-dee leaves			.2	20.0
Unidentified plant leaf			.2	20.0
GIZZARD CONTENTS				
Filamentous algae	25.0	50.0		
Sea Lettuce (*Ulva* sp.)			40.0	40.0
Porphyra sp.	75.0	100.0	20.0	20.0
Diddle-dee seeds			40.0	40.0
Unidentified plant			.2	20.0

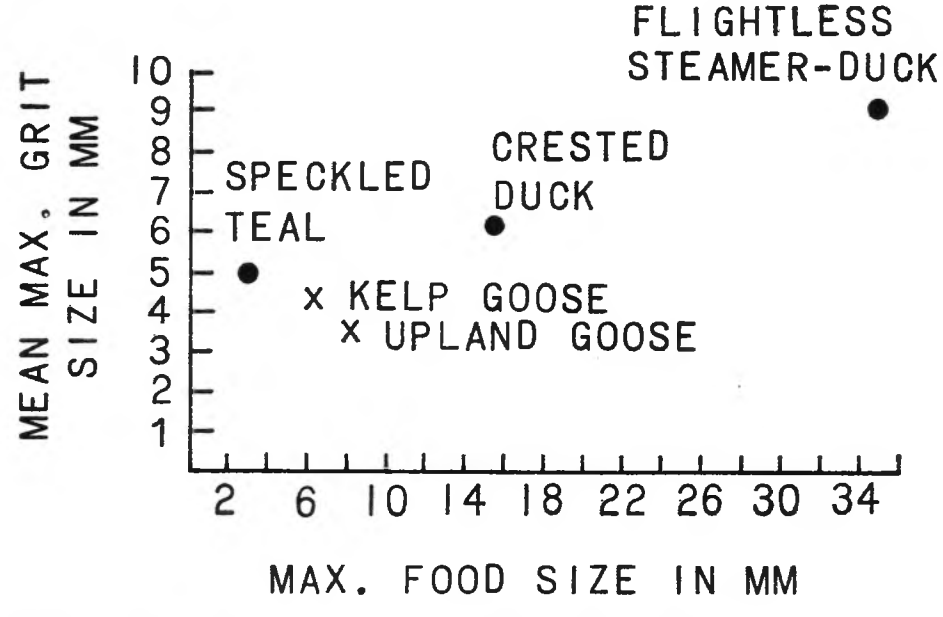


Figure 5. Relationship between maximum food size and of grit in the gizzard.

which formed the Fitzroy study area. At Fox Bay East, 232 adults were scattered continuously over the extensive rock strata exposed at low tide. Birds at Fox Bay seemed to prefer to pick at a very short 'stubble' of *Porphyra* rather than take other species. Indeed, there was evidence of overgrazing of this preferred species. Gladstone and Martell (1968) reported a flock of 316 on New Island.

Males awaiting females on the nest were seen eating green grasses on upland grassy swards near ponds. Pettingill (1965) also noted a family feeding in grassy uplands with Upland Geese. Two adults collected at Fox Bay East were full of diddle-dee berries, and residents indicated that this is a major food in winter.

The diet of young birds was more difficult to establish because those with known feeding histories were difficult to collect. Some observed or collected fed on finer, green filamentous algae, but usually took the same foods as adults. Blaauw (1912) suggested that Kelp Geese eat marine animals, but presented no definite evidence. The occasional amphipods recorded in this study were probably consumed accidentally. They avoided clams even though they fed in algal growths rich in these animals. A few mites were found in the oesophagus of one downy young.

Feeding by Kelp Geese was clearly tide related. During high tides, adults or adults with broods loafed or fed in areas not frequented during low tide. When algal beds were exposed birds walked or flew to choice feeding sites and fed voraciously. On several occasions adults started feeding as the tide dropped by swimming and feeding with their heads under water. Normally, they fed by walking on rocks and did not swim unless forced into water. Young birds fed on some algae found in gravel loafing areas above the high-tide line.

Feeding behaviour and habitat selection of other waterfowl

Because of the uncertainty of their status, observations on the feeding of the other waterfowl were rarely documented by collection. Birds were associated with certain pond types and plant communities, and feeding sites were examined for evidence of use.

Three species of the genus *Anas* used freshwater areas. Two, Brown (or Chilean) Pintail *Anas georgica spinicauda* and Southern Versicolor (or Silver) Teal *Anas versicolor fretensis*, are pond species and feed in the same ponds and in the same general manner as do Chilean Teal. Brown Pintail were seen widely, but never were abundant. The largest number seen on one lake was 15 birds on Swan Pond, Fitzroy. The few broods seen were always on ponds with native waterweed rich in amphipods and insect larvae. Pintails elsewhere in the world are known for their field feeding on grain outside the breeding period, but there are no natural or planted grain crops here to sustain large numbers of these birds over winter. One bird was seen in tidal pools in late summer, and feeding along the seashore is reported commonly in winter.

Versicolor Teal, known locally as Pampa Teal, were not common anywhere, though 13 occurred on Swan Pond during mid-summer. They preferred shallow, food-rich ponds where they fed with the head well under water, or upended. An adult was seen diving with Chilean Teal in a peat pond. One Versicolor Teal collected while feeding had an empty oesophagus and proventriculus, but the gizzard was full of clams and amphipods although it was feeding in an area in which only chironomid larvae were found in the net sample. Presumably it had just moved from a larger pond nearby where clams and amphipods were more common. Versicolor Teal and Brown Pintail were not seen in streams.

The Chiloe Wigeon frequented freshwater streams and ponds and estuaries (=creeks) where aquatic plants were abundant. At sites on small streams from which adults were flushed, uprooted *Lileopsis* sp. was found floating on the water's surface. Several Wigeon were associated with an estuary called Sand Pond at Fox Bay East where dense beds of wigeon grass *Ruppia* sp. occurred in very clear water. In addition, the one Class Ib young collected contained mostly the submergent algae *Nitella* sp. Adults and young were seen dabbling and pulling plants in the areas where *Nitella* grew between patches of native waterweed.

Areas frequented by flocks and broods of Black-necked Swans were often also used by Wigeon, but were always large waters of over 40 hectares. Favoured sites included both freshwater and estuaries, and a few birds spent a little time in marine kelp beds. In Swan Pond at Fitzroy, swans avoided native waterweed and fed in areas where *Nitella* sp. and some mud plantain occurred. In the brackish Swan Inlet west of Fitzroy, where about 40 swans were seen in midsummer, the common plants were water starwort *Callitriche* sp. and native water-

weed. On the Murrell River, a favoured wintering area, only a few swans were seen in summer. Plants were sparse but mud plantain did occur.

Flying Steamer Ducks *Tachyeres patachonicus* were the least abundant anatid although I suspect that they are sparsely distributed over a wide area and more common than the figures suggest. They were invariably found in large freshwater ponds with either sand or clay bottoms. Of seven ponds checked, five had either small 'fingernail' clams or snails. One brood was seen in an estuary, but this seemed unusual on the Falklands (Bennett 1924), whereas it is common in marine situations in Tierra del Fuego (Humphrey *et al.* 1970). Flying Steamer Ducks fed by diving even in shallow water of half a metre, but dabbling and upending were common, especially by juveniles. One adult hen contained remains of clams in the gizzard, and she and three young had seeds of diddle-dee in the gizzard. Evidently these seeds serve as grit for species that feed chiefly on animals, and they are retained for a long time.

The Ruddy-headed Goose *Chloëphaga rubidiceps* was less common on the East than on the West Falkland Islands, constituting 23% of 31 pairs of geese at Fitzroy but 46% of 39 pairs at Fox Bay East on the West Falklands. Taking all adults into consideration, Ruddy-headed Geese made up only 6% of 318 geese at Fitzroy but 31% of 238 geese at Fox Bay East. It also fed on fine meadow-grasses, but seems more of a grubber than a tip feeder and uses rootstocks and whole small plants as well as seed heads. Only one adult and one juvenile were collected.

Ruddy-headed Geese fed in association with Upland Geese, although broods remained isolated. According to Murphy's (1936) interpretation of Cobb (1933), this bird was known as the Mountain Goose as opposed to the Upland Goose, which was called the Valley Goose.

Invertebrate production in ponds in relation to waterfowl use

Cawkell and Hamilton (1961) observed that the ducks concentrated in the ponds containing waterweed, but that most ponds were rarely used. This response is related to substrate type and pond basin structure.

Ponds of sand and clay base in thin layers of peat tend to have shallow, sloping shorelines and probably more suitable physical and chemical bases for plant growth. Water clarity also may be involved. Those ponds with submergent vegetation provide good substrates for a variety of invertebrates, and it is this food source that obviously attracts all ducks except Chiloe Wigeon.

This pattern was well demonstrated on the ponds of the Fitzroy study area, where the greatest number of taxa of invertebrates and the largest standing crop in ml./m^2 were found in Swan Pond, which had the greatest species diversity of ducks and the greatest concentration of broods (Table IX). The high numbers of waterfowl species found at South Twin is due to its proximity to Swan Pond to which they come when disturbed by humans. The high number of invertebrate taxa in the five small ridge ponds sampled is surprising and biased by one nearly dry pond that was uniquely rich.

In the autumn of 1971 additional samples were taken in the Fitzroy lowland ponds for benthic fauna (Table X), but the ridge ponds were not sampled. These data again demonstrate (1) the richness of Swan Pond that always had the most waterfowl use, and (2) the minimal amount of food on North Twin, never voluntarily used by ducks for feeding. They landed there only rarely when disturbed in the adjacent Swan Pond.

Reproductive behaviour

Territoriality

Territorial behaviour is clear-cut and seemingly effective in all but the several

Table IX. Waterfowl species use of Fitzroy ponds in relation to pond invertebrates. November-December 1970. Figures in parenthesis indicate number of species of waterfowl that actually feed in the ponds.

Pond	*Substrate*	*Waterfowl species*	*Waterfowl broods*	*Invertebrate taxa**	*Invertebrates ml./m.2***
Swan	Sand-Clay	8 (6)	18 (13)	10	82.9
Fitzroy	Clay-Peat	1 (0)	2 (0)	5	8.6
South Twin	Peat	4 (2)	4 (2)	3	6.5
North Twin	Peat	0 (0)	0 (0)	3	1.1
Ridge (5 ponds)	Peat	2 (1)	3 (2)	8	12.9

* Maximum major invertebrate groups recorded in 3 or 4 samples of surface water and bottom substrate

** Maximum invertebrates recorded in 3 or 4 bottom samples

Table X. Invertebrate diversity and mean standing crop of benthic fauna in Fitzroy ponds, 5th November 1971.

Pond	*Substrate*	*Sample size*	*Invertebrates Maximum taxa*	*Mean ml./m.²*
Swan	Sand-Clay	6	10	27.8
Fitzroy	Clay-Peat	6	6	8.6
South Twin	Peat	6	4	7.7
North Twin	Peat	2	3	1.4

species of *Anas* that frequent rich lakes. Pair bonds are distinct and long lasting in all study species except Chilean Teal. However, there are some marked differences in mode of defence.

Kelp Geese are perhaps the most dramatic example of sexual dimorphism in waterfowl, with the male pure white and the female dark brown and white. The male awaits the incubating female in a conspicuous place, defends the site against both other males and females by displays and intense fighting (Pettingill 1965; Gladstone and Martell 1968), and is visible for miles (Vallentin 1924). These and most other Falkland Island waterfowl also show sexual dimorphism in body size, with males larger than females.

What seems to have been an unusual nesting area of Kelp Geese was located south-west of Stanley Commons at Seal Point. In this area, nests were found on peat islands and peninsulas covered by tussock grass and other coarse grasses, in freshwater peat ponds. The nests were all within a kilometre of the sea, but males stood guard and fed in meadow-grass areas. Most of these nests were begun two weeks later than nests at Fitzroy and at least two males in seven nesting pairs had dark tertiaries and primaries suggestive of yearling plumage (Murphy 1936). This may be a case of young birds establishing territories in a suboptimal habitat. Gladstone and Martell (1968) also noted a few breeding males with dark wings, but observed also that such birds were more common in flocks of non-breeders.

Upland Goose males also stand guard near nests or broods. Attacks by males on intruding pairs were seen, but such behaviour seems both less common and less intense than in Kelp Geese, perhaps because the territory is less restricted or better respected, and there is natural dispersion due to habitat (Figure 1).

Crested Ducks are highly aggressive, and waiting males defend the territory actively by flying head-low threat and constant wheezy calls. Such attacks can be intraspecific; one aggressive male on a freshwater pond attacked at least three species of *Anas*. Broods along coasts are normally well dispersed (Figure 3), and one brood per lake is usual.

Falkland Flightless Steamer Ducks are highly aggressive and vocal in their defence. The regular use of distinctive sites and inter-pair actions were so clear-cut as to leave no doubt as to the correctness of statements (Cawkell and Hamilton 1961; Pettingill 1965) that territorial sites are permanent and that females nest in the same sites annually. Battles involve underwater attacks and intensive fighting by both members of two competing pairs.

Flying Steamer Ducks were uncommon, but normally there was one pair per large pond. Two pairs with broods occurred on the very rich Swan Pond at Fitzroy, and occasionally a third male was seen. Some severe battles occurred but generally spacing was maintained at extremes of the pond. A third brood eventually appeared on the adjacent but less rich South Twin Pond.

Although active territorial defence in Chilean Teal was not observed, there is some evidence of spacing of broods (Figure 2). Although the concentration of broods on Swan Pond at Fitzroy may imply lack of territories, the size of territory necessary in a rich lake is probably much less than that in the food-sparse stream habitats. Brood-hens tended to remain separate from flocks of non-breeders, pairs or other broods. Pairs were common among flocks in food-rich lakes and the aggressiveness observed there was associated with competition for feeding sites.

Brown Pintails, Chiloe Wigeon and Versicolor Teal pairs with broods were normally observed as isolated pairs, but this may be a result of the low carrying capacity of the habitat. Once, two Pintail broods occurred in one bay of a large pond. Small flocks of all three species were seen, but Wigeon were usually isolated in pairs. Little aggressive behaviour was noted in any of these species, but their density reduced any opportunity to observe such behaviour.

Black-necked Swans generally were isolated as brood pairs, and residents confirmed these observations. They may be

social on large lakes, however, because three nests were within 15 metres of each other at Swan Lake on Dolphin Point (Port San Carlos).

Chronology of nesting

To show the general pattern of nesting by the five study species, the timing of broods of Class I (down feathers only) and of nests at any stage are indicated in Figure 6. It is quite possible that broods occurred outside the mid-October to mid-January observation period. Nevertheless, a pattern emerges that is supported by the general observations of residents. Rather short, seasonally defined nesting periods are suggested, with nests of Falkland Flightless Steamer Ducks and Upland Geese initiated early October and most Kelp Geese starting in early November. Both Crested Ducks and Chilean Teal seem to have longer breeding periods, and broods have been reported in every month of the year by Cawkell and Hamilton (1961) and by residents. Such observations are important in that they demonstrate that when climatic regimes are not so severe, winter breeding is not selected against. However, there is still an obvious concentration of breeding in the summer. Availability of invertebrates in coastal and pond areas may make winter breeding possible, but undoubtedly food resources are more abundant in summer because of increased solar input. Long-term data on temperatures show that means are above freezing in every month of the year, but data are needed on seasonal variations in production rates of plants and freshwater and marine invertebrates.

If birds do not mature precisely at one or two years of age, a spreading of the nesting period could result, where selective pressure for a restricted breeding season is lacking.

Non-breeding populations

Whereas populations of waterfowl in the northern hemisphere are dominated by species of the genus *Anas*, which tend to mature in one year, most species on the Falkland Islands do not seem to mature until two or more years of age. Large flocks of non-breeding birds are common during the summer among Upland Geese, Kelp Geese and Falkland Flightless Steamer Ducks. Non-breeding is suspected also in the Crested Duck and Chilean Teal. However, because the last two species breed at other periods of the year, better data are needed on their annual cycles.

Age of sexual maturity is not known even for Kelp Geese, Upland Geese, or Falkland Flightless Steamer Ducks, but two years is minimal (Cobb 1933), and three or more is likely in such territory-

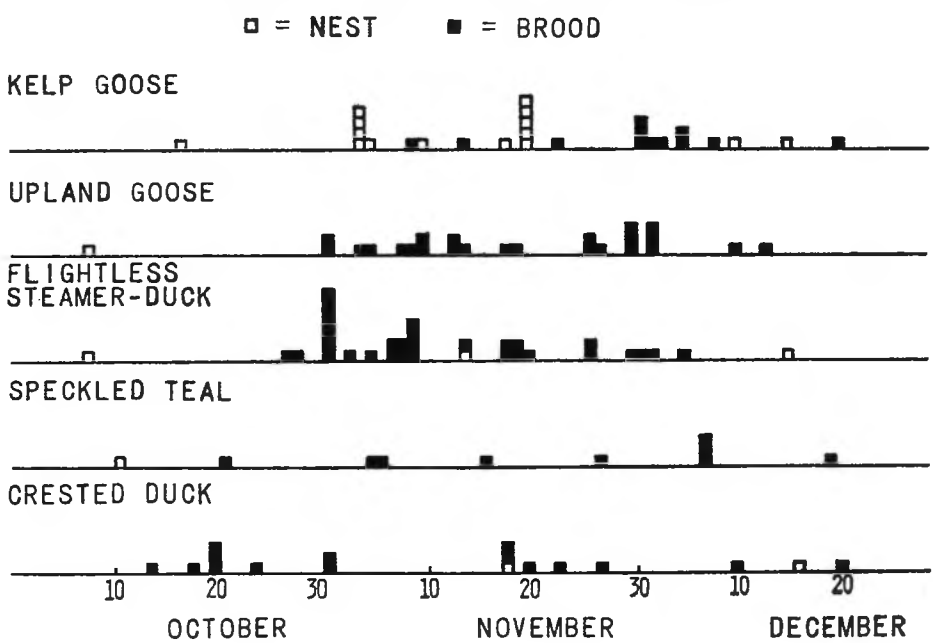


Figure 6. Estimated chronology of nesting based on Class I broods and nests (all stages) in the Fitzroy-Stanley area.

limited species. Residents reported that captive Upland Geese lay at the age of one year, but the large non-breeding population suggests that breeding at this age rarely occurs in the wild. Breeding of Kelp Goose males with dark primaries suggestive of immaturity has been noted earlier.

Some Falkland Flightless Steamer Duck pairs were on territory during the breeding season, but gave no evidence of nesting. Some were clearly young by both plumage and bill colour, but also distinctly more mature than birds in the large flocks of non-breeders, which are probably mostly yearlings. These flocks numbered 20-30 at the Fitzroy and Stanley study areas, but exceeded 200 in one flock at Port San Carlos. Banding studies are essential, because these birds may not breed until they are much older and can find and maintain a territory.

Pair bonds and parental care

Unlike northern hemisphere forms and more like many Argentine anatids (Weller 1968), Falkland Island waterfowl are strongly monogamous, probably permanently paired and remain with their broods until these are fully grown. This pattern was clear-cut in all five study species except Chilean Teal, which are also not clearly territorial.

Chilean Teal were commonly in pairs even in flocks, and sometimes when with broods. Generally, however, only females accompanied broods, and deserted the young when they reached the Class III stage (fully feathered but not flying). Females did attempt to protect their young by injury feigning, a behaviour pattern not seen in the other species, which normally just led the brood to water for safety. Distraction displays were reported in female Upland Geese by Gladstone and Martell (1968).

Males play a key role in defence of the young. Aggressive displays were seen in two male Upland Geese that stood their ground to protect young collected for the food studies. Male Falkland Flightless Steamer Ducks regularly charged gulls in defence of young. Females are more likely to merely lead the brood away from the interaction and are less defensive than are males. Losses of young were mostly at early ages (Table XI), as is typical of most waterfowl.

Males accompanied broods in several species not studied intensively: Black-necked Swan, Flying Steamer Duck, Chiloe Wigeon, some Versicolor Teal, Chilean Pintail and Ruddy-headed Goose.

The age at which young are ejected from the territory has not been determined for most species. One Falkland Flightless Steamer Duck brood observed regularly in Stanley was followed carefully by Mr. John Bound who reported that the parents chased the young when the latter were three months old and had full-grown wings. Pettingill (1965) presented data suggesting that young of both Falkland Flightless Steamer Ducks and Kelp Geese were ousted from the territory at about four months of age. Similar data need to be gathered for all species because of the importance of correlating growth rates with climate.

Growth rates of young

There is some evidence to suggest that Arctic species of waterfowl which are limited in the length of the breeding season by availability of ice-free water, food and good weather tend to have rapid growth rates. Hence Lesser Snow Geese *Anser caerulescens* mature in six weeks, whereas smaller dabbling ducks in temperate areas require six to nine weeks (Weller 1964). Since long day length and availability of food may be influential factors, it seems logical that less selective pressure is exerted on growth rate of birds where temperature is not limiting.

In the absence of marked birds, the assumption was that pairs remain in the territories and observations of broods observed periodically, if not from hatching to maturity, could be pieced together.

Table XI. Brood size in relation to age estimated at first observation by brood classification. Sample size, mean and range are presented.

	Ia			*Ib*			*Ic*			*IIa*			*IIb*			*III*		
Species	*N*	*M*	*R*	*N*	*M*	*R*	*N*	*M*	*R*	*N*	*M*	*R*	*N*	*M*	*R*	*N*	*M*	*R*
Upland Geese	19	5.5	1-9	37	4.4	1-7	26	3.8	1-7	21	4.1	1-7	11	3.9	1-6	3	4.0	4-6
Kelp Geese	17	3.8	1-9	3	2.7	1-5	3	2.7	2-3									
Falkland Flightless Steamer Duck	23	4.3	1-8	26	4.6	1-9	11	3.9	1-7	8	5.2	2-9	4	3.8	2-7			
Crested Duck	16	4.0	1-6	8	4.3	3-6	2	5.5	5-6	3	3.7	3-5	1	—	6			
Chilean Teal	4	3.2	2-5	4	2.7	1-5	3	2.3	1-4	5	2.2	1-4	3	6.0	5-7	4	2.0	1-3
Ruddy-headed Sheldgoose	13	4.4	2-15	4	2.5	2-3	3	3.3	1-5	3	2.3	1-5						
Flying Steamer Duck	5	4.3	1-6	2	3.5	2-5												
Versicolor Teal	3	4.7	4-5															
Brown Pintail	2	2.0	1-3							2	3.0	2-4						
Chiloe Wigeon	3	5.0	4-6	1	—	2												
Black-necked Swan	3	3.7	3-5															

Only a few cases were satisfactory for estimating growth to the flight stage, and these are summarised in Table XII. In general, the birds had much longer pre-flight periods than would be expected for a similar size in the northern hemisphere.

Table XII. Estimated growth periods to each flight stage in five common Falkland Island anatids.

Species	*Time weeks*	*No. obs.*
Chilean Teal	6-7	1
Upland Goose	9-10	1
Crested Duck	10-11	2
Falkland Flightless Steamer Duck	12	2
Kelp Goose	12-13	1

Chilean Teal differed only a little from the five and a half to six weeks maturation period of the northern Green-winged Teal *Anas crecca*, but Falkland Flightless Steamer Ducks and Kelp Geese required at least three months to reach maturity.

Discussion

The waterfowl fauna of the Falkland Islands is essentially that of continental South America or Tierra del Fuego (Olrog 1968). There is no subspecific differentiation among the ducks, but both the Upland Goose and the Kelp Goose are considered recognisable subspecies. Only the Falkland Flightless Steamer Duck is considered an endemic species.

In spite of the latitude, the small land mass and the moderating influence of the ocean reduces winter-summer temperature extremes, and there is little freezing of ponds and no heavy snow. As a result, there is less selective pressure toward time-specific breeding periods or toward rapid growth rate of the young as has occurred in the northern hemisphere. Moreover, pair bonds probably remain intact all year except for some species of *Anas* such as the Chilean Teal. Thus parental care of the young involves both sexes in contrast to the usual pattern in northern hemisphere Anatidae.

Species abundance

The relative abundance of various species (Table II) seems a product of available food resources. As would be expected, the most abundant species are herbivores on land (Upland Goose), sea (Kelp Goose), or brackish/freshwater (Black-necked Swan and Chiloe Wigeon). These herbivores constitute 65% of the total waterfowl observed (Figure 7). The remaining species are mainly carnivores, at least during the breeding season. Species that take food from the very rich tidal zone, the Falkland Flightless Steamer Duck and Crested Duck, rank first (18.6%) and second (7.1%) in abundance. Nearly as abundant is the Chilean Teal (6.4%), which is dominantly a freshwater species during the breeding season and has adapted to small widespread foods such

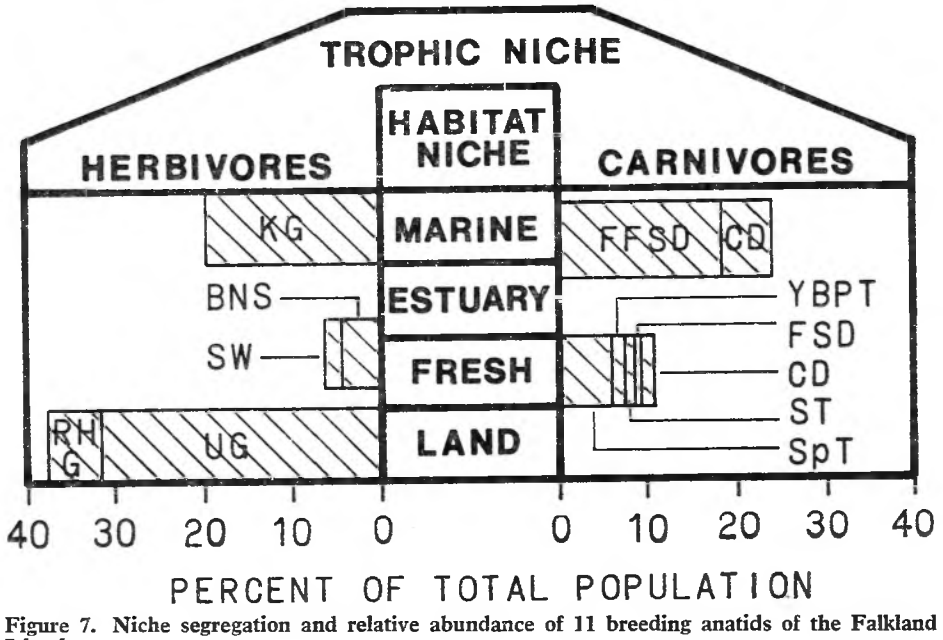


Figure 7. Niche segregation and relative abundance of 11 breeding anatids of the Falkland Islands.

as crustaceans and insect larvae in fresh water. It can also utilise seeds and berries in non-breeding periods. Teal, therefore, can use more diverse habitats, but often at low density.

Although basic primary productivity and complex food relationships primarily limit the numbers of many ducks, social structure and behaviour also may determine the size of the effective breeding populations. Productivity obviously is greatest in the shallow sea, so linearity of territories along the coast is a common pattern, and the number of possible territory sites probably limits the number of breeding pairs. Although the productive sea supports great numbers of non-breeding Falkland Flightless Steamer Ducks and Kelp Geese, further population increase may thus be limited. Upland Geese are less restricted to the seashore and also use rivers, creeks and ponds where drainage produces the green valley plant associations they use as food.

Niche and species diversity

The eleven regular species of breeding waterfowl probably survive with little competition because of the diversity of habitat niches (Odum 1971), which provide different sources of food. Where two species seem to use the same general habitat niche, they tend to differ in trophic (=food) niche. For example, of the three species that regularly use the seashore (Figure 7), Kelp Geese feed on marine algae along the shore, Falkland Flightless Steamer Ducks normally gets most food in offshore diving, and Crested Ducks tend to feed on invertebrates in algae, silt or gravel. The Steamer Ducks also may dabble in gravel, but favour deeper water even when not diving for food and select larger prey items (Figure 5). There is greater overlap in feeding sites and food item sizes of young birds of these two species, but generally the foods of Falkland Flightless Steamer Ducks are larger than those of Crested Ducks.

Although Chiloe Wigeon and Black-necked Swans are often found in areas with the same succulent food plants, the swans are limited to large, open areas, whereas Wigeon may use confined creeks and small pools. Moreover, their competition for food may be minor because of the abundance of their source. Further, more detailed studies may reveal that they utilise different food items or different parts of the same plant.

Among freshwater species, Flying Steamer Ducks obviously are the deep-water birds, which efficiently use a niche less easily and less regularly used by dabbling ducks. The situation in members of the genus *Anas* using shallow portions of freshwater ponds is more complex. They seem to overlap more in food use, but it was not possible to collect all species nor to have samples of sufficient size to be significant. From observations of these species in Argentina (Weller 1968) as well as from limited food data from Falkland Island birds, the species probably do differ slightly in habitat and trophic niche. Chilean Teal tend to feed on small food items and, having a bill with fine serrations, strain minute crustaceans out of the shallow and muddy pools or shorelines where they often feed. Versicolor Teal seem to feed in more permanent ponds, rich in submerged vegetation, and to select larger food items. No Chilean Pintails were collected on the Falkland Islands, but they are known for great adaptability in choices of food items and sizes. Their long neck equips them for bottom feeding on benthic organisms that smaller, short-necked species cannot reach. Hence, they often feed in deeper, more central parts of the ponds. Although there may be overlap in use of foods by dabbling ducks, the great seasonal abundance of such food organisms in rich ponds may not induce serious competition. Moreover, the social intolerance of the ducks may limit the density of flocks feeding there.

Because of the extensive and diversified grassland, the dominance of terrestrial grazers (Upland and Ruddy-headed Geese) is not surprising. What separates these species is uncertain, but the Ruddy-headed Geese would seem less dependent on green valleys and able to use drier sites and coarser grasses. They are most abundant on the drier western islands and in the drier regions of Tierra del Fuego.

Grass, geese and sheep

A conflict has arisen between man's efforts in wool production and the grazing by Upland Geese and Ruddy-headed Geese. This problem probably has been magnified by the creation of cultivated grasslands and expansion of meadow grass areas due to trampling livestock, resulting in increased carrying capacity for geese.

Both geese and sheep favour the green valley formations for grazing. Davies (1939) indicated that preferred foods of sheep include several plants also shown in Table III as being favoured by Upland Geese: meadow-grasses, native rush and native carrot. Overlap in food selection, however, is not complete. Geese do use

white-grass, *Roskovia*, *Carex* and diddle-dee berries, which are less favoured by sheep. Moreover, the competition with sheep is probably most severe in the breeding season, when goose pairs are restricted to areas suitable for brood rearing and moulting adults remain near water.

The conflict between geese and ranchers is exaggerated by the current poor price of wool, difficulties in marketing mutton or beef, and the resulting struggle for maximum production and financial reward. Bounties have been paid on geese for many years, but there is little evidence that they have led to a reduction in goose populations. Bounties are also paid in Tierra del Fuego (Ripley 1950), and farmers in Buenos Aires Province of Argentina harass and drive the geese by plane (Weller 1968). Such efforts are of questionable value and add to operational costs. On the Falkland Islands, the use of young geese for food is an effective means of population management where there are sizeable settlements, as at Stanley. Few Upland Geese survive there, although suitable habitat is abundant (Table II). If much discussed plans to limit goose numbers on farms are activated, some regulation over the extent of population control is essential, because the species is an important part of the attractive avifauna of the islands. Moreover, the role of geese in adding much-needed nitrogen fertilizers to poor, acid soils needs to be thoroughly investigated.

The future

The conservation of the Falkland Island fauna is essential for scientific reasons, but it may well become important to the island economy because of developing tourism. Although the waterfowl are not unique faunistically, the birds of the Falkland Islands collectively represent a fascinating group in which waterfowl are quite conspicuous. This, in combination with the rugged setting, will be attractive to lovers of natural history. A concentrated effort must be made to retain as much of the natural area as possible in an undisturbed state. Drainage of wetlands already has been initiated to increase grazing areas, and this procedure reduces bird species diversity, with greatest impact on the less common waterfowl. For example, Cawkell *et al.* (1960) called attention to the abundance of Flying Steamer Ducks on Burnside Pond near Darwin, but now visitors will see no water; only green grass, sheep and Upland Geese. Loss of such areas means loss of rare species and an increase in a few dominant species that sometimes become a nuisance.

Cawkell and Hamilton (1961) have suggested that some ducks have declined due to hunting. However, the decline has not been documented and harvest through sport hunting is not great. Hunting is probably not a controlling factor for even the rare ducks because it tends to be density dependent. Decreases in the diversity and richness of habitat niches are of greater significance.

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Summary

A variety of marine and freshwater habitats occur on the cold-temperate Falkland Islands. Although thirteen species of waterfowl have nested on the islands, only eleven are seen regularly. Intensive study of habitat selection, food utilization and reproductive behaviour of five species and general observations on six others revealed that waterfowl species were well-distributed with little overlap in food use even in the same habitat. Herbivorous species constituted 65% of the total waterfowl observed and different species fed on marine algae (Kelp Geese *Chloëphaga hybrida malvinarum*), upland grasses and forbs (Upland Geese *Chloëphaga picta leucoptera* and Ruddy-headed Geese *Chloëphaga rubidiceps*) or freshwater submergents (Black-necked Swan *Cygnus melanocoryphus* and Chiloe Wigeon *Anas sibilatrix*). Two carnivores utilizing marine inshore and tidal zones were next in abundance; Falkland Flightless Steamer Ducks *Tachyeres brachypterus* fed on bottom organisms by diving and Crested Ducks *Lophonetta s. specularioides* fed in the gravel and silt on smaller invertebrates. Three species of dabbling ducks were more social and omnivorous but mainly utilized the abundant invertebrates of freshwater ponds. Although some inter-specific competition was noted at edges of territories or feeding sites, species generally are segregated in different niches.

Reproductive behaviour patterns are influenced by a climate moderated by the sea and, although seasonal breeding is common in Upland Geese and Kelp Geese, nests of Crested Ducks and Chilean Teal *Anas f. flavirostris* have been recorded in all months of the year. Growth rate of young is slow by northern hemisphere standards, and territorial behaviour is more pronounced.

Upland Geese have become a dominant species because development of grazing lands provides choice habitat. In spite of competition with sheep for grass, protection is essential for all species of sheldgeese because they are important components of a unique avifauna significant to scientists and attractive to tourists. Although generally like the waterfowl fauna of Tierra del Fuego, that of the Falkland Islands is unique in one species (Falkland Flightless Steamer Duck) and two endemic subspecies (Upland Goose and Kelp Goose).

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The waterfowl of the Fraser Delta, British Columbia

BARRY A. LEACH

Introduction

An account has been given earlier (Leach 1970) of the establishment of a 'Slimbridge on the Pacific'. This paper describes the surrounding area, its waterfowl populations and the management problems.

The Fraser delta is part of the lowland which extends from the Coast Mountains of British Columbia southward across the alluvial plains of the Fraser River, the Skagit and other small rivers, to the southern extremity of Pugit Sound in the State of Washington. It may, however, be treated as a clearly defined sub-unit of this ecological area because recent environmental changes in the Fraser Valley have been more intensive than in the neighbouring area of Washington State immediately south of the international border. In this study the 'Fraser delta' will include those parts of the Fraser Valley's alluvial plain which are contained between the coasts and tidal reaches of the Fraser, Pitt, Serpentine, Nicomekl and Campbell Rivers (Figure 1).

The climate of the delta is mild, but subject to considerable variation. The average annual rainfall on the north mountainous side is 200 mm. (80 in.). In the centre, at Steveston on Lulu Island, it is 100 mm. (39 in.) and on the south side, at Boundary Bay it is 90 mm. (36 in.). Snowfall averages 36 mm. (14 in.) but in some winters it remains only a day or two. The average annual temperature at Ladner in the centre of the delta is 9.5°C. The minimum frost-free period is about 150 days per year and the average annual period is some 200 days (Taylor 1970). Due to the 'puddling' of cold air between the dykes, frosts tend to linger on the delta farmlands. The growing season begins in mid-March and lasts for 250 to 265 days.

The main geographical features of the lower valley and delta of the Fraser River were formed during the retreat of the Cordilleran ice sheet between fourteen and eleven thousand years ago. The great thaw left a broad fjord between the Coast Mountain Range to the north and the Cascade Range to the south-east. Relieved of the burden of ice 1,700 metres (5,500 feet) thick, the land rose about 300 metres (1,000 feet) so that by 9500 B.C.

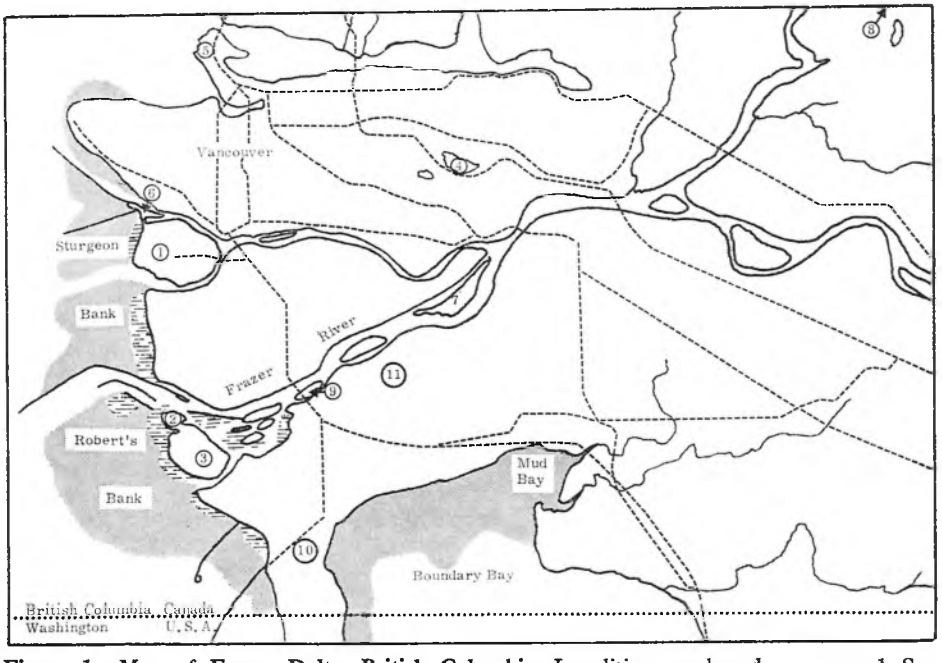


Figure 1. Map of Frazer Delta, British Columbia. Localities numbered on map: 1 Sea Island; 2 Reifel Island; 3 Westham Island; 4 Burnaby Lake; 5 Stanley Park; 6 Iona Island; 7 Annacis Island; 8 Pitt Lake, Pitt Valley; 9 Deas Island; 10 Tsawwassen; 11 Burns Bog.

the elevation was within 30 metres (100 feet) or less of its present elevation. The large moraines of glacial till, strewn across the lower parts of the valley, helped to contain vast alluvial deposits which raised the valley bottom out of the sea. Most of the present alluvial plain was marsh, but the hills formed by the moraines were covered with dense temperate Pacific coast rain forest predominantly cedar, fir and hemlock, with spruce, alder, maple and willow along the fringes.

The water levels of the Fraser River marshes were subjected to considerable changes by the spring run-off from the ice and snows of the vast mountain ranges in the river's watershed. These, together with the effects of the tides on the delta, reduced the habitat for waterfowl nesting in the larger marshes. However, the growth of a large population of beaver led to the creation of many ponds in the upland areas which provided breeding habitat for ground nesting waterfowl as well as tree nesting species such as the Wood Duck, Hooded Merganser, and perhaps American Goldeneye. Natural catchments in the hilly areas and depressions in the alluvial plain formed lakes, some covering hundreds of hectares. The larger islands of the delta comprised from west to east: tidal marshes, in which bulrush and cattail predominated; marshy meadows of grasses and sedges; and peatbog dominated by labrador tea and hard-hack. The combination of tidal marshes, islands, fresh marshes and lakes made the lower Fraser Valley the first major stopping place for waterfowl migrating southward down the Pacific Coast from Eastern Siberia, Alaska, and Arctic Canada.

The Stalo groups of the Coast Salish Indians settled in places where the forest met the river or tidal marshes. Here they had unlimited supplies of timber for houses and boats in close proximity to their main foods, salmon and shellfish. However, they also hunted mammals and birds in the river marshes. Night-hunting for waterfowl was conducted in dug-out canoes with a bright pitch fire burning on the prow. The hunters crouched in the shadow of a mat screen and paddled or drifted downstream close enough to reach the birds with five-pronged spears or nets. This method was remarkably similar to that used on the marshes of the Caspian Sea as described by Savage (1963). The Stalo Indians also hung nets between poles on the tidal flats in order to catch low flying waterfowl at night. Waterfowl feathers and down were woven together with the hair of dogs and mountain goats into the famous beautifully patterned blankets.

The arrival of the white colonists began a series of drastic environmental changes. The establishment of a Hudson's Bay trading post in 1827 at Fort Langley 56 km. (35 miles) from the mouth of the Fraser encouraged intensive beaver trapping. The depletion of this animal led to the disappearance of many ponds. The Gold Rush of 1858 resulted in a sudden influx of settlers, and the pre-emption, clearing and draining of land. In 1898 a great flood demonstrated the need to dyke the sea coast and tidal reaches of the rivers. This vast undertaking transformed most of the tidal marshes into farmland. Inland water bodies were also drained so that of the three hundred lakes and large ponds described by early settlers in the Municipality of Surrey, none now remains. Sumas Lake, which supported a large waterfowl population in the central part of the Lower Fraser Valley, was drained in the 1920's to yield 365 hectares (900 acres) of agricultural land.

In spite of the reduction of the marshes, large numbers of waterfowl continue to visit the Fraser delta during their migratory journeys. This is due to the survival of the extensive tidal mudflats of Boundary Bay and the estuarine marshes of Roberts Bank and Sturgeon Bank, which offer secure resting areas. Furthermore, these are matched by feeding habitat in the 70,000 hectares (175,000 acres) of meadow and arable lands still regularly flooded by the heavy rains between November and April.

Wetlands of the Fraser River Delta

Boundary Bay—Mud Bay

This bay was formed by tidal flow in the post-glacial period when the Fraser Valley was a fjord. The 6,000 hectares (14,800 acres) of inter-tidal flats are deltaic deposits of sands, interspersed with thin seams of clayey silt, mica, shells and organic materials. These support three basic plant communities important to waterfowl. (a) The eel grass *Zostera marina* beds on the lower tidal flats, which support considerable numbers of Black Brant, especially during the spring. (b) The red, green and blue-green algae community on the inter-tidal flats, associated with a large variety of small marine animals which are eaten by waders and dabbling ducks, especially Green-winged Teal. (c) The salt marsh, with several species of terrestrial halophytic plants, beyond the sea-dyke and on a

number of small islands in the eastern part known as Mud Bay. This community provides subsidiary foods for dabbling ducks and, in Mud Bay, an important loafing area, especially at high tide or rough weather. Beyond the flats the tidal waters provide feeding opportunities for large flocks of diving ducks, especially the scoters and scaup.

Roberts and Sturgeon Banks

These are the Fraser River's estuarine deposits of sand and silt which extend for several kilometres into Georgia Strait creating 13,000 hectares (31,800 acres) of inter-tidal flats. The higher foreshores of the delta islands support thick stands of bulrush *Scirpus* spp. and cattail *Typha* spp. Along the outer fringes the Lesser Snow Geese feed on rhizomes and shoots, associated with large flocks of American Wigeon and loafing Pintail. As in Boundary Bay, the deeper waters are attractive to a variety of diving ducks, grebes and loons.

The Fraser River Islands

The estuarine islands have a similar flora to the foreshore marshes described above. Their shores and channels are frequented by dabbling ducks. Further upstream, the larger river islands are intensively farmed and provide feeding areas for dabbling ducks. The trees along their shores afford nesting habitat for Wood Duck.

The Pitt River

This short river flows from Pitt Lake to join the Fraser a few miles east of New Westminster. The marshes south of the lake have been much reduced in recent years, but a wild remnant still offers habitat for Coast Deer *Odocoileus hemionus columbianus*, Black Bear *Euarctos americanus*, Bald Eagle *Haliaetus leucocephalus*, Osprey *Pandion haliaetus carolinensis*, and Sandhill Crane *Grus canadensis*. Considerable fluctuations in water levels due to heavy rainfall and the seasonal run-off from the adjacent mountains virtually limit waterfowl breeding to tree nesting species. Flocks of dabbling duck congregate in the Pitt River marshes in early autumn. Geese are also attracted to the more secluded parts of the marsh.

The Fraser Valley Farmlands

Together with the tidal flats and marshes, the farmlands constitute a major attraction to waterfowl. The most important are those closest to the estuarine marshes on Sea, Lulu, Reifel and Westham Islands and on the mainland north of Boundary Bay and along the valleys of the small rivers draining into Mud Bay. Further up the valley, Sumas Prairie, formerly the site of a shallow lake, and other extensive areas of stubble, maize, meadow and arable land also attract flights of dabbling duck.

Peat Bogs

Large sphagnum peat deposits are located on Lulu Island and south of the Fraser at Burns Bog. Although they are subject to flooding in winter and contain large open bodies of water in peat cuttings, the peat bogs lack vegetation attractive to waterfowl. Migrating waterfowl sometimes rest on the open waters and a few pairs of Mallard and Blue-winged Teal nest on the fringes of the bogs.

Lakes and ponds

The only natural shallow lake in the delta area frequented by waterfowl is one of 137 hectares (339 acres) located in the centre of Burnaby, an eastern suburb of Vancouver. Its shores are lined with cattail, and yellow flag *Iris pseudacorus* backed by marshy land and mixed woodland. Mallard, Blue-winged Teal, Cinnamon Teal, Gadwall and Wood Duck nest there. These are joined by flocks of migrating ducks in the autumn. Canada Geese visit the lake regularly. The White-fronted Goose and the Whistling Swan are rare visitors there.

Waterfowl

Forty-one species of swans, geese and ducks have been recorded on the Fraser River delta.

Group A. Breeding birds and regular wintering population.

1 Lesser Snow Goose *Anser caerulescens caerulescens*

This is the commonest wintering goose on the marshes of Roberts and Sturgeon Banks. From October till March there are usually about 3,000-4,000, but between March and April as many as 6,000. They feed along the tide line on the roots of bulrush, and very occasionally cattails. John Work, who kept a journal of the first exploration of the delta in December 1824, recorded that:

> "On the low land at the entrance of the (Fraser) River geese, particularly white ones, were very numerous and were by no means shy, they allowed themselves to be approached easily. Mr. McKay killed 3 of them."

Since then the Snow Geese have learnt to be more wary and they seldom venture over the sea-dykes except in stormy periods at high tide. However, in November 1971 at the Reifel Island refuge about 250 birds began to feed regularly on young grain beside the entrance road in close proximity to visitors. In the early 1960's several ringed geese were recovered indicating that they were hatched on Wrangel Island, NE. Siberia. Others have been recovered in central Oregon and south central California. This suggests that the Fraser and Skagit (Washington) deltas are mainly stopping places for birds wintering further south.

2 Great Basin or Moffitt's Canada Goose *Branta canadensis moffitti*

This is the large 'honker' which nests in the interior valleys of British Columbia. In the past it has been asserted that some of these birds migrate to the Fraser delta, but this is not proven. The status of this race has become difficult to define since the establishment of breeding populations of uncertain origin at Stanley Park in Vancouver, at the waterfowl refuge on Reifel Island, and at Burnaby Lake. Over a hundred pairs of these birds now nest in the Lower Fraser Valley. Some geese from the flock introduced to Elk Lake on Vancouver Island may also cross the Strait of Georgia to the Fraser River marshes.

3 Lesser Canada Goose *Branta canadensis parvipes*

This medium-sized Canada Goose is seen on the coast of British Columbia in October and November. Dozens of skeins, each of between 50 and 200 birds pass over the Fraser delta in mid-October. Some of these alight to feed on the meadows or to rest and preen on the tidal mud-flats or open water areas in Burns Bog. In the early 1960's a flock of up to two thousand birds wintered on Mud Bay, feeding on an 80 hectare (200 acre) private sanctuary in the vicinity. Increasingly frequent disturbance by poachers put an end to this situation. In 1963 gales drove unusually large numbers of these geese east of their main migration route along the west coast of Vancouver Island. About 10,000 spent several days on the Fraser delta, until the opening of the shooting season drove most of them southward. However, 2,000 remained till January at the newly-established waterfowl refuge at Reifel Island. Since then flocks of between 20 and 200 birds have visited the refuge annually between October and January.

4 Black Brant *Branta bernicla orientalis*

The main southward migration of Black Brant from Alaska to Baja California, passes the British Columbia coast far out to sea. However, several small groups arrive on the inside passage between Vancouver Island and the mainland, and winter in the shallow bays of Georgia Strait and Puget Sound, Washington. In recent years the beds of eel grass in Boundary Bay have supported a wintering population of only a few dozen birds. A decade ago 500-1,000 Brant were regularly seen there in midwinter. Between March and May the northward migration progresses along the coast. The Canadian Wildlife Service estimates that about 14,000 birds pass through Boundary Bay in this period. A few birds also occur regularly at Tsawwassen, South Roberts Bank. Non-breeding birds occasionally remain throughout the summer.

5 Pintail *Anas acuta acuta*

Like the American Wigeon, the Pintail is mainly a passage migrant but considerable numbers are present throughout the winter. Their preference for flooded arable land causes them to concentrate in the southern half of the delta. They arrive in August and their numbers peak in late October. The average number present October-December 1969 was

32,326. By mid-December most of them have moved south, but numbers build up again in February and remain high till early April. One pair nested for three successive years (1966-1968) at Serpentine Fen near Mud Bay, and three pairs successfully hatched a total of 16 ducklings at Iona Island in 1968.

6 American Green-winged Teal *Anas crecca carolinensis*

This little duck arrives on the coastal marshes in large numbers in September. In early October it appears to outnumber all other ducks, but by November there is a marked reduction from 20,000 to 3,000-4,000. Munro (1949) counted 4,500 in 1947, 4,000 in 1948 and 3,200 in 1949, all in January. During the spring this bird passes through the delta rapidly and the flocks are never as conspicuous as those in the autumn. This species occasionally breeds in the Lower Fraser Valley. A nest was unfortunately destroyed in the course of bulldozing the pen ponds at the Reifel Waterfowl Refuge in 1966. One pair nested at Iona Island in 1969.

7 Mallard *Anas platyrhynchos platyrhynchos*

The Mallard nests in the marshes, farmlands and parks of the Lower Fraser Valley. Large numbers pass through or winter on the delta. The Canadian Wildlife Service Census for October, November and December 1969 showed an average total of 34,602 on the tidal marshes. Although not the most numerous wintering duck they are the most highly prized quarry and constitute about 38% of the ducks shot on the Lower Mainland.

8 Gadwall *Anas strepera strepera*

Like the Cinnamon Teal, the Gadwall has increased as a breeding bird. About twenty pairs nest in the coastal area beside brackish sloughs and fresh water areas, especially at Burnaby Lake, Reifel Island, and near the Iona Island sewage lagoons. This duck is also present in the winter.

9 American Wigeon *Anas americana*

Large flocks of 'Baldpates' are evenly distributed throughout the marshes of the delta. Fluctuations in numbers in the autumn suggest that many thousands of birds are on passage to Oregon and California. Census figures for Wigeon show an average total of 45,582 birds between October and December. In January numbers drop, especially if frost or snow limits the grazing. Estimates by Munro (1949) of wintering populations in January of three consecutive years showed considerable variation. He counted from Fraser River mouth to Boundary Bay and found 7,590 in 1947, 1,060 in 1948 and 3,151 in 1949. Wigeon make up about 21% of the wildfowlers' annual bag. The main exodus is in April. A few birds linger into May but there are no nesting records for the Lower Mainland.

10 Blue-winged Teal *Anas discors discors*

This is a summer resident breeding in flat, open farmlands of the Lower Fraser Valley wherever ditches, sloughs, ponds and rivers offer suitable habitat. Numbers of breeding birds show considerable annual variation. They respond very readily to habitat management. The addition of small ponds and clumps of rushes to an open 12 hectare (30 acre) meadow on the Reifel Refuge resulted in a quadrupling of the nesting population the following spring. They arrive late in April and are gone by September. Some birds on passage north also visit the delta in May but they are seldom identified in the fall.

11 Cinnamon Teal *Anas cyanoptera septentrionalium*

Also a summer visitor, the Cinnamon Teal arrives early in April and nests in the same localities as the Blue-winged Teal. Numbers seem to have increased in the last decade; usually about forty pairs breed in the coastal area. It, too, leaves in late summer. Few birds have been recorded in winter.

12 Shoveler *Anas clypeata*

This duck is a local resident in the Lower Fraser Valley. In the winter it is usually seen in small groups of a score or two among large flocks of other species. It nests only in the few remaining localities where reedy cover adjoins a fresh or brackish pond. Thus the total breeding population in the delta is seldom more than ten pairs, located mainly at Iona, Sea and Reifel Islands.

13 Canvasback *Aythya vallisneria*

Flocks totalling about 200 winter on the coast. Smaller groups are also found on the inland waters of the Lower Fraser Valley.

14 Lesser Scaup *Aythya affinis*

This duck is found in small or scattered groups on inland waters or on the tidal

sloughs and bays between October and March. A few remain on the coast throughout the summer, but they do not nest.

15 Pacific Greater Scaup *Aythya marila mariloides*

This species winters in large numbers on the coastal waters especially in Boundary Bay where very large concentrations have been seen during peak migration between mid-October and December. During the rest of the winter the population is about 3,300 birds.

16 Wood Duck *Aix sponsa*

A common resident breeding where there are suitable nesting trees near bodies of fresh or brackish water large enough to offer it security. The felling of old poplars along the Fraser River and marshy sloughs led to a drop in numbers, but during the last decade the provision of nesting boxes in the Pitt Valley, Burnaby Lake, Reifel Island and Stanley Park has resulted in an encouraging increase. The Lower Fraser and Pitt Valleys have a nesting population approaching 200 pairs. Winter counts in the last two years have also shown an increase in numbers.

17 American Black Scoter *Melanitta nigra americana*

This species occurs less frequently than the other scoters. It is unusual to see more than a score or two wintering in any single location. They arrive early in October and all but a very few depart by late April.

18 Surf Scoter *Melanitta perspicillata*

This is the most common scoter on the open coastal waters. The total wintering populations number several thousand but they are so spread over the waters of Boundary Bay and Georgia Strait that it is difficult to make an accurate count. They arrive in late September and most depart by mid-April. Flocks of non-breeders, sometimes several thousand strong, linger through the summer months.

19 Pacific White-winged Scoter *Melanitta fusca dixoni*

This species arrives in mid-October, and reaches a total wintering population of about a thousand. Numbers dwindle through April and May. It is rare in summer.

20 Pacific Harlequin Duck *Histrionicus histrionicus pacificus*

These occur frequently in small groups on the coastal waters of the Lower Mainland. They nest along the mountain streams of the Coast Range. In mid-June the drakes return to the sea, where they are joined by the ducks and young in September or October. They prefer rocky shores and kelp beds and are less often seen off the estuary marshes.

21 Long-tailed Duck *Clangula hyemalis*

The 'Old Squaw' winters in large numbers on the open coastal waters. Flocks of several hundred birds are present from mid-October till mid-March.

22 Barrow's Goldeneye *Bucephala islandica*

This species nests in the southern interior of British Columbia and occurs on rocky sections of the Lower Mainland Coast between October and March in larger numbers than the American Goldeneye. The total of 3,388 counted within 15 miles of Vancouver in December 1970 is the largest concentration reported in the North American Christmas count.

23 American Goldeneye *Bucephala clangula americana*

Commonly observed in small or scattered groups along the coast and on inland waters between October and March. Small flocks remain until April. A few birds are seen during the summer, and one pair has nested at Burnaby Lake.

24 Bufflehead *Bucephala albeola*

This little duck is very common on salt and fresh waters throughout the winter. Even roadside ditches or ponds a few yards wide attract a bird or two. Because the wintering population is so scattered it is very difficult to assess its size. Only a few remain later than April or early May.

25 Hooded Merganser *Mergus cucullatus*

This species frequently winters on the coast. A few pairs also nest beside secluded wooded ponds and lakes in the Lower Fraser Valley.

26 Red-breasted Merganser *Mergus serrator serrator*

This species is common in the delta waters in the winter, arriving in September and October, when it prefers salt

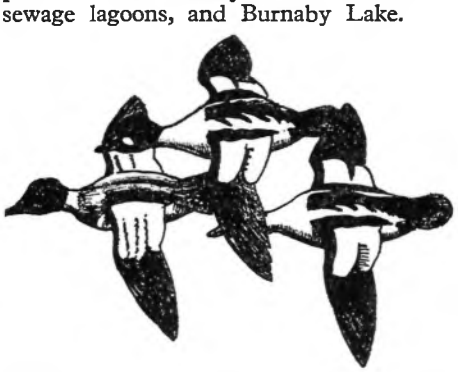
water. However, it is also attracted up the river estuaries by the movements of salmon parr. It leaves in March for the boreal forest in the north which it approaches via the Pacific Coast and major inlets.

27 American Merganser *Mergus merganser americanus*

This large 'saw-bill' is a frequently observed resident in the Lower Fraser Valley. During the winter it is found on fresh or brackish waters, usually in small flocks of up to twenty birds. However, over 400 have been seen together on one small lake. In the spring the pairs move into the clear waters associated with the mountains north of the delta.

28 Ruddy Duck *Oxyura jamaicensis jamaicensis*

This winters on tidal sloughs and sewage lagoons, normally in flocks of up to 50. However, congregations of several hundred have been reported. One or two pairs nest occasionally beside Iona Island sewage lagoons, and Burnaby Lake.



Group B. Species which occur regularly in small numbers.

1 Whistling Swan *Cygnus columbianus columbianus*

This species is an occasional passage migrant and rare winter visitor. Though their usual migration route is in the interior, in some autumns groups of over twenty fly over the delta. In 1965 many alighted in the valley near Mud Bay where over a score were illegally shot. Several of the survivors were nursed back to health in Stanley Park. A pair of these birds placed on Burnaby Lake nested there. Unfortunately the eggs were destroyed in 1966 and the cygnets were killed by waste oil discharged into the lake in 1967. A flock of 29 wintered in 1966 on Westham Island, 28 were seen on Sea Island in 1961, and groups of four to six birds occur regularly near Cloverdale between February and early May.

2 Trumpeter Swan *Cygnus cygnus buccinator*

A rare migrant on the coast. A pair lingered at Reifel Island for several weeks in the spring of 1969. They also occur regularly at Pitt Lake and Lulu Island.

3 Pacific White-fronted Goose *Anser albifrons frontalis*

This goose occurs occasionally in small numbers as a passage migrant in late September and early October. Groups of 30-40 birds remain on the delta for a few days, roosting on Roberts Bank or Boundary Bay and grazing on the adjacent farmlands. They also occur in the Pitt Valley. Single birds or pairs have wintered in recent years at Reifel Island, Burnaby Lake and Stanley Park.

4 Dusky Canada Goose *Branta canadensis occidentalis*

Vancouver Canada Goose *Branta canadensis fulva*

The large, dark plumaged Canada Geese which are occasionally observed or shot on the Fraser delta have usually been recorded as 'Western Canada Geese' or 'Queen Charlotte Canada Geese' because dark birds are found nesting on the Queen Charlotte Islands (*fulva*). However, *fulva* tends to be sedentary, whereas considerable numbers of *occidentalis* migrate along the west coast of Vancouver Island and winter in Oregon. Thus dark birds seen on the Fraser delta are likely to be the latter race.

5 Cackling Goose *Branta canadensis minima*

This little goose winters in small groups or singly on the delta, and occurs regularly at Reifel Island and Stanley Park.

6 European Green-winged Teal *Anas crecca crecca*

Recorded as a regular, rare transient in the Lower Fraser Valley. Its resemblance to *carolinensis* makes it easy to overlook. At least ten birds were observed in 1971.

7 European Wigeon *Anas penelope*

This bird winters regularly in very small numbers. A group has been observed feeding on the same meadow on Reifel Island throughout the last decade.

8 Redhead *Aythya americana*

Small numbers have been recorded on the delta coast during spring and winter months. The flock of 61 seen on Pitt Lake in February 1972 is the largest recorded.

9 Ring-necked Duck *Aythya collaris*

Small groups winter on freshwater ponds and sloughs in the Lower Fraser Valley. Occurs regularly at Burnaby Lake, Lost Lagoon and Pitt Valley.

Group C. Casual migrants and 'accidentals'.

1 Emperor Goose *Anser canagicus*

A casual winter visitor. A single bird wintered at White Rock, 1965-1970. It fed along the shore and roosted on a jetty beside the pier.

2 Baikal Teal *Anas formosa*

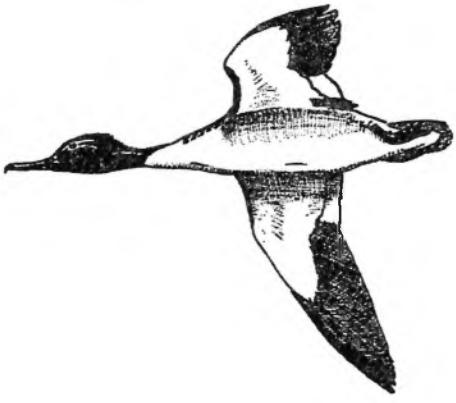
Recorded as accidental in the *Checklist of Vancouver Birds.*

3 Tufted Duck *Aythya fuligula*

A casual visitor to the Fraser Valley. One or two birds have occurred at Iona Island in the spring, and at Stanley Park in the autumn 1961, 1970 and 1971.

4 Smew *Mergus albellus*

One adult male seen on three occasions at Lost Lagoon, Stanley Park, Vancouver, in November 1970.



Management problems

Land use

The construction of 530 km. (330 miles) of dykes along the coastal and estuarine shores of the Lower Fraser Valley entirely changed the ecology of the delta. Though most of the construction took place at the turn of the century, the distributions and habits of the higher animals of the region are still undergoing responsive changes. These are further complicated by the impact of other human developments in agriculture, industry and urban growth.

Changes in agricultural practices in the Fraser Valley have resulted from improvements in soil analysis, drainage and irrigation, and from shifts in economic demands. Early in the present century grain farming was predominant, but dairy farming, beef-cattle finishing, poultry growing and market gardening have now taken over. It is claimed that reduction in the acreage under grain led to a drop in the wintering population of waterfowl, which were formerly attracted to the stubble fields. However, it seems likely that other changes, especially industrial and urban growth and increased hunting pressure, have had more detrimental effects upon the wintering waterfowl population.

The shores of the Fraser's North Arm have now become so congested with industrial activity that the only remaining waterfowl habitat of any significance is Iona Island, where sewage lagoons provide an artificial attraction to ducks. Sea Island foreshore is still valuable habitat, but the location of Vancouver International Airport there has resulted in action to reduce the avian population in order to prevent 'bird strikes' on aircraft. Annacis Island and the upper reach of the South Arm have also become industrial areas, but efforts are now being made by the Provincial Fish and Wildlife Branch and the Canadian Wildlife Service to secure the islands in the lower reaches for wildlife management. Further south, the construction of a large coal-loading jetty on Roberts Bank is the first phase in the development of a major deep-sea harbour. The loss of half of South Roberts Bank will be matched by the urban-industrial development of the adjoining delta farmlands. However, even this seems preferable to the six reclamation schemes proposed in the last decade, which would have converted much of Boundary Bay into industrial or residential sites. Though public protests have blocked these plans, suburban housing developments have covered much of the neighbouring farmlands around Ladner, and more are planned for the west shore of Boundary Bay.

The extension of suburban sprawl beyond the South Arm of the Fraser resulted from the construction of the Deas Island Tunnel in 1960. Ease of access also encouraged an increase in hunting pressure. This, in turn, has had effects upon the habits of waterfowl wintering on the delta, especially the geese.

Wintering populations

During the last three decades the Canadian Wildlife Service and the

Provincial Fish and Wildlife Branch have collected information about the size and content of the wintering wildfowl population. This process has been sporadic and conducted mainly to demonstrate the value of the waterfowl resources in terms of hunting recreation, rather than to provide ecological data (Taylor 1970). However, when combined with data from the Vancouver Natural History Society's annual bird counts and the observations of many other groups and individuals, the official statistics confirm that the Fraser delta has retained its importance as a wintering area or resting place for migratory waterfowl.

If it is to continue to do so provision must be made in the development of Greater Vancouver for the conservation of three types of habitat: (i) coastal waters and tidal flats; (ii) estuarine marshes; (iii) deltaic farmlands.

The coastal waters and flats meet the needs of the diving ducks, especially the scoters, scaups, goldeneyes, Buffleheads, and Long-tailed, Ruddy and Harlequin ducks. The eel grass beds of Boundary Bay are essential to the ecology of the Black Brant and are also important to the American Wigeon which use them as a secondary source of food, and to the diving ducks which seek animal foods therein.

The estuarine marshes must be considered together with the deltaic farmlands. The loss or reduction of either would seriously deplete the numbers of wintering dabbling ducks. The loss of the foreshore marshes would deprive the Lesser Snow Geese of an important staging and wintering area. Conversely, the preservation of these marshes alone might meet the needs of the Lesser Snow Geese, but it would not ensure the maintenance of the present wintering duck populations. The latter depend for much of their food upon the neighbouring agricultural areas and the tidal areas provide only secondary feeding opportunities. When frost or snow deprive the dabblers of their inland feeding opportunities, the numbers fall from several thousand to a few hundred. The survival of low-lying farmlands further up the Fraser Valley or in Washington State will not compensate for losses on the delta because the inland areas are more frequently under frost or snow.

Reductions in wintering populations of dabbling ducks and Canada Geese are undoubtedly also caused by the traditional shooting methods and the absence of any waterfowl management practices, other than the fixing of seasonal dates and daily bag limits. Apart from about 200 hectares (500 acres) of tidal marsh within the Reifel Waterfowl Refuge, all foreshore areas are open to shooting, as are all lands not specifically posted with 'No Hunting' signs. In these areas an average of over 15,000 duck hunters are able to hunt between sunrise and sunset. In 1965, for example, 16,600 hunted an average of 14.4 days each. This gives a total of about 240,000 waterfowl hunting days in the Lower Mainland. This figure is an impressive illustration of the economic and recreational value of the waterfowl resource. But, in the absence of any management or control, it also represents a terrible degree of continuous harassment for the ducks and geese. The harassment probably has more effect upon the survival rate of waterfowl than the actual annual bag of about 115,000 birds. The ability of the survivors to feed is severely restricted by the almost continuous presence of hunters in the most favourable marshes and meadows. Within a week or two of the opening of the season the great majority of geese quit the delta for the great refuges of Oregon and California. Most of those duck remaining quickly adopt the habit of flying inland after sundown and feeding under the cover of darkness.

The situation would be much improved if sanctuaries were established in the main feeding areas. In order to attract and hold a wintering population of geese they would each have to cover at least 200 hectares (500 acres). As described above, the provision of temporary sanctuary in Langley and a permanent refuge at Reifel Island had an immediate effect upon the migratory habits of considerable numbers of Lesser Canada Geese. There have also been progressive adjustments in the feeding habits of the Lesser Snow Geese at Reifel Island. The regular appearance of Moffitt's Canada Geese and White-fronted Geese in the Pitt Valley is clearly attributable to the presence there of large privately owned marshes where shooting is strictly limited.

The effect of the establishment of the Reifel Refuge upon the duck population is more difficult to assess. In the mid-sixties there were about 30,000 dabbling ducks there by November. According to T. Burgess, who has been working there on a study of duck food ecology, the peak number in 1968 was 63,500 and in November 1969 it reached 136,000. Casual observations at Boundary Bay and Sturgeon Bank did not indicate a corresponding decrease, so the increase at Reifel Island could be attributed to birds which

would previously have flown further south in earlier years.

In spite of these indications of the beneficial effects of refuges upon the size and variety of the wintering waterfowl populations, attempts to establish new refuges on the delta farmlands or to extend the boundaries of the Reifel Refuge to include more of the tidal flats and estuarine marshes have not yet met with success.

Breeding populations

The breeding populations of waterfowl in the Lower Fraser Valley are limited by the lack of suitable nesting areas beside fresh or brackish waters. Furthermore, there are considerable numbers of predators, including the Great Horned Owl *Bubo virginianus*, Cooper's Hawk *Accipiter cooperii*, Red Fox *Vulpes fulva*, Raccoon *Procyon lotor*, Mink *Mustela vison*, Opossum *Didelphis marsupialis virginiana*, several species of weasels and skunks, domestic cats and dogs. Nevertheless, the provision in a few localities of nest boxes for Wood Ducks, and of new nesting sites for Canada Geese, Mallard, Blue-winged Teal and Gadwall has evoked an immediate response from the birds. There is no doubt that an extension of this type of work would have marked effect upon the size of the breeding population of these species.

The shift towards habitat management

It is generally accepted that a clear habitat management plan would result in an immediate increase in both the wintering and breeding populations of waterfowl on the Fraser Delta. It would also help to prevent the loss of further valuable habitat, especially if the plan was part of a regional policy for the conservation of beaches and green belts. But until recently both the federal and provincial governments have been reluctant to acquire lands for wildlife management purposes. Similarly, duck hunters, who traditionally regard wildlife as common property, have strongly resisted attempts to place choice habitat in the exclusive hands of any limited group, whether for controlled hunting or sanctuary purposes. However, the deterioration in the quality of duck hunting and the closing of many areas close to the ever expanding suburban developments has made the British Columbia Wildlife Federation, which acts on behalf of the hunters' clubs, receptive to the idea of management policy for the remaining waterfowl habitat.

The development of the Reifel Refuge demonstrated on a small scale the value of habitat management. It also resulted in the decision by Ducks Unlimited (Canada) to extend its work into British Columbia. Together with the federal and provincial wildlife authorities this organisation has contributed to the establishment of a 6,500 hectare (16,000 acre) Wildlife Management Area in the Creston Valley in the interior of British Columbia. A similar Management Area embracing Boundary Bay, the North Roberts Bank, and the islands and waters of the South Arm of the Fraser River would seem an impossible dream if it were not for the fact that a green belt, extending across these areas and the farmlands between them, would also meet many other recreational and environmental needs of Greater Vancouver. Recent developments in regional government have brought the creation of such a green belt within the realm of possibility. Similarly, in some areas of the valley a few hunting clubs have taken the first steps towards the management of specific areas of farmland in co-operation with the owners. Some are now examining the possibility of habitat improvements and the introduction of Canada Geese, Wood Ducks and Mallard. Thus it is a time both of change and of opportunity for waterfowl conservationists in the Fraser River delta.

Acknowledgements

I should like to thank C. Shepard and R. W. Campbell of the Vertebrate Museum, U.B.C., E. W. Taylor and R. D. Harris of the Canadian Wildlife Service for their assistance in collecting data for this paper.

Summary

The Fraser River Delta, British Columbia, has extensive waterfowl habitat with both estuarine and freshwater marshes. Drainage and reclamation has significantly reduced these areas but sufficient remains to support substantial numbers of wintering waterfowl of a wide variety of species. The Delta is also of importance to migrant waterfowl, while small numbers breed there. Industrial and urban growth and increased hunting pressure are having detrimental effects on the wintering waterfowl population and it is vital that the various habitats are conserved, and sanctuaries provided to reduce the disturbance from shooting. The breeding population would benefit from the provision of nesting boxes and protection from predators. Habitat management is seen as the answer to the various threats.

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The Grey Teal at saline drought-refuges in north Queensland

H. J. LAVERY

Introduction

The precise nature of the habitat at which waterfowl ultimately seek refuge from the effects of frequent and prolonged periods of low rainfall in north Queensland, and the behaviour of flocks at these localities were investigated during 1965-1969 and are the subject of a series of detailed papers (Lavery 1972a, b, c).

The Australian Grey Teal *Anas gibberifrons gracilis* breeds during the late summer wet season at inland localities such as the Charters Towers Study Area, moves coastwards to sites including the Ross River Plains Study Area during winter, and eventually inhabits saline areas such as Cleveland Bay Study Area for the remainder of each dry season; occasionally suitable rainfall occurs to provide perennial habitat of all of these types within one district, as in the Lake Buchanan Study Area. These study areas made up the Townsville Study Region (Lavery 1970a, b, 1971).

Habits at saltwaters

(a) Behaviour

Grey Teal used saltwater habitat during the drier months of each year, for varying periods related to the timing and quantity of annual rainfall, particularly that in the adjacent hinterland (Figure 1). Birds first occurred at those saltwaters nearest to freshwaters, that is, usually at upper river estuaries and at saltpans.

Grey Teal at the saline habitat, and nearby freshwaters, were mainly occupied with feeding, locomotion and comfort (Figure 2).

The social organisation was of loosely-bound flocks of pairs, with some unpaired adult and young birds, predominantly males. Immature birds of both sexes were

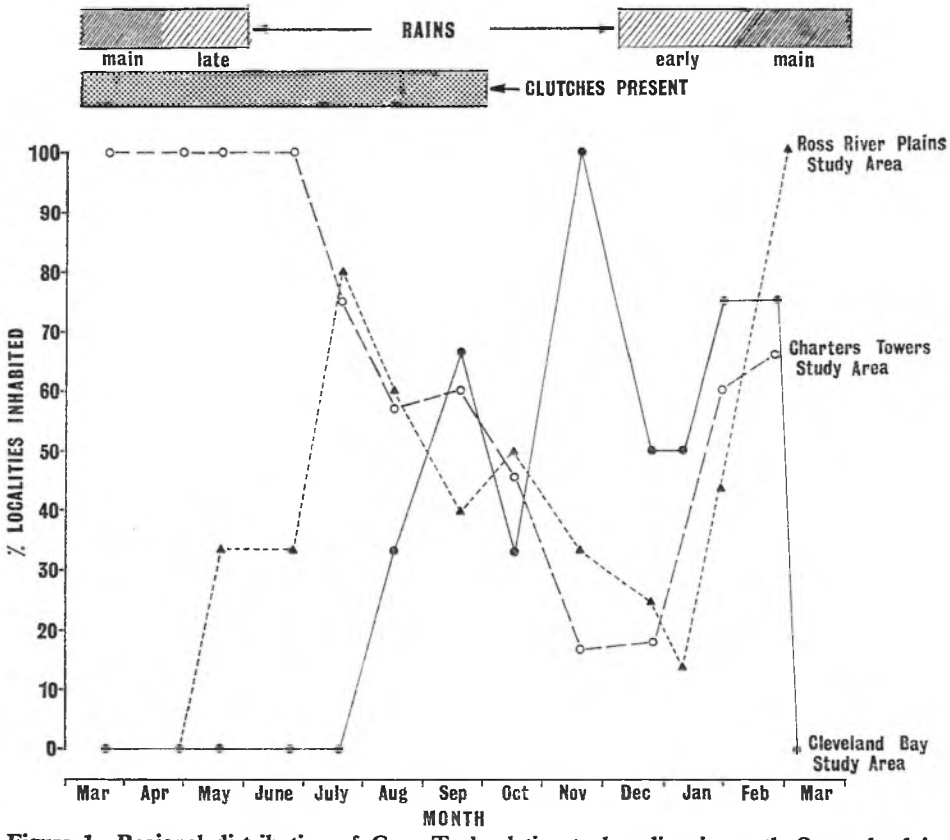


Figure 1. Regional distribution of Grey Teal relative to breeding in north Queensland in the flood year 1968 and late wet season year 1969.

E. E. Jackson

Plate V. Two dabbling ducks that breed in the Falkland Islands (p. 25), though photographed at Slimbridge. Both use freshwater habitats on the islands, especially small pools and upland streams. The Chilean Teal *Anas flavirostris* (above) is much more plentiful than the Chilean or Brown Pintail *Anas georgica spinicauda* (below). Note the young Pintail diving.

Philippa Scott

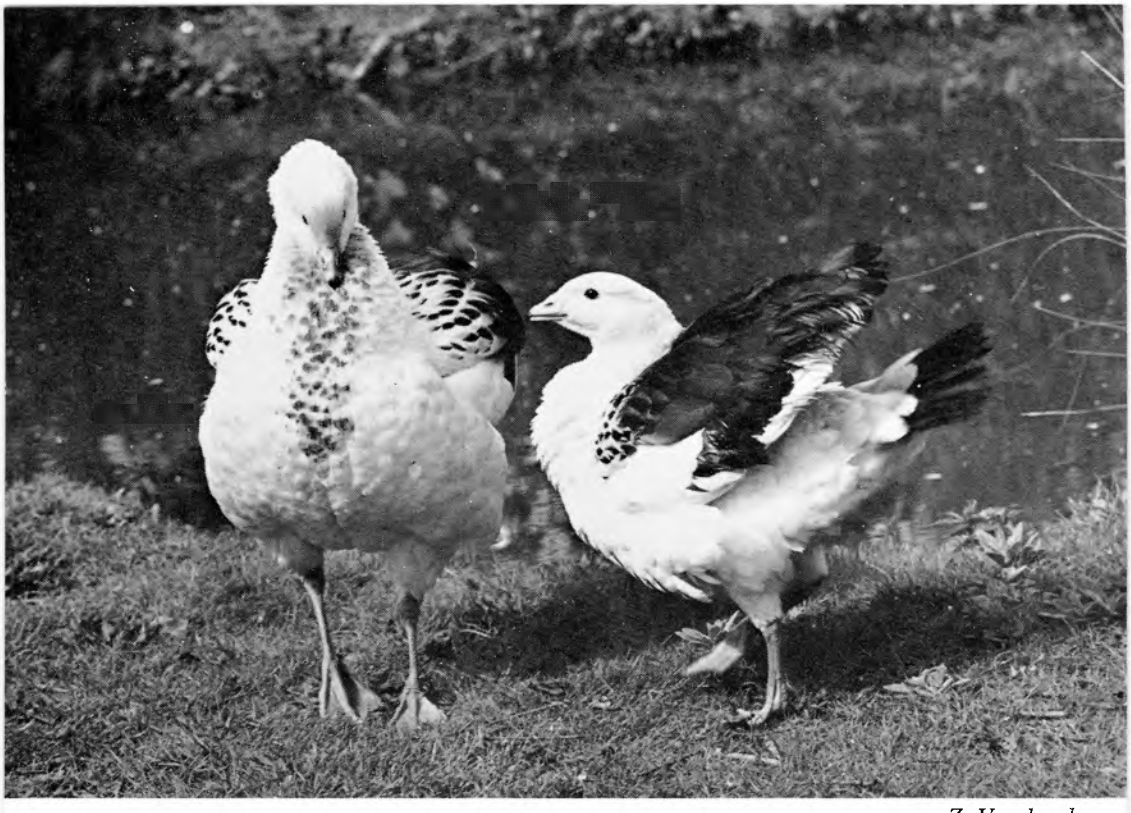
Z. Veselovsky

Plate VI.

Cereopsis Geese *Cereopsis novae-hollandiae* show several behavioural characteristics which separate them from the true (*Anser/Branta*) geese. (Above) The wing-raised, greeting display is reminiscent of 'puffing' in sheldgeese (*Tadornini*) cf. Plate VII).

(Below) The preen glands of the goslings do not function until they are at least two weeks old, and the female rubs on her own oil to make their down waterproof, just as do the primitive screamers (*Chauna*).

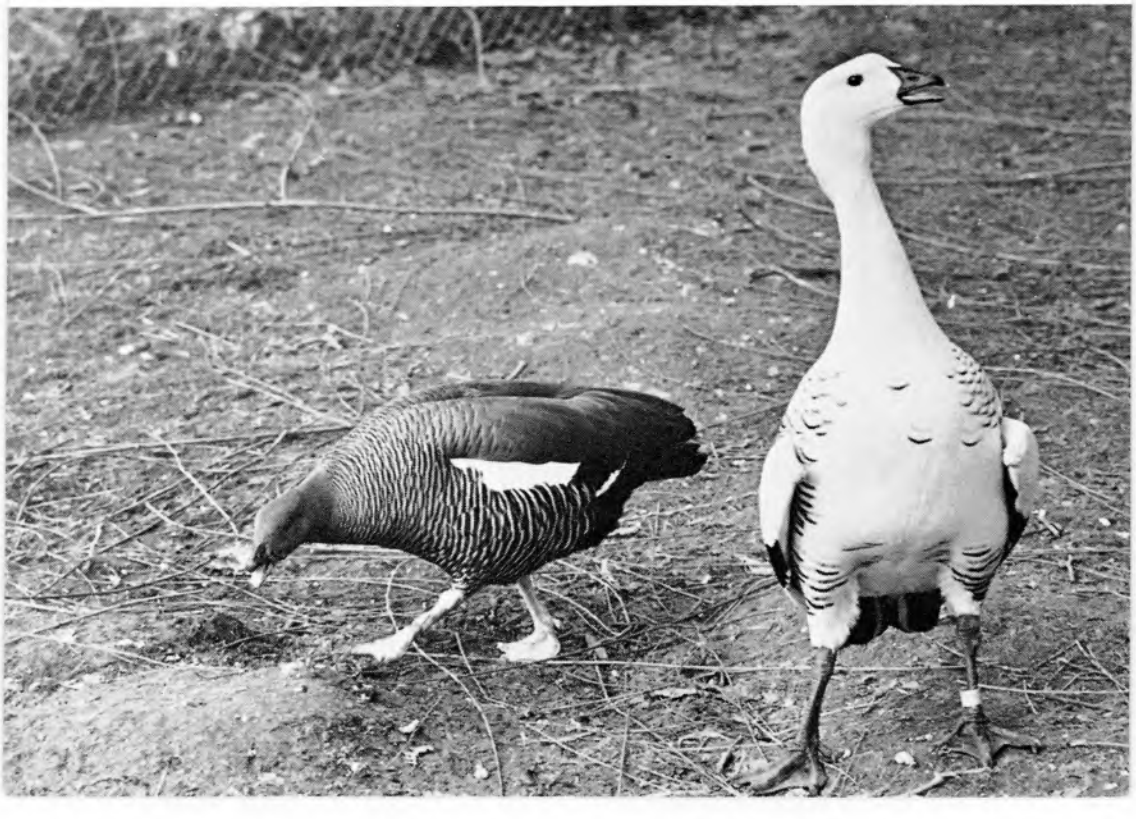
Philippa Scott



Z. Veselovsky

Plate VII. Two displays by pairs of *Chloëphaga* sp. (Above) A male Andean Goose *C. melanoptera* performs the 'puffing' display, 'incited' by his female, while (below) the female Greater Magellan Goose *C. picta leucoptera* 'incites' her mate who stands very erect, whistling. Note the large knobs for fighting on the wings of this highly territorial species.

Z. Veselovsky



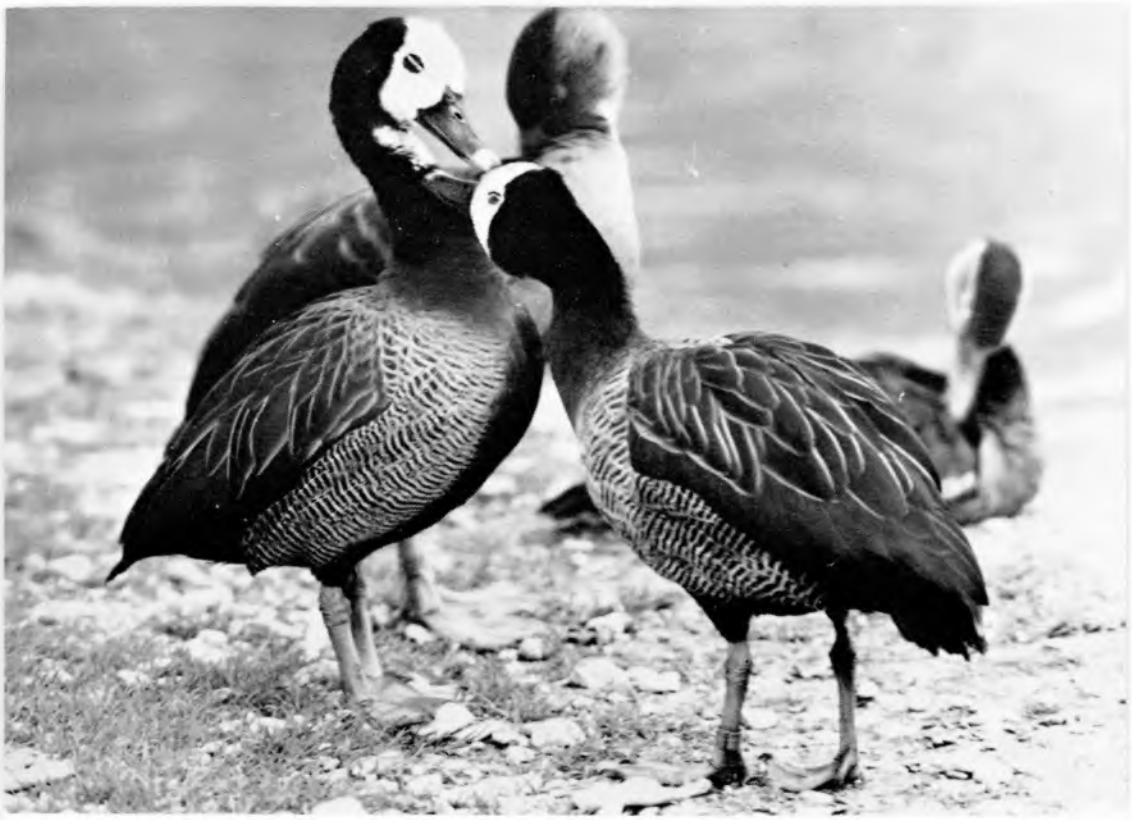


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Plate VIII. Mutual preening is part of the pair-bond maintenance behaviour in monomorphic wildfowl. Here the White-faced Whistling Ducks *Dendrocygna viduata* close their eyes while they preen (above), but the Orinoco Geese *Neochen jubatus* keep theirs open (below).

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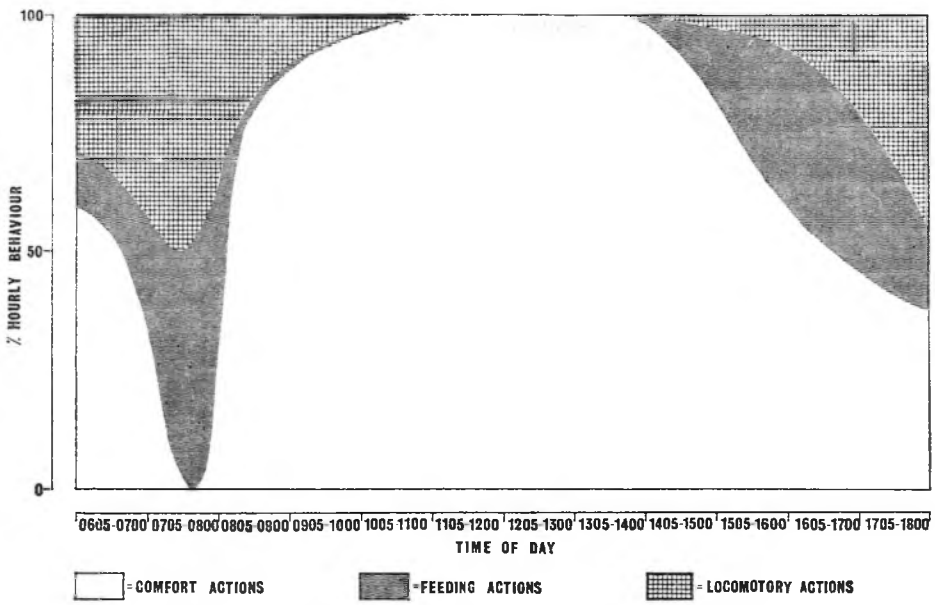

Figure 2. Mean diurnal behaviour of Grey Teal flocks at non-tidal saltwater habitat, Lake Buchanan, Queensland (after Lavery 1972b).

less frequent at saltwaters (1:4.1 adults) than at freshwaters (1:2.3) in samples of 228 birds.

Feeding governed all other activities. At non-tidal areas such as Lake Buchanan, birds fed for approximately five hours before sunset and, less intensely, for some three hours after sunrise. Thereafter they moved to suitable roosting grounds (Figure 2). At tidal localities such as Cleveland Bay, feeding at the water's edge took place at low tides irrespective of time of daylight.

Movements between saltwater and freshwater were rarely seen during daylight, and then at dusk and dawn and following disturbance by shooters. Habits of flocks at night were difficult to determine; night shooting was reasonably successful at some coastal freshwater swamps where no bird was present by day. On the other hand, some individual Grey Teal were seen roosting in the same places at the edge of non-tidal saltwater both at dusk and the following dawn.

(b) Diet

In years when birds arrived early at saltwater habitat, they usually first consumed seeds of coastal club rush *Scirpus littoralis* and other brackish-water plants then abundant. Subsequently the teal, including later arrivals at coastal areas, inhabited localities more and more saline and distant from freshwaters. Two marine molluscs then predominated both in the field and in their diet (Table I). Necklace neritinas *Pictoneritina oualanensis* were distributed in river estuaries confluent with saltpans, mostly below low water spring

Table I. Diet of Grey Teal in north Queensland (after Lavery 1972b).

Food (volume %)	*Ross River Plains Study Area*	*Cleveland Bay Study Area* *Ross River estuary*	*Cleveland Bay*
Seeds of freshwater plants	72	36	1
Freshwater animals	6	35	—
Seeds of brackish-water plants	22	—	—
Sewage effluents (plant seeds)	—	—	33
Marine animals	—	28	38
Necklace neritinas	—	19	23
Elongate little wedge shells	—	1	12
Indeterminable	—	1	28
No. of gizzards examined	107	26	16

tide level. Early in the dry season the sizes especially favoured by Grey Teal were present, but eventually this food became unavailable owing to unsuitable tides and size. Ultimately, birds moved down the estuaries to the tidal flats of open bays where other molluscs, notably elongate little wedge-shells *Amphidesma angusta*, predominated in the field and in the diet.

Although growing through the season, these shells remained sufficiently small to be consumed; calorific value and nitrogen content of shells also increased despite a decline in population density. The calculated maximum daily intake necessary for maintenance was 21,000 shells (occupying 1.5 m^2 × 3 cm. in depth) for an average adult male Grey Teal. This is comparable with that of the European Rock Pipit *Anthus spinoletta*, a bird of somewhat similar habits (Gibb 1956).

In late wet seasons, as in 1969, birds still inhabited saltwaters in February. Annual extreme spring tide flooding of adjacent saltpans then provided large amounts of harpactacoid copepods and blue-green algae *Microcoleus ?chthonoplastes* as food before either freshwater plants seeded or estuarine foods became available again.

(c) Conditions of birds at saltwaters

An improvement in the condition of birds while at saltwaters was clearly demonstrated by the seasonal increase in extent of fat deposition (determined by the method of McCabe (1943)) (Figure 3).

Parasitism by intestinal helminths and malfunction of the alimentary canal through intestinal impactions of fine sand did not occur at important levels. There were negligible changes in competition with associated birds, extent of food supplies, distribution of teal and occurrence of fighting.

(d) Drinking

Deliberate drinking of seawater was never observed although this obviously occurred at freshwaters. Salt water was ingested with marine foods; little was taken in compared with freshwater or compared with salt water consumed by other waterfowl such as Black Swans *Cygnus atratus*. Grey Teal maintained under cage conditions could only survive approximately one week without free fresh water.

No evidence of dehydration was apparent in birds collected from saltwaters. Although the freshwater habitat lacked suitable plant foods during drought, sufficient water remained for drinking. Birds moving to fresh water at night, especially in bright moonlight, provided the harvests of duck shooters.

Unusual ingestion of seeds of *Amaranthus* sp. from freshwaters and of tomato *Lycopersicon esculentum* and passionfruit *Passiflora edulis* from sewage, occurred during drinking (Table I) and was of apparently little value.

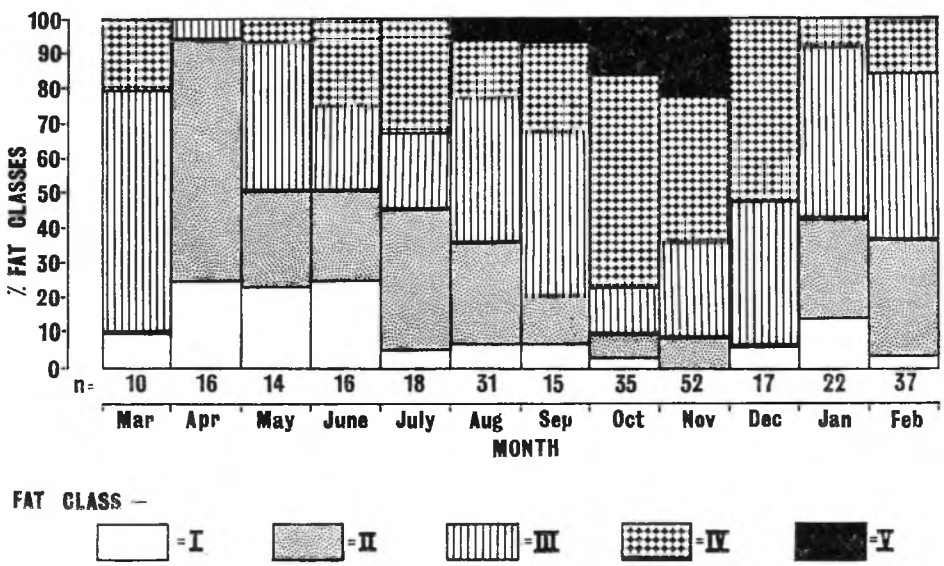

Figure 3. Condition according to extent of fat in Grey Teal collected in north Queensland study areas, 1968-1969 (after Lavery 1972b).

(e) Prolonged return to freshwaters

Time of year for departure varied considerably. Birds left, in all years 1959-1969, after a heavy rainfall of about five cm. following approximately 15 cm. of seasonal rain. The gonads of some males were in breeding condition before departure and before the rain had produced noticeable changes in freshwater habitat. Female oocytes enlarged at coastal freshwater habitat in the course of the birds return to inland breeding grounds. The gonads of birds held in captivity adjacent to coastal saline and freshwater habitat responded similarly to the rains.

Rainfall indirectly encouraged movement by instigating growth of freshwater plants; the birds preference for these could be readily stimulated during the drinking flights.

There was adequate food left at saltwaters after the birds departure; indeed, rainfall exposed abundant marine foods. The seasonal flooding raised water levels less than daily tides. Wet season weather conditions such as large wave actions occurred infrequently.

Apart from the abundant food supply, Grey Teal flock at saltwaters because of similar individual requirements of food and water, the patchy distribution of these resources and the relatively small roosting areas. Advantages to a population include maintenance of sex bonds, appropriate sequential utilization of food resources, attraction of immature birds to different habitat type ('local enhancement' of Hinde (1961)), and recognition ('social facilitation' (Hinde loc. cit.)) of breeding season by association of birds with the few males that responded quickly to appropriate stimuli.

Nasal glands

All Grey Teal examined in north Queensland possessed supraorbital nasal glands, 15.0-18.0 mm. in length and 3.5-6.5 mm. in width in adult birds, broadly similar in form to those described for other Anatidae (see for example Marples 1932).

Differences in individual size of nasal glands were in accordance with changes in sizes of the epithelial cells forming the walls of the lumena of the secretory tubules and, to a much lesser extent, in the length and width of the lumena. Histochemical tests for cytoplasmic basophilia, metachromatic substances and carbohydrates, and lipids/phospholipids, indicated an osmoregulatory extrarenal excretion.

Morphological appearances consequent upon histological structure permitted the glands to be classified readily into a series of stages according to weight. A concise histological basis for differentiation was provided by the secretory tubule lumena. Glands were grouped into three stages depending on whether the majority of lumen diameters were <1 mm. throughout their length (stage I, <165 mg. combined weight), <1 mm. in the distal portions only (stage II, 165-315 mg. combined weight), or >1 mm. throughout (stage III, >315 mg. combined weight).

Nasal gland stages II and III became predominant with increasing salinity of habitat (Table II). Moreover, enlarged nasal glands coincided with periods of saltwater utilization; relatively few birds had large nasal glands in years of widespread flooding, as in 1968. Most birds with stage I nasal glands had gizzard contents comprising only freshwater foods (20 out of 33 gizzards examined); birds with stage II glands mostly had a combination of freshwater and saltwater foods (21/30); and birds with stage III glands had saltwater foods dominating (18/19).

Table II. Frequency of occurrence of nasal gland stages in Grey Teal collected in north Queensland study areas, 1965-1967 (after Lavery 1972c)

Study area	*No. of birds in sample*	*Nasal gland stage*		
		I	*II*	*III*
Charters Towers	28	24	4	—
Ross River Plains	45	31	11	3
Cleveland Bay				
Lower Ross River (estuarine)	28	1	14	13
Cleveland Bay (marine)	37	—	14	23

The function of the nasal glands was tested by injecting saline solutions intraperitoneally, equivalent to amounts ingested with foods during the initial periods at saltwater habitat. Administrations of greater loadings were impracticable. The nasal glands enlarged with time, without concomitant decline in condition of the birds (Table III). After injecting a solution of 867 milli-equivalents per litre of sodium ion and 850 mEq./l. of chlorine ion, nasal gland excretion, collected at the external nares, had a mean concentration of 685 mEq./l. sodium ion and 666 mEq./l. chlorine ion, the concentrated sodium and chlorine balance appropriate to excessive sodium chloride, the major component of local saltwaters. Salts were also removed in lesser amounts in faecal material and urine, by evaporation from the general body surface, and by tears which left crystalline deposits around the eyes.

Table III. Distribution of nasal gland stages and other effects of salt loadings in Grey Teal (after Lavery 1972c).

Treatment	*Period (weeks)*	*No. of birds examined*	*Occurrence of nasal excretion daily*	*Nasal gland stage* I	II
Nil	0	4	—	4	—
1 × 10 ml. 5%-6% NaCl soln.	1	6	+	6	—
1 × 10 ml. 5%-6% NaCl soln.	2	6	+	4	2
1 × 10 ml. 5%-6% NaCl soln.	3	7	+	5	2
1 × 10 ml. 5%-6% NaCl soln.	4	5	+	1	4
1 × 10 ml. 5%-6% NaCl soln.	5	3	+	—	3
2 × 10 ml. 5%-6% NaCl soln.	5	3	+	—	3
1 × 10 ml. distilled water	5	2	—	2	—

Administration of magnesium chloride solution equivalent in concentration to that in local seawaters also produced a nasal excretion.

Allowing for the rate of development of nasal glands, there was a noticeable rise in concentrating abilities with increase in size.

The nasal glands of Plumed Whistling Ducks *Dendrocygna eytoni*, tested similarly and concurrently, also became progressively larger with time and with increased salinity of injected solutions. Body weight changes during treatment were similar to Grey Teal although recovery to normal weights following initial exposure was slower. Concentrations of sodium chloride in the nasal excretions in all instances increased with nasal gland enlargement. Differences from Grey Teal included (i) an insignificant increase in overall electrolyte discharge with progressive exposure, and (ii) a low ultimate level of concentration, reached earlier and covering a smaller range. It is perhaps relevant that waterfowl species that occasionally ingest saltwater foods, such as Black Ducks *Anas superciliosa rogersi*, have glands larger than freshwater species such as the Plumed Whistling Duck but smaller than the Grey Teal. The relative nasal gland size in Grey Teal was closer to that of species sharing links in ecology rather than taxonomy. Table IV compares the foregoing with Maned Goose *Chenonetta jubata*, Lesser Crested Tern *Sterna bengalensis* and Silver Gull *Larus novaehollandiae*.

Moulting

The ability to move to the marine environment, to and from freshwaters for drinking purposes, and eventually from saline areas for breeding is lacking for a part of each year in Anatini. The timing of the wing-moult is therefore important in the present context.

Captive and wild-caught Grey Teal shed and replace feathers within typical tracts during a postnatal, a postjuvenile and an immature moult, each readily distinguishable in young birds. The adult postnuptial and prenuptial moults, distinguishable only by moult of the flight feathers in the former, are usually repeated annually.

The moults of young birds were linked to their breeding seasons by development, and the flightless period was consistently late relative to the moult of other tracts. Immatures generally were not flightless at the same time as adults (Figure 4). Often the postjuvenile and immature

Table IV. Weights of nasal glands in Grey Teal and some commonly associated species (after Lavery 1972c).

Species	*Cleveland Bay Study Area* *No of birds examined*	*Mean relative weight (± S.E.) of combined nasal glands (mg./100 gm. body weight)*	*Charters Towers Study Area* *No of birds examined*	*Mean relative weight (± S.E.) of combined nasal glands (mg./100 gm. body weight)*
Grey Teal	32	89.7 ± 2.06	42	26.6 ± 0.58
Black Duck	2	25.6 (23.0-28.2)	12	18.0 ± 2.69
Maned Goose	5	15.0 (11.4-17.4)	10	16.6 ± 1.18
Plumed Whistling Duck	2	6.3 (5.0-7.6)	17	10.8 ± 0.55
Lesser Crested Tern	15	77.9 ± 3.32	—	—
Silver Gull	41	89.8 ± 2.96	—	—

moults took place at freshwater localities distant from the breeding grounds.

In the adult, replacement of all body feathers was prolonged and variable within and among tracts. Moulting was broadly continuous, occurring at all freshwater and saline habitat types.

Timing of the adult moults, as judged by the commencement of flightlessness, was no more regular than breeding, with which the postnuptial moult clearly was associated (Figure 4). No specific external factor initiated either general body or flight feather moulting, widespread at the same time in other waterbirds. No related loss of weight took place in adults during the protracted body moult; some loss of condition occurred during flightlessness but this was quickly regained.

Adults were flightless during the postnuptial moult for about three weeks (20 ± 4.3 days in 11 captive birds). The period varied, individually, in relation to other feather tracts (Table V), and in time of year. Both isolated birds and flocks moulted at freshwater habitat after the nesting season, the sexes remaining together. An extended breeding season, due to prolongation of the rains, as in 1968, led to postponement of the flightless period (Figure 4).

Adult Grey Teal thus have a highly flexible moult, particularly with regard to flightlessness. It follows that during years of relatively low rainfall when breeding is unsuccessful and saltwater habitat is used extensively, as in 1961, flightlessness can be postponed. This permits continued mobility at the rapidly diminishing freshwaters, and at saltwaters, and avoids

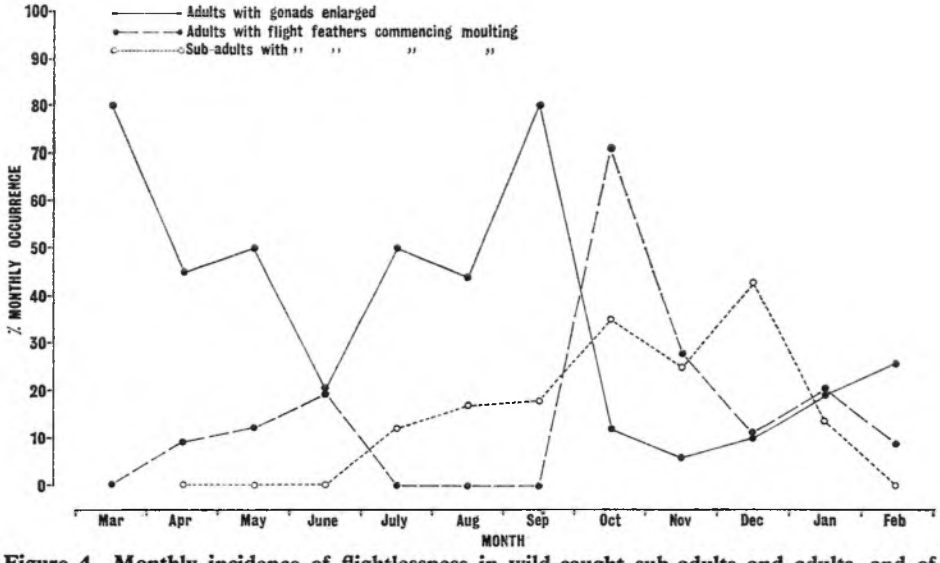

Figure 4. Monthly incidence of flightlessness in wild-caught sub-adults and adults, and of breeding in wild-caught adult Grey Teal collected in north Queensland, 1968-1969 (after Lavery 1972a).

Table V. Relative occurrences of synthesis of remiges in captive adult Grey Teal (after Lavery 1972a).

	Remiges commenced moulting (X)		*Remiges completed moulting (X)*	
Tract	*Before commencement of tract*	*After commencement of tract*	*Before commencement of tract*	*After commencement of tract*
Breast	X	X	X	X
Lower tail-coverts		X	X	X
Crown	X	X	X	X
Nape	X	X	X	X
Scapulars		X	X	
Tertials	X	X	X	X
Alula	X			X
Upper wing-coverts	X	X	X	X
Lower wing-coverts	X	X	X	X

additional loss of condition. The feathers of some birds during such periods are extremely worn.

Discussion

In north Queensland the Grey Teal characteristically used abundant foods available from saltwater habitat during the regular long periods when freshwater habitat was impoverished. Possibly all birds of each local population were involved and 80% of the diet was of marine origin during drought. The extent of dependence could not be fully assessed because of the birds seemingly erratic visits to freshwaters for drinking, when the quality of the atypical foods ingested with this water was unknown.

As birds moved farther from freshwater habitat, the opportunity to rejoin the populations remaining there declined. This was particularly so because the latter were continually on the move and because the saltwater birds flew in to drink water during those hours when freshwater birds were moving.

There was sufficient range and overlap in the times of availability of major food species to allow for the variation in birds habits based on the small annual differences in the pattern of rainfall in north Queensland. The use of saltwaters became less valuable the farther a bird moved from its breeding ground. For nomadic populations from southern Australia, there was little opportunity to synchronise their movements with the availability of those foods that facilitated the gradual process of acclimatization to saltwater habitat—particularly the enlargement of nasal glands to counter the excessive body salt loadings.

The general improvement in condition of birds during the period when saline drought-refuges were sought and occupied was in accordance with their limited activity, the continued occurrence of a suitable quantity and quality of food, and the absence of deleterious factors. This circumstantial evidence of good survival must be advanced because dead birds could not be located and because of the practical difficulties in banding.

Sex and age ratios stabilised at saltwaters following the decline from a high proportion of immatures in adjacent freshwater flocks. These latter birds did not possess enlarged nasal glands, indicating an avoidance of saline habitat, to be expected of freshwater-drinking birds about to become flightless.

The young from parents that bred sufficiently early in the year to allow their maturation could follow the sequence of foods leading to the marine environment, and had an advantage over later-bred birds. Birds that bred near to, although not necessarily beside, the saltwaters would thus be the most successful.

Because the Grey Teal is a highly fecund species, survival during the period at the saline drought-refuge implies mortality elsewhere, the local population remaining reasonably stable. The late immatures, accompanied by some parents, could be forced to move widely as nomadic flocks in search of freshwaters at which to moult, with small chance of survival (see also Frith 1963). The greatest mortality amongst the remainder may be due to starvation of birds at recently inundated freshwater habitat while returning to inland breeding grounds. Similar seasonal mortality has been described by Ward (1965) for the African passerine *Quelea quelea.*

It is important to relate the peculiar habits of the Grey Teal in north Queensland to general waterfowl conservation practices, which notably provide only protected freshwater habitat. The species is physiologically equipped to utilise a permanent over-abundance of marine food, so long as fresh water is near for drinking. Provision of sufficient freshwater localities along a coastal region could encourage a local saline drought-refuge population, although probably at the expense of adjacent districts; 16 of the 22 permanent freshwater localities nearest to Cleveland Bay were artificially constructed for other purposes. Provision of foods at these either by natural growth or artificial production is clearly unnecessary. The emission of fresh water into the sea, as at sewage outlets, is beneficial to Grey Teal, particularly in view of the relative impermanence of other artificial wetlands. (Lavery and Blackman 1971).

It is unnecessary to protect drinking localities against shooting because of the irregular nocturnal habits of the birds and the present low hunting pressure. Some additional pressure would not be harmful because the loosely-bound flocks can retreat out of reach to the sea. However, too severe exploitation could permanently affect a wide-ranging population limited by a sequence of food sources leading and conditioning birds from freshwaters to the sea after rapid breeding and moulting.

The physiological adaptation displayed by Grey Teal during periods of drought does not require the additional complex behavioural adaptations of species such as the Plumed Whistling Duck which

survive dry seasons by becoming gregarious upland grazers while remaining at freshwater habitat. Management effort should be concentrated on these species.

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Summary
Investigations were made of Grey Teal *Anas gibberifrons gracilis* in north Queensland, particularly at saltwater habitat during 1965-1969.

Non-breeding, mainly adult birds utilised saline areas during the annual dry seasons especially in droughts. The sequence of diet imposed by availability and by the birds physiological capabilities, was from brackish-water plant seeds in saltpans, to marine molluscs along open bays. Foods at the ultimate drought-refuge, mostly bivalve molluscs, were of sufficient quantity and quality to bring all birds into extremely good condition. Contact was maintained with freshwater habitat for drinking.

Departure from saltwaters was initiated by males after the wet season rainfall; a less strict sequence of decreasingly saline localities was quickly visited during the return to the breeding grounds while gonads of females became active. A preference for freshwater foods, coupled with breeding requirements, enforced departure despite the suitable food supplies still at saltwaters.

Use of saline areas for foods resulted in increased ingestion of salts. Functional supraorbital nasal glands provided the chief means of maintaining ionic balance; this physiological adaptation by Grey Teal is modest compared with the complex behavioural changes required of other local waterfowl.

The use of saltwater habitat with freshwater contact was facilitated in adults by an adjustable flightless period during the postnuptial moult; the disadvantages of lessened mobility and condition were thus delayed when necessary. Flightlessness during the immature moult was stereotyped and the advantage clearly lay with early-bred birds.

The majority of the population of Grey Teal in the region remained in good condition during drought. Mortality of such a highly fecund species was apportioned to late-bred immatures incapable of using saltwater habitat, and to birds returning to breeding grounds over drought-recovering countryside.

In north Queensland the general management techniques currently practised during drought to protect waterfowl are adequate for the Grey Teal population; the peculiar habits of this species confer additional insurance against the effects of an essentially arid environment.

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Icelandic Greylag Geese wintering in Britain in 1960-1971

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The Wildfowl Trust has, since its inception in 1946, devoted substantial efforts to the study of the distribution and abundance of wild geese in Britain. There are two justifications for doing so: first, to ensure that man-made threats to the birds and the places where they live are recognised promptly; second, geese visiting Britain provide exceptionally favourable material for investigating the population dynamics of large, mobile and long-lived animals. From both points of view the protracted investigations made by the Trust are increasing greatly in value as they are continued. Long runs of information are needed to give perspective and pattern to changes from year to year and from place to place that might otherwise appear haphazard or be incorrectly attributed to unimportant causes. This paper brings up to date accounts by Boyd (1959, 1963) of the winter distribution of Greylag Geese *Anser anser* in Britain and amplifies recent reports on annual changes in their numbers (Ogilvie, in Sedgwick, Whitaker and Harrison 1970; Boyd 1972).

There are small numbers of native Greylags breeding in Scotland and feral Greylags are now found in several parts of Scotland and England. This account is focussed on the much more numerous immigrants from Iceland. Over most of their present winter range those immigrants do not normally encounter the native and feral geese (Figure 1), though they do so regularly in Wigtownshire and the status of some small groups found elsewhere, particularly in the Inner Hebrides, remains uncertain.

The principal source of information is a series of censuses conducted in early November each year since 1960, in which nearly all the known haunts of Greylags have been inspected regularly. Additional data are provided by similar censuses made in March from 1963 to 1967 and by observations made within the framework of the National Wildfowl Count scheme (Atkinson-Willes 1963) during the months October-March at some of the roosts used by Greylags. Observations made in several localities in October and November on the proportion

of young geese and on family size are also helpful in understanding the changes in total numbers from year to year.

To anticipate results reported in later sections, the wintering population has greatly increased and the increase has been accompanied by substantial quantitative shifts in distribution though little change in range. As in nearly all studies of mobile animals, the analysis of causes of change is complicated by the imperfections of the data. Whether intensification of effort in counting or in other ways could improve the interpretation of the results sufficiently to justify substantial additional costs is a point for discussion.

The November censuses are conducted concurrently with those of Pink-footed Geese *Anser brachyrhynchus*. An account of the procedure was given by Boyd and Ogilvie (1969) in their report on changes in Pinkfoot numbers and need not be repeated at length. The method is to station observers at or near each roost known to be used at all regularly by either species and for the geese to be counted either while feeding nearby, on the roosting site itself, or while flying into or out of the roost. More than one count is obtained wherever possible, by duplication of observers and by the participants making repeated counts. When large numbers of geese are involved it may be necessary to estimate in units of 10, 50, or 100, rather than count individuals. The counts are restricted to one weekend, that closest to 10th November, by which date immigration of both species is virtually complete. Comparatively little shooting of Greylags occurs in Britain prior to that date, so that the number determined represents the total of adults and birds of the year that left Iceland and survived migratory flights of 950 to 1,500 kilometres.

Though the counting skill of the observers may differ and bad weather may make the task difficult, thus introducing an inescapable lack of rigour, the November censuses have proved reasonably self-consistent, although the same claim cannot be made for the numbers of geese recorded in the monthly Wildfowl Count samples.

The March censuses, though consistent with each other, failed to record sufficient geese to be compatible with the November figures, probably because in late March some geese do not consistently return to roost on permanent water and also because emigration may have begun. Even an extensive network of observers scrutinizing well-known tracts of country used by geese could not always be relied upon to produce a 'total count' at this time of year. Both Greylags and Pinkfeet are aggregated in larger flocks in autumn than later in the winter and are also then much less prone to 'park out' (Brotherston 1964) in grass fields or on moss or wetlands. It is justifiable to assert that the November counts from 1960 to 1971 have included a very high proportion of all the Icelandic visitors and that the proportion missed has not had a seriously distorting effect either upon the picture of year to year change or upon the pattern of distribution in early November.

In some ways Greylags are easier to find and to count than Pinkfeet: they less often occur in large flocks (of over 1,000 birds); they rarely fly more than a few kilometres to feed; they often leave the roost well after sunrise and return to it long before sunset; and relatively few frequent large estuaries which are difficult to oversee completely. The disadvantages in counting Greylags are that they occupy a larger number of roosts; their range includes parts of the country that are topographically complicated and with few local bird-counters; and they have a greater propensity for shifting from one roost to another on successive nights. The differentiation of immigrants from 'locals' in areas where there are native or feral geese is a difficulty confined only to Greylags amongst the British geese, and a difficulty that is growing with the spread of feral birds, though in the national aggregate errors in classification cannot have been important during the period of this study. A small proportion of the immigrants moves on to Ireland, but the number reaching there by early November is negligible. Even in mid-winter there are now fewer than 1,000 Greylags in Ireland (Cabot 1969), although the great decline in Greylag abundance during the previous twenty years (Ruttledge and Hall Watt 1958) has been checked since about 1966 (Flegg 1971).

Numbers in early November

The records of geese found in the November inventories are assembled in Tables I and II. Though most of the roosts are listed separately, some that are close together and are used concurrently or alternatively are grouped for simplicity. Records from scattered sites used infrequently are also amalgamated (for example in 'other Fife') to save space. Sufficient examples of individual sets of numbers remain to give an impression of the variability found at sites in persistent use and also to illustrate that some roosts ceased to be used during the last decade,

Table I. Numbers of Icelandic Greylag Geese found in Scotland and England in early November, 1960-1971.

Roosts listed from north to south and grouped by regions (see Figure 1). To reduce the size of the table, counts from nearby roosts that are used as alternates are grouped, as are records from infrequently used sites. In those cases the maximum number of sites used is shown in parenthesis after the group name. The rounding-off is that of the observers. No entry = not searched; — = no geese seen. Observations of native and feral geese have been omitted.

Region and site	*1960*	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*
Moray												
Orkney	—	—	—	—	—	28	—	—	45	26	—	—
Dornoch F. (2)	—	—	9	200	28	18	—	—	—	—	—	—
L. Eye	—	91	230	500	207	1750	1850	750	320	650	820	680
Cromarty F.	150	120	250	322	—	260	—	80	1700	600	—	500
Munlochy	4000	—	95	220	250	—	—		—	259	390	500
Beauly F.	406	—	164	—	349	40	700	350	335	374	50	281
Alturlie (2)	—	200	230	—	—	—	—	—	115	—	—	40
Moss-side				286	200	300	860	26	—	240	10	—
Findhorn (3)	—	—	—	—	110	—	—		552	21	—	46
L. Spynie	1220	472	850	798	1350	850	750	630	240	320	580	480
Insh			24	85	37	300	35	110	170	—	—	
Aberdeen												
L. Strathbeg	53	1166	1008	1200	3734	2200	3338	2000	800	4380	2600	4500
Ythan (3)	46	654	500	500	1200	326	642	3000	3610	9371	2070	4281
Kemnay		390	100	695		—	200	270	210	275	240	200
L. of Skene	—	—	—	—	150	—	330		190	700	1500	390
Angus and Perth												
Montrose	210	300	98	430	324	51	176	—	300	130	300	140
Forfar (2)	150	—	—	—	500	—	735	—	—	200	150	370
Lintrathen (2)	2150	4630	5900	4450	3350	3100	5050	5750	8480	9200	9800	8150
Blairgowrie (8)	3360	7330	7300	7030	10000	7370	15850	13050	10300	8650	12070	7690
Strathtay		225	89	47	514	150	340	1200	150	450	500	700
Rannagulzion	—	—	850	104	44	500	—	—	—	500	500	—
Drummond	2750	2800	2800	2984	4312	6000	10242	8050	9766	6116	7040	6290
Carsebreck	1150	3430	5500	4500	2337	4130	2400	3000	8280	780	5590	4470
L. Vennacher										180	20	162
L. Rusky	400		530	35	250	—	1	—	—	—	—	—
L. of Menteith	30	—	24	395	—	130	210	970	670	220	1000	600
Dupplin (3)	2302	40	390	780	380	690	1020	1925	1080	790	530	1500
Glenfarg	—	—	—	—	—	—	866	—	—	720	1500	410
Monikie	110	—	—	—	—	—	—	—	—	—	280	—
Firth of Tay	350	2000	366	120	1242	—	514	—	720	—	—	10
Fife and Kinross												
Cameron R.	2000	900	400	1500	1500	150	250	250	250	300	100	450
Kilconquhar	25	3	—	—	12	250	—	230	370	—	380	1896
Ballo	—	—	9	—	10	—	450	—	5	—	—	—
Carriston	—	—	—	—	—	—	—	150	185	850	40	650
other Fife (7)	100	—	16	22	70	—	28	640	63	—	—	36
L. Leven	—	350	1500	340	1200	1200	2180	680	1189	1013	1700	2520
Alloa	83	14	15	—	12	—	—	—	16	—	10	—
SE. Scotland												
Cobbinshaw	—	—	—	—	—	—	—	40	13	40	12	120
Harperrig	30	—	145	440	900	296	160	300	58	1800	750	270
Threipmuir	250	420	150	400	1050	800	250	580	140	450	—	110
Westwater	—	—	—	—	—	—	—	3	24	30	—	—
Portmore	—	—	—	—	710	—	420	—	—	700	310	360
Gladhouse	25	240	280	280	500	300	320	950	1090	800	2350	680
Watchwater	95	210	290	180	280	300	220	260	520	580	250	415
Hoselaw							50	450	312	440	650	930
other Lothians	—	—	30	—	300	25	190	—	10	1110	64	50
West Scotland												
R. Endrick	—	340	400	451	—	336	300	900	450	870	400	800
Lenzie	—	—	365	—	27	—	45			429	360	570
Hamilton (2)	14	—	—	—	—	—	—			—	—	—
Lochwinnoch (2)	50	8	—	—	—	—	—	—	—	6	—	—
Ayrshire (4)	63	62	243	166	161	1	10	—	164	10	100	366
Bute												
Bute (5)	1650	1220	2200	530	690	6300	3500	2500	3010	685	1150	1640
Arran		902		410			300	150		—		
Argyll												
Crinan	100	159	500	300	300	114	500	300	527	300	330	300
Carse					700	400	350	330	350	350	250	350
Kintyre (4)				220	190	400	221	117	383	369	110	828
Colonsay	436	142	109	83	—	13	—					
Islay			450	—	665	217	120	170	300	180	200	210
Solway												
C. Kennedy (3)	700	3800	3800	65	1630	3080	1850	800	300	2000	2500	2500
Bladnoch	407	500	80	300	—	—	125	6	384	363	530	704
Wigtown Bay	—	350	—	—	100	40	400	89	54	—	—	—
Fleet Bay (2)	—	34	111	—	80	21	80	100	—	15	10	—
L. Ken	—	325	250	150	900	250	117	350	395	300	580	550
Threave	350	360	550	120	220	1500	500	155	500	500	500	600
E. Kirkcudbright (3)	—	—	—	—	—	—	—	600		340	550	599
Lochmaben (2)	544	244	325	200	317	157	340	187	100	—	240	277
Caerlaverock	340	100	400	7	120	80	360	—	30	272	240	30
other Dumfries	—	—	—	—	—	—	—	—	—	55	420	325
Rockcliffe	—	72	150	—	—		9	—	250	—	40	14
Eden Valley							300	120	700	900	900	700
Northumberland (2)	25	39	132	300	105	150	135	150	110	480	480	757
Lancs. and West'd												
Kent est.	120	120	209	213	73	43	79	—	—	—	—	—
other (2)	12	—	—	26	—	—	—	38	—	—	—	—
Total (to nearest hundred)	26300	34800	40400	32400	43800	44400	58100	52600	60800	61800	64500	62600

while other new sites were adopted, sometimes as substitutes for those abandoned. In most cases of marked change some alteration in local circumstances can be found that might account for the shift. Since our concern here is with the national picture and a search for causes of broader scope, a detailed examination of particular cases would be inappropriate, but a few may help to show how changes in the site itself may be important.

In the south-east of Scotland, where most roosts of both Pink-footed and Greylag Geese have long been on man-made reservoirs, newly constructed reservoirs have quickly been occupied by geese. Watchwater, completed in 1954, is the most important one to be taken over by Greylags. Few Greylags have attempted to use the Westwater Reservoir, which has into the autumn, the geese have managed to increase. The Lake of Menteith provides another instance of a site formerly much used by geese that fell out of favour during the 1950's and has now been reoccupied, despite increased human activity.

A site-by-site review of the changes during the decade does not itself lead to a full understanding of how the increase in the total population from 26,300 in November 1960 to 64,500 in November 1970 has been achieved and accommodated. It is helpful to group the roosts into regions and compare the changes within and between them (Table II). The boundaries used (shown in Figure 1) are drawn through geographical breaks between groups of roosts. No convenient breaks occur in east central Scotland,

Table II. Regional totals of Icelandic Greylag Geese found in Scotland and England in early November, 1960-1971. Thousands of geese, to nearest 0.1; + = less than 50.

Region	*1960*	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*
Moray	5.8	0.9	1.9	2.5	2.5	3.5	1.9	1.9	3.5	2.5	1.8	2.5
Aberdeen	0.1	2.2	1.6	2.4	5.1	2.5	4.6	5.3	4.8	14.7	6.4	9.4
Angus and Perth	13.0	20.7	23.8	20.9	23.3	22.1	37.4	33.9	39.7	27.9	39.3	30.1
Fife and Kinross	2.2	1.3	1.9	1.9	2.8	1.6	2.9	1.9	2.1	2.2	2.2	5.6
SE. Scotland	0.4	0.9	0.9	1.3	3.7	1.7	1.6	2.6	2.7	6.0	4.4	2.9
West Scotland	0.1	0.4	1.0	0.6	0.2	0.3	0.4	0.9	0.6	1.3	1.3	1.7
Bute[1]	1.7	2.1	2.2	0.9	0.7	6.3	3.8	2.6	3.0	0.7	1.2	1.6
Argyll[2]	0.5	0.3	1.1	0.6	1.9	1.1	1.2	0.9	1.6	1.2	0.9	1.7
Solway	2.3	5.8	5.7	0.8	3.4	5.1	4.1	2.4	2.7	4.8	6.5	6.3
Northumberland	+	+	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.5	0.5	0.8
Lancs. and West'd	0.1	0.1	0.2	0.2	0.1	+	0.1	+	0	0	0	0
Total	26.1	34.8	40.4	32.4	43.8	44.4	58.1	52.6	60.8	61.8	64.5	62.6

Notes:
1. Bute count liable to be seriously incomplete in 1960, 1962, 1964-65.
2. Argyll count certainly incomplete in 1960-1963 and probably incomplete throughout period.

become a major haunt for Pinkfeet. The return of geese to Cobbinshaw Reservoir, which was probably the most important goose roost in the Lothians 30-40 years ago, seems to have followed some reduction in the human disturbance which had led to its desertion. A former haunt of some note, the Clyde valley from Bothwell Bridge to Hamilton Low Parks (listed in Table I as 'Hamilton'), was finally abandoned shortly after 1960, because of disturbance and destruction of some of the best feeding and roosting areas by motorway construction and other irreversible activities. In a few places, however, Greylags have persisted very close to heavily-settled and industrialized areas. The group using a flooded mining subsidence at Lenzie is a striking example. In Perthshire, the desertion of Loch Rusky followed disturbance by fishing and boating. At Rescobie Loch, near Forfar, where sailing continues well where the administrative county boundaries between 'Angus and Perth' and 'Fife, Kinross and Clackmannan' are followed, except that the whole of the Firth of Tay is assigned to Fife. (In recent years, although Greylags feeding on both the north and south shores have roosted on the inner firth, more have fed in Fife than in Angus or Perth; that was not so before 1960.)

In nearly all years a few roosts likely to have been occupied had either not been discovered or could not be inspected at the time of the census. However, the numbers missed were small in relation to the national total and it has seemed better to base most of the subsequent descriptions on the unadjusted counts, rather than engage in more or less elaborate exercises in interpolation. The national totals used here differ slightly from those published by Ogilvie (1970) and Boyd (1972) for that reason and also because

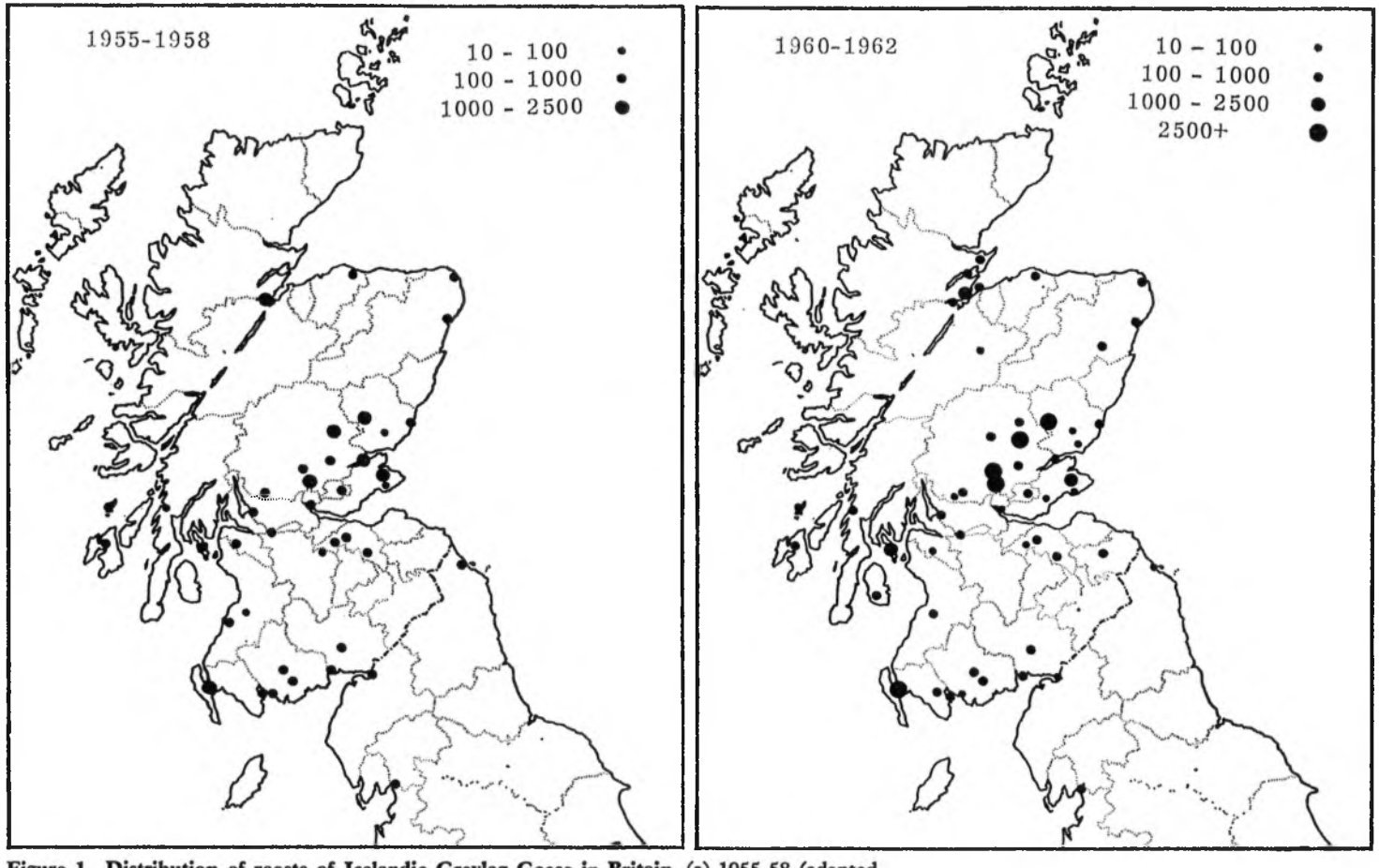


Figure 1. Distribution of roosts of Icelandic Greylag Geese in Britain. (a) 1955-58 (adapted from Boyd 1959). (b) 1960-62 (adapted from Atkinson-Willes 1963).

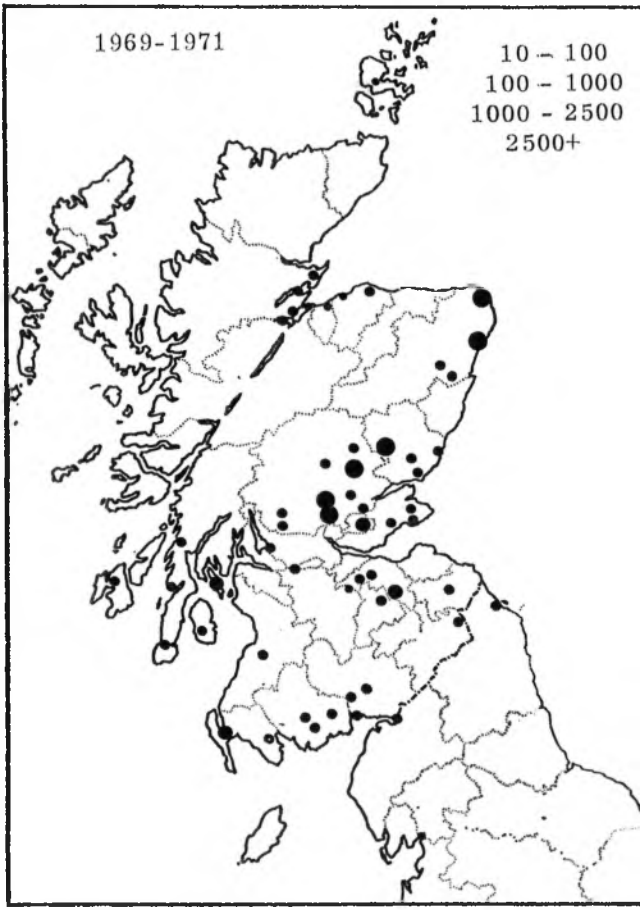
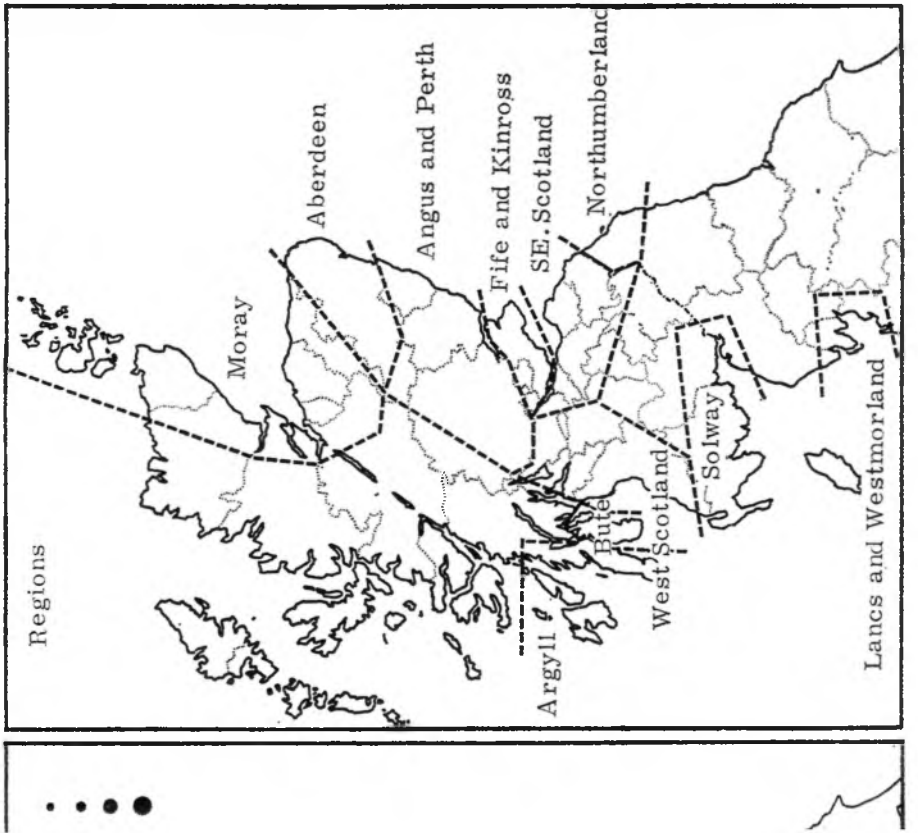


Figure 1. (c) 1969-71. (d) Regional boundaries and names.


Regions
Moray
Aberdeen
Angus and Perth
Fife and Kinross
SE. Scotland
Northumberland
Argyll
Bute
West Scotland
Solway
Lancs and Westmorland

of the exclusion from Table I of all geese believed to be feral or native.

The decision to use unadjusted counts leads to difficulties in estimating changes in numbers in two regions, Bute and Argyll. Buteshire comprises the islands of Bute and Arran and the two have been treated together in compiling Tables I and II. But the irregularity of observations on Arran makes it preferable to consider only records from the group of roosts on the island of Bute in looking at trends. The data from Argyll are particularly unsatisfactory. The haunts of Greylags in Kintyre and Knapdale were not covered adequately until 1964. None of the Inner Hebrides other than Islay has been reported on regularly, and some, perhaps all, of the geese there may be native or feral rather than Icelandic. Thus it seems best to omit Argyll from the comparisons between regions.

Table II shows marked differences between regions in the rate of population growth and in the scale of fluctuations. These may be appreciated more easily from Figures 2 and 3. The changes in regions are compared with the national growth in Figure 4 by means of five-year moving averages standardised to a base of 100 in 1962. This suggests that the rate of growth in Angus and Perth has largely determined that for the population as a whole, if only because that region has held almost three-fifths of the Greylags in Britain in November throughout the 1960's. More interestingly it suggests that, whereas the rate of gain nationally has been nearly linear, in Aberdeen and south-east Scotland it has been accelerating in recent years.

In Angus and Perth the steady growth has been upset in two recent years, 1969 and 1971, when, apparently in response to an unusually early and clean pick up of the cereal harvest in those counties, the numbers fell there noticeably. The consequent redistribution to other areas is seen most clearly in Aberdeen and in Fife/Kinross. In the former area, however, there has been an independent increase affecting both major haunts, the reasons for which are not clear. The furthest north area, Moray, shows no

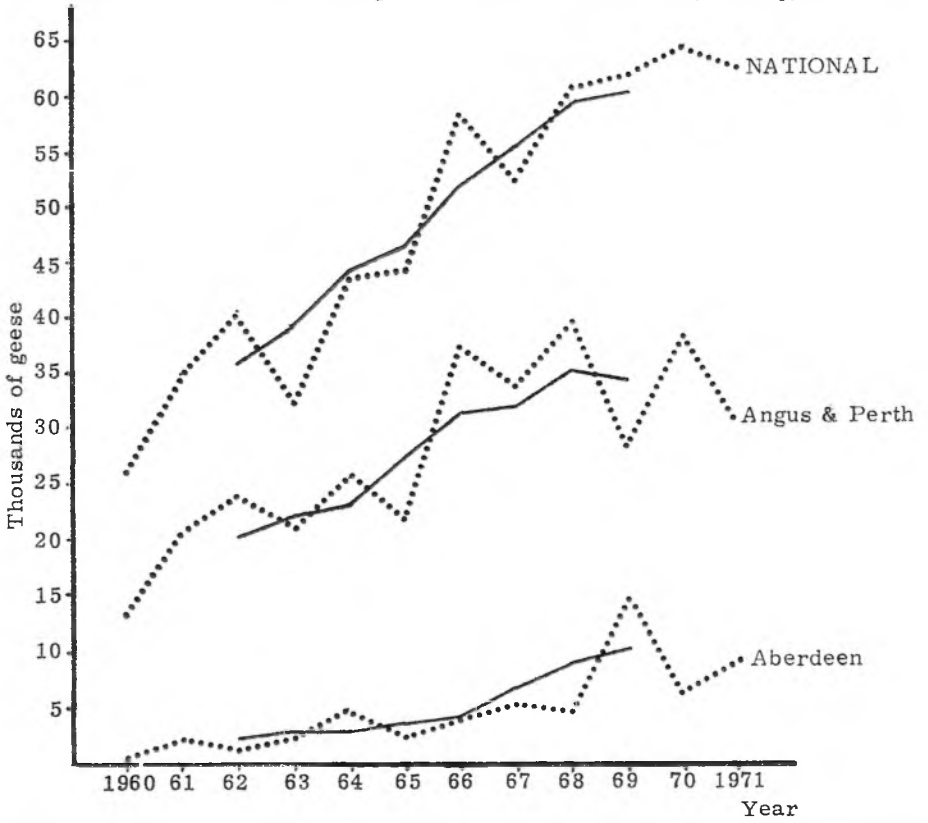


Figure 2. Numbers of Icelandic Greylag Geese found in Britain in November, 1960-1971. The middle and lower series of points record the numbers in Angus and Perth and in Aberdeen respectively. The solid lines are 5-year moving averages.

trend, but considerable fluctuation within the limits of the relatively small numbers involved. A similar pattern was true of Fife/Kinross until the recent upsurge, which may, however, be associated with the abnormal situations of 1969 and 1971. It is perhaps surprising that more changes have not taken place in this area in view of the massive alterations in Angus and Perth immediately to the north. The very small numbers in West Scotland and in Northumberland also showed a surge in recent years which can be linked with 1969 and 1971.

The most marked variations over the period can be seen on the Solway where

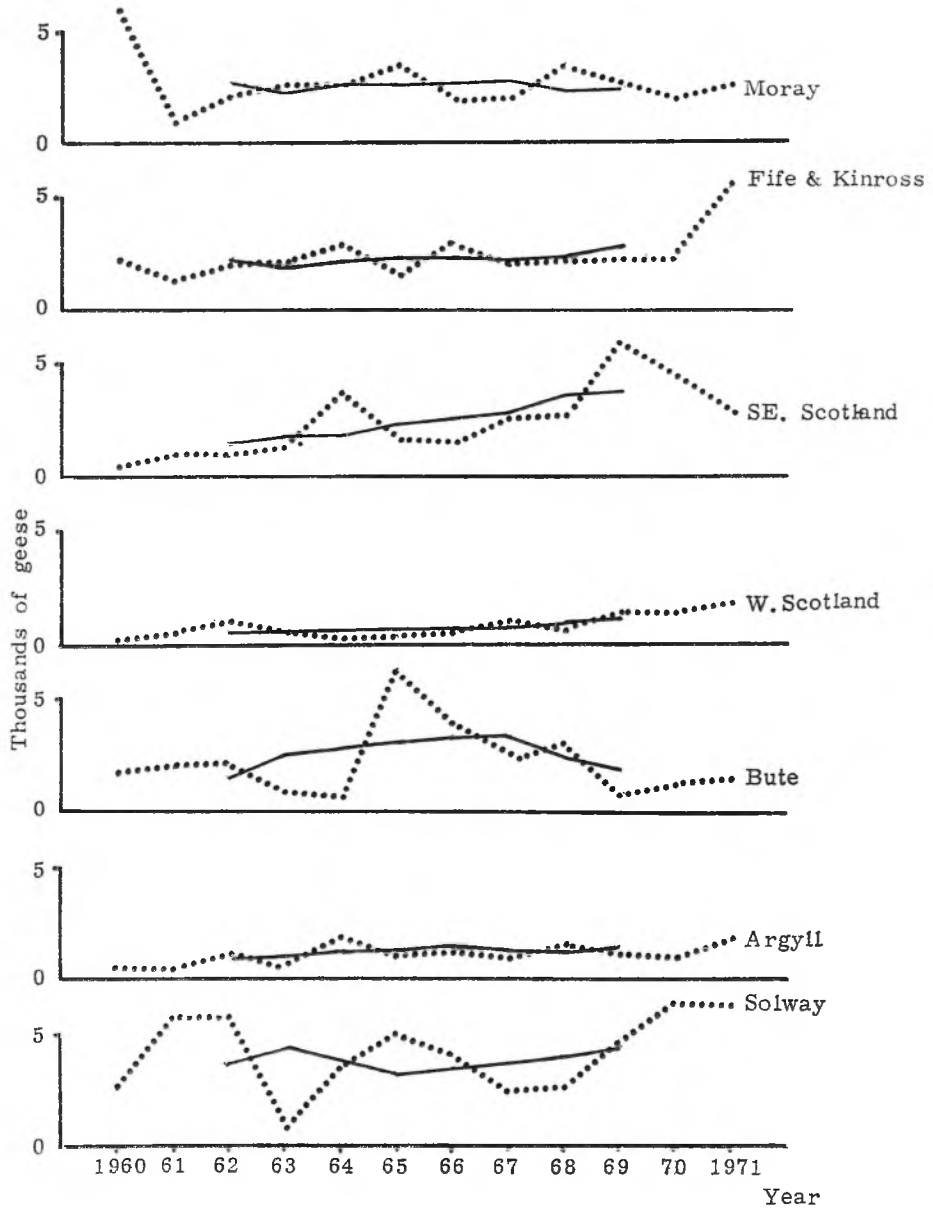


Figure 3. Numbers of Icelandic Greylag Geese found in different regions of Scotland and northern England in November, 1960-1971, with 5-year moving averages. (Aberdeen, and Angus and Perth, see Figure 2.)

there have been successive periods of high and low numbers. There is no obvious explanation for this. The only clear example of absolute decline comes from the north-west of England where the small and long-dwindling stock of immigrant Greylags has just about disappeared. On Bute, where a decline is noticeable since the mid-1960's, there have been determined attempts to reduce the number of wintering Greylags following complaints of agricultural damage.

The growth of the Icelandic Greylag population as a whole can only have been achieved by an excess of recruits over losses. The only way in which redistribution within Britain can have assisted that result is by reducing losses. However the distribution in early November is most unlikely to be decisive in determining losses, because November is not a critical period for food supplies, hard weather or mortality due to shooting. Thus a crucial question becomes: do the geese found in various sites in November experience correspondingly different mortality during their subsequent stay in Britain? Alternatively, has a reduction in losses been associated with changes in mid-winter distribution not necessarily related to the distribution in early November?

The question cannot be answered directly, because there are no data measuring losses due to shooting or to other causes. The simplest indirect

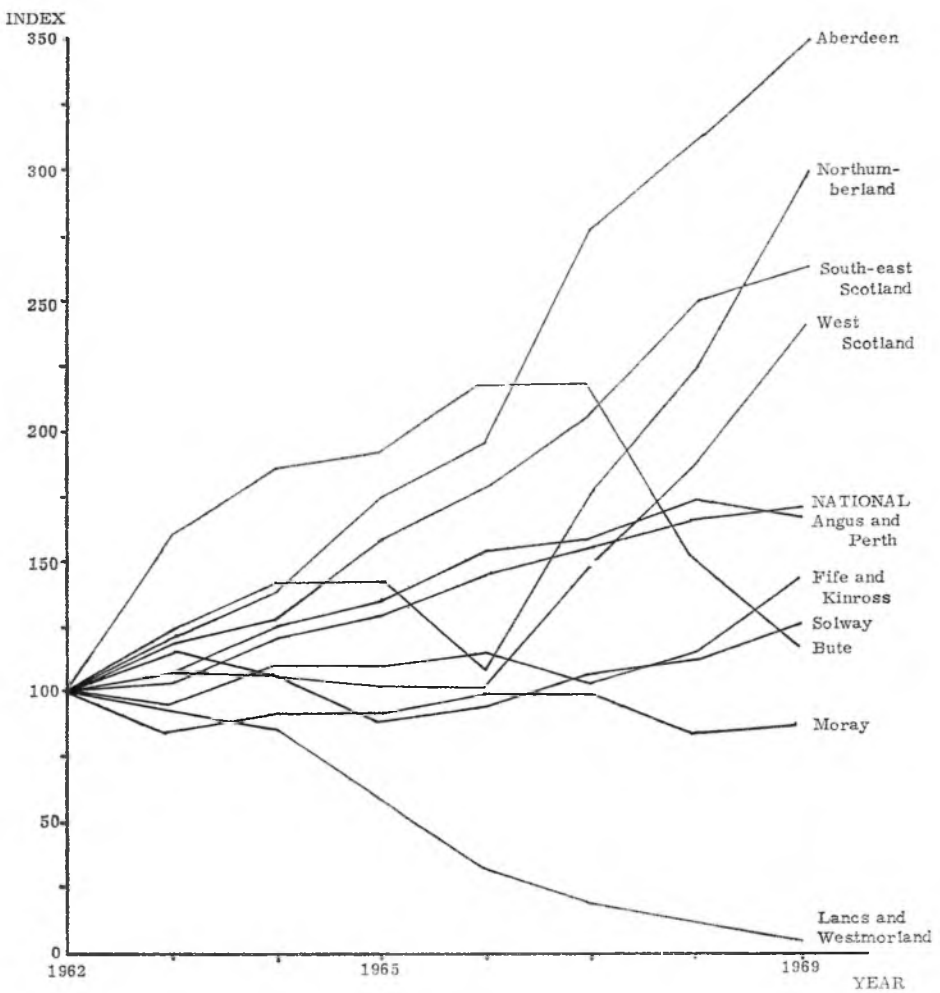


Figure 4. Relative changes in regional abundance of Icelandic Greylag Geese in Britain in November, 1960-1971, as shown by 5-year moving averages standardised to 1962 = 100.

measure will in principle be provided by a comparison of the results of the November censuses with those made in a similar fashion in late March, when censuses were attempted in 1963-67. The March counts, assembled by regions and by years, are summarised in Table III. Table IV records apparent regional changes from November to March. Over the five winters, three regions (Moray, West Scotland and Bute) showed substantial increases in average numbers from the autumn to the spring. Since no immigration was likely to have been occurring on a detectable scale in midwinter (though very small numbers of Greylags from Europe occasionally straggle to England, especially during hard winters (Atkinson-Willes 1963)) and since the population was being depleted by deaths, those regional increases clearly reflect internal movements which are also demonstrated by the substantial decreases recorded in Aberdeen, Angus and Perth and south-east Scotland. There is indeed a paradox in the results, which seem to show the highest rates of winter loss in those regions where the rate of increase from November to November has been greatest.

Recoveries of ringed Greylags from 1950 onwards had shown a tendency for those marked in east Scotland in the autumn to move south and west in the course of the winter and it had been inferred that such shifts were due to the generally greater severity of the weather in the east (Boyd 1959). The observations in 1963-1967 were consistent with such an explanation.

A supplementary approach is available using the month by month records from roosting sites visited by observers taking part in the National Wildfowl Count scheme. Their observations are made on the Sunday closest to the middle of the month (the range of dates was 12th-18th), from September to March. There are virtually no Icelandic Greylags in Britain in September and immigration is still gathering momentum in mid-October, so that most interest lies in the numbers seen from November to March.

These counts are designed to record the numbers of ducks present and therefore observations are made during the hours of daylight, rarely early or late enough to record roosting geese. However, Greylags more than other geese are prone to visit their roost during the day, and also to flight home up to two hours before sunset.

Table III. Numbers of Icelandic Greylag Geese found in regions of Britain in late March, 1963-1967. Thousands of geese, to nearest 0.1; + = less than 50.

Region	*1963*	*1964*	*1965*	*1966*	*1967*	*Mean*
Moray	2.5	2.7	6.0	1.8	2.7	3.2
Aberdeen	1.2	0.8	2.8	3.0	5.4	2.6
Angus and Perth	5.9	10.0	9.5	12.2	17.7	11.1
Fife and Kinross	0.7	1.8	2.3	0.8	4.4	2.0
SE. Scotland	0.2	+	+	1.3	0.7	0.5
West Scotland	1.3	1.1	1.2	1.3	0.5	1.1
Bute	5.6	2.4	2.8	2.9	5.9	3.9
Argyll	1.3	1.1	1.4	0.5	1.7	1.2
Solway	5.0	2.6	5.1	3.4	3.9	4.0
Northumberland	0	0	0	0	+	+
Lancs. and Westmorland	0.3	0.2	0.2	0.2	0.2	0.2
Total	24.0	22.7	31.3	27.4	43.1	29.8

Table IV. Changes from November to March each winter in numbers of Icelandic Greylag Geese found in different regions of Britain, 1962-63 to 1966-67. Thousands of geese, to nearest 0.1.

Region	*1962-3*	*1963-4*	*1964-5*	*1965-6*	*1966-7*	*Mean*	$\frac{March}{Nov.}$ %
Moray	0.6	0.2	3.5	− 1.7	0.8	0.7	+ 28
Aberdeen	− 0.4	− 1.6	− 2.3	0.5	0.8	− 0.6	− 19
Angus and Perth	−17.9	−10.9	−13.8	− 9.9	−19.7	−14.4	− 56
Fife and Kinross	− 1.2	− 0.1	− 0.5	− 0.8	1.5	− 0.2	− 10
SE. Scotland	− 0.7	− 1.3	− 3.7	− 0.4	− 0.9	− 1.3	− 74
West Scotland	0.3	0.5	1.0	1.0	0.2	0.6	+113
Solway	− 0.7	1.8	1.7	− 1.7	− 0.2	0.2	+ 5
Balance of total	−16.3	− 9.6	−11.6	−17.0	−14.9	−14.0	− 32

The Wildfowl Count sites regularly covered hold a substantial proportion of the total of Greylags, although the sample is biased, in relation to the known distribution in November, by an over-representation of Fife, the Lothians and island of Bute, and by under-representation of Angus/Perth and of the Solway. The sites used in preparing the subsequent analysis are as follows:

Moray: L. Eye, Beauly Firth, L. Spynie; *Aberdeen:* L. Strathbeg, R. Ythan and Slains L., L. of Skene, Kemnay; *Angus and Perth:* Lintrathen Res., L. Kinnordy, L. Rescobie, Forfar L., L. of Lowes, Butterstone L., L. Clunie, L. Marlee, L. Stormont, Haremyre; *Fife:* Lomond Reservoirs, Carriston Res., Kilconquhar L., Cameron Res., Eden estuary, Tullibody I. (Clackmannan); *SE. Scotland:* Threipmuir Res., Gladhouse Res., Harperrig Res., Portmore L.; *West Scotland:* south-east L. Lomond (R. Endrick mouth), Lenzie L., Barr L., Castle Semple L., Croot L., Martnaham L. Shankston L.; *Bute:* Lochs Ascog, Dhu, Fad, Greenan, Quin; *Solway:* Caerlaverock NNR., Lochs Arthur, Milton and Rutten, L. Ken, Wigtown Bay.

Because of the vagaries of the sample, which is affected by irregularities in coverage as well as by the exaggerated fluctuations to be expected in any subsample, it seems better to group the data in periods of three seasons than to consider each season separately.

The grouped data are displayed in Table V covering the period 1960-61 to 1968-69. The totals of 'goose months' indicate a rate of population increase similar to that derived from the November censuses. The index at the foot of that table, in which changes through the winter are standardised against a value of 100 for November in each period (thereby eliminating the effect of growth in total numbers) makes a point of some interest. The growth of the October index from the early to the later years of the decade implies that the proportion of Icelandic Greylags arriving in Scotland

Table V. Changes in regional abundance from October to March as indicated by Wildfowl Count records for 1960/1 to 1968/69.

Sites used are listed in Appendix 1. Monthly figures are 3-year means, in thousands, to nearest 0.01. The small samples from Argyll and England are omitted.
Period 1, 1960/1 to 1962/3; 2, 1963/4 to 1965/6; 3, 1955/7 to 1968/9.

Region	*Period*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Thousands of "goose months"*
Moray	1	.1	1.0	.4	.2	.3	1.1	3.1
	2	.3	1.3	1.6	1.7	2.1	1.5	8.5
	3	.7	1.1	.4	1.0	.3	.5	4.0
Aberdeen	1	.2	.4	.5	.3	.4	.4	2.2
	2	1.3	1.4	1.4	1.3	.5	.6	6.5
	3	1.8	2.5	.7	3.0	1.6	1.9	11.5
Angus and Perth	1	1.1	2.4	.9	.6	.8	1.1	6.9
	2	1.1	4.0	3.2	.7	1.0	.4	10.4
	3	2.1	5.6	4.3	3.8	1.7	.7	18.2
Fife	1	.1	.9	.7	.2	.2	.3	2.4
	2	.5	1.1	.8	.7	.8	.8	4.6
	3	.4	1.2	.7	1.4	2.2	1.6	7.5
SE. Scotland	1	.1	.1	0	.1	0	0	.3
	2	0	.9	.4	.4	.2	.1	2.0
	3	1.0	1.1	1.0	.3	0	0	3.4
West Scotland	1	0	.3	.2	.3	.5	.1	1.4
	2	.1	.5	.3	.2	.6	.2	1.9
	3	.1	.2	.2	.2	.4	0	1.1
Isle of Bute	1	0	1.5	2.4	2.8	1.4	2.0	10.1
	2	.1	1.9	2.4	2.7	1.4	2.1	10.6
	3	.2	1.6	3.9	4.1	1.9	1.7	13.4
Solway	1	0	.2	.7	.6	.4	.4	2.3
	2	0	1.5	1.3	.9	.5	.6	4.8
	3	.8	1.1	.9	1.1	.4	0	4.3
Total	1	1.6	6.8	5.8	5.1	4.0	5.4	28.7
	2	3.4	12.6	11.4	8.6	7.1	6.3	49.3
	3	7.1	14.4	12.1	14.9	8.5	6.4	63.4
Index (Nov. = 100)	1	24	100	85	75	59	79	
	2	27	100	90	68	56	50	
	3	49	100	84	103	59	44	

by mid-October has been rising rapidly.

W. B. Alexander (in Fisher 1951) in a diagrammatic summary of the migrations of Greylags to and from Britain indicated arrivals throughout October and continuing until mid-November. By 1960 it was our general impression that in most years few migrants were delayed later than the first week of November and this seems to have continued to be so, except perhaps in 1969. Dr. Finnur Gudmundsson has confirmed that few Greylags remain in Iceland after the beginning of November (pers. com., Dec. 1971).

The decrease in the March index, coupled with the lack of change in that for February, suggests that a corresponding increase in emigration prior to mid-March has been occurring. Alexander suggested that emigration began early in March, a possibility risked when selecting a date late in the month for the end of winter censuses. However, Dr. Gudmundsson knows of no evidence that the geese are now returning to Iceland earlier in the spring, the main return of Greylags being in April.

This evidence of changes in the timing of the mass of migration has an immediate implication, that the apparent losses from early November shown by the late March censuses may be due to emigration as well as deaths. (For a direct estimate of mortality during the winter a census in February would be far more useful. However, it would be very liable to interference from bad weather, which was why the census was deferred until March.)

If emigration has not begun in February the change in the sample counts from mid-November to mid-February might be expected to serve as a measure of mortality. Certainly the aggregate sample shows a substantial, and very similar, drop in each of the three periods used. But, as will emerge after the later section on recruitment, an apparent reduction of 41–45% in the population from November to February is too large to be consistent with the year to year changes shown by the November inventories. Regionally, the inconsistencies are worse. Presumably this is because the geese do not redistribute themselves in such a way that the sample of roosts observed tends to contain a constant proportion of the geese in the region.

At the least, analysis of the Wildfowl Count data has shown that even full Greylag censuses at frequent intervals would be unlikely to provide measures of mortality distinguishable from the effects of local and long-distance movements.

Seasonal and regional distribution of ringed Greylags

Greylags have been ringed in Iceland, as goslings or as moulting adults, from 1929 onwards. The numbers marked have been small, so that the subsequent recoveries are too few to demonstrate changes in distribution or mortality, with one striking exception. Of 15 recoveries in the British Isles before 1950, six were in Ireland and nine in Scotland; there was only one recovery, in Moray, between 1950 and 1960; since 1960 there have been 12, 11 in Scotland and only one in Ireland.

The number of Icelandic Greylags ringed in Britain is rather larger (1,247) but nearly a third of them were marked in the period 1950-1953 and catches of 609 in Perth and Angus in November 1963 and 88 in Bute in February 1966 provide the only samples in the last decade. By November 1971, 315 recoveries had been reported, 180 after autumn 1960. Such limited numbers cannot provide detailed information on distribution changes or mortality but are sufficient to produce evidence of several important characteristics.

A similar withdrawal from Ireland, and northern England, is evident in the recoveries of British-ringed Greylags: from 1950 to 1955 there were eleven recoveries in Ireland and two in England. From 1955-56 to 1959-60 there was one in Ireland and one in England. Since 1960 there have been no recoveries in Ireland or England.

Little of interest can be learned from recoveries about changes in distribution within Scotland, perhaps largely because the samples ringed at different times were caught in different places, so that the tendency for most recoveries to occur relatively close to the place of ringing obscures any evidence of shifting (Table VI).

Recoveries in Iceland of Greylags ringed in Britain give no indication that geese taken together in winter are especially liable to return to the same part of Iceland; but it is rather unlikely that such association would be revealed by recoveries scattered thinly over many years. A more important result is that the numbers of recoveries in Iceland have formed a relatively constant proportion of the numbers ringed, irrespective of the place or period of marking (Table VII). This is consistent with observations by Dr. Finnur Gudmundsson and Dr. Arnthor Gardarsson (pers. com., Dec. 1971) that the kill in Iceland has not risen greatly, despite the increasing number of

Table VI. Regional distribution of recoveries in the British Isles of Greylag Geese ringed in Britain 1950-1966.

	Where and when ringed						
Where found	*Dumfries/ Kirkcudbright 1950-53*	*Montrose 1952*	*Kinross 1953*	*Braco (Perths.) 1959*	*Blairgowrie/ Coupar Angus 1963*	*Bute 1966*	*Total*
Moray, Aberdeen	1	1	1	3	9	1	16
East central Scotland	5	13	36	12	66	—	132
Solway	21	7	15	6	10	—	59
Bute	5	—	—	4	1	4	9
Other Scotland	5	2	2	2	7	2	15
England	1	2	—	—	—	—	3
Ireland	6	1	5	—	—	—	12
Total	34	26	59	27	93	7	246
recoveries within 20 miles	12	4	13	6	37	4	76
as % of recoveries in same region	57	31	36	50	56	100	50
as % of all recoveries	35	15	22	22	40	57	31

Greylags and their fondness for cultivated areas, especially young grass. Complaints led to a change in the law in 1965 to permit shooting by farmers at any time when damage was occurring, but this has not led to substantial increases in the number shot. Hunting of geese for sport was almost unknown in Iceland until very recently. Some now occurs, particularly in the south-west, but it is still insignificant.

When recoveries in Britain are related to the numbers marked in different places at different times the proportions recovered are seen to have fallen greatly in recent years, after remaining high and steady during the 1950's. This suggests either a fall in the proportional kill or in the proportion of ringed birds shot that are reported. Remarkably enough, though the number of British recoveries has fallen the annual mortality, as estimated from the recovery series (i.e. numbers recovered 1, 2 . . . n years after ringing) has actually increased, from 23.1 ± 2.9% prior to 1956 (Boyd 1957) to 34.0 ± 2.29% for the geese marked in 1963. (In each case the mortality was calculated by the method due to Haldane (1955).) Such an increase could conceivably be due to a rise in losses due to causes other than shooting. Using the method due to Hickey (1952) to estimate such losses fails because the estimated annual mortality does not increase with an increase in the recovery rate, an unusual occurrence. It seems likely that the high estimate is an artefact, due to the vulnerability of this and similar methods of estimates to departures from the assumption of constant annual survival and constancy of reporting.

The Greylag recoveries are too few to allow the question to be resolved but an analogous situation has arisen in the recoveries of Pink-footed Geese ringed in Britain and Iceland from 1950 to 1959, which will be discussed elsewhere (Boyd and Ogilvie, in prep.). For the Pinkfeet, and so most probably for the Greylags also, it seems likely that the estimated value of the hypothetical constant annual mortality is seriously biased upwards, particularly for recent years.

Table VII. Changes in the recovery rates in Iceland and Britain of Greylag Geese marked in Britain 1950-1966.

		Recovered within 5 years of marking				*Total recovered so far*	
		in Iceland		*in Britain*			
Marked	*Number released*	*Number*	*% of marked*	*Number*	*% of marked*	*Number*	*% of marked*
1950-1952	134	8	6.0	31	23.1	46	34.3
1953	285	10	3.5	73	25.6	99	34.7
1963	104	3	2.9	25	24.0	33	32.7
1966	613	30	4.9	84	13.7	126	20.5
1959-1961	88	5	5.7	6	6.8	11	12.5
Total	1224	56	4.6	219	17.9	315	25.2

Recruitment

Under favourable conditions of lighting an experienced observer with a good telescope can distinguish Greylag Geese in their first autumn from older geese at distances of up to 300 metres and it is possible by protracted watching to recognise family parties, of parents accompanied by 1-8 young. Geese caught for ringing in rocket-nets can also be identified as 'young' or 'adult', though family parties cannot be recognised. The collection of information on brood sizes and the proportion of young geese is, however, laborious and often frustrated, so that the annual samples summarised in Table VIII are small in proportion to the total population.

Among Pink-footed Geese in Britain, Boyd and Ogilvie (1969) showed that over the period 1950-1968 both the mean brood size and the proportion of young (first winter) birds tended to decline, reaching very low levels in 1967 and 1968. Regular information on the recruitment of young Icelandic Greylags was not collected until 1958. Figure 5 shows that, as in the Pink-foot, there was a downward trend in both mean brood size and the proportion of young from 1958 to 1968. In 1969, and in 1970, both statistics were considerably higher. (In the Pink-footed Goose too there was evidence of improved breeding success in both those years.) However, the 1971 data indicate that the halt in the downward trend may have been only temporary.

The cause of the decline in mean brood size and relative numbers of young during a period of rapid increase in the size of the total population cannot be inferred from the numerical data alone and too little is known about the factors affecting reproductive success to pusue the topic in detail.

The reduction in mean brood size was associated with a virtual disappearance of broods of five or more and an increase in the proportion of families with only one young bird. Where useful samples from different regions were obtained in one year there was no evidence of local differences in mean brood size or in the proportion of single-young families or of large broods.

There are few indications of regional differences in the proportion of young in some, though not in most, years. Over the period 1959-1965 the proportion of young birds on Islay was 37.9%, compared with 27.0% in Angus and Perth. It is quite likely that the Greylags visiting Islay are well segregated in winter from those visiting eastern Scotland; they may indeed not be Icelandic birds at all. In general, however, the differences between regional samples in any year do not exceed those between subsamples from within a region. Given the low level of precision attainable in the field in censusing the population, it seems adequate to treat the entire population as homogeneous with respect to the proportion of young birds in any year, although there are important differences from one year to another.

Population budgeting

If the observed age ratios in the annual samples can be taken as estimates of the ratio in the entire Icelandic population, it is possible to estimate from the successive

Table VIII. Mean brood size and proportion of young Greylag Geese observed in Britain each year in late October and early November, 1958-1971.

Year	*No. of geese inspected* *total*	*1st w.*	*1st w. total*	*5-year moving average*	*No. of broods*	*Mean brood size*	*5-year moving average*
1958	750	216	.288		17	2.88	
1959	318	110	.346		29	3.44	
1960	694	302	.435	.377	62	3.45	3.33
1961	883	353	.400	.355	8	3.75	3.22
1962	1126	358	.318	.341	23	3.13	3.13
1963	1715	472	.275	.296	35	2.31	3.06
1964	1415	391	.276	.266	13	3.00	2.84
1965	1115	235	.211	.224	21	3.09	2.57
1966	1070	266	.249	.181	17	2.65	2.37
1967	1297	143	.110	.173	68	1.78	2.16
1968	975	59	.060	.181	32	1.31	2.01
1969	581	138	.238	.167	60	1.97	1.85
1970	830	208	.251		33	2.36	
1971	1618	283	.175		128	1.85	
Sum	13319	3534			548		
Mean			.265			2.31	

November censuses both the number of recruits and the losses suffered from one census to the next. The difference between the total count in year (n) and the number of adults in years (n+1) is a measure of the losses, convertible to a crude mortality rate (d) by expressing the difference as a proportion of the total count (N) in year (n).

In November most families still comprise two adults with varying numbers of young (although later in the winter rather more families have only one adult). Thus the number of successful parents may be established by multiplying the number of young geese by 2/(mean brood size): 'successful parents' here having the restricted meaning of adults that have not only reared young to the flying stage but also brought them safely through their first southward migration. If it is assumed that mortality rate does not vary with age, it is also possible to calculate the presumed age composition of the population by applying the successive yearly survival rates (s=1−d) to each cohort of young geese.

The results of some of these calcula-

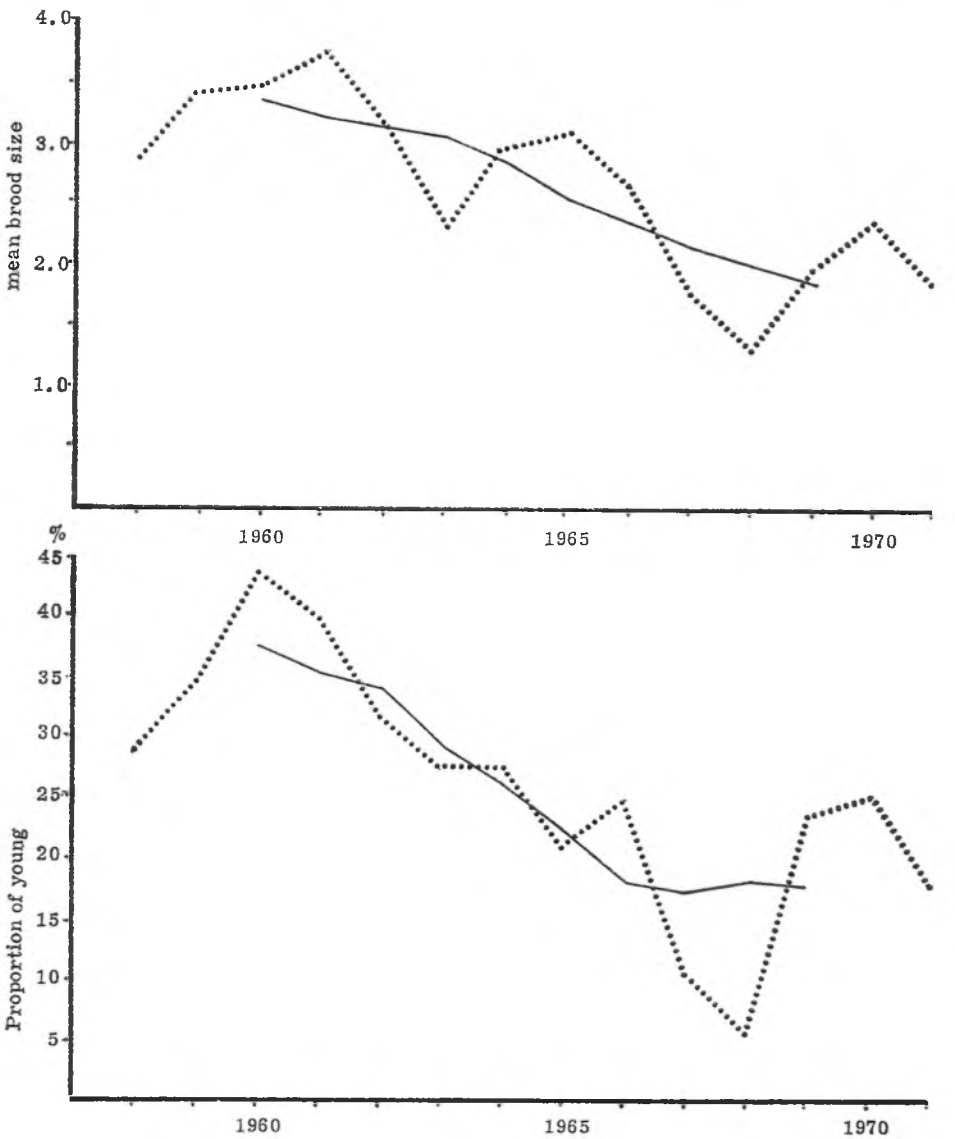


Figure 5. Changes in proportion of young geese (lower) **and in mean brood size** (upper) **in autumn samples of Icelandic Greylag Geese, 1958 to 1971, with 5-year moving averages.**

tions are illustrated in Figure 6, the numerical values being given in Table IX.

When the estimates of annual survival rates from the census results and the estimates of adult survival from recoveries of ringed geese are brought together (Table IX), it is clear that the two are not fully compatible after 1960-61. As already noted, the recoveries suggest a relatively high annual mortality, not tending to diminish. The census results require much lower annual losses, culminating in the absurdity of a survival rate of 107%

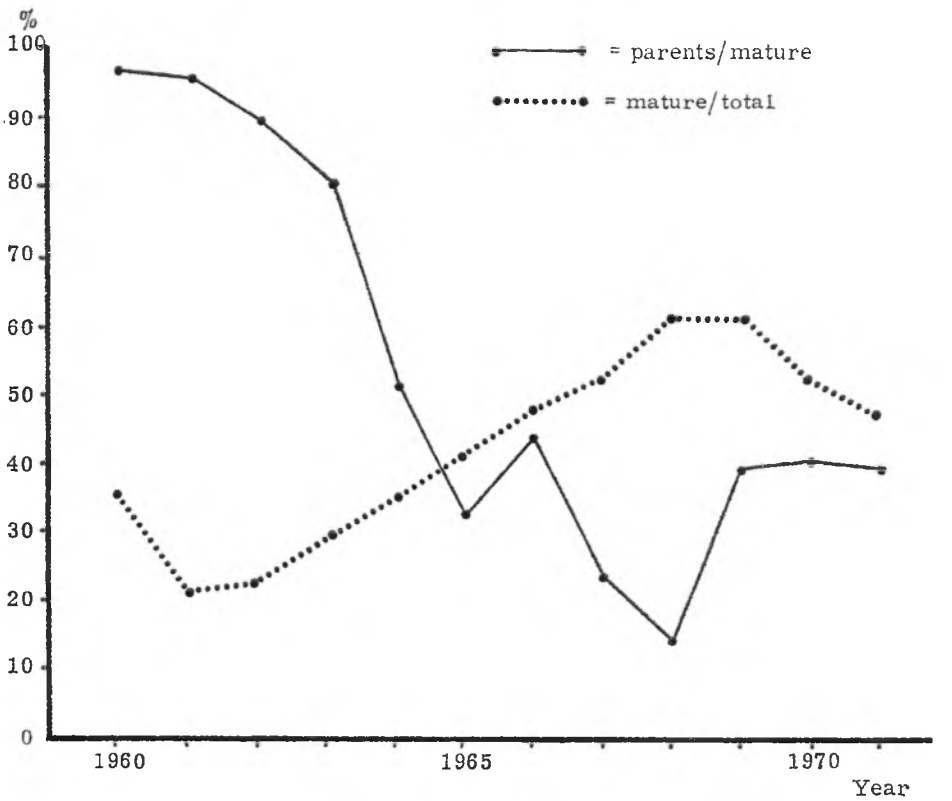


Figure 6. Estimates of the proportion of mature birds (over 3 years old) in the Icelandic Greylag Goose population in Britain, November 1960-1971; and of the proportion of mature birds that were parents.

Table IX. A population model for the Icelandic Greylag Geese in Britain in November, 1960-1971. Estimates in thousands of geese: 'mature' geese are those more than 3 years old, that could have bred in preceding summer.

Year	*Young geese Y*	*Parents P*	*Mature geese M*	*Parents/ Mature P/M*	*Mature/ Total M/N*	*Total geese N*	*Survival % (census)*	*Survival % (ringing)*
1960	11.5	6.7	6.9	.97	.26	26.3	79.5	80.5
1961	13.9	7.4	7.7	.96	.22	34.8	79.0	51.1
1962	12.9	8.2	9.1	.90	.22	40.4	58.2	73.9
1963	8.9	7.7	9.5	.81	.29	32.4	97.8	64.6
1964	12.1	8.1	15.5	.52	.35	43.8	54.9	59.0
1965	9.4	6.1	18.3	.33	.41	44.4	98.2	68.1
1966	14.5	10.9	24.7	.44	.48	58.1	80.6	57.9
1967	5.8	6.5	27.4	.24	.52	52.6	(107.0)	—
1968	3.7	5.7	37.2	.15	.61	60.8	77.5	—
1969	14.7	14.9	37.7	.40	.61	61.8	78.2	—
1970	16.2	13.7	33.8	.41	.52	64.5	80.0	—
1971	11.0	11.9	30.0	.40	.48	62.6	—	—

from November 1967 to November 1968 and with very few deaths in 1963-64 and 1965-66. While we do not have any good quantitative information on the scale of Greylag shooting in Scotland in recent years, there seems no reason to believe that in each of these three winters the kill fell below 1,000 birds. The explanation of the anomalies must be in terms of censusing and sampling, rather than biology. Possibly the rate of increase of the total numbers in November has been exaggerated by growing efficiency in locating flocks of Greylags or by greater generosity in estimating the numbers within flocks. Alternatively, the sampling for the proportion of young birds may have been unrepresentative, with few or no observations in recent years in places where young geese were plentiful, or with some unwitting changes in the criteria for identifying young geese. The choice of explanations seems likely to remain a matter of opinion, rather than rational decision, and is not of great importance if the limitations of the original data are kept in mind when they are being used for analysis. It is evidently impracticable to produce detailed year-by-year estimates of high reliability.

Yet the lack of precision should not be allowed to obscure several very clear trends. There can be little doubt that from 1960 to 1970 the Icelandic Greylag population more than doubled its size and that while it was doing so the number of potential breeders (geese three years old or more, and possibly some of those two years old) increased four or five times. But the estimated proportion of mature geese that brought young to Scotland fell very greatly (Table IX); for several years at the start of the decade most of them seem to have been successful, while in 1969 and 1970 only two-fifths may have succeeded and in 1967 and 1968 the situation was even worse. This decline in success was accompanied by a marked reduction in the number of large families.

An increase in total numbers not accompanied by an increase in recruitment of young birds can only have been achieved in one of two other ways. Either there was a reduction in the mortality rate of full-grown geese or the concept of the population as a closed one ceased to be appropriate and recruitment by adult immigration was occurring. Despite the minor complications due to native and feral geese, and to the changing role of Ireland as a wintering place, there is no evidence at all of the occurrence of immigration on the necessary scale.

Attempts to detect changes in mortality, nationally and regionally, by means of sample counts having proved inconclusive, this study has identified two major problems for further investigation without offering explanations for either. First, if the death rate of full-grown Greylags has been falling, and continues to fall, what has caused the change? Second, was the reduction in effective fertility during the last decade due to intra-specific regulating mechanisms rather than to extrinsic factors? If so, what were they?

If under some conditions nearly all the mature geese can be successful parents, are those conditions likely to obtain, even if only once, in the next few years? If so, the relative levelling off in numbers from 1966 to 1970 could be followed by another upsurge. Where could 80,000-100,000 Greylags, with similar numbers of Pinkfeet, be accommodated, in Iceland and in Britain?

Wild geese and conservation policy

There are two themes that have emerged repeatedly from the Wildfowl Trust studies of wild geese that have still to be acted upon by those organisations with statutory responsibilities for wildlife conservation. The first is that censuses and surveys, however well they may describe what has happened, do not provide an adequate basis for forecasting what may happen in the future. Successful prediction calls for understanding of the causes of change, which can only be obtained by research into all phases of the annual population cycle. The most obvious and important subjects for research include a study of breeding groups in Iceland. Their breeding biology has hardly been examined. This must, however, be linked with more detailed work in winter. Comparatively little is yet known about the factors governing fertility among wild geese though there is increasing evidence from North America that the condition of the birds in late winter and spring is at least as important as the state of the Arctic nesting grounds (C. D. MacInnes, unpub. report). Thus the study of Greylags before they leave Britain in the spring could be of considerable value. This paper has brought to light several other areas where our knowledge could usefully be greatly improved. In particular we need better monitoring of the changes in distribution that take place both between and within winters, and to discover the reasons behind them. We have all too little understanding of the effects of, among other things, food supply, disturbance and shooting pressure. Yet without such knowledge we may

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Plate IX. (Above) Greenland White-fronted Goose *Anser albifrons flavirostris*. (Below) Emperor Goose *Anser canagicus*. (See p. 92.)

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Philippa Scott

Plate X.
(Above) Male European Pochard *Aythya ferina.*
(Below) Philippine Duck *Anas luzonica.* These photographs clearly illustrate differences in body proportion, leg position, and consequent stance between a diving duck and a dabbling duck.

Philippa Scott

be forced to guess and could get the answers seriously wrong.

Superficial monitoring is cheap, easy and obvious and should be continued. Research is rather more expensive, and may fail to provide ready or agreeable answers; and the financial climate is unpropitious for increased funding. This relates to the second theme: in Britain, and in most other countries where any efforts at wildfowl conservation are being made, policies have been based on the idea that what are most needed are ameliorative and restorative measures to offset the consequences of the destruction of wetlands and the harmful effects of other human activities. Yet most of the geese visiting Britain are flourishing, despite the manifest dangers in being alive, so that the problems they pose are those of abundance rather than decline. In such circumstances continued oversimplified emphasis on 'protection' leads to anachronistic absurdities. The Greylag Geese in central Scotland provide an excellent example.

The latest legislative act (1967) intended to improve the welfare of wild geese in Britain made it illegal to offer dead wild geese for sale. The intention was to diminish the incentive for a few market hunters to kill very large numbers of geese. This legislation had scarcely come into force before farmers in Perthshire were complaining more loudly than ever of the alleged damage wrought by the greatly increased numbers of geese and were seeking special rights and assistance in killing or driving off the birds. Effective conservation activities should be based on thorough biological knowledge, with an appreciation of the dynamic capabilities of wildfowl populations, which enable them to solve most of their own problems more ably, and certainly far more speedily, than men can do. This is not a justification for indolence but a stimulus to action, to prove wrong the dictum of Benjamin Jowett: "Research, research, a mere excuse for idleness. It never has achieved, and never will achieve, any results of the slightest value."

Acknowledgements

Over the years several hundred people have helped to accumulate the information on which this study is based. We are fortunate indeed in having had their help, and in having been able to spend more time than most of them in watching and counting geese ourselves.

The Nature Conservancy and the Natural Environment Research Council have provided substantial financial support to the Wildfowl Trust for the conduct of this and other population studies. H. Boyd is indebted to Mr. J. E. Bryant, Director, Eastern Region, Canadian Wildlife Service for supporting his continued concern for British geese.

Summary

Greylag Geese *Anser anser* breeding in Iceland winter in Scotland, with very small numbers in the north of England and in Ireland. Counts made in Britain in early November each year since 1960 show this population to have increased from about 26,000 in 1960 to over 64,000 in 1970, the rate of growth having slowed since 1966. The geese have been concentrating increasingly in the east and north-east of Scotland, both in November and later in the winter. Mean brood size fell from 3.45 in 1960 to 1.31 in 1968, returning to 2.36 in 1970 but was 1.85 in 1971; the proportion of young birds fell correspondingly, from 43.5% in 1960 to 6.0% in 1968, returning in 1969 and 1970 to very close to the period average of 25.0%. The number of mature geese in the population increased 4-5 times during the decade. In 1960-1962 most of the mature geese in the population seem to have brought families to Scotland; subsequently the proportion of successful mature birds fell to only about 15% in 1968 and to 40% in 1969-1971. The gross annual mortality rate estimated from the census and age ratio data was only 13.3%. The true rate is probably somewhat greater. There is no good evidence of a trend in annual mortality during this period.

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Breeding biology of feral Greylag Geese in south-west Scotland

JOHN G. YOUNG

Introduction

The Greylag Goose *Anser anser* is the sole goose species indigenous to Britain. In former times, it evidently bred widely over much of the country, but by the middle of the eighteenth century had largely been exterminated as a breeding species by Man, mainly as a result of intensive drainage schemes and other alterations to the preferred habitat, but also by more direct persecution. By the 1920's, Greylag bred only in a few remote parts of north-west Scotland and the Hebrides.

About 1930, Greylag were reintroduced to south-west Scotland by the late Lord William Percy, who transferred eggs and goslings from the native colony on South Uist to the Earl of Stairs' estate at Lochinch near Stranraer, Wigtownshire (the late Lord David Stuart, pers. com.). Around the same period they were also introduced to another area in Galloway (the late Gavin Maxwell, pers. com.) whence they spread to Mochrum. The present stock is derived from these three sites. The introductions were an immediate success, the birds being afforded protection in both summer and winter by the landowners concerned.

By the mid-1950's they had increased significantly and the range had extended to central Galloway. Surveys were made in 1966, 1968 and in 1971, and in the last year at least 129 pairs bred in some thirty localities, in four counties, producing 362 goslings. In addition some 600 failed or non-breeders were found, and the total stock in late July was estimated at about 1,160 birds, the largest feral population in Britain.

A further paper will deal specifically with the historical aspect of this reintroduction and with the current distribution and status. The present paper discusses some aspects of the breeding biology, from data gathered in 1962-1971. The material presented was collected in the author's spare time, incidental to the location of breeding areas, and is therefore limited. Greylag appear very susceptible to disturbance while nesting and are thus probably unsuitable for intensive research.

Nest site location (Table I; Plate III facing p. 32)

The 476 nests examined were all adjacent to water and grazing fields, and 415 (87%) were on wooded islands on lochs, where incubating females were presumably safer from predation by foxes. Some 30 nests were round the margins of lochs, usually where there were no islands. Lochs with unwooded islets often held breeding colonies of Common Gulls *Larus canus* or more usually Black-headed Gulls *Larus ridibundus* and Greylag did not breed in association with these species. (In 1968 and in 1971 two pairs of Greylag successfully reared broods in an inland colony of Herring Gulls *Larus argentatus*, nesting on ruined buildings on an island at Mochrum.) Twenty-three nests were in vegetation near the banks of slow flowing rivers, and seven were on moorland, and one in natural woodland, up to 1,000 metres from water. Nests were usually near a feature which offered some shelter, or a screen from neighbours in areas of high nest density.

Nests

Nest building was by both sexes. Sixteen marked nests at one locality in 1971 took 3-6 days (mean 4.3) to complete. All nests were on solid ground, no floating nests in *Phragmites* were found in the extensive areas of *Phragmites communis*

Table I. Positioning of Greylag nests.

	Number
Foot of tree	184
By rock or large stone	97
By blown tree root	37
In ground vegetation: (*Calluna*, bracken, rushes, etc.)	36
By buildings or dykes	35
In secondary vegetation: (bramble, conifers, *Phragmites*, rhododendron, etc., beside fallen tree trunks)	27
Under fallen branches	12
In holes	4
On top of 2 m. tree stump	1

at some breeding localities. The mode of construction was extremely variable but simple. There is no interweaving and the nest was fragile and of various materials loosely placed on top of one another, with additions throughout incubation. Some nests gained up to 6-8 cm. in height from the laying of the first egg to hatching. No Greylag were ever seen to fly with anything in the bill, and of ten nests examined minutely, all the materials were obtainable within two square metres. Larger objects like twigs were lifted in the bill, at times carried a few steps, but usually dropped or flung with a jerking movement over the back in an apparently haphazard manner. After some initial construction or gathering in of materials, the nest was shaped from both outside and inside. In two observed cases this was done by the female prodding, lifting and laying the material with the bill. Titivation continued throughout laying and incubation. In most nests a foundation of twigs, up to 26 cm. long, was laid, to which was added dead leaves of ivy, holly, oak, birch, rhododendron sp., bracken, *Phragmites*, *Typha* and *Sphagnum* or moss species. The final lining was dead grass, usually *Molinia*, together with a variable amount of breast down increasing as incubation progressed. Nests tend to be distinctive, ranging from mere depressions in *Calluna* or rushes, to nests built completely with mosses or lichens, and large bulky structures of bracken, *Phragmites* and sticks. Forty nests on average had a circumference of 141 cm., a diameter of 41 cm., a rim of 8 cm., and a bowl depth of 6 cm.

The highest density of nests was on the 300 sq. m. Island of Inch, White Loch, Lochinch, where in 1968 there were 42 nests. The distance between the nests, measured from the centre of the bowls, ranged from 2-21 m. (average 11.1 m.), an average of approximately 1 nest per 7 square metres. The dispersal of nests over the island seemed to be regulated by the availability of suitable cover. Elsewhere nests have been found one metre apart, but generally are more widely dispersed. The nesting population is apparently dependent on the number of suitable islands per loch rather than the area of particular islands. In 1971, on Lochs Ochiltree, Dornal and Maberry, birds used all the suitable islands with not more than two nests on any, irrespective of size or vegetation cover. This has been a recent development at Ochiltree especially, where previously most of the nests were concentrated on the largest island. Since 1964 they have been subjected to increased disturbance at the nest.

Other than on Inch Island, nest density seems to be limited by the degree of tolerance of neighbours. There was no significant difference in clutch size or predation losses between high density and low density areas.

Some nest sites have been used for at least five successive seasons. This was most noticeable where nests are in holes. Apparently featureless sites are also reused. In 1968, 110 nests were marked with cedar stakes driven in to 2 cm. above ground. The following year 80 nests (72%) were within 1 metre of the 1968 site and 12 nests (11%) were within 20 cm. Even after three years 72 nests (67%) were still within 1 metre of the 1968 sites and seven nests (6%) were within 20 cm.

Eggs

The eggs are ovate, rarely elongated, fairly smooth and creamy white when laid. They become progressively stained pale to dark brown during incubation. The varying intensity of staining often made it possible to tell the last egg laid and, in smaller clutches, even the laying sequence. In clutches over nine it was possible to tell eggs laid after completion of the original clutch, probably involving two females. There was no evidence that white eggs increased the chance of predation.

The 200 eggs measured ranged from 71-98 mm. by 52-65 mm. (mean 85.4 × 59.0 mm.). This confirmed the finding (Young 1964) that Galloway eggs tend to be smaller than those from continental Europe but are indistinguishable from Icelandic eggs. The results agree very closely with those of British eggs measured by Jourdain (Witherby *et al.* 1939). The freshly laid eggs weighed from 142 to 180 grams, a mean of 165 grams. Weighed 8-10 days before peak days of hatching, the range was from 122-172 grams, a mean of 148 grams, an average weight decrease of 10.3%.

Egg laying

Data from 15 nests in 1971 indicated that usually a single egg was laid daily. Eggs were laid at any time of day with a slight preponderance towards mid-morning. In two nests there were one day gaps between the first and second egg, and in three nests before the last egg. In Galloway the peak periods of laying and hatching varied only slightly between years and there was no correlation with prevalent weather patterns. Normally the first eggs were to be seen at the large

colony at Lochinch about 4th-10th March (D. Lawson, pers. com.), while the majority of the birds laid in the last week of March and the first ten days of April. There is no evidence of earlier laying in general in an area of high density, the peak dates at Lochinch being similar to other localities. Of all the clutches examined 80% were begun within a mean of 6.5 days of each other. Similarly 67% of the clutches hatched within a mean of 7.2 days, generally in the period of the last few days of April and the first two weeks of May.

Incubation

This was commenced after the last egg was laid, and carried out by the female alone. The incubation period was exactly 29 days in 20 individual eggs whose laying and hatching dates were accurately known. Individual eggs lost during incubation were not replaced. At Lochinch where eggs were annually removed for introduction elsewhere, newly hatched goslings have been noted at the end of July, indicating replacement clutches. together to form larger assemblies, but at Lochinch, where the first clutches are generally removed, recognition of broods by gosling size is not difficult. In areas of high nest density male polygamy, which was proved on three occasions elsewhere, is perhaps regular, leading to two clutches being laid in the same nest but brooded by a single female.

Behaviour at nest during incubation

Males remain for long periods in a sentinel position, especially towards the end of incubation, either standing or swimming near the nest. Intruding humans are heralded by the male honking loudly and flying round the site, often landing clumsily on the water and immediately taking off again. Some females allow an approach of up to 3-4 metres before flying off the nest calling loudly, others leave the nest as soon as the male sounds the alarm. Most males leave the vicinity of the nest after the female has come off, and some fly to graze. Females usually remain, either flying round calling, or swimming with neck erect, sometimes

Table II. Observed clutch sizes and brood sizes of Greylag Geese in Galloway.

Year	*No. nests examined*	*No. eggs*	*Mean clutch size*	*No. broods observed in July*	*No. juvs.*	*Mean brood size*
1963	4	19	4.8	12	56	4.7
1964	10	60	6.0	22	95	4.3
1965	20	118	5.9	32	116	3.6
1966	60	352	5.9	26	107	4.1
1967	70	420	6.0	32	141	4.4
1968	120	720	6.0	81	346	4.3
1969	100	584	5.8	70	262	3.7
1970	10	67	6.7	35	139	4.0
1971	82	451	5.5	55	206	3.7
Total	476	2791	5.9	365	1468	4.0

No. in clutch or brood	1	2	3	4	5	6	7	8	9	10	11	12
Clutches			21	61	98	172	82	20	7	6	4	5
Broods	15	23	88	130	55	29	20	1	1	1	1	1

Clutch size and distribution are given in Table II and agree closely with the data of Jourdain (Witherby *et al.* 1939). The mean clutch size of 476 clutches was 5.9.

Clutches in the range of 3-9 were probably from one female. Clutches of 8 and 9 may be related to age and breeding experience, since the larger clutches were regularly at the same nest sites. The clutches of 10-12 eggs were all in areas of high nest density, mostly at Inch Island, and may be attributable to females who have lost or deserted their own clutch. One female is quite capable of covering such abnormal clutches and broods of 10, 11 and 12 have been seen with a pair of adults (Table II). Goslings often group head bowing, and with the tail erect. Following the male alarm females usually, but not always, cover the eggs by dragging down and loose material of the nest rim over the clutch. There is no evidence to suggest that the rapidity of leaving the nest or the completeness of egg-covering is related to age and breeding experience. The return may be rapid, i.e. within minutes, in other cases it takes over an hour. Occasionally if the disturbance is protracted, the female may also give up and go to feed.

At night females sleep most of the time on their nest. They defecate away from it and join other females and males to roost on other parts of the nest island or

on surrounding water. Females may feed at night to restore depleted reserves.

Hatching

Data taken from 40 eggs in eight nests during 1968 indicated that eggs hatched at all times of the day. It took 46-52 hours from the first tapping for the gosling to emerge completely. It took 24-30 hours from the first break in the outer shell surface. The complete broods hatched within a 12 hour period and the whiter eggs, presumably laid last, were not significantly later. The weather was dry and warm and the goslings were dry within 2-3 hours.

The weight of 32 goslings, within three hours of being hatched, ranged from 125-134 grams (mean 127 gm.), i.e. 79% of the mean fresh egg weight. The goslings are nidifugous and can run, swim, dive and feed within hours of drying. Five dives of a four-hour-old gosling averaged 4.7 seconds. Individuals of the same age were noted pirouetting while swimming and feeding on surface water insects.

Checks were made on the hatching success of 147 nests, by examination of the contents and condition of the remaining egg shells. Of these nests 143 (97.3%) hatched at least one egg. Of the original 873 eggs, 699 (87.6%) hatched successfully.

Predation

Greylag Geese appear to have few natural enemies, which take insignificant numbers. Eggs were seen to be predated twice by Carrion Crows *Corvus corone*, on both occasions attempting but failing to carry off an egg. Eventually the eggs were rolled out of the nest and then broken into with the bill. It is widely believed by local gamekeepers that the Carrion Crow is an important predator of the Greylags but there is very little evidence to support this.

Great Black-backed Gulls have been seen to predate eggs twice. According to a local gamekeeper, one mainland site had the whole clutch of five predated by Rat *Rattus norvegicus*. The causes of failure in 460 nests are detailed in Table III.

Greylag goslings were seen killed by feral Cat *Felis* sp. twice and were found in the guts of Pike *Esox lucius* on three occasions, one 6.4 kg. fish having taken an almost three-quarters grown gosling. Predation by Pike is reported by local fishermen to be fairly regular. Otter *Lutra lutra* is not thought to be a significant predator. Fox *Vulpes vulpes* is probably the main predator of goslings, there being 12 local reports.

On 20th June 1965, at Loch Dornal, two adult Great Black-backed Gulls landed beside a creche of 20-25 goslings attended by three flightless adults. One circled hopping round while the other made repeated darts towards the goslings, which had gathered into a tight pack. The adult geese ran towards the gulls, hissing, with the body low and the neck extended in an aggressive posture. The attack persisted for some 20 minutes before the gulls gave up without success.

The only natural predator of adult geese appears to be the fox, which has taken females on the nest, occasionally birds roosting on mainland sites and moorland, and regularly kills wounded birds during the shooting season. In 1968 a fox earth was situated on an island at Mochrum where three pairs of geese nevertheless reared goslings.

Brood survival

The sizes of broods in July of each production year are given in Table II. From an overall mean clutch size of 5.1, the mean brood size in July was 4.1. Since 1964 a second count of brood sizes was taken in late September before immigrant Greylag of Icelandic origin had arrived

Table III. Causes of nest failure of 460 Greylag nests in Galloway.

Factor	*Number of nests*
removal for hatching and introduction elsewhere	350
disturbance through fishing	57
deliberate destruction of eggs (agricultural interests)	31
moor burning and drainage	13
disturbed by dogs or cattle	2
female death (egg peritonitis)	4
killed on nest by fox	2
shot on nest	1
Total	460

Table IV. Comparison of the breeding success, by brood size, of the feral Galloway Greylag Geese and the immigrant Icelandic stock. Icelandic data from Boyd and Ogilvie (1972).

	Galloway			*Icelandic*	
Year	*Mean brood (July)*	*Juvenile % (September)*	*Mean brood*	*Juvenile % (November)*	*Mean brood*
1963	4.6	—	—	27.5	2.3
1964	4.3	18.0	3.0	27.6	3.0
1965	3.6	20.2	3.0	21.1	3.1
1966	4.1	19.4	3.5	24.9	2.6
1967	4.2	24.0	4.0	11.0	1.8
1968	4.3	22.7	3.6	6.0	1.3
1969	3.7	24.6	2.8	23.8	2.0
1970	4.4	25.0	3.2	25.1	2.4
1971	3.7	20.0	3.4	17.5	1.8
mean	4.1	mean	3.2	mean	2.2

(Table IV). This gave an overall mean brood size of 3.2, to be compared with the overall mean brood size of Icelandic birds in Scotland of 2.2 in November (unpublished data from the Wildfowl Trust). The Icelandic birds of course had to face the rigours of a harsher environment, and inevitable losses during migration and from shooting when they arrive in Britain. The much smaller fluctuations in annual production by the sedentary, feral population are very noticeable.

Acknowledgements

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Summary

Greylag Geese *Anser anser* were reintroduced to south-west Scotland about 1930 and by 1971 the population was estimated at over 1,000. They prefer to nest on wooded islands in a variety of sites. Laying and hatching dates were consistent from year to year. Old nest sites are re-used and most females lay four to six eggs. Some clutches are by two females and bigamy was proved. Incubation is by the female alone and lasts 29 days. The behaviour during incubation is described. Eggs are smaller than those of Continental Greylags but indistinguishable from those collected in Iceland. They hatch at any time of day and the goslings weigh on average 127 grams. There is no significant natural predation. Repeated brood size counts indicate good gosling survival compared to the Icelandic population.

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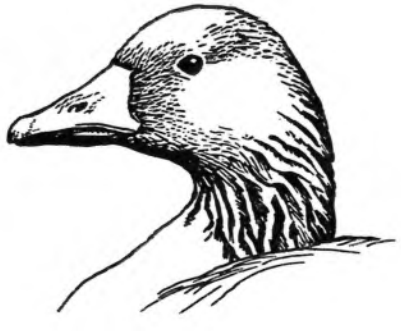

Accidental poisoning of wild geese in Perthshire, November 1971

S. BAILEY, P. J. BUNYAN, G. A. HAMILTON, D. M. JENNINGS and P. I. STANLEY

Introduction

During the latter half of the 1950's the use of persistent chlorinated hydrocarbon insecticides for cereal seed dressing led to the deaths of increasing numbers of seed-eating birds, particularly following the use of dressed seed for spring sowing. Investigations (Turtle *et al.* 1963) by the Pest Infestation Control Laboratory (P.I.C.L.) of the Ministry of Agriculture, Fisheries and Food (M.A.F.F.) showed that aldrin, dieldrin and heptachlor used to dress cereals sown in spring were almost certainly responsible for the incidents. As a result of these investigations and the concern of the general public and various ornithological and naturalist organisations, it was agreed in 1965 that these dressings should not be used on spring-sown cereals, and that in autumn they should be restricted to those areas where there was a real danger of attack by wheat bulb fly *Leptohylemyia coaretata.* Although the agreement reached with manufacturers and distributors of pesticides under the "Pesticides Safety Precautions Scheme" is voluntary it appears to work well in practice, and reports of mass bird deaths of the type previously seen are now relatively rare. However, partly because of continuing minor incidents, successive official reports (for example Cook 1964) have urged the development of less persistent seed dressings and a few alternatives are now available. Two cereal dressings based on the more acutely poisonous, but less persistent organophosphorus pesticides, chlorfenvinphos (2-chloro-1-(2,4-dichlorophenyl)vinyl diethyl phosphate) and carbophenothion (S-(4-chlorophenylthiomethyl) diethyl phosphorothiolothionate) have recently come into use. We wish to report the poisoning of some hundreds of Greylag Geese *Anser anser* as a result of the use of one of these pesticides and thereby draw attention to hazards which might arise following the use of such seed dressings in certain special circumstances.

Field details and background to the incident

Boyd and Ogilvie (1972) report that the large majority of the Greylag Geese wintering in Britain come from the population breeding in Iceland and that the Greylags enter Britain during October. In the autumn, up to two-thirds of the wintering stock is concentrated in east central Scotland particularly the counties of Angus, Perth and Fife. Counts in November each year reveal that the present wintering population amounts to approximately 60,000 to 65,000 birds. In east central Scotland, the Greylags typically roost inland on small areas of water and feed on agricultural land within a few miles of the roost. Strathmore, an area of low-lying agricultural land well provided with standing water in the form of numerous small lochs and rivers, holds a large wintering Greylag population including at least 3,000 birds on the River Isla near its confluence with the Tay.

The incident took place on arable land bordering the lower part of the River Isla. It has been normal practice for these fields to be sown at the end of October with winter wheat and barley and for a seed-dressing to be used to protect the grain against wheat bulb fly and fungal attack. On about 40 hectares of winter wheat and barley sown in this area between 25th and 27th October 1971 at least 200 geese had died by 1st November. Birds still alive were observed to have foam emerging from the beak and to have blood in their droppings. The presence of grain on the surface of these fields was also reported. Six geese were sent at this time to the Veterinary Investigating Officer (V.I.O.), East of Scotland College of Agriculture, Perthshire, for post-mortem examination. A further six corpses were obtained on 8th November by the East Craigs Laboratory of the Department of Agriculture for Scotland (D.A.F.S.).

Geese continued to die for at least a week, 500 being a reasonable estimate of the total number of deaths. Most of the geese were buried by the farmers on whose land they died so that the exact numbers and species are not known. However, samples sent for examination were Greylag Geese with the exception of one Pink-footed Goose *Anser brachyrhynchus* and it seems likely that the incident involved predominantly Greylags.

A selection of the tissues, including the crop contents, brain and liver from six birds was received by P.I.C.L. from the V.I.O. (1-6) and one whole goose (7) was obtained from D.A.F.S. who also

sent two specimens to the Veterinary Laboratory, M.A.F.F., Lasswade, for post-mortem examination. The warden of the Loch Leven National Nature Reserve kindly supplied two shot Greylag Geese for comparative purposes (8 and 9).

Methods and results

Post-mortem examination

The post-mortem examinations carried out by the East of Scotland Agricultural College, Lasswade, and the P.I.C.L. revealed that birds picked up during the early part of the incident had died fairly quickly with little deterioration in general condition. The crop and gizzard contents included considerable quantities of soil and wheat, some of which showed evidence of a red dye. Birds dying later in the incident showed loss of condition and had almost empty crops and gizzards. At least two of the specimens had haemorrhages into the large intestine. Bacteriological examination and examination for parasites revealed nothing of pathological significance.

Organochlorine pesticide residues

Portions of the livers from three geese were extracted by the method of Taylor *et al.* (1964) and analysed on a Pye 104 gas-liquid chromatograph (g.l.c.) equipped with a ^{63}Ni electron-capture detector. The analysis was carried out on a 3 ft. × 4 mm. internal diameter (i.d.) glass column packed with 2.5% silicone oil and 0.25% epikote on 100/120 mesh celite and maintained at 160°. Two birds had no detectable residues whilst the third contained 0.1 parts per million (ppm) p,p'DDT, 0.1 ppm p,p'DDE and 0.04 ppm p'p'DDD.

Total mercury residues

Combined organic and inorganic mercury was measured in portions of the livers from three geese and in portions of the combined crop and gizzard contents from six geese. The samples were digested with nitric acid and hydrogen peroxide (Monk 1961) and the inorganic mercury thereby formed, estimated by a flameless atomic absorption method (Hatch and Ott 1968) with the final measurement on an EEL 240 atomic absorption spectrophotometer. Results are given in Table I, in milligrammes (mg.) and parts per million (ppm).

Organophosphorous pesticide residues

Portions of three livers and six crop and gizzard contents were admixed with anhydrous sodium sulphate to give a friable powder and continuously extracted with hexane. Analysis of the crop extracts, on a Pye 114 g.l.c. equipped with a phosphorous-specific thermionic detector using a 5 ft. × 4 mm. i.d. glass column packed with 5% diethylene glycol succinate on 100/120 mesh chromosorb W maintained at 230°, showed one major peak identified as carbophenothion. The identity was confirmed on two other columns by comparison of the retention times with an authentic sample. The liver extracts showed no peaks on the thermionic detector. By addition of an internal standard it was demonstrated that carbophenothion was unstable in the hexane extracts and therefore possibly in the crop contents. Thus results shown in Table I are almost certainly an underestimate of the quantities of carbophenothion remaining in the crop and gizzard at death.

Thin layer chromatography (t.l.c.) was also carried out on the hexane extracts of the crop contents. Silicagel G (500 micron) coated glass plates were run to a length of 150 mm. with 5% acetone in toluene and developed by the method of Mendoza *et al.* (1968) which is specific for esterase inhibitors such as the organophosphorus pesticides. A major and a minor cholinesterase inhibiting spot (Rf 0.74 and 0.22) was found in all the extracts and in the standards, and an additional spot (Rf 0.14) was found in the crop contents. The latter was probably

Table I. Total carbophenothion and mercury content of dead Greylag Geese.

	Carbophenothion	*Mercury*	
Goose	*Total crop and gizzard content (mg.)*	*Liver content (ppm)*	*Crop and gizzard content (ppm)*
1	17		3.0
2	1.2	0.8	1.1
3	0.7	0.6	
4	1.2		1.1
5	1.7		0.7
6	0.6		0.1
7		0.3	1.1

an oxidative metabolite of the pesticide. The liver extracts showed none of the above spots but did contain another cholinesterase inhibiting compound (Rf 0.02) which also appeared to be an oxidative metabolite. These results were confirmed on a second t.l.c. system.

Mass spectral confirmation

The 70 eV mass spectrum of the major component of the hexane extract of the crop and gizzard contents of goose 1 was obtained using a Pye 104 g.l.c. coupled to an AEI MS 30 mass spectrometer. It was found to be identical with the mass spectrum of carbophenothion.

Esterase determinations

Cholinesterase measurements were carried out on spun extracts of brain from all the geese by the standard method in use in the laboratory (Bunyan *et al.* 1968a) using a Radiometer automatic titration apparatus. Because measurements had not previously been made on tissue from Greylag Geese, two control birds (8 and 9) were also examined. All measurements were checked for linearity with both time and concentration. Results are shown in Table II. Brain protein levels were measured by the method of Lowry *et al.* (1951).

Although the control sample (8 and 9) was small, brain cholinesterase is generally a reliable parameter with a small deviation and we feel justified in concluding that all the geese from the incident exhibited depressed brain cholinesterase levels. However, whilst most of the values approached 90% inhibition which is our normal criterion of death due to organophosphorus poisoning (Bunyan *et al.* 1968b), only one (5) fully met the criterion. It may be that spontaneous reactivation occurs following the inhibition of cholinesterase by carbophenothion and further investigation is required to resolve this matter. However, starch gel electrophoresis of brain extracts coupled with histochemical staining for cholinesterase and α-naphthyl acetate esterase activity using methods described elsewhere (Bunyan and Taylor 1966) gave isoesterase patterns consistent with inhibition by comparison with patterns from the two controls. Unfortunately only in one case (7) was a wider range of tissues available to compare with the controls. However, measurements of triacetin esterase, α-naphthyl acetate esterase and phenyl benzoate esterase in brain, liver and kidney as well as starch gel electrophoresis of liver extracts from this bird all indicated a reduction of esterase activity consistent with organophosphorus pesticide poisoning.

Table II. Brain cholinesterase levels in Greylag Geese.

Goose	*Brain cholinesterase**
1	0.82
2	1.03
3	1.60
4	0.70
5	0.32
6	1.99
7	0.66
8	4.85
9	3.65

* μmol acetylcholine hydrolysed/h/mg. protein

Gas-liquid chromatographic analysis using electron capture and phosphorous specific thermionic detectors at the Agricultural Scientific Services Laboratory, D.A.F.S., confirmed the presence of carbophenothion in liver, breast muscle, crop and gizzard contents from other Greylag Geese involved.

Conclusion

It would appear that the dead geese had consumed considerable quantities of grain dressed with carbophenothion, a mercurial fungicide and a red dye. The agreement between the quantities of mercury and carbophenothion found in the crop contents is consistent with this conclusion and a commercial dressing having these three constituents is now available. The levels of mercury found in the liver are unlikely to have been lethal. There are no published data on the toxicity of carbophenothion to birds but the esterase measurements made on these geese support the conclusion that death was due to organophosphorus poisoning.

Significantly grain was still visible on the surface of the newly sown fields after the incident and it is also notable that a second smaller wave of deaths occurred after a nearby area was sown. Almost all of the grain eaten by Greylags is picked up from the surface and there is no evidence that they dig for properly sown grain (Kear 1963). Sowing under the most favourable conditions can leave some grain on the surface so that the presence of large numbers of geese in this particular part of the country can give rise to special problems. Greylags frequent the area in very large flocks at the time of autumn sowing and continue to be present in smaller numbers until April, so that it would be difficult to sow when geese are absent. Carbophenothion, although it may be generally preferable to a chronic and persistent poison like dieldrin, is an acute poison and might

present a greater hazard to geese under these conditions. In areas regularly visited by geese such factors as the type and degree of insecticidal treatment required, and the sowing practices may repay attention, while scarers properly used (D.A.F.S. 1971) could prevent birds from feeding on newly sown fields. It is also known (Hutson and Hathway 1967; Bunyan *et al.* 1971) that certain organophosphorous compounds whilst generally of low toxicity can be highly toxic to a few species and it may be an unfortunate coincidence that carbophenothion is unduly toxic to Greylags. The apparent absence of casualties among other seed-eating species known to frequent the area lends support to this suggestion. More work will be required to clarify this point and to test how far species variation in toxicity extends among the organophosphorus pesticides currently in use. It thus becomes important to ensure by methods such as those described that, with the introduction of less persistent seed dressings, isolated incidents of the type described are avoided.

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Summary

Following the autumn sowing of wheat dressed with carbophenothion and a mercurial fungicide in an area of Perthshire visited by Greylag Geese *Anser anser* some hundreds of the birds were found dead. Analytical and biochemical investigations gave results which were consistent with poisoning by carbophenothion. Conclusions are drawn about this incident and and some suggestions made to reduce risks in future.

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Moult migration of Emperor Geese

N. G. BLURTON JONES

Salomonsen (1968) reviewed the data on moult migration in waterfowl but he makes no mention of the Emperor Goose *Anser canagicus* in this context. Kistchinski (1971) reports a moult movement of this species in NE. Siberia. Observations made in western Alaska in 1960 suggest, especially when taken together with the remarks of Fay and Cade (1959), that in this part of its range also the Emperor Goose has, like many other geese, an approximately northern moult migration.

The author, along with R. G. B. Brown and D. J. T. Hussell, spent the period from 8th May to 28th July 1960 in the Hooper Bay area of the Yukon-Kuskokwim delta in western Alaska. The main object of study during this period was Sabine's Gull *Xema sabini* (see Brown, Blurton Jones and Hussell 1967) but we separately gathered data on various other topics of interest to ourselves, for example wader distraction displays (Brown 1962), breeding of passerines (Hussell 1970), and distribution and breeding biology of geese.

The Hooper Bay area, and its rich avifauna, has been well described by Brandt (1943) and Fisher and Peterson (1956). It is mostly flat, waterlogged, and less than 15 metres above sea level. Prominent habitats include mudflat, expanses of pond-strewn grass and sedge flats just above high tide level, rolling hillocks with grass, sedge and *Empetrum*, and still more ponds. Nearby Cape Romanzof, the seaward end of the Askinuk mountains, and Dall Point in the lowland near our base camp are two of the westernmost parts of Alaska's west coast. Emperor Geese were extremely common nesting birds all over the lowland areas near the sea, and on average were pleasantly tame.

Our base camp from mid-May to July was at the base of Panowat Spit on the south shore of Igiak Bay. Our normal daily routine consisted of a walk about one and a half kilometres inland to the Sabine's Gull colony from our camp near the coast, interspersed with occasional walks for supplies to the village of Hooper Bay 13 km. to the south. Although I regularly recorded the direction of travel of any geese seen in flight, purely local flights, easily seen in this open landscape, were not often recorded. Flight directions were estimated in relation to the local landmarks.

The spring arrival of geese was not conspicuous, although the data in Table I show the effects of one day of abundant movements (27th May). But towards the end of June a brief but very large scale movement of Emperor Geese occurred. The numbers, directions and dates of the flocks recorded are summarised in the tables. Table I shows the number of Emperor Geese flying past in each week during our stay in the area. Table II shows the number of birds flying in each direction.

It is evident from the tables that large numbers of Emperor Geese were passing over Igiak Bay and out to sea, well clear of Cape Romanzof which is approximately NNE. of our base camp, during 19th-25th June. The biggest movement was on 20th June (1,059 birds recorded). Most of the birds involved (they flew low and could be clearly seen) had unstained white

Table I. Numbers of Emperor Geese recorded, (1) flying past, and (2) stationary or moving locally. (Period from 5th-24th July was spent away from base camp.)

Week		*No. flying*	*No. stationary or local*
May	8-14	2	2
	15-21	17	23
	22-28	160	95
	29- 4	0	11
June	5-11	15	82
	12-18	0	90
	19-25	1186	412
	26- 2	263	252
July	3- 9	(0)	(110)
	10-16	(0)	(200)
	17-23	(0)	(0)
	24-28	0	100

Table II. Directions of flying flocks of Emperor Geese during the two major movements.

Direction	*May 27*	*June 20-July 1*
ENE	0	0
NE	0	0
NNE	59	17
N	29	54
NNW	45	234
NW	8	660
WNW	0	428
W	0	0
WSW	4	0
SW	0	0
SSW	3	0
S	0	0
SSE	0	0
SE	0	0
ESE	0	56
E	0	0

heads and a dark spot near the beak, described as immature plumage in Delacour (1954). After this time pairs with goslings were abundant in the area and were not accompanied by immatures. This was in contrast to the position before hatching when pairs were often accompanied by immatures. We could not exclude the possibility that failed breeders also left. This would have to be checked in any study of breeding success of territory-owning pairs.

Examination of a map of the Bering Sea shows the direction of most of the flying flocks to be approximately towards St. Lawrence Island. Fay and Cade (1959) describe large numbers of moulting, non-breeding, immature Emperor Geese along the southern shore of St. Lawrence from 20th June-15th August, about half of them leaving again by early September. Consequently it seems highly likely that there is a large scale moult migration of Emperor Geese to St. Lawrence Island. This migration resembles that of most of the geese mentioned by Salomonsen (1968), in that it is approximately northward and predominantly concerns non-breeders. Fay and Cade (1968) report that the moulting Emperor Geese were mostly among the lagoons of the south coast. This would be a very safe area compared to the expanses of albeit wet and boggy mainland from which the larger ponds are disappearing at this stage in the summer. Salomonsen made the important suggestion that the removal of competition for food with parents and the new generation of siblings is a major survival value of the northward moult migration of geese. But in addition it is tempting to suggest the value of a good refuge as another selection pressure favouring the northward moult migrations of geese.

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Summary

Observations on Emperor Geese *Anser canagicus* in western Alaska indicate a northward moult migration probably to St. Lawrence Island.

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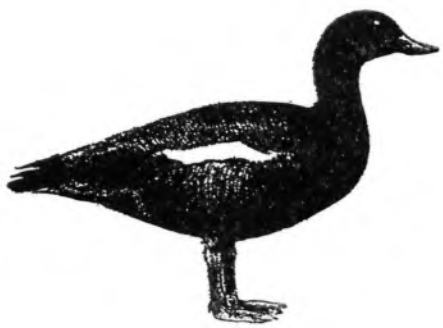

Mortality and exploitation of Paradise Shelduck

MURRAY WILLIAMS

Introduction

The Paradise Shelduck *Tadorna variegata* is probably more intensively exploited by Man than other Tadornini. The largest and most conspicuous of New Zealand's native waterfowl, it was extensively taken as food by Polynesian Man from the beginning of his settlement. Most of the remains which pre-date European settlement have been recovered from Maori camps or middens; the earliest known remains dated A.D. 1249 ± 47, are from Waimataitai (Zander 1967). The Maori appreciated that the species was flightless during moult and Buller (1893) reported them capturing up to 5,000 birds in a single operation in the Marlborough district. Beattie (1920) described in detail a similar round-up on Lake Waihola, Otago, in 1859, the capture technique being similar in many respects to that used during this study.

Following European colonization about 1840, native forest was felled and in its place pasture was established. This resulted in an increase in Paradise Shelduck numbers and an extension of their range. As a consequence, it became an increasingly important game bird, and, in the 104 years of statutorily-controlled shooting, has been subjected to varying levels of exploitation. During the past 20 years, shelduck populations through New Zealand have been declining (Williams 1971). This paper analyses band returns from two populations to determine the role of exploitation in their declines.

Materials and methods

Capture and banding techniques

The Wildlife Service has banded Paradise Shelduck at sites near Gisborne since 1961 and near Taihape since 1962. A total of 6,866 birds were banded in these areas up to and including 1969 and information detailing the recovery of 1,143 birds had been forwarded to the Banding Office by 31st October 1970.

The birds were caught on their moulting areas in early January. Two capture techniques have been used. Small pens were constructed on the water's edge and a long wire-netting lead extended out into the water. Rowing boats then drove the birds slowly around behind and then back down the lead into the pens. On small waters, or following two or three drives on large waters, under-water netting was employed. A four-inch mesh nylon gill net, corked and lightly weighted, of variable length (often 60-80 metres) and approximately two metres deep was extended at right angles to the shore. The birds were herded slowly towards the net and, on reaching the corkline, most dived. This behaviour was encouraged by banging oars on the water and shouting. Birds became entangled in the net and surfaced. The net was quickly gathered into boats and spread out on the shore. The process of disentanglement was performed with great care in order to prevent damaging the developing remiges. There was a 1-2% mortality from drowning in the net.

Three different types of metal bands were used during the study period; aluminium, monel metal and, finally, stainless steel. There is, however, no evidence to suggest aluminium bands failed to last the duration of this study. Aluminium bands have been worn by Black Swan *Cygnus atratus* for as long as 15 years (C. J. R. Robertson pers. com.).

The banded populations

Although the Gisborne and Taihape banding sites (Figure 1) are only about 80 miles apart, there is almost no movement between the populations. The medial recovery distance for both populations is less than 20 miles and 95% of all birds were recovered within 50 miles of their banding site (unpublished data).

The moulting flocks comprise both immatures (i.e. birds 15-18 months old undergoing their first wing moult) and adults. The birds in the banded sample, however, were not allocated to age classes.

Life tables

Readers not conversant with life table terminology are referred to Reid (1966) for a lucid explanation. The method of analysis follows Hickey (1952) and Farner (1955). All but six of the recoveries were made during the shooting season (May and June) and all birds had been shot. The banding year is 1st January to 31st December except for 1970. Thus, the birds are banded 4-5 months before the shooting season in the same banding year. The recovery of bands for birds banded in 1961 and 1962 is considered complete.

Results

Mortality rates for males and females of both populations are presented in Tables I-IV. At Gisborne (Tables I-II), both sexes experienced similar mortality in the year of banding (i.e. year 0-1) and in subsequent years but at Taihape (Tables III-IV) the females' year-of-banding mortality and weighted mean mortality

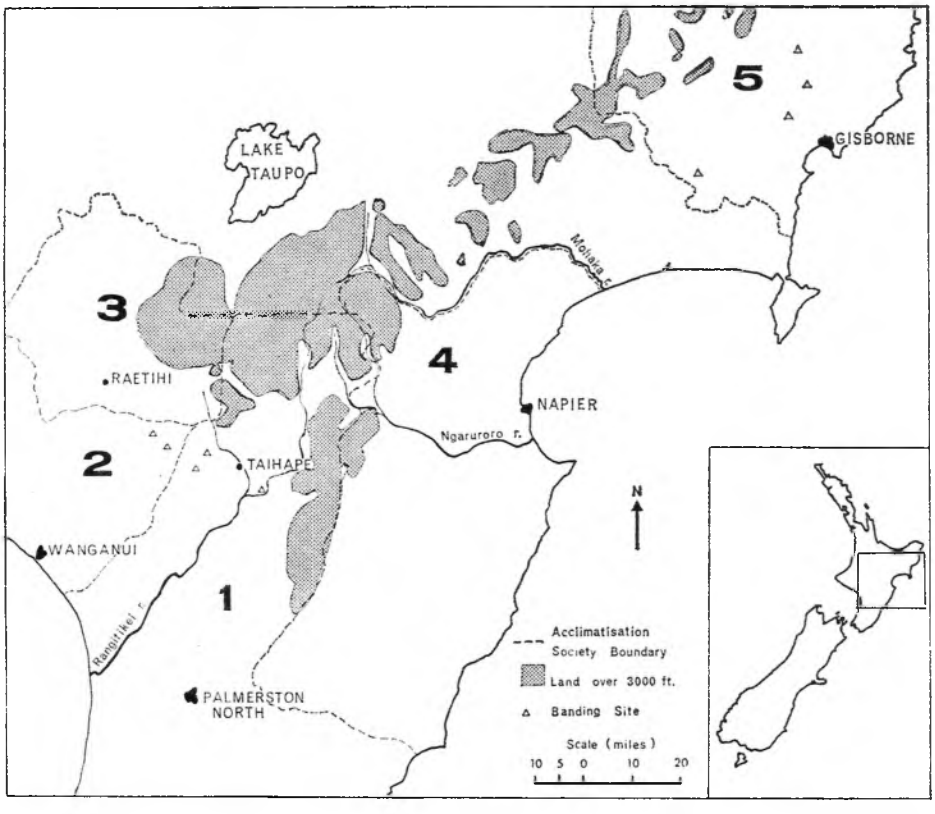

Figure 1. Map showing place names mentioned in the text, banding sites, and Acclimatisation Society districts as follows: 1. Wellington; 2. Wanganui; 3. Waimarino; 4. Hawke's Bay; 5. Gisborne.

(Mw) are higher than those of the males.

Mortality rates were also calculated for the Gisborne population ignoring data from the 1970 shooting season. (In this year, the season was shortened from two months to one month and the daily limit reduced from ten to three.) For females the year-of-banding mortality was 48.0%, the average over the subsequent four years was 27.6% and Mw. for all years up to the 7-8 year class was 38.4%. For males, the corresponding figures were 45.7%, 26.0% and 33.0%. These results are similar to those from Taihape in that females experience a greater overall mortality than males, despite the fact that,

Table I. Mortality, survival and expectation of further life of male Paradise Shelduck banded near Gisborne 1961-1969.

Year banded	*Number banded*	*Recoveries in years following banding* 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	*Total recovered*
1961	159	14	2	8	2	0	0	0	0	3	0	29
1962	71	3	3	1	4	1	1	0	1	0		14
1963	241	21	9	6	1	1	1	4	0			43
1964	321	30	9	3	4	3	3	1				53
1965	275	24	10	7	4	2	3					50
1966	237	17	8	6	3	1						35
1967	290	29	13	7	2							51
1968	323	44	15	8								67
1969	293	37	22									59
Total	2210	219 of 2210	91 of 2210	46 of 1917	20 of 1594	8 of 1304	8 of 1067	5 of 792	1 of 471	3 of 230	0 of 159	401
% of bands recovered		9.9	4.1	2.4	1.3	0.6	0.8	0.6	0.2	1.3	—	21.2
Mortality series		46.8	19.4	11.3	5.9	2.9	3.5	3.0	1.0	6.1		
Cumulative % of bands recovered		46.8	66.2	77.5	83.4	86.3	89.8	92.8	93.8	99.9		
Survival series		53.2	33.8	22.5	16.6	13.7	10.2	7.2	6.2	—		
Mortality rate %		46.8	36.5	33.6	26.3	17.4	(average 2nd to 5th year classes = 28.5)					
Expectation of further life		1.6 years	3.3 years (using average mortality 2nd to 5th year classes)									
Weighted mean mortality rate (Mw) over years 0-1 to 7-8 = 36.4%												

Table II. Mortality and expectation of further life of female Paradise Shelduck banded near Gisborne 1961-1969.

Year banded	*Number banded*	*Recoveries in years following banding* 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	*Total recovered*
1961	218	23	3	8	4	3	1	0	0	1	1	44
1962	143	8	5	2	1	1	4	1	2	2		26
1963	207	20	5	5	0	2	3	0	1			36
1964	227	16	6	3	2	0	3	1				31
1965	176	23	9	3	2	2	0					39
1966	210	5	10	6	3	1						25
1967	210	20	3	5	1							29
1968	160	13	9	3								25
1969	284	42	15									57
Total	1835	170 of 1835	65 of 1835	35 of 1551	13 of 1391	9 of 1181	11 of 971	2 of 795	3 of 568	3 of 361	1 of 218	312
% of bands recovered		9.3	3.5	2.3	0.9	0.8	1.1	0.3	0.5	0.8	0.4	19.9
Mortality series		46.5	17.8	11.6	4.7	3.8	5.7	1.3	2.7	4.2	2.3	
Mortality rate %		46.5	33.2	32.6	19.4	19.8	(average 2nd to 5th year classes = 26.3)					
Expectation of further life		1.6 years	3.3 years (using average mortality 2nd to 5th year classes)									
Weighted mean mortality rate (Mw) over years 0-1 to 7-8 = 35.0%												

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Plate XI. (Above) A female Musk Duck *Biziura lobata* uses its tail as a rudder when swimming in a tight circle; (below) it rolls almost completely on its back whilst preening its belly.

Philippa Scott

E. E. Jackson

Plate XII. (Above) The Gadwall *Anas strepera* is now firmly established as a feral species at Slimbridge, breeding freely in the pens.
(Below) A charming study of recently hatched cygnets of the Black-necked Swan *Cygnus melanocoryphus*.

K. W. Holder

in both areas, the recovery rate for females is lower indicating they are less likely to be shot.

Survival curves (Figure 2) show that cohorts from both populations decline at similar rates for the first three-four years. Thereafter, however, the Taihape cohorts quickly become extinct whereas Gisborne cohorts may survive into the ninth year.

The expectation of life after banding is calculated from the formula: Expectancy (in years) = (2−m)/m (where m = annual mortality). Gisborne birds at banding have an average expectation of further life of almost 1 year 8 months (1.6 years), but those which survive their first year after banding have a further average life expectancy of just over three

Table III. Mortality and expectation of further life of male Paradise Shelduck banded near Taihape 1962-1969.

Year banded	*Number banded*	*Recoveries in years following banding* 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	*Total recovered*
1962	67	16	5	0	1	0	0	0	0	0	22
1963	49	7	3	1	1	0	1	0	0		13
1964	105	18	6	3	1	4	3	0			35
1965	148	7	12	5	7	1	2				34
1966	211	17	9	6	3	4					39
1967	230	20	16	7	5						48
1968	216	20	8	3							31
1969	379	23	7								30
Total	1405	128 of 1405	66 of 1405	25 of 1026	18 of 810	9 of 580	6 of 369	0 of 221	0 of 116	0 of 67	252
% of bands recovered		9.1	4.7	2.4	2.2	1.6	1.6				21.6
Mortality series		42.0	21.8	11.3	10.2	7.4	7.4				
Mortality rate %		42.0	37.4	31.2	41.2	48.0					

(average 2nd to 5th years classes = 39.7)

Expectation of further life 1.9 years 2.0 years (using average mortality 2nd to 5th year classes)

Weighted mean mortality rate (Mw) over years 0-1 to 4-5 = 39.5%

Table IV. Mortality and expectation of further life of female Paradise Shelduck banded near Taihape 1962-69.

Year banded	*Number banded*	*Recoveries in years following banding* 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	*Total recovered*
1962	85	12	4	0	0	0	0	0	0	0	16
1963	50	8	1	0	1	0	2	1	0		13
1964	80	14	1	1	2	2	0	0			20
1965	171	8	6	0	6	2	0				22
1966	184	17	9	7	1	2					36
1967	207	17	6	1	3						27
1968	168	6	10	2							18
1969	371	20	6								26
Total	1316	102 of 1316	43 of 1316	11 of 945	13 of 777	6 of 570	2 of 386	1 of 215	0 of 135	0 of 85	178
% of bands recovered		7.7	3.3	1.2	1.7	1.0	0.5	0.5			15.9
Mortality series		48.8	20.6	7.3	10.1	6.6	3.3	3.0			
Mortality rate %		48.8	40.2	23.8	45.0	51.5					

(average 2nd to 5th year classes = 40.1)

Expectation of further life 1.6 years 2.0 years (using average mortality 2nd to 5th year classes)

Weighted mean mortality rate (Mw) over years 0-1 to 4-5 = 43.0%

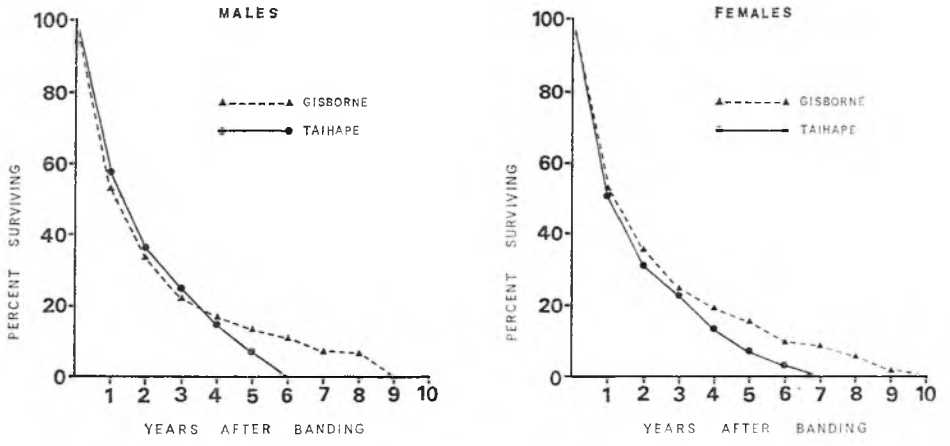

Figure 2. Survival curves of male and female Paradise Shelduck banded at Gisborne and Taihape.

years. Taihape birds have a similar life expectancy at banding and those surviving their first year can expect on average to live another two years.

Exploitation

The aim of management investigations on Paradise Shelduck is to determine the optimum level at which the species may be exploited. This level will necessarily fluctuate from year to year for it will depend on such factors as the success of the breeding season and the effect and intensity of the previous year's shooting.

Many factors influence shooting pressure. Daily bag limits and season length are the statutory regulators of waterfowl harvest. At Gisborne, the daily limit was 10 during 1961-1969 but was reduced to three in 1970. Taihape birds were recovered from areas controlled by the Wellington, Waimarino and Wanganui Acclimatization Societies (Figure 1). These Societies in 1962 allowed daily limits of 15, 10 and 10 respectively but thereafter all limits were 10 per day. Throughout New Zealand, the shooting season is usually of one month's duration. However, during 1962-1970 Paradise Shelduck could be hunted for two months in the Wanganui and Waimarino areas and similarly in Gisborne during 1965-1969.

Weather during the shooting season also affects shooting pressure. Fine weather and clear skies cause birds to fly high and out of gun range resulting in a low harvest.

One statistic widely used as an index of shooting pressure is the year-of-banding recovery rate (Table V) (Balham and Miers 1959; Imber and Williams 1968; Geis *et al.* 1969.) This is in fact a poor indicator of shooting pressure for many factors influence it. If adults survive their year-of-banding better than immatures (as for Mallard *Anas platyrhynchos* in New Zealand (Balham and Miers 1959)) then the immature:adult ratio in the banded sample may influence the first year recovery rate. Another variable is the co-operation of shooters. The percentage of recovered bands that were reported probably varied from year to year during this study. Initially, a shelduck wearing a band was a novelty and, under these circumstances, the shooters probably reported most of the bands they obtained. But as the study progressed, an increasing proportion of the population were wearing bands. Most birds were recovered close to their banding site. There is little novelty in this. A reduction in bag limit and season length may also cause poorer co-operation. The apparent reduction in shooting pressure at Gisborne in 1970 (Table V) as a result of reducing both the length of the season and daily limits is almost certainly not real. Analysis

Table V. Percentage of bands recovered in the year of banding.

	Gisborne		*Taihape*	
Year	*Males*	*Females*	*Males*	*Females*
1961	8.8	10.5	—	—
1962	4.2	5.6	23.9	14.1
1963	8.7	9.7	14.3	16.0
1964	9.4	7.1	17.1	17.5
1965	8.7	13.0	4.7	4.7
1966	7.2	2.4	8.0	9.2
1967	10.0	9.5	8.7	8.2
1968	13.6	8.1	9.3	3.6
1969	12.6	14.6	6.1	5.4
1970	6.1	7.0	—	—

of shooting diaries showed that the average harvest per shooter was almost identical in 1969 and 1970 (T. A. Caithness pers. com.).

It is also possible that the distribution of the shooting mortality over the various age classes of the population may fluctuate from year to year. (This does not negate the assumption that recoveries represent age-specific frequencies of death suffered by the population. By using pooled recovery data from several years, these year to year fluctuations are minimised.) An analysis of data from Table I will show that fluctuations in the recovery rate of older age groups do not always follow those of the year-of-banding recovery rate. For example, the year-of-banding recovery rate decreased from 12.6% in 1969 to 6.1% in 1970 (Table V) but that for birds in the second year after banding rose from 5.4% to 8.6% and for birds in their third year after banding from 2.8% to 3.1%.

The non-return of bands, along with crippling losses (i.e. shot birds which die but are not retrieved by the shooter), also affects estimates of the proportions of the population dying from shooting and from other (natural?) causes. For example, Table I shows that of 1,000 birds alive at banding, 468 died during the first year but only 99 of these were reported shot. There are no good data to indicate the magnitude of these two important corrections, merely reasoned guesses. Balham and Miers (1959) suggested 12% as a conservative estimate for crippling losses of Grey Duck *Anas superciliosa* and Mallard and estimated that shooters failed to return about 20% of all bands they obtained. However, Caithness (1969), analysing shooting diaries, considers crippling losses to be no more than 5%. Imber and Williams (1968) discussed a Canada Goose *Branta canadensis* population in which a high percentage were banded. On the basis of questionnaire response, they calculated that 25% of all bands were not returned and, from information supplied by shooters, they thought a crippling loss of 25% might be conservative. Recent work on a sedentary Canada Goose population at Lake Forsyth, New Zealand, in which most birds are banded has lead M. J. Imber (pers. com.) to suggest that shooters there fail to return about 40% of all bands they obtain.

For Paradise Shelduck, the percentage of bands not returned is likely to be similar to that for Canada Geese. They are a comparatively sedentary species and the proportion of the population wearing bands has steadily increased throughout the study. In subsequent discussion I will use the estimate that one band in three is not returned. Crippling losses are probably related to the terrain over which shooting occurs. This species is shot over two very different terrains. Like Grey Duck and Mallard they may be shot over waters surrounded by thick *Typha* marsh; alternatively, they may be hunted, like Canada Geese, over river flats and open hill country. In the absence of any reliable data, in subsequent discussion an arbitrary 10% is used as an estimate of crippling losses.

Let us apply these crude estimates to data from Table III where 20% of bands are recovered after five years.

1) banded birds *reported* shot in first 5 years = 20.0%

but one band in three is not reported

∴ 2) banded birds *shot and collected* = 30.0%

3) crippling loss is 10% = 1/9 collected birds = 3.4%

∴ 4) total banded birds *shot and killed* over five years = 33.4%

Now, the mean annual mortality over these five years = 39.5%

∴ 5) after 5 years, total mortality of banded birds = 92.0%

∴ 6) proportion banded birds that were shot

$$= \frac{33.4\%}{92.0\%}$$

$$= 36.3\%$$

Thus 36.3% of the mortality in any one year is due to shooting. The mean annual mortality of 39.5% is therefore estimated to consist of 14.3% from shooting and 25.5% from other causes.

How meaningful are these estimates? The 1962, 1963 and 1964 cohorts in Table III have provided band returns of 32.8%, 26.6% and 33.4% respectively (the latter two are not yet complete) which indicates the *minimum* proportion dying from shooting. After only two years, 20% of the 1969 cohort in Table II have been reported shot. If, as deduced above, almost two-thirds of total mortality is due to causes other than shooting, it is remarkable that not one recovery has been made of a bird found dead outside the shooting season. I can only conclude that my estimates of crippling losses and the non-return of bands considerably understate the true situation. New Zealand shooters may be failing to report almost

as many bands as they return or crippling losses are considerably greater than previously believed, or both. The necessity for reliable data on these factors is obvious and in their absence, meaningful estimates of shooting mortality are precluded.

Mortality and productivity

In managing this species an important question is whether its reproductive output can sustain a population subjected to the mortality rates described earlier.

The average number of young per pair that must survive to the start of the life tables (15-18 months) in order to maintain a stable population may be calculated from the survival series thus:

$$X = \frac{1}{\frac{1}{2}(S_1 + S_2 \ldots S_n)} \quad \ldots \quad \ldots \quad (1)$$

where X = number of young per pair that must live to 15-18 months

$(S_1 + S_2 \ldots S_n)$ = survival series

Alternatively, it may be calculated, as Balham and Miers (1959) have shown, from the formula

$$X = \frac{Mw}{50(1-M)} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where Mw = weighted mean mortality rate

M = year-of-banding mortality rate.

Note:

(a) For ease of calculation, subsequent discussion assumes all birds are 15-18 months old at banding. The banded sample does include an unknown proportion of adults (27-30 months and older). In 1970, the immature:adult ratio in the moulting flocks at Gisborne was 65:35.

(b) Survival series is derived from the cumulative percent of bands recovered and is illustrated in Table I (see also Reid 1966).

Using data from Table II, Gisborne pairs are required to rear 1.15 (by formula 1) or 1.31 (by formula 2) young to the age of 18 months. Using Table IV, Taihape pairs are required to rear 1.57 (by formula 1) or 1.68 (by formula 2) young to 18 mnoths.

The productivity of Paradise Shelduck is largely unknown but is currently being studied. Oliver (1955) records clutches of 5 to 11 and McAllum (1965) reported the average size of 22 successful broods at fledging was 6.0. If we accept, for a working example, 6.0 young per pair at fledging, 1.31 and 1.68 per pair at 18 months and assume that all birds of banded age and older breed successfully, then mortality from fledging to banding cannot exceed 78% at Gisborne or 72% at Taihape. Obviously, all members of the population will not breed successfully and it is doubtful if many two-year-olds will even attempt to breed (Boyd 1962). In the Common Shelduck *T. tadorna* more than 50% of pairs attempting to breed may fail to produce young (Hori 1964). The only data so far available on Paradise Shelduck breeding success is recorded by G. P. Adams (N.Z. Wildlife Service files) where only nine of 24 intensively observed pairs appeared with broods. If only half of the population did not attempt breeding or failed completely and the remainder fledged 6 young per pair, then mortality of young from fledging to banding age cannot exceed, at Gisborne 57% and at Taihape 44%. The mortality of Paradise Shelduck in their first year of life is unknown (but under investigation). It will obviously be higher than that recorded in any life table in this paper (Lack 1954). Male Mallard in New Zealand, banded 2-3 months after fledging, suffer 65.9% mortality in the subsequent year (Balham and Miers 1959). If the various assumptions and estimates involved in these calculations are only approximately correct, clearly Paradise Shelduck cannot withstand current mortality rates without declining in numbers, as are both the Gisborne and Taihape populations (Williams 1971).

Mortality of other New Zealand waterfowl

Table VI lists the mortality rates of five of the six game waterfowl in New Zealand (data not yet available for Shoveler *Anas rhynchotis*). Balham and Miers (1959) considered that about 57% of the Grey Duck population die from shooting but only 30% of Mallard do so. Imber and Williams (1968) suggested that, in the period 1957-1962, approximately 29% of Canada Geese died from shooting. In the period 1963-1966, with the advent of special shooting seasons, 70% of all adult mortality was due to shooting. Since these authors may have underestimated the proportion which die from shooting, it is clear that New Zealand waterfowl are subjected to an intensive shooting pressure and Paradise Shelduck obviously share this.

Table VI also indicates that Paradise Shelduck are experiencing a mortality rate almost twice that suffered by Common Shelduck in Britain and Europe.

Table VI. Adult mortality rates of hunted New Zealand waterfowl and other shelducks.

Species	*Sex*	*Year of banding mortality rate* *Male*	*Female*	*Mw (all years)* *Male*	*Female*	*Source*
Mallard	M	47.6	59.9[a]	49.4	58.0[a]	1
Grey Duck	M	64.7	73.2[a]	59.2	69.2[a]	1
Canada Goose				33.4[b]		2
Black Swan				15.3[c]		3
Paradise Shelduck (Gisborne)	M	46.8	46.5	36.4	35.0	Table I, II
Paradise Shelduck (Taihape)	M	42.0	48.8	39.5	43.0	Table III, IV
Common Shelduck				20 ± 5		4
Common Shelduck				22.5 ± 3.5		5

Notes:
(a) Figures include both adult and juvenile females as the authors were unable to accept the ageing of females to be accurate.
(b) Birds were one year old or older at banding.
(c) Refers to Lake Ellesmere population. Birds are banded as cygnets; the Mw is the average adult mortality over years 4-5 to 9-10.

Sources:
1 Balham and Miers 1959. 2 Imber and Williams 1968. 3 M. J. Williams unpublished data. 4 Boyd 1962. 5 Young 1964.

Conclusion

Data presented in this paper suggest that the mortality rates of Gisborne and Taihape Paradise Shelduck are greater than these populations can sustain without declining in numbers. The role of shooting in causing the present decline cannot however be established with any degree of validity until reliable estimates of productivity, first year mortality, crippling losses and non-return of bands are available. However, because shooting pressure is the one factor that can be easily altered and controlled, it would seem essential to lower it so that mortality and productivity are equated. The recently reduced daily limits at Gisborne, and over most of New Zealand, are an important first step in reducing the level of exploitation. It remains to be seen, however, if the new limit of three is the effective conservation measure required. It may require less shooter-effort to reach the new limit and it may also act as an incentive to shooters to 'get their limit'. If it were found that shooting pressure remained too high, a useful alternative would be to apply a more severe restriction to that part of the game season during which the majority of birds are shot. Analysis of shooting diaries (Caithness 1969) showed that in 1969 at Gisborne, 50% of the total harvest occurred during the opening weekend, the remaining seven weekends of the season each accounted for approximately 7% of the kill. This pattern is similar to that recorded by Balham and Miers (1959) for Grey Duck and Mallard. At Taihape in 1969, 30% died on opening weekend and 10% on other weekends. By applying a lower limit to the opening weekend, the total harvest may be significantly reduced.

The Paradise Shelduck is a particularly important game bird in the Gisborne and Taihape areas. Caithness (1969) recorded it comprised 25% of the total waterfowl harvest at Gisborne and 30% at Taihape compared with an average of 3% over the rest of New Zealand. Elsewhere it is shot in substantial numbers only in Southern Lakes and South Canterbury districts of the South Island where it forms 14% of the harvest.

Paradise Shelduck are well adapted to the open hill farmland of New Zealand and there is no shortage of this habitat. Prudent management at this time, starting with a reduction in shooting mortality, perhaps even total protection for a limited period, will allow consolidation of the species' recent spread over the entire country and ensure its continued availability as a game bird.

Acknowledgements

This paper owes much to the efforts of Mr. H. McAllum who, while an Officer of the New Zealand Wildlife Service, initiated studies on Paradise Shelduck. It is also the result of considerable field effort by many Wildlife Service Field Officers and trainees, particularly Messrs. A. G. Hall, P. T. Fisher and T.

Thompson. Neither would it have been possible without the co-operation of shooters in the two districts and the landowners on whose properties the moulting sites are located.

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Summary

Two apparently discrete populations of Paradise Shelduck *Tadorna variegata* were studied in New Zealand. Of 6,866 banded when moulting at 15-18 months or older, 1,143 were reported shot. Weighted mean annual mortality after 15-18 months for all years in one population was 36.4% for males and 35.0% for females; for the other 39.5% and 43.0%.

The recovery rate for females was lower than males indicating they are less likely to be shot. Year-of-banding recovery rate (%) is shown to be an unreliable statistic for monitoring the intensity of shooting.

In the absence of reliable data, crippling losses and non-return of bands were arbitrarily estimated to be 10% and 33% respectively, but reasons are given for believing these estimates considerably understate the true situation.

If half the adult pairs raise six young per pair to fledging, a stable situation can only result if mortality from fledging to banding is less than 57% for one population and 44% for the other. Mortality rates are compared with those of other waterfowl hunted in New Zealand and other shelducks.

Both populations are declining and shooting pressure should be reduced until population stability is achieved. Ways of doing this are discussed.

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British recoveries of Mallard ringed at Borough Fen Decoy, Northamptonshire

M. A. OGILVIE and W. A. COOK

The overseas recoveries of Mallard *Anas platyrhynchos* ringed at Borough Fen Decoy, Northamptonshire, since 1957 were analysed recently (Ogilvie and Cook 1971). This present paper deals with the far more numerous recoveries within the British Isles from the same ringing station. The main approach has been to see whether each season's recoveries can be used to monitor the Mallard population which the ringed sample represents. Particular attention has been paid to seasonal variations in mortality, numbers and local movements. With Automatic Data Processing of recoveries becoming available at the Nature Conservancy's Biological Records Centre, Monks Wood, Huntingdon, it should in future be possible to make annual analyses along the most promising lines indicated in this paper. Thus rather soon after the end of each shooting season it can be discovered what the winter mortality levels have been in relation to the size of the population the previous autumn. Such information should considerably improve our knowledge of the population dynamics of Britain's commonest waterfowl species.

The last analysis of British recoveries of Mallard ringed at Borough Fen Decoy was by Boyd and Ogilvie (1961). They demonstrated that Mallard ringed at the Decoy wandered little during the winter season of ringing, 22% of recoveries being within 10 miles (16 km.) and 90% within an irregular boundary varying between 40 and 80 miles (64 and 128 km.) from the Decoy, and largely following watersheds. A further important finding was that no less than 86% of recoveries in the season after ringing were in this 'dispersion area', further indicating the sedentariness of British-bred Mallard and the adoption of traditional wintering areas by immigrant Mallard from the Continent. This pattern of restricted movements has been confirmed in the present analysis. It has important implications both when discussing the conservation of Mallard and when seeking to use ringing to monitor populations. Results from ringing at Borough Fen do not necessarily apply to other populations within the country.

Materials and methods

The numbers of Mallard ringed at Borough Fen Decoy in each ringing season (July to March) from 1957-58 to 1970-71 are set out in Table I according to month of ringing. It can be seen that within the period the seasonal total has varied from 1,100 to 2,596, and that the principal catching time is from August to November with September predominating. The ratio of males to females in the catch is close to unity. The annual variation in the catch is governed by several factors, some of which, such as breeding success, can be checked (see below). Less easily measurable are local flooding, disturbance of the Decoy by farming activties, availability of natural food in the area, and the weather.

Much of the analysis has been confined to recoveries made by the end of February of the season of ringing (same season recoveries). The shooting season in Britain ends on 20th February on the coast, having closed on 31st January inland. Virtually all recoveries reported

Table I. Numbers of Mallard ringed each month at Borough Fen Decoy, 1957-58 to 1970-71.

Season	*July/Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb./Mar.*	*Total*
1957-58	5	736	102	211	190	73	91	1408
1958-59	78	592	386	341	207	63	75	1742
1959-60	322	1031	548	331	164	105	73	2574
1960-61	133	515	238	67	28	59	39	1079
1961-62	516	479	271	187	65	90	175	1783
1962-63	98	663	257	170	50	0	20	1258
1963-64	223	648	338	170	42	95	75	1591
1964-65	666	1027	454	326	22	26	75	2596
1965-66	413	523	123	17	14	25	27	1142
1966-67	481	986	237	209	108	53	113	2167
1967-68	374	1171	563	278	105	63	65	2619
1968-69	264	554	238	189	51	15	9	1320
1969-70	211	738	193	267	76	53	51	1589
1970-71	219	610	61	98	52	35	25	1100
Totals	4003	10273	3989	2861	1174	755	913	23968

during the open season are from shooting; other causes such as flying accidents amount to less than 2% in most winters.

Same season recovery rates

Birds ringed after the start of the open season (1st September) will be at risk for shorter periods than those ringed before. Ideally only recoveries of birds ringed before the start of the shooting season should be used to provide information on seasonal variation in recovery rates. In this present study, however, the numbers ringed at that time are barely large enough to provide adequate samples of recoveries. Therefore all same season recoveries have been used and a correction factor applied to allow for the date of ringing in relation to the start of the shooting season, following Bellrose and Chase (1950). They used a simple ratio that involved the number of weeks ringed birds were actually available for shooting and the number of weeks that these ringed birds would have been available if they had all been ringed before the start of the shooting season. The correction is made separately for each ringing season.

The first step is to establish the number of ducks ringed in each shooting season (taken as 1st September to 15th February, as the nearest whole number of weeks), and then to find the date by which half the birds have been ringed. This mid-point of the ringing season assumes that all the birds were ringed on that date a known period from the start of the season and from its end. The number of same season recoveries of birds ringed during the shooting season is then multiplied by the ratio (total period of ringing within the shooting season)/(the period from the mid-point of ringing to the end of the season). To this figure is added the number of recoveries from birds ringed before the start of the shooting season, and the whole expressed as a percentage recovery rate of the total ringed.

For this method of correction, the recoveries must be made at a fairly even rate through the shooting season. Somewhat surprisingly the recoveries are indeed made at a remarkably constant rate during the season with no real peak at its start or end. Recoveries made in the second and subsequent seasons after ringing in 1959-60 to 1961-62 are set out in Table II to demonstrate this point.

Table III gives the same season corrected recovery rate for each season together with the data used in calculating them. It can be seen that in every season except 1962-63, when ringing ceased at

Table II. Distribution of recoveries through the shooting season. Birds ringed 1959-60 to 1961-62 and recovered in 2nd and subsequent seasons.

Month	*Period*	*No. of recoveries*	
Sept.	I	18	
	II	14	
	III	21	
	IV	13	
Oct.	I	22	
	II	11	
	III	22	
	IV	14	
Nov.	I	17	
	II	19	
	III	17	
	IV	14	
Dec.	I	15	
	II	13	
	III	12	
	IV	22	
Jan.	I	21	
	II	17	
	III	11	
	IV	17	(a)
Feb.	I	5	
	II	1	
	III	4	(b)
	IV	1	

(a) Jan. 31st is end of inland shooting season.
(b) Feb. 20th is end of coastal shooting season.

the onset of severe weather in January, the ringing period lasts 24 weeks, and that in most seasons the mid-point of ringing is very close to the start. This keeps the corrections needed comparatively small (20% or less in ten of the fourteen seasons).

The most useful way that these same season corrected recovery rates can be applied is to use them to calculate mortality rates. Using the method of Bellrose and Chase (1950) the annual recovery rate is expressed as a percentage of the ultimate total recovery rate. The latter can only be discovered when all recoveries from a season's ringing have been received. Clearly this takes several years and for the most recent years an adjustment must be made to allow for the fact that some birds are not yet dead. However, the birds die so rapidly that after only a few years the great majority of the recoveries have been notified. Table IV sets out the number of recoveries made each season, plus the cumulative percentages, for Mallard ringed in the three seasons 1957-58 to 1959-60. It can safely be assumed that virtually all these recoveries have now been received. By the end of the third season nearly 80% of the recoveries had already been made, and this rose to over 87% by the end of the fourth. Taking these percentages as typi-

Table III. Same season corrected recovery rates, 1957-58 to 1970-71.

Season	*Weeks of ringing from 1 Sept.*	*Weeks from mid-ringing period to 28 Feb.*	*Same season recoveries ringed after 1 Sept.*	*Corrected total*	*Same season recoveries ringed before 1 Sept.*	*Total recoveries*	*Corrected recovery rate (%)*
1957-58	24	21	82	94	0	94	6.8
1958-59	24	18	99	132	5	137	8.0
1959-60	24	19	163	206	29	235	9.2
1960-61	24	21	58	66	10	76	7.1
1961-62	24	19	98	124	47	171	10.0
1962-63	16	13	114	140	6	146	11.8
1963-64	24	20	91	109	24	133	8.5
1964-65	24	20	161	193	68	261	10.3
1965-66	24	22	47	51	38	89	7.9
1966-67	24	21	118	135	50	185	8.7
1967-68	24	20	196	235	44	279	10.7
1968-69	24	20	50	60	12	72	5.5
1969-70	24	20	93	112	15	127	8.2
1970-71	24	22	37	40	21	61	5.6

Table IV. British recoveries of Mallard ringed at Borough Fen Decoy in 1957-58 to 1959-60, and recovered each season since ringing, up to April 1971.

Season	*same*	*2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*	*8th*	*9th*	*10th*	*11th*
No. of recoveries	466	213	92	87	53	29	21	9	3	2	4
Cumulative %	47.5	69.4	78.8	87.7	93.1	96.1	98.2	99.1	99.4	99.6	100.0

cal for the whole period they have been used to adjust the recoveries received from ringing for more recent seasons by adding to the number of recoveries so far made the number to be expected in the future based on this declining rate per annum. Even for quite recent seasons of ringing the adjustment is going to be comparatively small.

The same season and second season mortality rates are displayed in Table V. The figures for same season rates up to and including 1968-69 can be assumed to be quite accurate. The adjustment to 1969-70 is probably too large to be sure of its final correctness, and a figure for 1970-71 would not be meaningful at all. No distinction has been drawn between adult and first year birds. Although the latter are known to have the higher mortality rate, the proportion of adult birds in the ringing totals is low (Table VI), generally less than 10% and only once as high as 19%. There is no correlation between the proportions or actual

Table VI. Breeding success of Mallard indicated by percentage of juveniles caught at Borough Fen Decoy in July to September. Ageing techniques were not developed until 1959-60.

Season	*% juveniles*	*Season*	*% juveniles*
1959-60	93	1965-66	81
1960-61	98	1966-67	95
1961-62	90	1967-68	84
1962-63	86	1968-69	92
1963-64	99	1969-70	95
1964-65	93	1970-71	86

Table V. Season of ringing mortality rates, and rates from previous season's ringing.

	Mortality rates			*Mortality rates*	
Season	*Season of ringing*	*Previous season's ringing*	*Season*	*Season of ringing*	*Previous season's ringing*
1957-58	41.9	—	1964-65	55.4	42.3
1958-59	45.5	40.4	1965-66	50.0	41.0
1959-60	52.2	45.8	1966-67	56.1	45.5
1960-61	41.2	30.8	1967-68	55.6	38.2
1961-62	54.0	44.5	1968-69	39.3	33.0
1962-63	61.8	54.1	1969-70	(56.2)	(43.0)
1963-64	55.5	37.0	1970-71	—	—
			Means (excl. 1969-70)	50.9	41.1

numbers of adults in the ringing totals and the same season mortality rates.

The correlation between the corrected same season recovery rates given in Table III and the same season mortality rates in Table V is very high ($P<.001$); higher indeed than one would have expected even allowing for the large contribution that the same season recovery rates make to the final total. Furthermore the correlation between the same season mortality rates and the mortality rates for birds ringed the previous season (shown in Table V) is also good ($P<.01$). Both correlations add considerable weight to the conclusion that the corrected same season recovery rate is a valid figure and that it is a direct indication of the mortality rate for that season which normally can only be calculated after several more seasons have elapsed. The corrected same season recovery rate which can be calculated shortly after the end of the shooting season is therefore of considerable value as a means of monitoring the mortality of the population.

This direct relationship between recovery rate and mortality rate was first used by Hickey (1952) to discover the natural mortality rate if there were no shooting. Figure 1 plots the two sets of figures for the Borough Fen Mallard. The line drawn through the points on the graph has been extended to the left to where it crosses the vertical axis at about 20%. This figure represents non-shooting mortality, when virtually no recoveries will be made. Crissey (1964) has suggested that such low natural mortality rates indicate that the carrying capacity of a wintering area exceeds that required by present populations. Mortality rates for other species and other populations of Mallard need to be calculated before this could definitely be said to apply to British conditions. It is pertinent to point out that the number of Mallard wintering in Britain has in fact increased by about 30-40% in the period of this study (Atkinson-Willes 1970; Atkinson-Willes and Yarker 1970, 1971).

The mortality rates in Table V exhibit no trends and the range of season of ringing figures is comparatively small with only the very severe winter of 1962-63 showing clearly the increased mortality that was suffered that year. This confirmation of the hard winter effects encourages belief in the reliability of the mortality rates. It will be possible to study future peaks or troughs within a month or so of the end of the shooting season thus greatly increasing the chances of discovering the causes. If a trend in the rates develops it too will be detected earlier.

The mean of the season of ringing mortality rates at 50.9% and the mean

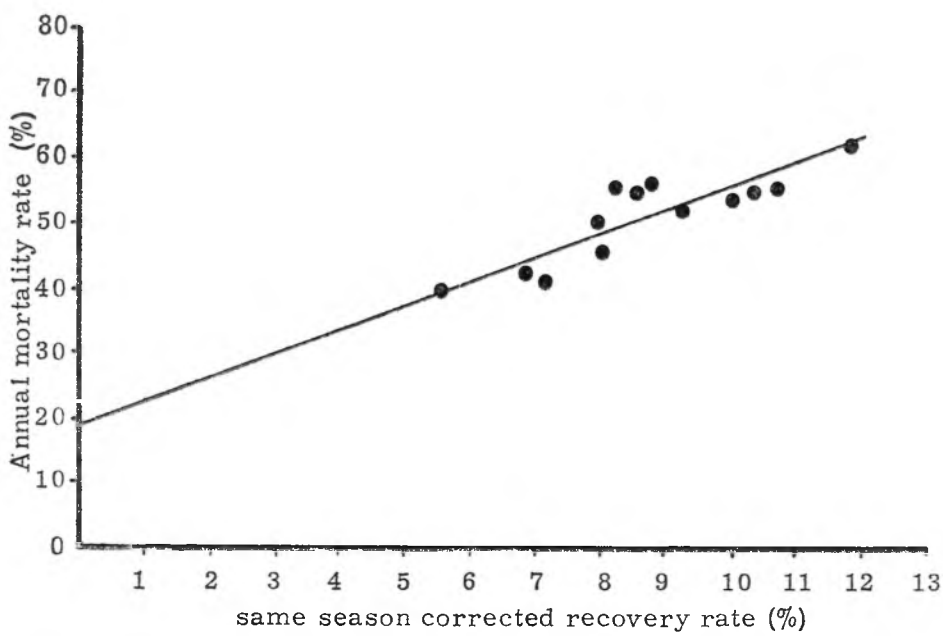

Figure 1. Relationship between recovery rates from shooting and season of ringing mortality rates for Mallard, 1957-58 to 1969-70. The point where the line cuts the vertical axis represents the mortality percentage assuming no shooting.

of the rates from the previous season's ringing at 41.1% can be compared with past calculations. Boyd (1962) found a mean annual mortality rate of 48% for birds recovered after the first 1st January of their life, while Wainwright (1967) excluded all birds in their first year of life and obtained a mean annual mortality rate of 43%. The figures given in Table V are reasonably close to these estimates bearing in mind the different age categories used.

Population size

It would be useful if the size of the decoy catch was related to the size of the population available. The latter is affected among other things by the success of the past breeding season and also by the numbers of foreign immigrants coming in during the autumn and winter. Ogilvie and Cook (1971) attempted to measure the latter but found that only in a few years were there marked influxes and these did not tie in with the numbers being caught late in the season.

Variations in breeding success of British Mallard ought, on the face of it, to be reflected in the proportions of adult and young birds in the catch, particularly in July, August and September. The data are restricted to these months partly to confine the sample to known British birds and partly because as the autumn progresses an increasing number of males become impossible to age. However, there are almost certainly differences in the catchability of adults and young Mallard in a decoy, and the proportions caught in each season (Table VI), although varying to some extent, bear no relationship to the catch size (Table I).

The National Wildfowl Count Scheme run by the Wildfowl Trust monitors the size of the Mallard population wintering in Britain (Atkinson-Willes 1970; Atkinson-Willes and Yarker 1970, 1971; Atkinson Willes and Garvey 1972), but because ringing has shown that British Mallard are subdivided into more or less discrete groups the national indices that have been published are not necessarily closely related to the Mallard numbers around Borough Fen. For this reason an analysis was made of the numbers of Mallard counted on about 40 waters within the dispersion area of the Decoy delimited by Boyd and Ogilvie (1961). This extends up to 80 miles (128 km.) from it. It is sad to have to relate that no sort of correlation could be found between the numbers of Mallard being caught and ringed at Borough Fen Decoy and the numbers counted on various combinations of waters at different distances from the decoy, and that this applied to both between and within season comparisons. The most that could be found was some agreement in the first five years of the study between the number of birds being ringed in September and the number counted in that month, but thereafter the number counted increased fairly steadily while the number being ringed fluctuated in no regular manner.

To some extent the sample of waters being counted is not representative of the waters holding Mallard in the area. Some of the more important Mallard haunts are not adequately counted, usually because of difficulties inherent in the topography, for example of the Wash and the North Norfolk coast. Furthermore the Mallard is the one species of British wildfowl which has a relatively large proportion of its population dispersed over very small waters, including ponds and drainage ditches which of course abound in the Fens. These latter naturally do not warrant coverage by the Wildfowl Count Scheme. Thus, although it would have been useful if some relationship could have been established between the numbers ringed and the population size as measured by the existing wildfowl counts, the fact that it could not is not all that surprising.

Wainwright (1967) and Matthews (1968) have also tried to establish relationships between counts of ducks and the number caught for ringing, at Abberton Reservoir, Essex, and Nacton Decoy, Suffolk, respectively. Wainwright found that there was good agreement between the number of Teal present on the reservoir, a very important haunt for this species, and the number he was catching in his cage traps. Matthews, however, analysing decoy catches of Mallard, Teal and Wigeon found only slight agreement between the Teal catch and national counts, and none with the other species. The correlation seemed to be confined to very good catches in seasons with unusually large numbers of Teal in the country but otherwise little agreement.

The conclusion would therefore seem to be that the population size cannot be measured by that of the catch, and also that the catch size is not affected by variations in the numbers of duck present at any rate within the range experienced in recent years.

Reporting rate check

One very important point to be checked in any ringing programme involving birds with high recovery rates from shooting is

whether the reporting rate declines over a period of years. This would particularly be expected for birds shot close to the ringing station, where the shooter would repeatedly be sending ringing details for the birds that he had shot that differed very little from each other. "Reporter boredom" has then often been recorded, and this affects the quality of the recovery data.

Table VII sets out the same season recoveries of Mallard in three categories of distance from Borough Fen Decoy, up to 10 miles, from 11 to 30 miles, and over 30 miles (16 km., 17 to 48 km., and over 48 km.). These recoveries are then expressed as recovery rates in each season and, further, as proportions of the totals. These convincingly show that there has been no fall off in the proportion of recoveries being reported from close to the decoy and is almost certainly a reflection of the good relationship between the decoyman and the local wildfowlers, who have been made aware that every recovery is of value even though the information relating to it may look rather uninterestingly familiar.

Table VII. Reporting rate check.

Season of recovery	*Number ringed*	*Same season recoveries*			*Recovery rates (%)*			*% at different distances*		
		<10 m.	*11-30*	*>30*	*<10 m.*	*11-30*	*>30*	*<10 m.*	*11-30*	*>30*
1957-58	1408	20	39	23	1.4	2.8	1.6	24	48	28
1958-59	1742	23	42	39	1.3	2.4	2.2	22	40	38
1959-60	2574	28	76	88	1.1	2.9	3.4	15	40	45
1960-61	1079	15	16	37	1.4	1.5	3.4	22	24	54
1961-62	1783	35	58	52	2.0	3.3	2.9	24	40	36
1962-63	1258	38	39	43	3.0	3.1	3.4	32	32	36
1963-64	1591	27	50	38	1.7	3.1	2.4	23	44	37
1964-65	2596	59	76	94	2.3	2.9	3.6	26	33	41
1965-66	1142	24	36	25	2.1	3.1	2.2	28	42	30
1966-67	2167	63	50	55	2.9	2.3	2.5	37	30	33
1967-68	2619	66	98	76	2.5	3.7	2.9	27	41	32
1968-69	1320	26	15	21	2.0	1.1	1.6	42	24	34
1969-70	1589	36	26	46	2.3	1.6	2.9	33	24	43
1970-71	1100	22	34	38	2.0	3.1	2.5	26	41	33
Totals and means	23968	482	655	665	2.0	2.7	2.8	27	36	37

Local movements

Borough Fen Decoy is situated near the south-western corner of the extensive Fens, flat rich farmland dissected by innumerable drainage ditches, and about fifty kilometres from the south shore of the Wash. The nearest permanent standing water is at some large gravel pits between three and four kilometres to the north-west; winter floodwater could be found regularly until about 1963, but only occasionally since, in the Nene Washes about 12 kilometres south-east. Further afield most of the wetlands are to the north and east, including the Wash, the Ouse Washes and north Norfolk. As might be expected, the larger part of the recoveries come from these areas. However, significant numbers do move in other directions, and the overall picture is set out in Figure 2. The figures represent the percentages in each of the four directions for each distance category from the ringing station. The directions of recovery have been grouped around north and north-east, east and south-east, south and south-west, and west and north-west. Directional differences between seasons were generally slight, and it was not possible to find any relationship between the percentage recovered in different directions and distances and the seasonal mortality rates. It can be concluded that the latter are not dependent upon shooting in any one or two particular areas.

Conclusions

The present scale of ringing at Borough Fen Decoy produces between 62 and 240 same season recoveries per season. A level of 200 recoveries per annum was regarded as a reasonable target by Matthews (1966). This applied to all recoveries not just same season, which would amount to about half of these (see Table IV). In only eight of the fourteen seasons now being considered were there as many as 100 same season recoveries. In order to achieve this number of recoveries, between 1,500 and 1,700 Mallard should be ringed each season. There is thus no reason to consider a reduction in the present ringing of Mallard at Borough Fen Decoy, rather the opposite, if sufficient recoveries are to be received for annual analyses along the lines given in this paper to be made. This was also our conclusion (Ogilvie and Cook 1971) following the analysis of foreign recoveries of Mallard.

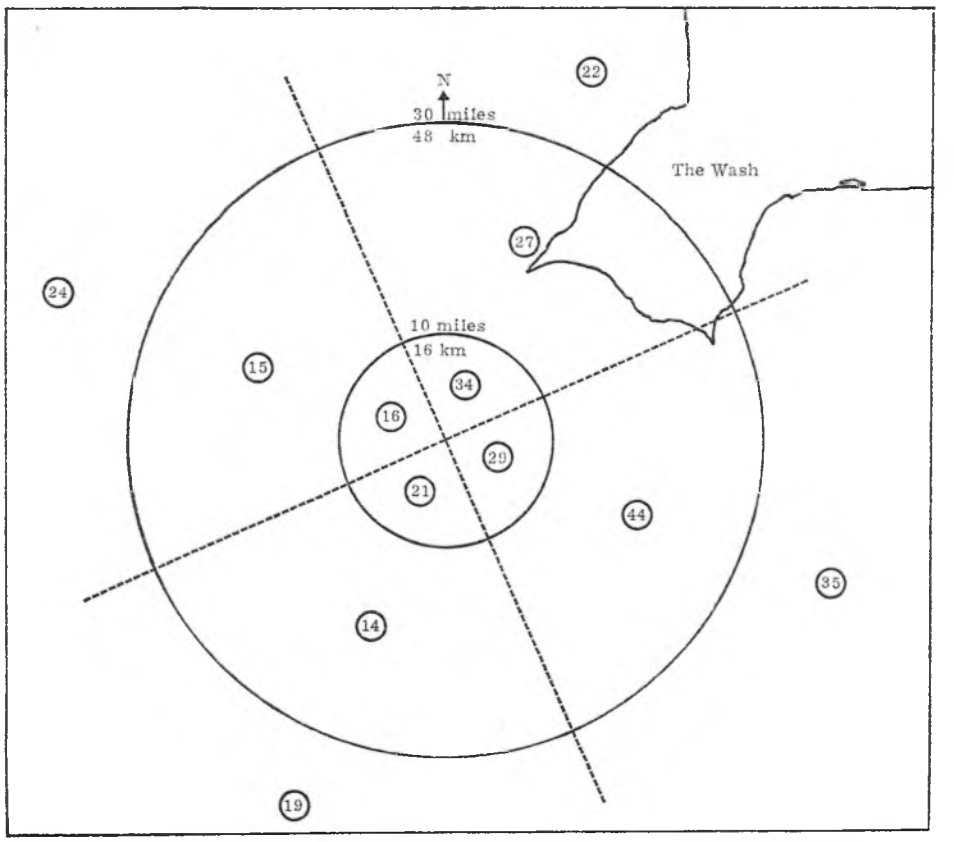

Figure 2. Distance and direction from Borough Fen Decoy of same season recoveries of Mallard. Figures are percentages for each distance category.

The distribution of ringing through the season is anything but even, with a great preponderance being done in September. It would be preferable if the numbers ringed in each month could be made more equal but catching of Mallard in a duck decoy is not so easy to adapt. If the catch for any single month or shorter period is pegged to a predetermined ceiling, it may be found that catching falls off completely later in the same season and the necessary minimum total for the season may not be reached at all. With the requirement for a certain minimum number of recoveries each season, it is necessary to set any early season catch limits as high as possible, if they are to be set at all. On the basis of the last fourteen seasons the number in which a more than adequate sample has been ringed was far exceeded by those in which the catch has been insufficient.

Acknowledgements

We would like to thank all the wildfowlers for returning the rings of birds they have shot and for not suffering from "reporter boredom". We are also grateful to the British Trust for Ornithology for making the recovery information available for analysis. Mr. T. A. Gibson was responsible for compiling several tables of basic data. Prof. G. V. T. Matthews was very helpful with suggestions and criticisms in the early stages of this paper.

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Summary

British recoveries of Mallard *Anas platyrhynchos* ringed at Borough Fen Decoy, Northamptonshire, have been analysed. A corrected same season recovery rate is used to calculate season of ringing mortality rates which form an effective way of monitoring annual variations immediately after the end of each shooting season. The natural mortality rate for this population of Mallard, if there were no shooting, would be about 20% per annum. The season of ringing mortality rate has varied between 39.3% and 61.8%, the latter in the severe winter of 1962-63. The number of birds ringed each season does not seem to have any relationship with the annual breeding success as measured by the percentage of adults in the catch, or with the size of the population measured by counts on waters within 80 miles (128 km.) of Borough Fen. There has not been any falling off in the reporting rate of recoveries, even close to the ringing station. The distribution of recoveries round the Decoy follows topographical features favourable to Mallard. The present scale of Mallard ringing at the Decoy is only just adequate to provide the necessary number of recoveries for annual analysis.

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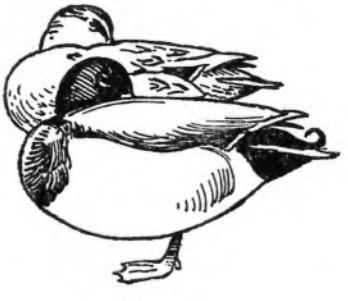

Mute Swan weights in relation to breeding

C. M. REYNOLDS

Introduction

In the course of a general study of the Mute Swan *Cygnus olor* of the Upper Thames valley, a considerable amount of weight data has been obtained. This paper analyses these weights and attempts to relate them to some aspects of the breeding of this species.

Details of some other aspects of this study are given elsewhere (Perrins and Reynolds 1967) and need not be repeated here. The main study area extends radially for about 25 km. from Abingdon (51°40′N., 1°17′W.). It contains about 95 km. of the River Thames together with the lower reaches of several of its tributaries, and many gravel pits and small lakes. The area is largely surrounded by higher ground, up to 200 m., which holds few swans, whereas the approximate mean height of the river valleys (and nests) is 60 m. above sea-level.

Since 1966, the early summer population of swans has dropped from 450-500 to 300-350 (110 to 80 breeding pairs). The non-breeding flocks are now composed mainly of first and second year birds, whereas earlier, up to a third would be three years or older. This decrease has been observed elsewhere (Minton 1971). The main flocks are at Abingdon (40-90 birds) and Oxford (now usually only 30 birds, but up to 100 in the past), and there are several smaller flocks in rural areas. There are also large numbers in Reading, just south of the main study area.

Nearly all the study population have been ringed, and many individually colour-ringed. Considerable numbers have also been ringed at Reading. The majority are of known age when ringed, i.e. in their first or second years. Since 1967, a high proportion of the swans caught have also been weighed, and more recently sexed by cloacal examination. Swans are weighed only when caught for ringing, colour-ringing, the removal of fish-hooks or in a few cases the identification of nesting adults. The mass round-ups, used elsewhere, have not been employed and the swans have remained comparatively tame and easy to study. This policy does, however, result in considerable unevenness in the season and age distribution of swans weighed. Most weights have come from flock birds during the winter. These comprise immatures together with some of the breeding birds. The majority of nesting adults stay on their territories unless the weather is very adverse.

A simple technique is used for weighing swans. Upon capture, two strips of cloth are used to tie the wings and feet together. The hook of the balance is inserted under the strip holding the wings. All the weights have been taken to the nearest 100 gm. The swans are not usually tied in this manner for more than a few minutes. As with all other stages of capture and processing, weighing is usually carried out by one person.

The following analysis is based on 947 weights from 574 swans of known sex (295 females, 279 males) taken in the main study area up to 31st March 1972. In addition the weights of 100 swans at Reading are given for comparison. The majority were sexed cloacally, but many by behaviour while subsequently nesting or occupying territories. The weights of a further 70 birds have been discarded as their sex is as yet unknown. In all the tables, means calculated from less than 10 weights are shown in parentheses.

Weights

Mean values

The means together with the standard deviations and observed ranges, are given in Table I for each age and sex class used. The year has been divided into two periods. 'Winter' comprises the months September to March and, for first and second winter males and first winter females only, April. For these latter categories the April weights are similar to those in winter but differ considerably from the summer ones. This can be readily seen from Figure 1. The third year and older birds have been separated into two groups. The first (adults) are known to have nested or held a territory (and may have nested) in the relevant year. The second (non-breeding) are those which apparently have not bred or whose summer activity is unknown. The summer adult females do not include eight weighed in early April. These had a mean of 10.65 kg. (range 9.7-11.7 kg.), demonstrating the large weight gains made before egg-laying. Similar gains are probably made in March by the early nesters, but none as yet have been weighed.

It can be seen from Table I that the mean weights increase considerably during the first two years. The male weights appear more variable than those of the females. There is a considerable difference between the weights of adults and non-breeding birds of both sexes. There is

Table I. Weights (in kg.) of Mute Swans in the study area.

	Sample	*Males*		*Observed*	*Sample*	*Females*		*Observed*
Age class	*size*	*Mean*	*S.D.*	*range*	*size*	*Mean*	*S.D.*	*range*
1st winter	159	9.69	0.73	8.1-12.1	221	7.82	0.79	5.5- 9.5
1st summer	42	10.87	0.98	9.3-13.5	36	8.34	0.72	6.4- 9.7
2nd winter	112	10.43	0.93	8.9-13.0	75	8.42	0.74	6.1- 9.8
2nd summer	16	11.19	1.19	8.9-13.4	12	9.08	0.77	7.9-10.2
3rd winter and older non-breeding	86	10.34	0.91	8.4-12.7	45	8.36	0.69	7.6- 9.7
3rd summer and older non-breeding	8	(11.05)	—	9.7-11.8	4	(8.48)	—	7.7- 9.9
Adult winter	59	11.80	0.89	9.2-14.3	35	9.67	0.64	7.6-10.6
Adult summer	21	11.87	0.83	10.6-13.5	6	(9.65)	—	8.3-10.8

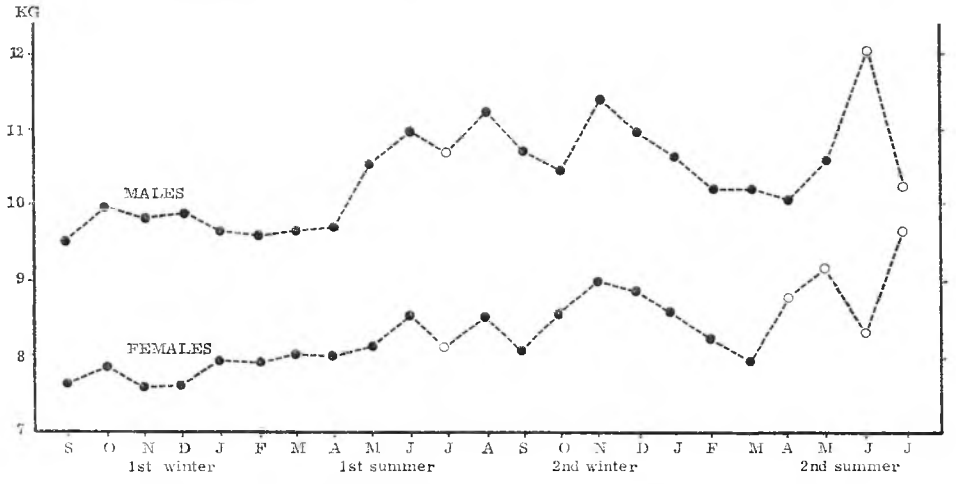

Figure 1. Mean monthly weights in the first two years from fledging. Means for samples of less than 5 weights are indicated by open circles. The standard errors are 0.1-0.2 kg. in the first winter and up to 0.4 kg. later.

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Plate XIII. Some pairs of Hawaiian Geese *Branta sandvicensis* are reliable enough to be allowed to raise their own young at Slimbridge. (Above) Goslings at three weeks; (below) newly hatched.

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E. E. Jackson

Plate XIV. Improved facilities at Eastpark Refuge, Caerlaverock. (See p. 140.) (Above) A screened approach to the new Observation Tower from the farm buildings (on the left). Half a mile of double earth banks blend well with the scenery, both outside and within the corridor (below).

E. E. Jackson

little difference between winter and summer for the adults (except for April females), but there is a considerable difference between the two periods for the non-breeding males.

Table II gives the values for the small sample of weights from Reading, only just over 30 km. from Abingdon. Surprisingly enough, the first and second winter males are significantly ($P<0.05$) heavier. There is comparatively little interchange between Reading and the study area. The North Berkshire Downs and Chilterns probably form a natural boundary, with only a narrow gap for the Thames. It has been shown elsewhere (Minton 1971) that Mute Swans prefer to avoid high ground. It is possible that the differences in weights are due to the feeding for cygnets being better on the Kennet, a clean chalk river just south of the Downs, than in the study area. Some cygnets ringed while still on their natal territory in the south of the study area have been weighed in their first winter in Reading, and these were on the light side for the Reading birds, but normal for the study area. The two heaviest swans yet weighed were both first year birds in Reading (14.8 kg. in December, and 15.0 kg. while flightless in June).

Monthly variation

Figure 1 shows the mean monthly weights for the first two years. For most months except in the summer there are samples of at least 5 (14-35 in the first winter). It can be seen that the mean weights of newly fledged cygnets in September is hardly lower than in the rest of the winter. In fact, during the first winter the mean weights are fairly constant, and there is little change until May when they begin to rise just before the moult. Newly flightless first summer birds (199 over six years) have been recorded from 29th May until 12th August, with a mean date of about 5th July, and a standard deviation of about 15 days. There was little difference between the sexes, except that the spread was slightly less for females. There was a tendency for the heavier swans to moult earliest.

In the second year the decline in mean weights of flock birds in the late winter may be partially due to the heavier birds moving out to find territories. This applies especially in recent years, when quite a few second year birds have nested. The absence of a similar decline in the first year birds supports this argument. However, it is possible that the lighter first year birds die off owing to food shortages thus leaving the average unchanged. Yet the lightest female weighed in winter (5.5 kg. in December) survived to at least her second winter. Again, the average weight increase for birds weighed in both their first two winters were 0.66 kg. for females (21 birds) and 0.65 kg. for males (14 birds), very similar to the differences between the population means (0.60 and 0.73 respectively).

The second summer samples are rather small. For birds actually in moult and aged at least two, the average weights were 9.7 kg. for females (3, 9.4-9.9 kg.) and 12.0 kg. for males (6, 11.0-13.4 kg.).

Variations between years

For the first and second winter weights, the samples are large enough to examine the differences between years. However, the second winter means are probably affected by the decreasing population which would allow more younger birds to leave the flocks, hold territories and perhaps breed. This would superimpose a weight decline over the years for this group. Thus it seems only valid to look for annual differences in the mean weights for the first winter samples.

Table III gives the mean weights and sample sizes for the first winter weights for the different years. The last five years have reasonable samples and it can be seen that the means fluctuate in parallel for the two sexes, but with more marked differences in the females. The latter are just significant at the 5% level, but not those for the males which have larger standard deviations. There are thus some indications of weight differences from year to year, perhaps influenced by the summer conditions, or the proportion of early broods. It may be possible in the future, with more data, to investigate whether the first winter weights, and later weights, can be related to the nest site, parents and/or laying date.

Table II. Weights of Mute Swans in Reading.

	Males			*Females*		
Age class	*Sample size*	*Mean*	*Observed range*	*Sample size*	*Mean*	*Observed range*
1st winter	22	10.55	9.1-14.8	18	7.93	6.3- 9.2
1st summer	10	12.22	9.7-15.0	6	(9.77)	8.4-10.3
2nd winter	20	11.48	10.0-14.4	13	8.69	7.2- 9.7

Table III. Mean first winter weights for different years.

		1966	*1967*	*1968*	*1969*	*1970*	*1971*	*All*
Male	Mean	(9.15)	9.71	9.54	9.79	9.61	9.76	9.69
	Sample	2	20	25	51	37	24	159
Female	Mean	(7.90)	7.72	7.57	8.04	7.72	7.78	7.82
	Sample	5	15	36	82	71	12	221

Some relationships between weights and breeding

Late winter weights and summer activity

As the majority of the swans which have been weighed at an age of more than two years have also been colour-ringed, it has been possible to determine the summer activities of a large proportion of those known to be alive. These activities can be divided into 'Nesting', 'Territorial' and 'Non-breeding'. The first category is obvious, but the others need defining. 'Territorial' implies that the swan was paired and held a territory for several days at least, but was not actually proved to have nested. This applies especially to late nesting birds and those who lost their clutches from predation or flooding. The proportion of genuine non-nesting territorial birds is far lower than in Staffordshire (Minton 1968). 'Non-breeding' covers all the birds which are known to have been non-territorial and in the flocks between late March and early May. Some birds were not located during the summer, but were known from later observations to have been alive. This group probably contains territorial and perhaps even a few nesting birds, together with non-breeding birds which moved to other flocks, but for present purposes it is termed 'Unknown'.

Figure 2 relates the weights of swans in January, February or March to their subsequent activity in summer. All these weights are obtained from birds in the flocks when they were more than two years old. In several cases there are two or more weights from the same swan in the same winter. It is clear that normally swans need to attain weights of 10.6 kg. for males and 8.8 kg. for females, before they can hold a territory and breed, in this study area. There have been only one male and two female breeding swans and one territorial female below these limits and one definite non-breeding male above the limit. One male caught in his 5th, 6th and 7th winters weighed 10.1, 10.5 and 12.2 kg. respectively. In the first two following summers he was non-breeding, while in the third he was territorial, but probably did not breed. That spring was late and only one new nesting pair was found instead of the usual 15-20. The 'Unknowns' (16 males and 10 females) were scattered both sides of the limits, as would be expected from the composite nature of this category.

The two males differing from the normal pattern were both weighed in 1967, when the breeding population was high. They were both weighed three times during the winter and their weights have been joined in Figure 2. The light nesting male's mate was found on eggs in late May (i.e. a late or replacement clutch) and he too could have been a 'replacement' for an earlier male who died during the spring. Alternatively, as his weights were showing an increase, it is possible that he passed the normal limit before the pair took up the territory. The heavier non-breeding male was not recorded for a few days in late March. However, his future mate for the following four years was already nesting with her current mate, so it is very probable that he was non-breeding. The single low-weight female may well have put on weight before returning to her nest site. She was a past breeder who had briefly brought her brood into the flock.

Even if it is assumed that all the 'Unknowns' were non-breeding, the separation at the weights is still highly significant ($P<0.1\%$) for both sexes (after continuity corrections, $\chi^2=14.3$ for females and 26.6 for males, compared with 10.82 for the 0.1% level with one degree of freedom). Each individual has only been counted once at its highest weight.

The time of breeding

Before attempting to interpret the adults' weights, it is necessary to know when breeding takes place. The easiest parameter for this is the date of laying of the first egg. Mute Swans in this area appear, without exception, to lay on alternate days, usually during the morning. One egg was observed being laid at 10.15 G.M.T. The newly laid egg appears fresh and clean, but gradually the freshness fades until after two days the eggs are indistinguishable. If the freshest egg can be dated, that of the first egg can be deduced, assuming that no eggs have been taken, and further visits will obtain the full clutch size. If the latter and the date of hatching are known, an estimate of the first egg date can again be made.

The average incubation period appears to be 35 days (based on clutches for which precise information is available (4 of 34 days, 11 of 35, 3 of 36).

Figure 3 shows the relationship between the date of the first egg and clutch size. As can readily be seen the clutch size decreases as the spring progresses. The line of regression (and correlation coefficient) has been calculated for clutch size on date using the 120 definite first clutches. The seven known repeat clutches have not been used for this calculation, but they did not differ significantly. The clutches are mostly from the years 1966-1971, but there are a few for 1952-1965. Taking 1st April as day 0, the regression equation for clutch size (E) on date (d) is $E=7.93-0.098d$. The standard error of the gradient is 0.0075. The correlation coefficient is -0.78 which for this sample size is highly significant. The regression lines calculated for the different years (or year groups for small samples) are nearly parallel and separated by less than a day. The mean clutch size is 7.52, which is higher than earlier figures (Perrins and Reynolds 1967). Only completed clutches have

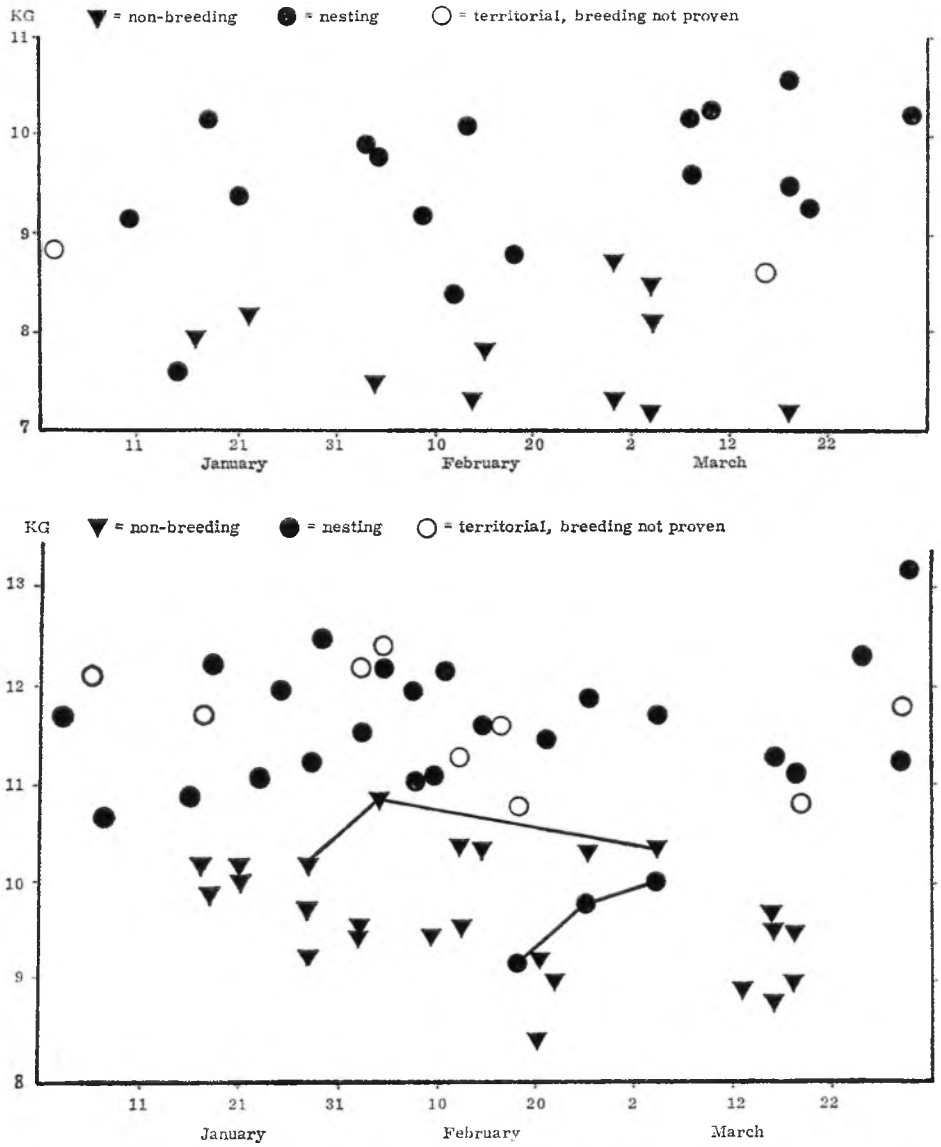

Figure 2. Late winter weights of third year and older Mute Swans in relation to their subsequent summer activity; (above) **females,** (below) **males.**

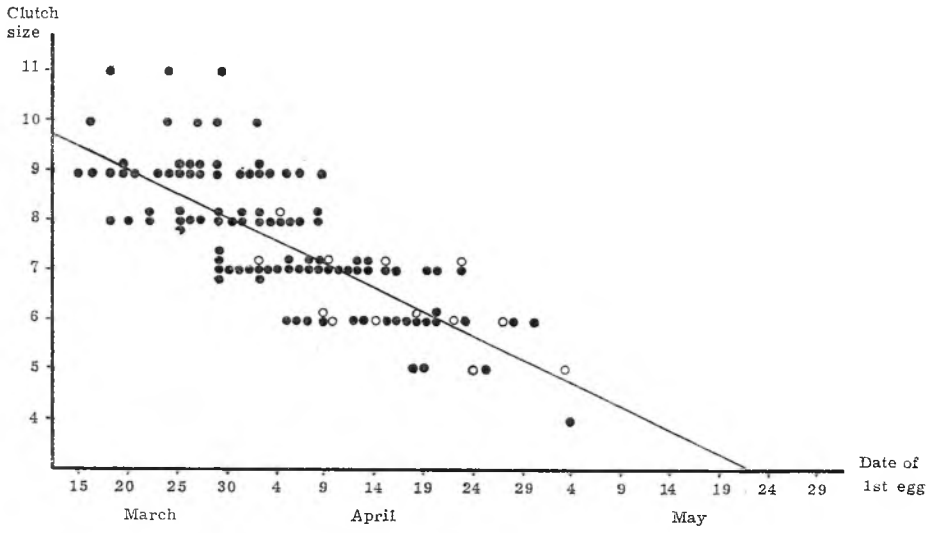

Figure 3. Clutch size in relation to the date of the first egg.

been considered here. There is also a bias towards large clutches. For a clutch of 11 eggs the date of the first egg may be determined on any of the 22 days of the laying period, whereas for a clutch of four it is only possible on eight days. In addition late nests, i.e. smaller clutches, are less likely to be re-visited to determine the full clutch because little time is available outside the school holidays.

Only 13 clutches are from females known to be breeding for the first time and these are shown on Figure 3 by open circles. Another 13 from the earlier years have no record in the previous year either of breeding or non-breeding. The remaining 94 clutches are from females known to have nested in the previous year.

It can be seen that the clutch sizes of first-time breeders tend to be lower than those of past breeders. Age does not otherwise appear to have a significant effect. Individual females may vary considerably from year to year in both clutch size and date.

As there is this strong correlation between large clutch size and early laying (with a gradient of approximately $-1/10$ egg per day for the regression line), there must be some selection pressure acting in favour of early breeding. The early clutches are initiated during March, when the natural vegetation has hardly begun to grow. The large clutches are not particularly confined to the urban areas, where the natural food may be augmented by bread, but occur just as frequently in rural areas.

For 67 broods for which the date of the first egg, the number hatched and the number surviving to three months are all known, it is possible to see how the production of young varies with the date of the first egg (Table IV). The number of cygnets hatched is used rather than the number of eggs laid, as egg losses do not depend on the date of laying, but instead to random events such as flooding and human predation. It can be seen that the earliest cygnets survive best. Although the survival rate appears the same for middle and later clutches, more young are actually produced from the early April clutches. This situation holds for many other species (Perrins 1970) and may be explained by relating it to the first few weeks after hatching. As has been shown in an earlier paper (Reynolds 1965), the main mortality in cygnets occurs in the second week after hatching. It was also

Table IV. The production of young with respect to laying date.

Date of first egg	*Number of broods*	*Cygnets hatched*	*Cygnets reared*	*% reared*
up to 31 March	19	135	98	73
1-15 April	30	171	92	54
after 15 April	18	80	45	56

shown that there was a significantly higher survival rate in territories with good surface vegetation, mainly duckweed *Lemna* sp. Presumably in the early summer this provides a conveniently sized food particle for small cygnets, but as the summer progresses, it becomes too large and tangled for any small cygnets then hatched. Thus later broods may have difficulty in finding sufficient food.

Spring weight increases in breeding females

As has been mentioned earlier, breeding females make considerable weight gains just before laying. Unfortunately only four of the breeding females caught at or near their nests during the laying period have been weighed. All were from early April and were up to 2 kg. above normal. Their details are as follows:

Date weighed	Weight (kg.)	1st egg laid
5.4.68	11.7	<15 April
9.4.68	11.3	3 April
9.4.72	11.5	8 April
15.4.68	10.9	c. 4 May

By contrast, one female having completed a clutch of unknown size (due to egg-stealing) by late April weighed only 7.5 kg.

The average weight of 15 eggs, unincubated but at least a day old, was 353 gm. (range 330-390) mostly from early April clutches. The heaviest egg weighed extends the range given in Scott *et al* (1972). Thus females will lay between 1.5 to 4 kg. of eggs depending on clutch and egg size. During the pre-laying and laying period the females spend relatively little time near the nest, but seem to be feeding for most of the time, unless there is a good food source, i.e. bread, close by. Meanwhile the male usually does most of the nest building and guarding of the eggs before incubation begins. The female does most of the incubation. Thus a build-up of the food reserves is necessary for the female to nest as early as possible. Similarly the males need to have sufficient food reserves to enable them to defend the territory and guard the eggs without spending much time feeding.

It is possible to postulate a relationship between the level of a female's food reserves and when laying (or egg formation) is possible. If laying is initiated when the food reserves reach a threshold value, which decreases with time (perhaps governed by day-length), and the clutch size is determined by the food reserves, then the relationship between date and clutch size follows. This is shown diagrammatically in Figure 4 with a fairly arbitrary threshold weight

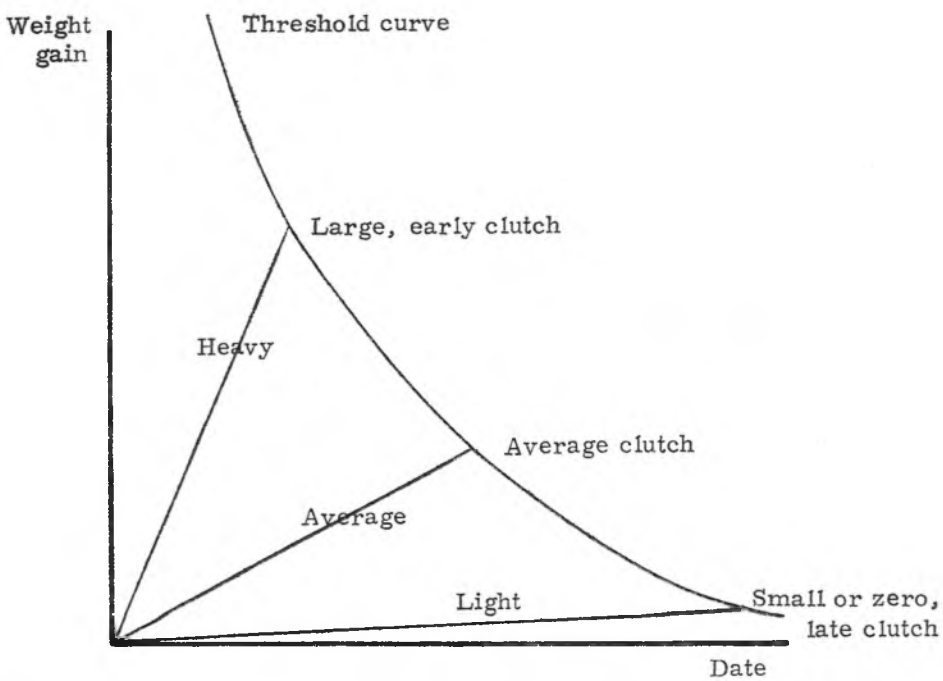

Figure 4. Theoretical diagram to illustrate the gain in weight by a female swan prior to the breeding season, the date of laying and the clutch size.

curve, for three hypothetical birds showing heavy, average and light weight gains.

Acknowledgements

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Summary

This paper analyses 947 Mute Swan *Cygnus olor* weights, obtained in the Upper Thames valley, with respect to age, sex and season. It was shown for third year or older swans that weights of 10.6 kg. for males and 8.8 kg. for females divided the heavier nesting and territorial birds from the lighter non-breeders. There is a high (negative) correlation between the clutch size and the date of laying of the first egg. The regression line for clutch size on date has a gradient of −1/10 eggs per day, for 120 first clutches (4–11 eggs) started from 15th March to early May. First-time nesting females tended to lay later than previous nesters, and thus had smaller clutches. About 70% of cygnets hatched were reared from early broods (started in March) compared with about 55% from later broods. Females increased their weight by up to at least 2 kg. just before laying. A theoretical model is put forward relating the female's weight, date of laying and the clutch size.

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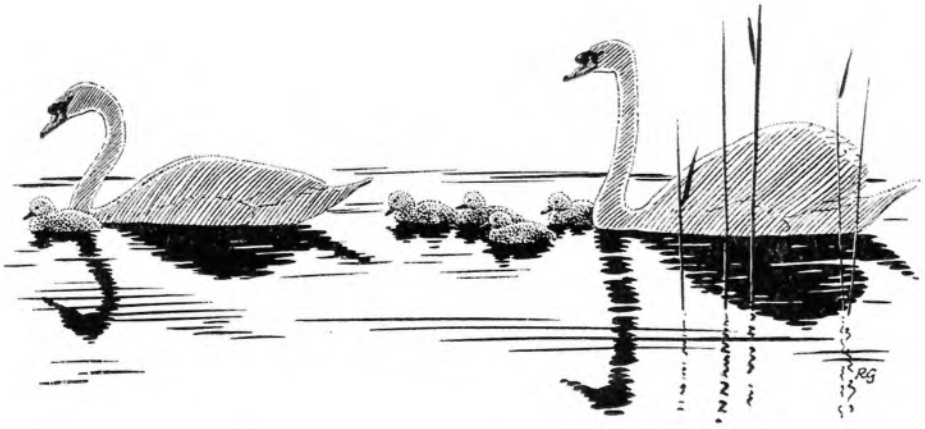

One hundred and fifty years of Mute Swans on the Thames

STANLEY CRAMP

Introduction

The custom of marking and pinioning Mute Swans *Cygnus olor* has persisted for many years on the river Thames between central London and Henley, though it has now apparently died out elsewhere except on the rivers Yare and Wensum, near Norwich (Ticehurst 1957). The swans are recorded for the Crown, the reigning monarch being the Seigneur of Swans, and the two Livery companies, the Vintners' and the Dyers', who have a royalty of a game of swans on the Thames (i.e. a right to all the swans on the Thames which are marked with their marks). The Dyers' Company have kept an annual record of the swans counted during swan-upping since 1823 and have most generously made this available.

The colourful pageant of swan-upping involves a four-day survey by boat to count all swans, pinion the young and mark them where appropriate. From 1823 it took place in early August each year, then in 1878 the introduction of the August Bank Holiday resulted in a change to the present date of the second or third week in July. By means of a prior survey the location of breeding birds is known and during swan-upping search is made for all breeding adults and their young. In a few instances when the populations were high, the numbers of other adults were estimated, whilst in some years a shortened course was followed (see later). Despite these minor limitations, the swan-upping figures almost certainly provide a picture of population trends more accurate than is available by most other census methods and there can be few, if any, animal populations in a given area which have been surveyed at a similar period each year for as long as 150 years.

The swan-upping totals

The annual counts extracted from the records of the Dyers' Company for the years 1823-1972 are given in Table I. They show (a) adults with young, i.e. the number of successful breeding birds at the time of swan-upping, (b) the number of young and (c) the number of other adults, i.e. non-breeding birds and those birds which may have bred or attempted to do so but have no young at the time of the survey. For some years the counts are known to be incomplete, including 1851 when the course from Runnymede to Henley was not covered and from 1940-1950 when the swan-upping began at Putney Bridge instead of central London. The normal course begins near Blackfriars Bridge in central London and so far as is known, this has been the practice in all other years. However, as the records show only where the first swans were encountered, which might be some distance upstream, it is possible that in some years the start was made higher up without this being specifically recorded. This is perhaps unlikely and in any case would not affect the broad picture.

The main trends in the total numbers recorded and the numbers of adults with young are perhaps best illustrated by Figure 1 where three-year moving averages have been used to smooth out the annual fluctuations. The picture is, on the whole, one of rather little variation. Thus for all swans counted, the total for much of the 150 years varied only between 400 and 600 birds. The main exceptions were (a) at the beginning of the recorded counts when totals climbed slowly from a little over 200 to reach the 400 level after ten years or so, (b) a brief period in the 1850's and early 1860's when a total of 600 was exceeded and (c) an astonishing rise to over 1,000 birds, followed by an almost equally rapid fall, in the 1950's and early 1960's. Even these peak figures, however, seem to have been exceeded in earlier centuries, for the secretary of the Venetian Ambassador Capello, writing to his master in 1496 said "It is a truly beautiful thing to behold one or two thousand tame swans upon the river Thames as I and also Your Magnificence have seen" (Ticehurst 1957). The number of successfully breeding birds (adults with young at the time of swan-upping) ranged, with few exceptions, between 50 and 100 almost from the start until the late 1920's. Then it rose above 100 birds until 1950, slowly declining since 1959 to reach the lowest figures recorded, except for the very earliest years.

Although the relative stability of both the total numbers of swans and the successfully breeding birds is perhaps the most striking fact, it is tempting to try to explain the relatively few, although in some cases marked, variations which did occur. It must be said at once that this attempt has largely failed, perhaps in part because our knowledge of the various possible factors affecting swan numbers is inadequate even in recent

years and almost non-existent for the earlier periods. As the fluctuations in the total number of swans and in the number of successfully breeding adults appear to be largely independent, they are examined separately.

Successfully breeding adults and young

The numbers of successfully breeding adults (in pairs) and young have been analysed over 10-year periods for three stretches of the Thames: A—Central London to Putney; B—Putney to Staines;

Table I. Counts at the annual swan-upping on the River Thames, 1823-1972.

Year	Adults with young	Young	Other adults	Total	Year	Adults with young	Young	Other adults	Total	Year	Adults with young	Young	Other adults	Total
1823	32	55	159	246	1873	84	173	320	577	1923	76	138	281	495
4	8	19	164	191	4	78	143	325	546	4	74	147	324	545
5	48	72	121	241	5	36	54	320	410	5	82	191	363	636
6	44	71	153	268	6	86	149	275	510	6	82	105	356	543
7	36	69	178	283	7	60	82	278	420	7	92	118	371	581
8	44	74	170	288	8	58	110	281	449	8	110	130	383	623
9	50	93	186	329	9	28	57	312	397	9	112	117	294	523
30	32	60	234	326	80	68	108	214	390	30	132	191	272	595
1	52	108	216	376	1	54	85	233	372	1	148	188	284	620
2	50	72	240	362	2	68	136	213	417	2	90	145	348	583
1833	68	131	217	416	1883	80	144	194	418	1933	110	148	335	613
4	58	126	240	424	4	46	71	241	358	4	110	146	405	661
5	44	99	275	418	5	54	85	209	348	5	116	158	382	656
6	80	165	214	459	6	38	58	193	289	6	118	131	348	597
7	98	200	246	544	7	54	103	199	356	7	118	142	401	661
8	68	127	311	506	8	54	111	191	356	8	174	179	364	717
9	70	110	255	435	9	68	116	177	361	9	130	133	324	587
40	74	144	277	495	90	80	130	168	378	40	(110)	(110)	(252)	(472)*
1	48	80	305	433	1	48	101	229	378	1	(118)	(118)	(242)	(478)*
2	66	199	252	517	2	68	129	229	426	2	(148)	(148)	(159)	(455)*
1843	68	137	298	503	1893	68	120	193	381	1943	(102)	(103)	(201)	(406)*
4	104	175	305	584	4	76	143	190	409	4	(136)	(175)	(128)	(439)*
5	66	100	369	535	5	60	114	213	387	5	(136)	(176)	(139)	(451)*
6	70	103	280	453	6	78	168	242	488	6	(156)	(176)	(113)	(445)*
7	52	86	322	460	7	98	181	247	526	7	(100)	(99)	(91)	(290)*
8	68	110	322	500	8	92	170	315	577	8	(102)	(154)	(110)	(366)*
9	80	144	335	559	9	82	184	316	582	9	(100)	(197)	(70)	(367)*
50	72	125	332	529	00	74	118	283	475	50	(84)	(161)	(111)	(356)*
1	(58)	(117)	(227)	(402)*	1	90	165	238	493	1	52	94	264	410
2	76	148	418	642	2	72	119	228	419	2	48	83	554	685
1853	74	142	441	657	1903	26	41	229	296	1953	60	124	514	698
4	62	87	440	589	4	88	186	148	422	4	60	105	743	908
5	34	65	417	516	5	72	132	159	363	5	46	77	1031	1154
6	72	122	369	563	6	66	124	188	378	6	80	157	914	1151
7	120	209	339	668	7	50	91	248	389	7	66	110	776	952
8	108	179	421	708	8	66	120	237	423	8	62	95	796	953
9	110	214	472	796	9	72	137	257	466	9	46	72	823	941
60	18	36	547	601	10	68	111	281	460	60	46	91	703	840
1	96	159	422	677	1	74	154	247	475	1	46	96	734	876
2	34	62	426	522	2	68	123	278	469	2	46	91	542	679
1863	62	116	386	564	1913	84	152	254	490	1963	42	64	484	590
4	58	126	413	597	4	82	142	254	478	4	32	65	449	546
5	46	73	408	527	5	52	106	290	448	5	38	81	557	676
6	80	139	336	555	6	68	117	289	474	6	26	30	574	630
7	68	115	346	529	7	46	94	342	482	7	48	91	431	570
8	104	191	283	578	8	52	81	341	474	8	32	54	336	422
9	66	108	322	496	9	70	134	173	377	9	24	26	415	465
70	72	136	321	429	20	44	107	270	421	70	34	41	265	340
1	62	112	342	516	1	58	108	218	384	1	24	42	242	308
2	82	146	294	522	2	66	128	241	435	2	46	83	270	399

* Partial counts only (see text).

Table II. Adults with young at the time of swan-upping on three stretches of the Thames.

Year	Stretch A Pairs	Stretch A Young	Stretch B Pairs	Stretch B Young	Stretch C Pairs	Stretch C Young	Total Pairs	Total Young	Average no. of young per pair A	B	C	Total
1823-32	—	—	94	324	104	369	198	693	—	3.45	3.55	3.50
33-42	4	21	163	620	170	740	337	1381	5.25	3.80	4.35	4.13
43-52	15	70	207	711	(135)	(464)	(357)	(1245)	4.66	3.43	(3.44)	(3.49)
53-62	4	9	174	566	186	700	364	1275	2.25	3.25	3.76	3.50
63-72	3	7	131	383	216	872	350	1262	2.33	2.92	4.04	3.61
73-82	3	10	90	330	217	757	310	1097	3.33	3.67	3.49	3.54
83-92	—	—	77	288	218	760	295	1048	—	3.74	3.49	3.55
93-1902	—	—	144	500	251	982	395	1482	—	3.47	3.91	3.75
1903-12	4	11	121	465	200	743	325	1219	2.75	3.84	3.71	3.75
13-22	—	—	131	501	180	668	311	1169	—	3.82	3.71	3.76
23-32	—	—	209	607	290	863	499	1470	—	2.90	2.98	2.95
33-42	(—)	(—)	272	634	354	779	(626)	(1413)	(—)	2.33	2.20	(2.26)
43-52	(—)	(—)	212	574	296	844	(508)	(1418)	(—)	2.71	2.85	(2.79)
53-62	—	—	130	488	149	530	279	1018	—	3.75	3.56	3.65
63-72	—	—	63	217	110	360	173	577	—	3.44	3.27	3.34

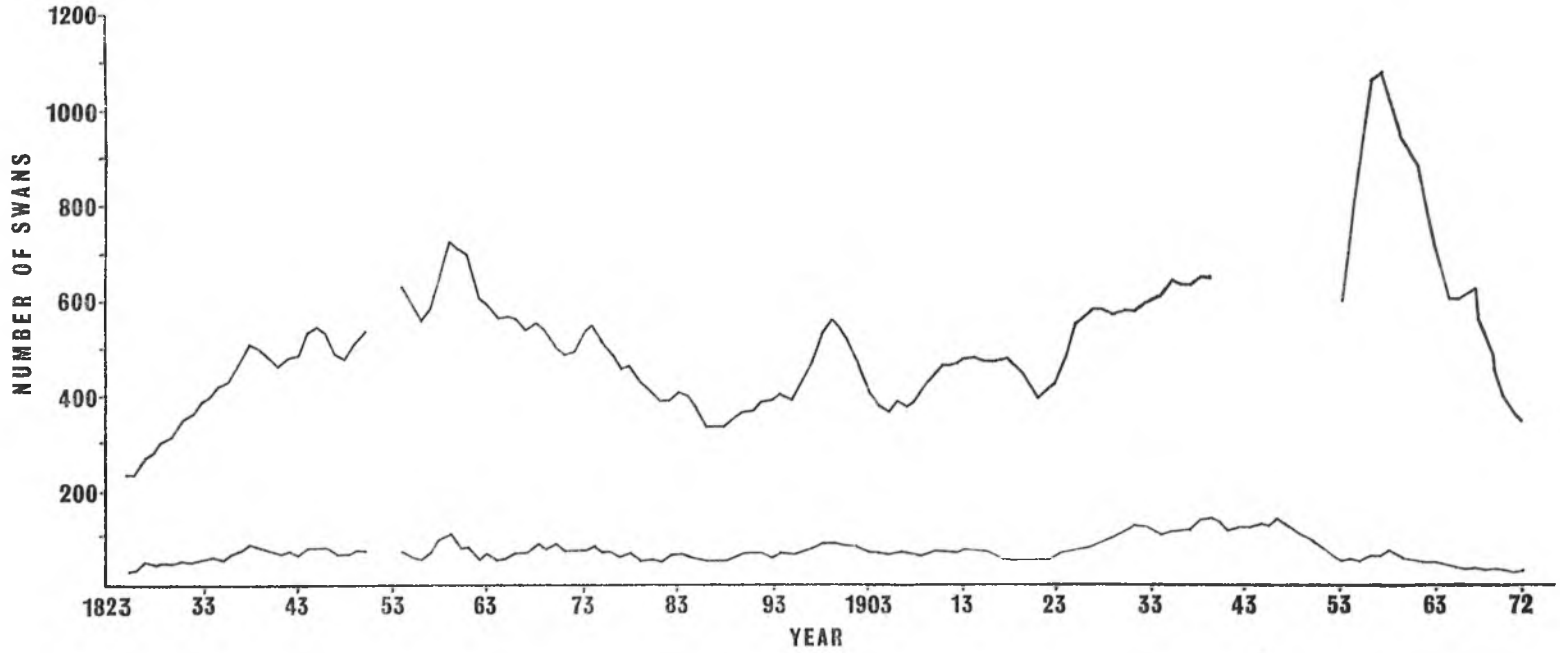

Figure 1. Numbers recorded at swan-upping in three-year moving averages. Above—all swans; below—adults with young. Gaps represent incomplete counts.

and C—Staines to Henley (Table II). Although stretch A was apparently partly undeveloped, especially on the south bank, at the start of the period, it has been built on throughout its length for many years now and much of it is restricted by embankments. It has therefore never offered many suitable nesting sites for swans and the last pair with young was recorded there in 1908. Unsuccessful attempts, however, have been made more recently; thus in 1955 a pair nested at the Chelsea Dock Basin, but was robbed (Cramp 1967). Stretch B from Putney to Staines was developed much later; indeed for much of the first hundred years the built-up areas were limited and largely confined to the lower stretches. Even now there are a number of suitable nesting sites, including many islands. Though human pressures, both along the banks and from boating, have steadily increased, there has been no parallel decline in the number of pairs breeding successfully. Indeed after the usual low totals in the first decade, which might mean that the techniques of locating breeding pairs were then being developed, numbers increased to 1843-1852, then fell steadily from 1893-1902 and after three decades of near stability rose to peak figures in the next thirty years, especially between 1933 and 1942. They then fell again, reaching an all-time low in 1963-1972. It may be wondered if this rise between 1923 and 1952 was due to a greater public benevolence towards swans, resulting in both increased feeding and reduced interference with nesting birds, but it is much more difficult to account for the recent decline, unless human pressures on and near the river are now outweighing these. Whatever the causes, a very similar pattern is found on stretch C from Staines to Henley which physically has changed less during the period, although there has been a similar though smaller growth in human pressures. On this stretch, except for the 1823-32 decade, the number of pairs with young remained fairly stable for the first hundred years, then showed a similar rise from 1933 to 1952, with the peak also in 1933-42, and a recent decline. The average number of young per pair counted in each ten-year period for the three stretches are also shown in Table II. These figures, of course, represent young of various ages, as found and marked at the time of swan-upping. They are, therefore, only a rough measure of breeding successes as the time of swan-upping has varied somewhat (see Introduction) and in early breeding seasons there would tend to be fewer young surviving. The figures for stretch A are too small to be of value, but there is a general tendency, as might be expected, for breeding successes as shown by these counts to be higher on the less disturbed stretch C. It is also interesting that on both stretch B and C the lowest numbers of young per pair were found in the three decades 1923-1952 when the number of successfully breeding pairs reached the highest levels.

Other adults

This category includes both adult birds which have not bred or, because of failure at the egg or young stage, did not have young at the time of the counts, and birds not fully adult in their first or second years. Although all the young are caught and pinioned at swan-upping, the swan population of this stretch of the Thames is not self-contained, for pinioned birds can move elsewhere in the Thames basin by swimming, and some tributaries of the Thames, such as the Colne and Lee hold considerable breeding populations (Cramp 1957, 1963), whilst full-winged birds can, of course, fly in or out. The numbers of other adults on the Thames, therefore, almost certainly reflects both local factors and population trends over a wider area.

Whereas in the case of adults with young similar trends were found in stretches B and C, in this case the closest parallels are between stretches A and B (Figure 2). In both there was a tendency to increase after the first decade, reaching a peak in stretch B in the early 1860's and a little earlier in stretch C followed by a decline in both, which lasted until the 1920's. These trends may well reflect, especially in stretch A, a decline in natural foods because of the development along the banks and increasing pollution. In stretch B there was then a rise until 1939, followed by a decline until 1951, perhaps connected with less bread being provided by the public during the war and the years immediately following. There was then a marked and very rapid increase to the highest figures in the series in 1956. In stretch A the position is less clear, as no counts were made there from 1940 to 1950, though a similar but smaller increase occurred in the early 1950's. In both stretches these increases were relatively short-lived and numbers declined fairly rapidly to more normal levels. On stretch C the trends from the 1930's to the present day parallel closely those in the other two stretches, but earlier the position was almost reversed, with the highest figures from the 1860's

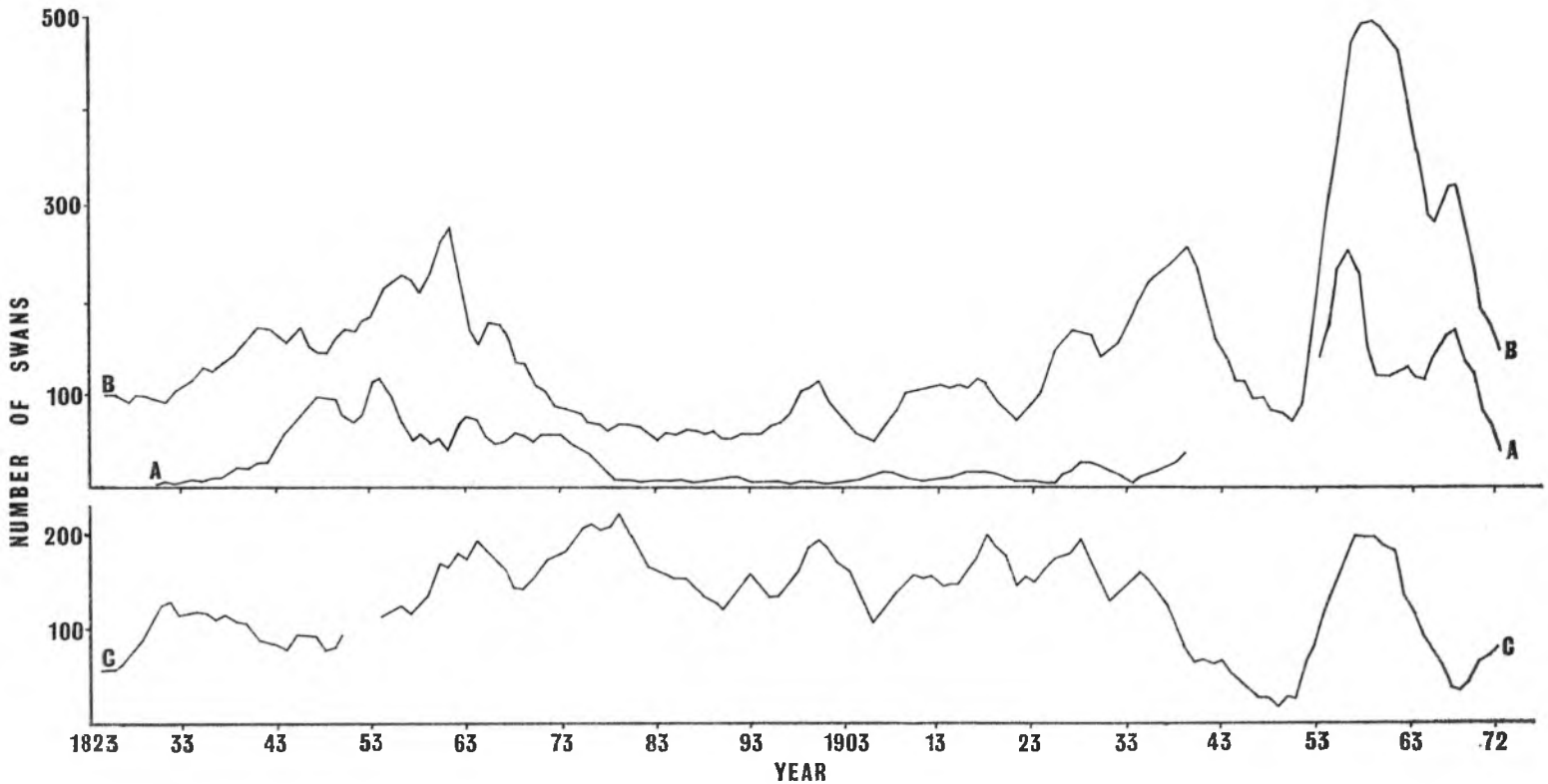

Figure 2. Numbers of other adult swans (three-year moving averages) on three stretches of the Thames. A. Central London to Putney; B. Putney to Staines; C. Staines to Henley. Gaps represent incomplete counts.

to the 1920's when they often equalled and sometimes surpassed the peak in the 1950's.

Again, the causes are not easy to establish. Large flocks of non-breeding birds in the 1950's were found mainly at sites where rubbish was being loaded on barges and more rarely where grain spillages occurred, or at such places as Richmond, Kingston and Staines, where they were fed by the public. Although some of the rubbish loading areas have since been closed (for example at Waterloo, resulting in the virtual disappearance of large flocks there), the changes in both these sources of food have not been sufficiently marked to account for the recent sudden and rapid fall in numbers. Ogilvie (1967, 1972) has discussed recent changes in the numbers of Mute Swan in Britain. The evidence suggests that the population reached a peak in 1959 and then declined. National indices based on winter counts suggest a marked rise from the winter of 1954-55 to 1956-57, a continuing high level between then and 1959-60, followed by a decline to 1963-64, since when the total winter population has fluctuated around 80% of the peak level. There were, however, marked regional differences and he pointed out (1967) that there was no migration of Mute Swans and little movement other than following watercourses. The decline in numbers on the Thames occurred two years earlier, from 1957, and has been much more marked. Ogilvie showed that the hard winters of 1961-62 and 1962-63 contributed to the national population decline, but there is little evidence that these had any marked effect on the numbers of swans on the Thames. He also noted two other factors which have resulted in increased swan mortality in recent years—collisions with overhead wires and oiling. Overhead wires are perhaps less numerous along these stretches of the Thames than in some other areas, but oiling incidents are not infrequent. A major disaster occurred in December 1956 when the sinking of an oil barge at Battersea led to the known deaths of 243 swans (Cramp 1963); this could well have played a part in the earlier decline in numbers on the Thames already discussed.

Acknowledgements

I am much indebted to the Worshipful Company of Dyers for permission to make use of their records of swan-upping on the Thames and for their kind and ready assistance in dealing with my queries.

Summary

Counts of Mute Swans*Cygnus olor* made from 1823 to 1972 on the annual swan-upping expeditions on the Thames between central London and Henley-on-Thames are given and the trends illustrated by graphs based on three-year moving averages. For much of the 150 years the total numbers of swans varied between 400 and 600, rising above this briefly in the late 1850's, with a more striking increase to over 1,000 birds in the 1950's, followed by an almost equally rapid fall. The numbers of adults with young tended to vary between 50 and 100 until the late 1920's, rising above 100 until about 1950, thereafter declining markedly. Possible reasons for some of these fluctuations are discussed.

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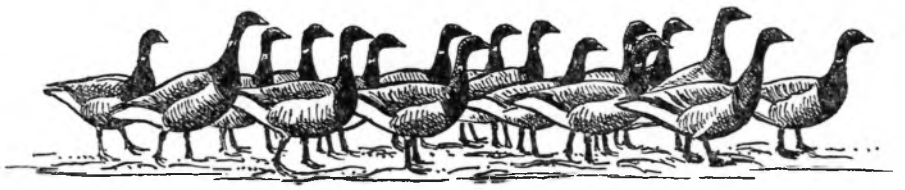


Research, Conservation and Education

The Wildfowl Trust's contributions in 1971

Research

This year saw the beginning of a new ten-year Contract with the Nature Conservancy, financing the directorate and monitoring services of the Trust. The monthly wildfowl counts, and the international mid-winter counts continued to be co-ordinated by Mr. Atkinson-Willes, assisted by Mr. Garvey (p. 126). Under the Contract, automatic data processing and computer facilities were made available at the Biological Records Centre at the Nature Conservancy's Monks Wood Experimental Station. We are particularly grateful to the Head of the Centre, Dr. F. H. Perring, and his staff for their assistance in getting this important development under way. Mr. Salmon is permanently out-posted at Monks Wood.

Mr. Ogilvie continued to organise the collection of data on goose populations and also was responsible for the ringing programme which is likewise becoming automated through Monks Wood. He was himself engaged on a ringing study of colonially breeding Mute Swans in Dorset, jointly with the Edward Grey Institute, Oxford University. He also operated, on a restricted basis, the Slimbridge Decoy. Mr. Cook continued to operate the Borough Fen Decoy, Mr. King the traps at Abberton Reservoir, while Mr. Revett took over the Nacton Decoy (pp. 128-130).

A new three-year Grant from the Natural Environment Research Council enabled Dr. Owen to continue his studies on the feeding ecology of grazing wildfowl. He started a study of the Barnacle Geese at the Trust's Eastpark Refuge, Caerlaverock. There Mr. Campbell, with the assistance of Mr. Colley, carried out observations and routine measurements (p. 140). Much of Dr. Owen's work on the White-fronted Geese at Slimbridge was published or is in press. Work on the feeding of Wigeon on the Ouse Washes was continued in close co-operation with the Royal Society for the Protection of Birds.

Work on the feeding behaviour and nutrition of captive wildfowl was continued by Dr. Kear, with the advantage of a fine new rearing room specifically designed for the purpose. Several student projects on behaviour were supervised. One of Dr. Kear's responsibilities is to ensure that the vast amount of factual data on wildfowl, collected throughout the Trust's history, reaches publication. She is also concerned, with Dr. R. K. Murton, in a continuing series of analyses of breeding in relation to latitude. The new team monograph, *The Swans*, was seen to the presses. Miss Evans, together with the Scott family, continued the fascinating study of the Bewick's Swans (p. 132). Miss Evans made a four-panel display for the swan observatory. More progress was made on the analysis of the Mallard orientation collected by Mr Cook, while preparations were made to widen the study to other species at Nacton. Prof. Matthews was elected President of the Association for the Study of Animal Behaviour, of which Dr. Kear continued as Secretary.

The routine monitoring of the collection's health was continued by Mr. Wood, with Mr. Humphreys giving veterinary advice. Further progress was made towards controlling the diseases to which wildfowl are prone. The co-operation of Dr. A. McDiarmid of the Agricultural Research Council was again most valuable. The X-ray machine was extensively used to monitor the Bewick's Swans for lead pellets (p. 132). Post-mortem material was distributed to a number of external workers while the reference collection of skin and skeletal material at Slimbridge was further expanded.

G.V.T.M.

WILDFOWL CENSUSES AND COUNTS IN BRITAIN, 1971-72

Goose censuses

Pink-footed Goose *Anser brachyrhynchus.* The annual autumn census was carried out on 6th/7th November. 65,000 Pinkfeet were counted, a drop of about 7,000 on the previous year. There were 22.2% young birds present indicating an average breeding success, though the mean brood size was low at 1.9.

European White-fronted Goose *Anser albifrons albifrons.* Peak numbers were very low at 6,000 in mid-January. The main causes of the low numbers were the mild winter and a very poor breeding season (8.5% young birds with a mean brood size of 2.0).

Greenland White-fronted Goose *Anser albifrons flavirostris.* Despite a very poor breeding season (12% young birds), numbers in the two main haunts in Eire and western Scotland were about average. No complete census was attempted.

Greylag Goose *Anser anser.* The annual census on 6th/7th November showed there were 64,000 Greylags in the country, almost the same as in the previous year. The breeding season was of below average success (17.5% young; mean brood size 1.8).

Barnacle Goose *Branta leucopsis.* The Solway wintering population, which breeds in Svalbard, reached a peak of 3,700 in November. There were 15% young birds; mean brood size 1.8. The Greenland population also had a below average breeding season with 13.6% young birds and a mean brood size of 1.8. However, the main wintering haunt of Islay showed a further slight increase in numbers with 16,500 in November and 17,000 in March. No counts were made elsewhere in its wintering range.

Light-bellied Brent Goose *Branta bernicla hrota.* The maximum count at Lindisfarne was about 700 in mid-February. There was no complete count in Ireland this winter.

Dark-bellied Brent Goose *Branta bernicla bernicla.* Following two very good breeding seasons, 1971 was an almost total failure with less than 1% of young birds in the flocks. Not surprisingly the maximum counted in Britain was down on last winter, to 18,000 in mid-January.

M.A.O.

Duck counts

Shelduck *Tadorna tadorna.* Unusually large numbers were present and the seasonal index was easily the highest on record, the previous highest being in 1969-70. Many arrived before the November count and a further major influx occurred in January.

Teal *Anas crecca.* The last two years have seen a welcome increase in this species. Although the seasonal index was slightly lower than that for 1970-71, it was higher than the seven previous ones. For the second successive year there was an influx in mid-winter, probably from the Netherlands, and the Ouse Washes held 5,320 in December. In February numbers were unusually high in western England.

Mallard *Anas platyrhynchos.* There was a marked decrease in numbers from the level reached in the previous year, but the seasonal index was close to normal, in fact five of the last seven years have had very similar seasonal indices. In the autumn and early winter numbers were high in south-east England and low in Scotland, but by late winter numbers were generally low. Poor breeding results in 1971 may have been at least partly responsible for the decrease.

Wigeon *Anas penelope.* A total of 35,556 were counted on the Ouse Washes on 11th February and about 23,000 at Lindisfarne in early winter, but apart from these two concentrations numbers elsewhere were generally lower than usual. Nevertheless, it was another very good season and the February index was the best for sixteen years.

Pochard *Aythya ferina.* This was an extremely good year with Scottish counts being particularly satisfactory. In January there was a peak of 7,500 on a loch near Edinburgh. A sharp increase in numbers occurred in 1965-66 and in spite of a few poorer years since, the population is apparently holding at this high level.

Tufted Duck *Aythya fuligula.* This species has had another very successful season. Throughout the winter there have been abnormally high numbers in England and Wales, though rather low counts in Scotland. The full run of seasonal indices from 1948-49 to 1971-72 indicates a fairly steady increase in numbers during the first ten years, then a period of relatively little change and finally a substantial increase in the last two years.

Season Indices 1971-72 (1959-60=100)

Shelduck	136	Wigeon	137
Teal	64	Pochard	193
Mallard	102	Tufted Duck	124

International Wildfowl Census 1971-72

The sixth census was held in mid-November 1971 and mid-January 1972. In Britain the number of sites covered was fewer than in the previous winter, with 941 in November and 1098 in January. The drop in the totals of ducks counted is partly a reflection of this and partly due to the very mild winter. The numbers of duck seen in Britain were as follows:

Species	*November 1971*	*January 1972*
Shelduck	21087	31940
Pintail	10942	10023
Teal	36339	42249
Mallard	124420	119293
Gadwall	1177	620
Wigeon	99195	136032
Shoveler	5567	4759
Eider	4730	5493
Pochard	28749	31112
Tufted Duck	31988	35006
Scaup	8563	15417
Common Scoter	1393	4000
Velvet Scoter	54	199
Long-tailed Duck	169	761
Goldeneye	5104	10430
Smew	5	40
Red-breasted Merganser	1187	1876
Goosander	600	1336
Totals	381269	450586

G. L. Atkinson-Willes
P. L. Garvey

DUCKS RINGED BY THE WILDFOWL TRUST, 1971

	Abberton	*Nacton*	*Borough Fen*	*Deeping Lake*	*Slimbridge*	*Others*	*Totals*
Shelduck	3					2	5
Pintail	3	204	1	3	7	12	230
Teal	674	240	231	3	13	2	1163
Mallard	1000	580	1045	252	222	6	3105
Gadwall	8	1		1	3		13
Wigeon	78	151		5		1	235
Garganey	10						10
Shoveler	50	14	1	4	3		72
Red-crested Pochard	1						1
Pochard	54			8			62
Tufted Duck	362	3		102			467
Scaup	1						1
Smew	3						3
Red-breasted Merganser				1			1
Totals	2247	1193	1278	379	248	23	5368

M.A.O.

ABBERTON RESERVOIR, 1971

The beginning of the year was relatively mild and calm with only two short snowfalls. January was the best month with 227 duck ringed, 61 of these Wigeon taken in the Middle Section. The mid-January count showed a total of 4,279 duck of 10 different species, well above the average.

Two Smew caught in the large deep water trap on the Top Section, called the 'Smew Trap' in 1958, were the first of this species therein. Here a lead was established with Tufted Duck, contributing largely towards the record total.

White-fronted Geese and Bewick's Swans were disappointingly scarce, not more than ten being seen at any one time, and Bewick's only reached a maximum of nine, these grazing some flooded pasture during early February. The early spring passage of duck was rather meagre and, apart from Tufted, the catching was poor. The first pair of Garganey was seen on 22nd April; a pair was caught in June. Breeding was probably attempted.

As in many other SE. districts, Mallard experienced a poor breeding season, whereas Shoveler, Tufted and Pochard did rather better than normal. Some big broods were produced, and a few ducklings successfully caught and marked, together with their parents.

Maintenance work was started in March with a complete repair and paint up of the ringing caravan, which, despite its age, still serves its purpose admirably. From then until the autumn every spare moment was spent in overhauling the boats, traps and other gear.

Further effort was made to increase the catch of summering duck, in addition to the now regular trapping of moulting Mallard, but without great success. The moulting flock of Pochard, which reached a maximum of 2,094 on 2nd August, proved to be as elusive as ever and efforts to get them in the cage trap on the Dam proved quite futile. However, a few were caught flightless in a circular diving duck trap freshly sited at the NE. corner of the Middle Section. Abberton's first flightless Gadwall was ringed in August.

Regrettably no lead of Shoveler was obtained during September when over 400 were counted. Rather late in the autumn it was found that under certain circumstances an occasional one would enter the portable traps along the open shore, a new departure, and it is hoped that it may be possible to exploit this discovery in future.

The exceptionally heavy rainfall in June had ensured a steady extraction from the River Stour and in spite of the dry summer and early autumn the Island was not exposed until early October. The anticipated rains did not come and the Island remained partly awash until the beginning of December. Although Teal numbers were exceptionally low, those present were attracted to the Island and the smallness of the catch is largely attributed to the failure to risk placing traps thereon.

Trapping was concentrated on the Top and Middle Sections. The quick, clean harvest left little spilt grain to attract the dabbling duck on to the stubbles at the western end and catching quickly petered out. The best month was September, when the highest autumn count was 5,640. Some Pochard were caught during this month, mostly in the 'Smew Trap'.

There was little severe weather up to the end of the year, explaining the generally low numbers of duck. Teal were down to just over 100 by mid-December. Two very late Garganey were caught in October and a Smew in December. The ringing total for the year was 2,247 distributed as shown in the tables, below and on p. 127.

Fred Trust's passerine ringing group achieved some useful ringing. Two new birds were noted for Abberton, a Bluethroat and a Barred Warbler. Goldcrests were also unusually plentiful during the autumn passage. Among other rare visitors in 1971 was an Osprey which stayed for some days towards the end of May, but probably the most delightful birds seen were the Bearded Tits which were present in small numbers on the Top Section from October until the end of the year.

Organised field parties were entertained at the Public Bird Watching Site and shown the Exhibition Caravan, containing photographs, recovery maps and models. Whenever possible a display of duck ringing was staged as an added interest.

Deep gratitude is again extended to the Essex Water Company for their continued indulgence in the use of their reservoir as a Ringing Station, and for the financial and practical help and the many facilities afforded during the year.

Numbers of duck ringed each month at Abberton in 1971.

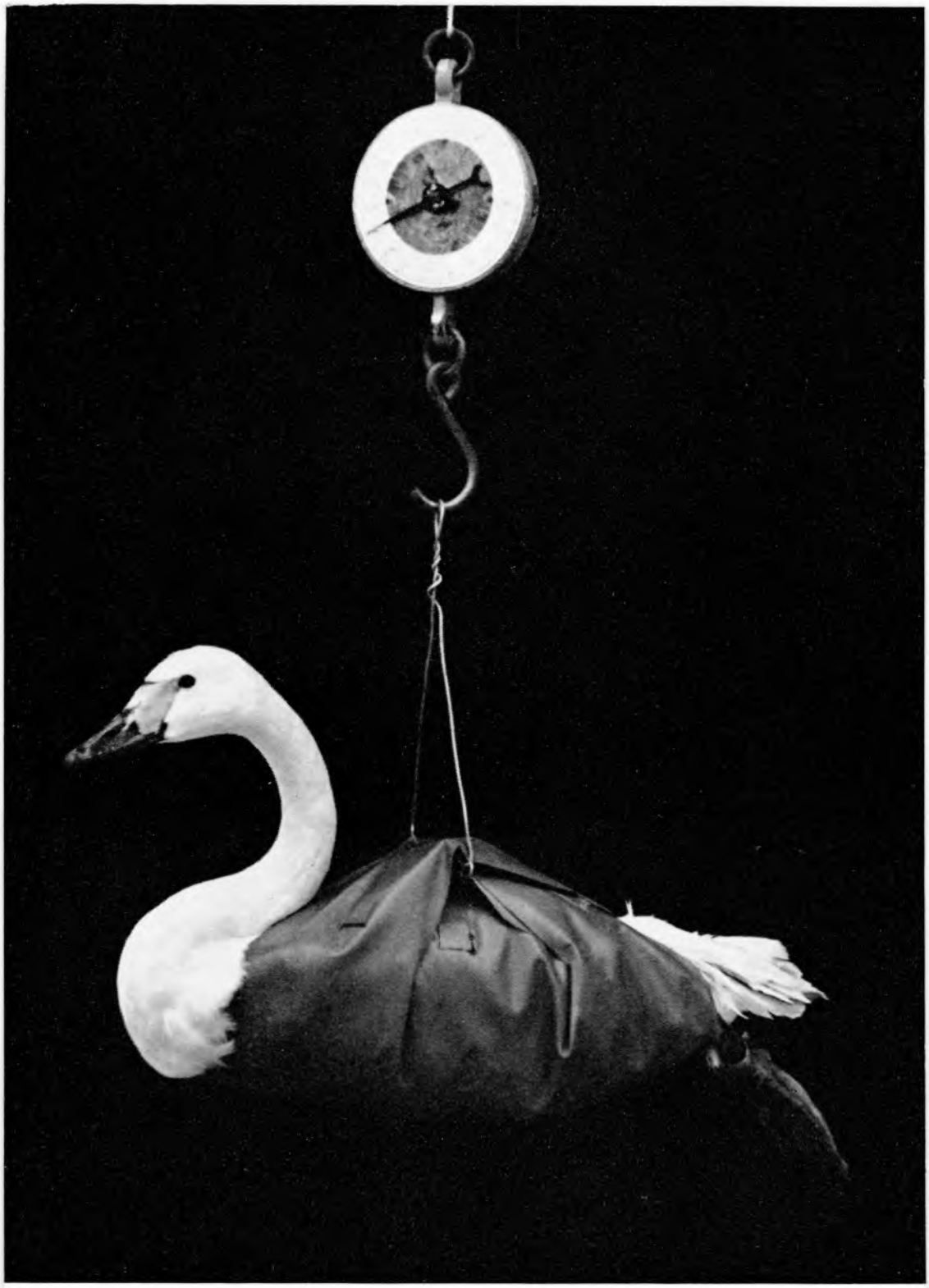
January	227	July	128
February	91	August	232
March	94	September	400
April	67	October	369
May	51	November	292
June	59	December	237

R. King

Philippa Scott

Plate XV. A notable breeding success at Slimbridge was the rearing of seven White-winged Wood Duck *Cairina scutulata* (see p. 135), an endangered species which we are attempting to propagate in captivity. (Above) An immature showing the dark crown and pale edgings to the body feathers. (Below) Five of the ducklings with their distinctive divided eye stripe.

E. E. Jackson



E. E. Jackson

Plate XVI. A Bewick's Swan *Cygnus columbianus bewickii*, caught for ringing at Slimbridge, held comfortably in a specially designed jacket. This greatly facilitates the weighing, measuring and X-raying. (See p. 132).

BOROUGH FEN DECOY, 1971

The icy grip that held the Decoy pond at the end of 1970 continued until 7th January. After that up to 100 Mallard and 50 Teal returned. A total of 58 duck were taken in this month plus 74 from the trap at Deeping Lake.

February, by contrast, was a very open month, and only 23 duck were taken in the Decoy plus 55 from Deeping Lake. The Decoy counts hovered around 50 Mallard plus 25 Teal.

Trapping was very spasmodic throughout March and although the Decoy was not closed until the 25th only 17 duck were taken. The Deeping Lake trap was more productive with a take of 70. The season's total, including re-traps, was 1,495 for Borough Fen and 379 for Deeping.

Large, dangerous willows were felled early in April providing stakes for Peakirk. The shoots then produced the thick low cover essential for efficient Decoy operation. The Vicar of Boston, the Rev. David Scott, and Mr. John Moore rebuilt the NE. pipe, demolished in 1969 by a fallen White Poplar. The *Glyceria* that had become established in that pipe in two years had made it unworkable and was completely dug out. About 60 bundles of reed were cut for screen repairs.

By May mowing becomes the main chore, entailing some 20 man hours of labour per week May to July. The annual Decoy opening on the last weekend in May attracted 98 people. The 29th was wet and cold but the 30th was a really splendid afternoon.

The small influx of Mallard that appeared in early June and peaked at 110 was tackled and 70 were caught. Heavy rain caused a tree in full leaf to fall over the little end of the house pipe on the 20th, and two days were spent in clearing up the debris.

On 9th July the Canada Geese were rounded up at Grimsthorpe Park, Lincs., assisted by members of the Spalding and Whittlesey Wildfowling Clubs. Every one of the 409 geese there were caught, and 123 were removed and transported to pastures new by the wildfowlers.

In July the Decoy was opened for the 1971-72 season. The maximum Mallard count during August was 240 on the 16th and 135 duck were taken. About five tons of tail corn were given by Mr. Riddington of Crowland and stored for autumn and winter use. Piper, the Decoy dog, had a liver infection and pneumonia towards the end of the month but a series of antibiotic injections had him on his feet again in a few days.

Superb anti-cyclonic weather conditions spoiled the prospects of good catches in early September. Brilliant sunshine gave hard sharp shadows and made the duck very wary; the sight of the dog would raise the pond. The numbers using the pond only topped 500 on two occasions while a peak of over 1,200 is more usual this month. Despite efforts by Piper only 315 duck were captured.

On the 25th Piper went off his food and on Sunday evening the 26th, he died, having made his first catch on 11th September 1958 and his last on 22nd September 1971. He is buried on the bank of the filler drain in company with many earlier Pipers whose loyalty and devotion cover three centuries.

The prospects for October looked bleak. The best day count for the month was on the 25th with 475 Mallard, 220 Teal and 15 Shoveler. 293 ducks were caught.

A mongrel collie/terrier puppy was obtained in November to become Piper II. She was about six weeks old, golden coated with white feet. On the 11th a very unorthodox catch was made by dropping her over the Dog Leap and walking up the pipe. She followed on the other side of the screens and lured in six Mallard. Gale force winds on the 21st damaged the end wall at the West pipe and this was rebuilt in moonlight after evening flight. Catching was minimal towards the end of the month due to early frost and the clampdown of fog, although the 447 caught was on a par with earlier seasons. This harder weather improved the take at Deeping, and Tufted Duck began to figure in the ringing totals. This trend continued through December, 85 having been ringed by the end of the year.

Nests were recorded at the Decoy for the British Trust for Ornithology and 124 cards were forwarded for inclusion in the Nest Record Scheme.

Monthly ringing totals of duck caught at Borough Fen Decoy and Deeping Lake, 1971.

Month	*Borough Fen Decoy*	*Deeping Lake*
Jan.	45	63
Feb.	20	38
March	20	69
April	—	21
May	—	—
June	57	—
July	13	—
August	117	9
Sept.	289	—
Oct.	246	46
Nov.	344	39
Dec.	86	94

W. A. Cook

NACTON DECOY, 1971

The 174 duck caught and ringed during January were the last to be handled by 'Tom' Baker prior to his retirement in June. His remarkable career as decoyman at Nacton had spanned 52 years during which time he handled close on 200,000 wildfowl, establishing Nacton Decoy as one of the most successful ever in a period when decoys generally were in decline. He was succeeded on 1st June by his son-in-law, Don Revett, and although officially retired Tom still insisted on doing a full day's work which was a great help toward the maintenance effort.

June and July were devoted to essential jobs around the Decoy pond, including attention to erosion at the sides of the pipes and landings, putting new netting on the large end of the North pipe, erecting some new dog-screens at the South and West pipes and digging out sludge from the pipes and drainage ditches.

An innovation at Nacton this year was an Open Day for Wildfowl Trust members. This was held on 20th June but only nine members availed themselves of this unique opportunity to see the Decoy. The day's events included viewing the ponds, demonstration of the catching technique, display of recovery maps and a nature walk.

Three large sycamore trees in a dangerous condition and overshadowing the Duck house were felled and removed. An adjacent small keep-pond which was in a state of disrepair was cleaned out, refenced and later in the year made into a keeping-aviary for full-winged wildfowl in connection with projected orientation work with Pintail and Wigeon. Unfortunately the aviary was not ready before the season's Pintail/Wigeon catch petered out, but two Mallard releases indicated an unusual directional preference compared with Slimbridge and Borough Fen results, although there may have been some bias due to the selection of release site. However, all is ready for some serious orientation work in 1972.

Mallard started arriving back on the pond in early August with numbers building up steadily to a peak of about 900 during the first week in September. The first Pintail and Wigeon of the season were seen on 19th August. Counts of 250 Pintail were obtained on many days during the first three weeks of September. Wigeon numbers were similar during the daytime but on several occasions there were spectacular influxes of some 400 birds at dusk—alas, too late to catch them and they flighted again before dawn. Decoying during September was frustrated by seemingly endless days of bright sunshine without a cloud in the sky; conditions which are not conducive to successful operation as there are problems when shadows are projected on to the dog screens, and the ducks are apparently reluctant to enter a pipe under such circumstances. However, catches could be made early and late in the day so that a reasonable number of birds were ringed.

By mid-October wildfowl numbers had decreased dramatically in the continuing mild weather and Pintail and Wigeon were notably absent during November and December. An unusual catch for Nacton was three Tufted Duck. Pochard were much in evidence in November and December, with 65 on 28th November but they would not respond to the dog.

Throughout the season two decoy dogs were in use; a 12-year-old dog who at first seemed reluctant to work for her new master but later on proved quite reliable and was responsible for the bulk of the season's catch, and a two-year-old who in her first full season was rather excitable and unreliable.

The Decoy Cottage was modernised to provide basic amenities and structural alteration inside enabled a better utilisation of the rooms. A start was made on a general clean-up and restyling of the approach area to the ponds. This had become largely overgrown with elders and laurels giving it an unkempt appearance out of character with the rest of the Decoy.

The pond was disturbed by intruders on three known occasions. This was despite warning notice boards. Almost contant patrolling of the perimeter of Decoy Wood was necessary at weekends during October against would-be chestnut gatherers. The Decoy is extremely vulnerable to unauthorised entry since it is completely unfenced and the tranquility of the pond is under constant threat. Disturbances can, in extreme cases, cause large numbers of wildfowl to defect altogether for the remainder of the season or their intended halt on migration.

Numbers of duck ringed each month at Nacton in 1971

January	174	July	—
February	—	August	108
March	—	September	512
April	—	October	236
May	—	November	122
June	—	December	41

D. Revett

Conservation

The data on wildfowl distribution, numbers, migration and mortality form the basis for protective and other legislative measures by the Nature Conservancy and other bodies concerned with wetland conservation. Similarly the ecological studies provided the basis for the scientific management, particularly at the Trust's own refuge at Slimbridge, Eastpark, Caerlaverock (p. 140), and Welney (p. 140). Close liaison was maintained with many conservation bodies, especially the Royal Society for the Protection of Birds and the Wildfowlers' Association (W.A.G.B.I.), directly and through the Conservancy's Wildfowl Conservation Committee, of which Prof. Matthews was Vice-Chairman.

Liaison with other countries was through the International Waterfowl Research Bureau, whose headquarters remained at Slimbridge with Prof. Matthews as Director and Mr. Carp as Administrator. The extremely important International Conference on the Conservation of Wetlands and Waterfowl, at Ramsar, Iran, in February, and the Convention which emerged from it have already been described in WILDFOWL 22. The I.W.R.B. organised an international Swan Symposium at Slimbridge in December, attended by researchers from as far away as Alaska, Japan and New Zealand. This was followed by the I.W.R.B.'s Executive Board Meeting, to make a complete week of international activity at the New Grounds. The Final Act of the Ramsar Conference was published within three months and work continued on the massive Proceedings through the rest of the year. The I.W.R.B. Bulletin was also prepared and circulated. The Symposium papers may be published in book form.

G.V.T.M.

SLIMBRIDGE: THE WILD GEESE, 1971-72

European White-fronted Goose *Anser albifrons albifrons*

The first arrivals were ten on 5th October, and by the 11th 94 were present. A slow build up through November took the flock to 400 on the 26th and then it increased a little faster to reach 1,210 on 16th December and 1,800 by the end of the month. 2,600 were present on 13th January and 2,800 on the 21st. The flock stayed at this level until early February when it increased to 3,200 on the 4th and a very low peak of 3,350 on the 9th. Thereafter it dropped to 2,500 on the 23rd and by 2nd March only 1,100 remained. Further departures occurred and 535 were counted on the 6th. These stayed until the 14th and the last one was seen the next day.

The extraordinarily low peak count was a reflection firstly of the extremely mild winter both in England and in the Netherlands, the main winter quarters for this population, and secondly of the very poor breeding season of 1971. Only 8.5% young were counted in the flocks, one of the lowest proportions ever recorded at Slimbridge, with a mean brood size of 2.0. The figures are averages of several counts taken at intervals during the winter.

Lesser White-fronted Goose *Anser erythropus*

An adult was present from 22nd January until late February while a first-year bird was seen briefly on 14th February.

Bean Goose *Anser fabalis*

An adult appeared with some of the earliest Whitefronts, on 8th October, and stayed right through the winter until well into February. It was joined by a second adult on 22nd January, which also stayed for about another month. Both were characteristic of the Western race, *fabalis*.

Pink-footed Goose *Anser brachyrhynchus*

Nine were first seen on 3rd January and up to 14 were seen during the month. A single one was still present on 14th February.

Barnacle Goose *Branta leucopsis*

A single adult was present from 4th to 13th January.

Dark-bellied Brent Goose *Branta bernicla bernicla*

An adult was first seen on 2nd December. It stayed through the winter and was last observed on 6th March.

M.A.O.

SLIMBRIDGE: THE WILD SWANS 1971-72

This winter the first five Bewick's Swans came to Slimbridge on 25th October. Three of these were complete newcomers to Slimbridge, while the other two, Antony and Antonia, had become well established in previous winters. It was interesting that, like the first swans to arrive last winter, these birds did not reappear the next day. Indeed the three never returned; Antony and Antonia did on 12th December. There is no apparent reason why these first birds do not settle. The Rushy Pen has always been cleared of visitors by the time they fly in, for they usually are first seen on the river estuary, or else arrive early in the morning before the Trust is open.

Numbers built up to 67 during the first four days after which there was a lull for 12 days. Then another four days of massive influx followed, with fairly constant arrivals during November. By the end of the month 292 swans had been recorded, 16 more than the same date last winter, the record year so far. December, however, took the puff out of our sails: during the next four weeks only 43 swans arrived; in the next three days there was a moderate surge ahead of 28. On 1st January, as a feeble climax, the greatest number of Bewick's, 311, came to Swan Lake on one day for the season. This grand total was exactly 100 less than in the previous winter, and considerably down on the past three winters.

Disappearances began very early: on 10th January in the middle of mild wet weather 107 birds left, but of these only 40 were genuine departures. The rest returned sooner or later, for prolonged stays or irregular appearances. And so, although by 13th January numbers had dropped to 161, they slowly built up again as new birds continued to arrive, and old ones returned. By 1st February the total was up again to 297; however, by the middle of the month it was around 130, and never rose again beyond about 160 (at the end of the month). Numbers continued fairly high, however, until mid-March; then, within a week they were all gone, the last ones leaving on 22nd March.

The final total of recognised individuals for the season was 528, which was down on the past two seasons. The cygnet proportion was also low, 11%, and the mean brood size was 1.7. There was only one pair with four cygnets; six had three; eight had two; and there were 19 singles. Of the total, 258 had been here in previous seasons making the return rate of adults and yearlings 55%.

During the winter 161 swans were caught, and 88 were ringed for the first time. Some improvements had been carried out to the catching and holding systems, which generally made the process more efficient: the last pen into which the swans are herded was made considerably smaller, and was constructed out of plastic covered wire so that any possible damage to the birds was eliminated. The smaller pen makes it easier to catch them up individually. Also during last summer, new plastic jackets to restrain the swans during processing had been designed and constructed. They were made from P.V.C.-coated 'Trevira' with fastenings of 'Velcro', so that the jackets are very quick to do up, and are adjustable according to the swan's size. All the processing can be done with the jacket in place, except for measuring the wing, which is done at the end anyway. The jackets can be hosed down after each catch, and any dye washes off them.

The policy of X-raying was continued, especially as plates of birds also X-rayed in the previous winter would show if any shot had been gained in the intervening year. Efforts were concentrated on yearlings and juveniles, and the results for the two years are as follows:

	Total	*Adults*	*Yearlings*	*Juveniles*
Total X-rayed	181	111	36	34
With shot	57(31%	41(37%)	11(31%)	5(15%)

Differences between the two years in the percentage of juveniles and yearlings with shot in them were not significant, as samples were so small in the first year.

A distinctly higher proportion of the adults were carrying lead in 1971-72 (49% of 35) than in the previous year (32% of 76). We feared that perhaps the yellow-tailed birds were attracting the attention of shooters. However, this was not the case, for 79% of 1970-71 yellow-tails returned this season as against 81% in a sample of similar age and Slimbridge experience. Incidentally, some of the returnees still had a few yellow feathers, so the dyeing programme is throwing interesting light on the moult sequence.

The suggestion that shooting pressure on this protected species was increasing gave particular interest to the 14 birds which were X-rayed in both years. The shot content in 12 was the same. Two had gained, both previously having one shot each. Schoolboy now had two, and Pie

21 of three different sizes. If swans were caught again during the winter, the opportunity was taken to re-X-ray them. This showed that one bird, Guy, contained six pellets on 30th November, but by 2nd February had gained two more. He had only spent seven days away from Slimbridge in the interim.

At the beginning of January the remains of 12 swans were found on the Dumbles and other fields close to the Trust. Six of these had quite certainly died recently. All had been got at by foxes, but it was impossible to say whether the swans had been alive or dead when this happened. Certainly the tides were very high, which may have encouraged the swans on to dry land at night, and there were thought to be a lot of foxes in the area. One swan, Denise, did provide a clue as to the reasons for the deaths. When X-rayed it was found that she had a lead pellet in her head, which had pierced the optic nerve. Had the pellet been lodged there previously she would have been seen to be blind in one eye when on Swan lake two days earlier. She was not, so she must have been shot near the Trust. Her mate, Oliver, was also found dead very close to her. We can only conjecture that he landed with her when she was shot and was pounced by a fox, for they were near to a hedge. They were one of our most interesting pairs of swans, for although they had come to Slimbridge every year since 1967-68, they did not appear regularly, but seemed to vary their attendance according to weather or population pressure on the pond. All the swans found at this time were X-rayed, but, of course, the foxes had removed varying amounts of the evidence. The local Wildfowlers' Club was as upset as we were at this oafish destruction by Marsh Cowboys of these lovely, protected birds (one of the cygnets X-rayed alive during the winter had pellets of the size often used by clay-pigeon shooters). Certainly we can no longer comfortably assume that our swans are only shot when overseas.

A pair of Whooper Swans came regularly to Swan Lake between 29th December and 20th January. They had been before in February 1970, although it was uncertain at the time if they were a pair (see WILDFOWL 21). Then one of them had no tail feathers, but these appeared quite normal this winter.

Sightings of Slimbridge Bewick's Swans in Britain and Europe, December 1971 to April 1972

The first swan catches at Slimbridge were in November and they continued until early February. Just before release 96 swans had their tail and wing tips dipped in picric acid, a yellow dye, for easier identification away from Slimbridge. All sightings of Slimbridge swans, whether identified by dye, ring, or bill pattern alone or in combinations are shown in the Table. Actual numbers are obviously impossible to reach in certain categories, as some of the birds reported could be the same individual moving around.

An analysis was made as to how the swans were identified as having been at Slimbridge. It was assumed that the dye attracted an observer's attention before a ring or bill pattern. Swans seen from the Observatory on the Trust's Welney

Table. Distribution of marked swans in north-west Europe, winter-spring 1972.

Period	*Ireland*	*Britain west of Slimbridge*	*Within 40 km. of Slimbridge*	*Britain east of Slimbridge*	*Ouse Washes*	*Netherlands*	*West Germany*	*Denmark*	*East Germany*	*Sweden*	*Poland*
Dec. III	1	—	2	—	2	—	—	—	—	—	—
Dec. IV	4	—	—	—	8	—	—	—	—	—	—
Jan.. I	1	—	—	—	8	—	—	—	—	—	—
Jan. II	1	—	—	4	13	—	—	—	—	—	—
Jan. III	1	2	—	3	17	3	—	—	—	—	—
Jan. IV	1	1	—	1	18	8	—	—	—	—	—
Feb. I	2	—	2	1	19	1	—	—	—	—	—
Feb. II	6	3	12	1	20	4	—	—	1	—	—
Feb. III	1	—	—	1	20	3	9	—	—	—	—
Feb. IV	—	—	9	—	17	1	9	—	—	—	—
Mar. I	—	—	—	1	20	6	9	—	—	—	3
Mar. II	—	—	—	—	15	1	5	—	1	—	—
Mar. III	—	—	—	1	29	11	17	—	2	—	—
Mar. IV	—	—	—	—	—	—	1	—	1	3	—
April I/III	—	—	—	—	—	—	2	1	2	3	—

Refuge on the Ouse Washes were excluded as conditions there cannot really be classed as those of the field. The attraction of artificial feeding would allow a higher proportion of swans to be recognise by ring or bill pattern alone.

The minimum number of swans to be identified by dye was 56; 20 (and two cygnets, by association) were recognised by bill pattern only; 24 were recognised by ring alone, and of these, the numbers of ten were read.

Sightings are very much fewer before mid-December. One ringed bird was seen on Öland, Sweden, on 15th October. A ringed swan arrived at Welney at the end of October, and was joined by another in the third week of November. They were still there a month later, and did not move on to Slimbridge.

It is not possible to say yet whether artificial feeding at Welney will affect the numbers (and especially of established swans) at Slimbridge. Certainly 23 known swans were identified at Welney, none of which moved on to Slimbridge. Seventeen swans, which were at Slimbridge earlier in the winter, arrived later at Welney. However, Karoo, which arrived at Welney on 25th January, after having been at Slimbridge the day before, returned six days later to Slimbridge, although she only stayed two days. Nothing was then heard of her until she called in at Welney again for five days at the end of March. It will be fascinating to see what those birds that sampled Welney this winter will do next year.

Other swans that were recognised and which had not been checked in at Slimbridge this winter were six in Ireland; two in Britain; five in the Netherlands; and three in West Germany.

It is interesting to note that swans had moved from Slimbridge to the Netherlands as early as the third week of January and to Poland by the first week of March. These early eastward movements were also noted in 1970-71, another mild winter.

Two sightings were of especial interest: Gold left Slimbridge with Miller on 9th February, but on 18th March was seen on the river Dove in south Derbyshire, alone in the company of two Mute Swans. Similarly Cumula and Nimbus left Slimbridge on 10th January. Three weeks later Nimbus returned alone and stayed until 18th March. Meanwhile Cumula had been reported from the Netherlands on 22nd February, from where she disappeared on 12th March.

The number of sightings was certainly swelled by the fact that Dafila Scott and I made a special trip to find Slimbridge swans, starting on 17th March. On that date we recognised 28 swans out of a total of 360 at Welney. Of these, 16 had been at Slimbridge during the winter, including Cuba and Castro and their two cygnets. The interesting point about this family is that they first arrived at Slimbridge with three cygnets and one of their cygnets from the previous year, called Cupid. Quite early in January Cuba and Castro disappeared with two of the cygnets, leaving behind Cupid and the third cygnet. It is not known where they went, but on 1st February they returned for the day. Far from the family reuniting, Cupid and the cygnet remained behind until 18th March, while the rest of the family disappeared, to turn up later at Welney.

By contrast, another pair at Welney was Compass and Point. They too had been at Slimbridge and left their cygnet of the previous year, South, with which they had been associating, behind there. But they only had ten days to themselves at Welney. Then South flew in, and all three were still there on 17th March.

The next three days Dafila Scott and I spent looking at the swans in the Netherlands, the only large flocks being found in the fields between Bunschoten and Nijkerk (groups of 175 and 29) and on the Veluwemeer near Strand Horst (group of 27). The grouping on the fields altered slightly during the next two days, and the total number diminished to about 70 by 21st March. No swans were found on the river Yssel, which was extremely low. Out of the total number of swans, about 170 were close enough for the bill patterns to be seen well, and ten Slimbridge birds were found (all between Bunschoten and Nijkerk). These comprised four with Darvic rings, one with a metal ring only, one unringed, and a pair, Peasant and Gypsy, with their two cygnets. This pair were also seen in the Netherlands by Dafila Scott in spring 1970, but then on the Yssel, when the weather had been much wetter. None of the birds were dyed, but were approachable by foot to about 150 yards.

On 21st March we moved on to West Germany, passing on the way an area reported to be a well-known resting place for migratory swans—a dead arm of the river Ems at Vellage, south of Weener. No swans were to be seen, however.

The following three days were spent on the Elbe estuary, north-west of Stade, where in some springs 800 or more Bewick's Swans have been reported. We found groups totalling about 450 individuals on the Asselersand and Gauensie-

kersand, areas theatened by industrial development, and another 500 individuals, also in large groups, on the Allwördener Aussendeich. A further 34 swans were seen on the Nord-Kehdingen flats. Because of the very dry weather we were able to approach the swans by car across the fields outside the main dyke, and sometimes get to within 80 yards of them. Problems did, however, arise because of the very strong sun and resulting dark shadows, the heat haze and the strong wind which shook the telescope. A total of 14 Slimbridge birds were found. On the Asselersand there were two yellow tails. Another four were on the Allwördener Aussendeich, plus two ringed swans, and the Peasant/Gipsy family again! We found them on the 22nd, having last seen them in the Netherlands four days earlier. The last three swans were a pair called Beachcomber (ringed) and Beechnut and their cygnet. Beachcomber was particularly interesting, as his ring number had been read, on the upper Elbe, on 27th February. He had therefore moved north-west at a time when he might have been expected to go east. However, presumably it was not time to go east, and the river just became too low near Hitzacker, where he was seen. When Dafila Scott and I visited this area on 25th March, only seven swans were found (up to 13 dyed swans were seen there last spring and reports of up to 700 birds were received). Similarly only 18 Bewick's were seen on the Stor south of Kellinghusen the day before, whereas eight dyed birds had been reported from there the previous spring.

On returning to Britain we found that the last swans had left Slimbridge on 22nd March and Welney on the 25th. There appeared to have been no corresponding increase in the Netherlands or Germany. Do late leaving birds make longer flights, over-flying these countries? All the Slimbridge swans seen in the Netherlands and Germany had left Slimbridge by 13th February, and so they would have had plenty of time to settle down in either of these countries again. It is fascinating to know even a little more about the swans' movements and migration, especially at this individual level; but how to find out about the rate of travel of individuals, and more especially their motives which may be in complete contrast to those of other individuals, remains a problem for the future.

Mary Evans

SLIMBRIDGE: CURATOR'S REPORT FOR 1971

A thousand birds of ninety kinds were reared at Slimbridge in 1971.

Perhaps the satisfaction of the season was that fifty-eight Hawaiian Geese were hatched—the largest number so far at Slimbridge—of which fifty-four survived.

The breeding of the White-winged Wood Duck was a minor triumph as the birds had only been reared once before in captivity, by Mr. Schuyl at Rotterdam before the war. Then a pair of pinioned birds bred in a small open enclosure. It is not known what happened to the birds that were hatched or how long they survived in captivity.

White-winged Wood Duck were first represented at Slimbridge by a consignment from Siam which arrived in the summer of 1955. In those days our aviary accommodation was at a minimum and the ten birds that arrived, after quarantining, were let loose in the Rushy Pen. During the quarantine period the difficulty was to find the right food. Grain, biscuit, bread, etc., were refused but minced eel was eaten avidly. This was gradually mixed with biscuit and wheat and finally, by the time the birds were released, they were more interested in the biscuit and wheat than the eel. They survived for four or five years and although the females were seen going in and out of nesting boxes no eggs were found and the last bird died in 1960.

In 1968, under the auspices of the World Wildlife Fund, some birds were caught in Assam as juveniles by Mr. Sam Mackenzie and they were eventually sent to Slimbridge in February 1969. They turned out to be five males and one female. Subsequently in January 1970, a further four females and two males arrived. This gave the Wildfowl Trust five pairs of these very rare birds, four pairs of which were pinioned. Two pairs were sent to other aviculturists in order to spread the chances of propagating the birds. The full-winged pair was put into our Guinness Aviary where their diet consisted of turkey starter crumbs, wheat, brown bread, biscuit meal, minced beef, minced eel and dried shrimp, together with duck weed.

Various kinds of nesting sites were provided. In the fork of one tree in the aviary a box 2′ × 18″ with 6″ sides was

fixed and filled with peat, earth and leaves. A similar sized kennel 18″ high at the hip with a 6″ square hole in one end was placed in another tree. Another kennel was available at ground level and yet another in the winter house, raised on logs a foot from the ground. The last was eventually the selected nesting site.

The eggs are very similar in size and shape, though somewhat more opaque, to the Muscovy and were laid over a period of fourteen days. But the importance of the breeding project restricted our observation as to when the bird actually started to incubate. It did seem that she was never on view after eight eggs had been laid. It was surmised that the incubation period would correspond with the Muscovy but no one was allowed near the nest during the incubation period. Finally after thirty-three days both birds were seen on the pond and we could then examine the nest. At this stage nine out of the ten eggs were found to be chipping. Within forty-eight hours the female bird was on the pond with nine ducklings, one of which was obviously the weakling of the family. Within twenty-four hours it was apparent that the male was going to cause a great deal of trouble as he spent his time catching the ducklings and dunking them in the pond. Consequently he was removed during the rearing period.

The ducklings themselves are not very distinctive, being dark brown and yellow, rather like large Mallard ducklings except that the post orbital stripe turns up almost at a right angle to the dark brown cap (Plate XV, facing p. 128). The legs are duo-coloured like all Cairinini, in this case black and yellow.

The remaining ducklings grew well on a diet of minced shrimp, turkey starter crumbs and duck weed. When they were fully feathered they were removed from the mother to another aviary and the male was re-united with her.

The adolescents had a brown rather than black plumage and it was apparent that two of them, a male and a female, were going to be much whiter on the head and neck, with more white blotches over the body than the other birds. At a year old the female of these two is almost completely white on the head and neck and the back has large areas of white. This would seem to confirm that the mystery bird shown in a photograph in the Eighth Annual Report (1957) might well have been this white form of White-winged Wood Duck.

S. T. Johnstone

PEAKIRK: CURATOR'S REPORT FOR 1971

The breeding season commenced with the Cereopsis Goose laying its first egg on 15th February.

The weather was mostly wet during January, February and March, and this was followed by fine conditions in April and May, more rain in June, and further good weather in July and August

In order to finalise domestic matters in the New Service Area, a start was made during the winter by the Curator's staff on the construction of a covered Sitting Hen Box Area, and work on this project was completed by the beginning of March ready for the breeding season. This building is able to accommodate up to 72 sitting hens, and the general care and management of these is now greatly facilitated.

Unfortunately none of the pairs of breeding Ne-ne on the Neaverson Area laid, and it is considered that the area is possibly too isolated and exposed for the successful breeding of this species. Arrangements will be made to quarter these birds in the Main Side Pens for the 1972 season.

Further achievements were obtained from the Trumpeter swans; six out of seven eggs were hatched and the cygnets successfully reared to maturity.

A 'first ever' within the Trust was recorded when the only pair of Ring-necked Ducks at Peakirk laid and young were reared. This pair of birds was introduced to the New Grounds from Slimbridge in March 1966. The birds nested close to the water's edge on the island near the railway line, and the first of a total of eight eggs was laid on 2nd June. Unfortunately five of the eggs proved to be infertile, but after an incubation period of 26 days, the remaining three eggs were hatched and reared.

In addition to the rearing of five young Red-breasted Geese, other more notable species bred included Ross's Goose, Cackling Canada Goose, Patagonian Crested Duck, New Zealand Brown Duck, Baer's Pochard and Maned Goose.

P. R. Vardy

Slimbridge breeding results, 1971.

Species	*Date of first egg*	*No. of eggs*	*Infertile*	*Hatched*	*Hatched by parent*	*Total reared*
Magpie Goose	24.5	27	22	3		1
Eyton's Whistling Duck	17.6	23	7	15		13
Fulvous Whistling Duck	20.3	43	10	25		15
Cuban Whistling Duck	29.3	10	3	4	7	1
White-faced Whistling Duck	18.5	25	6	19		18
N. Red-billed Whistling Duck	20.5	19	11	7		7
S. Red-billed Whistling Duck	24.3	80	9	71	25	45
Black Swan	8.2	9	5		4	4
Black-necked Swan	11.2	11	1		10	4
Trumpeter Swan	27.4	8	1		1	1
Swan Goose	1.5	10	6	2		2
Western Bean Goose	20.4	6	6			
Russian Bean Goose	4.5	10	3	4		4
Pink-footed Goose	1.5				3	2
Pacific White-fronted Goose	9.5	5	1	4		4
Greenland White-fronted Goose	20.4	13	6	3	2	4
Lesser White-fronted Goose	24.4	23	6	14		11
Western Greylag Goose	11.4				20	20
Eastern Greylag Goose	25.4	4			4	4
Bar-headed Goose	24.4	26	18	4	8	4
Lesser Snow Goose	30.4				17	11
Greater Snow Goose	6.5	6	5	1	4	5
Ross's Goose	16.5	4	3	1		1
Atlantic Canada Goose	28.3				23	23
Moffitt's Canada Goose	12.4				1	1
Giant Canada Goose	25.3	5	2	3	10	10
Lesser Canada Goose	7.4				6	6
Taverner's Canada Goose	4.5	5	5			
Cackling Canada Goose	3.5	8	5		4	7
Hawaiian Goose	3.2	123	34	58		54
Barnacle Goose	20.4				24	22
Black Brant	30.5	4	2	2		2
Red-breasted Goose	30.5	5	5			
Ruddy Shelduck	3.4	10	9	1	7	7
Cape Shelduck	22.3	4	1	3		3
New Zealand Shelduck	8.3	9	3	4		4
Common Shelduck	12.4	14	3	10		10
Egyptian Goose	1.2				14	14
Abyssinian Blue-winged Goose	18.4	14	5	6		6
Andean Goose	9.4	19	12		5	5
Ashy-headed Goose	14.4	6	1	4	4	4
Greater Magellan Goose	14.4	4		3		3
Cereopsis Goose	15.1				3	1
Patagonian Crested Duck	3.4				5	5
Andean Crested Duck	20.4	3		3		3
Marbled Teal	8.5	76	23	51		49
Bronze-winged Duck	8.4	5	1	2		
Hottentot Teal	11.2	9	4	2		2
Versicolor Teal	10.4	29	8	20		17
Puna Teal	24.4	13	6	7		7
Red-billed Pintail	26.4	19	11	6		6
Bahama Pintail	7.4	42	17	23		23
Chilean Pintail	6.3				12	12
Northern Pintail	12.3	15	12	2		2
Falcated Teal	19.4	14	7	4		4
Australian Grey Teal	19.6	14	11	3		3
Chestnut-breasted Teal	18.4	12	3	9		8
New Zealand Brown Teal	1.4	5	4	1		1
Hawaiian Duck	12.4	30	10	20		18
Laysan Teal	11.4	16	8	7		7

Species	*Date of first egg*	*No. of eggs*	*Infertile*	*Hatched*	*Hatched by parent*	*Total reared*
Mexican Duck	3.4	6	4	1		1
Indian Spotbill	5.5	15	14	1		1
New Zealand Grey Duck	15.4	8	3	5		4
Pelew Island Grey Duck	16.4	16	1	15		14
Philippine Duck	29.4	36	3	33	10	34
African Yellowbill	20.4	22	6	16		16
Abyssinian Yellowbill	30.3	26	12	14		12
Gadwall	16.4					50
European Wigeon	18.4	34	2	24	8	17
American Wigeon	9.5	26	8	13		4
Chiloe Wigeon	7.5	30	14	12		11
Blue-winged Teal	20.4	20	20			
N. Cinnamon Teal	10.5	10	2	6		5
Cape Shoveler	25.4	8	3	4		4
Australian Shoveler	10.4	19	19			
Common Shoveler	1.5	33	11	14		14
New Zealand Shoveler	21.5	10	4	4		2
Ringed Teal	19.4	36	29	7		7
European Eider	5.5	39	16	19		14
King Eider	14.6	4	4			
Spectacled Eider	17.5	1	1			
Red-crested Pochard	10.3	47	12	32		26
Rosybill	13.5	13	9	4		4
African Pochard	7.5	7	2	5		5
European Pochard	30.4	11	1	8		8
Redhead	25.4	19	4	7	4	7
Common White-eye	13.5	38	10	14	7	11
Baer's Pochard	30.5	20	10	10		8
Australian White-eye	20.3					2
New Zealand Scaup	22.3				9	8
Tufted Duck	30.4	40	1	38		38
Lesser Scaup	16.4	7	1	6		6
Mandarin	13.4	39	3	36	7	36
Carolina	23.3	41	1	39		20
L. Brazilian Teal	1.6	5	4	1		
Comb Duck	16.6	15	6	7		1
White-winged Wood Duck	23.5	9			9	7
Muscovy Duck	16.5	10	4			
European Goldeneye	20.4	5	5			
American Goldeneye	23.4	10	10			
Bufflehead	?	1		1		
Smew	3.5	41	23	11		4
Red-breasted Merganser	3.6	8	3	1		
North American Ruddy Duck	1.5	31	18	7	20+	25
Greater Flamingo	18.6	?				5
Chilean Flamingo	25.5	?				13
Andean Flamingo	17.4	7	7			

Peakirk breeding results, 1971.

Species	*Date of first egg*	*Eggs incubated*	*Eggs hatched*	*Young reared*
Fulvous Whistling Duck	12.5	23	3	
Southern Red-billed Whistling Duck	1.7	10	7	2
Black-necked Swan	4.3	5	2	2
Trumpeter Swan	24.4	7	6	6
Swan Goose	10.4	12		
Western Bean Goose	22.4	4		
Pink-footed Goose	7.5	16	10	5
Greenland White-fronted Goose	30.4	13	6	6
Lesser White-fronted Goose	18.5	4	1	1
Western Greylag Goose	26.4	22	10	6
Emperor Goose	24.5	15	2	1
Lesser Snow Goose	3.5	11	2	2
Ross's Goose	10.5	6	2	1
Taverner's Canada Goose	21.4	12		
Cackling Canada Goose	24.4	11	8	7
Barnacle Goose	3.5	30	13	10
Red-breasted Goose	12.6	9	6	5
Ruddy Shelduck	23.4	6	2	2
Cape Shelduck	10.4	5	3	3
New Zealand Shelduck	13.5	6	1	1
Common Shelduck	25.4	51	32	32
Andean Goose	29.5	8	2	1
Ruddy-headed Goose	21.4	6	5	3
Lesser Magellan Goose	12.4	14	10	7
Greater Magellan Goose	17.5	4	4	3
Cereopsis Goose	15.2	6	3	3
Patagonian Crested Duck	9.5	7	4	4
Marbled Teal	10.5	20	18	14
Bahama Pintail	10.6	11	6	2
Northern Pintail	4.5	12		
Chilean Teal	13.4	17	5	1
Falcated Teal	30.5	3		
New Zealand Brown Duck	14.4	15	7	5
Mexican Duck	24.4	23		
North American Black Duck	10.5	10	1	1
Laysan Teal	30.4	11	7	5
Philippine Duck	12.5	10	2	2
Abyssinian Yellowbill	25.5	8	5	3
Gadwall	10.5	27	11	11
European Wigeon	3.6	13	11	11
American Wigeon	18.6	5	1	
Common Shoveler	2.5	21	20	14
Red-crested Pochard	17.4	47	11	5
Rosybill	17.5	36	19	18
Southern Pochard	30.5	7		
European Pochard	29.4	8	6	4
Redhead	27.5	8	4	3
Baer's Pochard	5.6	10	6	2
Ring-necked Duck	2.6	8	3	3
Tufted Duck	23.5	30	13	7
Lesser Scaup	26.5	1	1	
Maned Goose	7.4	15	3	3
Mandarin Duck	7.4	20	3	2
North American Wood Duck	26.3	65	32	14
North American Ruddy Duck	16.5	9	2	

WELNEY WILDFOWL REFUGE, 1971

It was another very good year at Welney with large numbers of ducks and swans using the refuge area. Wigeon numbers were particularly high in January with about 20,000 present on the 30th, out of some 32,000 counted on the whole of the Ouse Washes. Thereafter the total dropped away to 8,500 on 20th February, 5,000 on 27th February and 20th March, and 3,000 on 3rd April. Mallard numbers stayed around the 2,000 level through January falling to under 1,000 from mid-February onwards. The highest Teal count was 1,700 on 16th January. Pintail reached a peak of 400 on 23rd January while Shoveler reached 350 on the 16th. Only small numbers of both species remained after the end of February.

No less than 1,234 Bewick's Swans were counted on the whole of the Ouse Washes on 18th January and even this record was beaten on 15th February when 1,278 were present. The number on the refuge during this period fluctuated between 300 and 400. Many of these were fed daily outside the Observatory building. Up to 25 Whooper Swans were frequently with them. Small parties of White-fronted Geese were seen in the area during January, but never more than 20. A flock of 64 paid a brief visit from 27th February to 3rd March.

The breeding season was rather mixed with one pair of Ruffs probably though not certainly breeding either in or just to the north of the refuge. Only two pairs of Godwits bred, compared with five in 1970, but both were sucessful in rearing young to the flying stage. Black Terns called in but did not stay. A pair of Short-eared Owls laid a clutch of seven eggs and reared five young. The male was notable in his defence of the nest; on one occasion almost knocking out the warden with a blow to the head. Most duck species had a good season and three broods of Teal and two each of Garganey and Tufted Duck were noted. Snipe and Redshank also bred well.

Mallard numbers were high in the autumn with 3,500 present throughout September, and over 2,000 for most of the rest of the year. There was little natural flooding until early December and the other duck species were not numerous until then, though there were 8,000 Wigeon as early as 13th November. After the Washes flooded numbers rose rapidly and there were 18,000 Wigeon on 31st December as well as 1,800 Teal, 400 Shoveler and 150 Pintail. The first Bewick's Swans returned on 6th November and by early December there were over 180, with 232 present at the end of the month. The daily feeding routine in front of the windows of the Observatory quickly got into its swing providing the spectacle of a great flotilla of swans closely pursuing the warden with his barrow full of grain. Up to 20 Whooper Swans were again with them.

Developments during the year included the purchase of an additional wash bringing the Trust's holding up to 601 acres (243 hectares). The main screen bank was further extended to about 850 metres with spurs at each end projecting 100 metres into the washes. A new corridor was constructed at the southern end of the refuge extending northwards from the road across the washes for about 700 metres. Several new observation hides were installed along the new banking, bringing the total on the refuge to 29.

Wigeon House was opened as a guest house from March and was well booked from then on. The total number of visitors to the refuge in the year was over 800. This included a visit from T. R. H. Prince Philip, Prince Charles and Prince Andrew on 10th January.

M.A.O.

EASTPARK REFUGE, CAERLAVEROCK, 1971-72

Barnacle Geese

The first arrivals came in force with 1,250 present in the afternoon of 25th September though there had been none in the morning. The flock increased further during the next four weeks: 1,500 on 28th September; 2,010 on 9th October; 3,100 on the 11th and 3,200 on the 21st. On 11th November, 3,700 were counted but this peak number remained for only eight days, the flock reducing to 3,200 throughout the latter half of November and December. From 11th to 24th January the flock again increased, to 3,400. In February there was a maximum of 2,350 at Caerlaverock, while in March and April the maximum numbers were 440 and 340 respectively.

The numbers of geese at Caerlaverock fluctuated widely, often, as last winter, on a daily basis. Flocks of geese were seen to leave heading south-west to the main Kirkcudbrightshire haunts on several occasions and their return was frequently noted as well. There were at least some Barnacle Geese at Caerlaverock on almost three-quarters of the days between October and April on which observations were made (see Table).

The Table also shows the percentage of geese noted each month on the merse, the Eastpark Farm arable, and on other arable in the Caerlaverock area. It can be seen that there has been a marked increase in the amount of arable feeding, both within and outside the Refuge. Very detailed observations are being made of the feeding distribution and behaviour of the Barnacle Geese as part of a research project.

Observations on Barnacle Geese at Caerlaverock, 1971-72

Month	*Observation days* *Present*	*Absent*	*Goose days*	*% on merse*	*% on Eastpark arable*	*% on other arable*
October	23	0	89280	36.9	62.3	0.8
November	18	3	78520	16.1	57.4	26.5
December	18	4	61660	78.8	21.2	—
January	25	0	93030	7.0	54.1	38.9
February	7	15	8236	41.2	58.8	—
March	7	13	3174	24.2	69.5	6.3
April	11	8	1032	92.0	8.0	—
Total	109	43	334932	31.6	51.1	17.3
Total 1970-71	*136*	*33*	*183616*	*42.1*	*44.3*	*13.6*

From a sample of 706 geese examined in good conditions the proportion of young was observed to be 15%, and the average brood size 1.8.

A number of searches of other Barnacle haunts in the Solway were made during the winter. The main alternative haunts to Caerlaverock is Rockcliffe Marsh at the inner end of the firth. Here there were occasional flocks of up to 100 until the end of January. Then on 3rd February the main flock left Caerlaverock and up to 1,200 birds were regularly seen at Rockcliffe and also at Cardurnock Point, Cumberland, on the south side of the firth. The remaining 1,200 to 1,500 birds spent most of their time on farmland between Southerness and Southwick Marsh, Kircudbrightshire, across the River Nith from Caerlaverock.

What was almost certainly the same white Barnacle that was seen in the 1970-71 winter returned in late September and was seen frequently thereafter. Another white Barnacle (a first-winter bird) was also seen many times from 10th October. The two never associated and were therefore presumably not related. The first bird did not appear to have any of the light brown-edged feathers on its back that distinguished the bird of the previous winter, while the first winter bird had quite distinct light brown wing coverts, as well as other odd light brown-tipped feathers on its back and neck.

Pinkfeet

Large numbers of Pinkfeet were present in the area throughout the winter but only a few hundreds fed on the refuge until after the end of the shooting season in February. On 27th February up to 4,000 Pinkfeet were feeding on the merse and fields, and during March there was a maximum of 3,500 present there. On 5th March it was estimated that there were about 10,000 Pinkfeet feeding on the north side of the Solway. Numbers gradually declined during March and April and the last of the winter were 49 feeding on the merse on 9th May.

Greylags

Up to 110 were recorded in the locality during the winter, with a maximum of 52 recorded on the refuge.

Other wildfowl

An adult Light-bellied Brent was seen with the Barnacles for most of the winter. Two Greenland Whitefronts were seen among the Pinkfeet on 29th February and 1st March. A Lesser Snow Goose, presumably an escape, was also with the Pinkfeet from 20th to 23rd February.

The enclosure area of ponds with the tame wildfowl proved very attractive to wild wildfowl and at various times through the winter the following were seen inside the fence for shorter or longer periods: 3,100 Barnacle Geese, 700 Pinkfeet, 7 Greylags, 3 Whooper Swans, 1 Bewick's Swan, 285 Mallard, 65 Wigeon, 45 Teal and smaller numbers of Shelduck, Shoveler, Pintail, Pochard, Tufted Duck and Red-breasted Merganser.

Developments

During the summer 2½-metre high screen banks were constructed, providing screened approaches along both sides of the Saltcot Road to the Nature Conservancy's observation tower, and along both sides of the Avenue to the new two-storey tower built by the Trust. Screen banks were also constructed around three sides of the wild area of the enclosure to prevent disturbance to the visiting wildfowl. By the middle of September over three and three-quarter kilometres of bankings had been built and grass seeded to blend in with the surrounding countryside. At field entrances, gates with wooden slat screening were erected.

Nineteen fibre-glass hides were built into the banks at strategic viewing points. The new Avenue tower holds up to thirty people and provides a magnificent view over the refuge and the inner Solway. The Nature Conservancy have provided a 'wrap-round' observation point at the base of their Saltcot tower. This gives an excellent view over the merse.

The fox-proof fence surrounding the enclosure was increased to take in an area of eight hectares and a large pond constructed, measuring approximately 100 × 50 metres and two and a half metres deep in the centre. A wooden observatory was erected overlooking this pond; the building also serves as an interpretative centre for the refuge and houses a set of wall books prepared by the Trust's education department. Inside the enclosure quantities of willows, brambles and rushes have been planted to provide nesting cover along the edges of the ponds.

The removal of earth to build the screen banks has produced shallow ponds and scrapes along the bases of all the banks. These are proving to be most attractive for different waders and ducks, but most gratifying of all is that the Barnacles often use them for drinking and washing. This has at times brought the geese within a few metres of the watchers in the hides.

The farmyard was levelled and laid with tarmac and the general tidying up of the farm more or less completed. Nearly two and a half kilometres of new field fencing was erected and the final development work of the year was the laying of hard core into the entrances of all field gates.

L. T. Colley was appointed assistant warden in August 1971.

Visitors

A total of 1,070 people visited the refuge and were escorted round the various facilities.

C. R. G. Campbell

Education

With Prof. Matthews and Dr. Kear holding honorary staff positions at University College, Cardiff, several undergraduate courses were undertaken, and the work of two Ph.D. students at Slimbridge supervised. At Bristol University, Prof. Matthews gave other courses to undergraduates and supervised a third Ph.D. student. Undergraduates from other universities, namely Bath, Birmingham, Leicester, London, Manchester, Oxford, Reading and Southampton visited Slimbridge. Research projects at most of these were assisted by facilities or specimens. The Trust received a visitation from nearly all the Vice-Chancellors and Principals of the British Universities, in one hectic afternoon.

Mr. Jackson prepared a display, consisting of 12 double-sided wall book panels, for the observatory building at Eastpark, Caerlaverock.

A total of 567 school parties were handled at Slimbridge, comprising 21,468 children, and at the Youth Hostel there were 2,200 overnight stays by members of Field Study Groups.

With the Gate records showing 234,015 people paying for admission at Slimbridge and Peakirk, an impressive number are exposed to the educative influence of the birds themselves and to the existing wall displays. A particularly encouraging feature was a rise in the number of people coming in the winter months, when the wild swans, geese and ducks are to be seen at their best.

G.V.T.M.

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THE WILDFOWL TRUST

SLIMBRIDGE, GLOUCESTER

The aims of the Wildfowl Trust are:

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

TERMS OF MEMBERSHIP

LIFE FELLOWS	A single payment of £100.00. Entitled to all privileges of Full Membership (see below) but with free entry with one free guest to any refuge which is open for visiting.
FELLOWS	£5.00 a year. Privileges as for Life Fellows.
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ASSOCIATE MEMBERS	£1.50 a year. Entitled to free entry to Slimbridge and to Peakirk (but may opt for free entry to any one other refuge which is open for visiting instead of Peakirk). Entitled to entry at half price to other refuges which are open for visiting. Receive a free copy of bulletins.
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CORPORATE MEMBERS	£1.00 a year. Limited to educational establishments, youth clubs and bodies which are members of the Council for Nature. Entitled to a free copy of WILDFOWL and bulletins. Free entry for one adult per each ten members of a party. Details for party visiting may be obtained from each refuge.
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NOTE. The 16-page Annual Report and Accounts of the Wildfowl Trust for 1971 have been distributed separately to Members.