

birds and a well-equipped research station, in 1962 the Foundation purchased a property which had previously been developed as a private game farm. It is the Niska Waterfowl Research Station, situated in a Federal Wildfowl Sanctuary on the River Speed, five kilometres from the campus of the Ontario Agricultural College at Guelph. Dr. Antoon de Vos is the Station Director and the noted wildlife photographer William H. Carrick is Resident Manager.

Niska has facilities for holding and rearing small numbers of wild waterfowl. Existing buildings are suitable for modification as a library, laboratory and office. Living quarters for visiting scientists and resident students will be built. There is ample land on the property to build small dugouts and impoundments, to demonstrate management methods available to private land owners. In addition to a research area which will be closed to the public, a demonstration area capable of attracting tens of thousands of visitors annually is planned.

Research programme

The Ontario Waterfowl Research Foundation supports a study of waterfowl movements in relation to Luther Marsh, an artificial wetland of 5,000 acres situated 60 kilometres from the research station. It is

co-operating with individuals and other agencies in studies of stocking, productivity of selected habitats, screening of herbicides, and appraisal of artificial nesting devices. Foundation personnel ringed 2,606 ducks of eight species, and 238 other birds, between 1961 and 1963.

Additional research by the Director of the Research Station and Executive Director, being supported directly by grants to their employing agency rather than through the Foundation, includes studies of the breeding behaviour of Trumpeter Swans (*Cygnus cygnus buccinator* Richardson), breeding biology of the Redhead (*Aythya americana* (Eyton)), and productivity of selected wetland habitats at Long Point and other places.

This Foundation is interested in waterfowl research as it relates to Ontario. Its research station facilities may be used by scientists and students who are supported by other granting agencies. In addition, the Ontario Waterfowl Research Foundation may support basic research in waterfowl biology which does not require the facilities of the research station.

Further details of the Foundation's operations may be obtained from the Executive Director, P.O. Box 163, Guelph, Canada.

Extinction and the Anatidae of New Zealand

G. R. WILLIAMS *Lincoln College, Canterbury, New Zealand*

Summary

The historical and present status of each species of Anatidae found in New Zealand is described and causes of change are discussed. Of 19 native or self-introduced species believed to have bred, five natives and two Australian stragglers became extinct before European settlement. *Mergus australis* is the only native species to have become extinct since 1800. Seven native species survive: all but two have been reduced in numbers or range, or both. The Grey Teal and the Shoveler continue to thrive. The two in greatest danger are the Brown Teal and the Blue Duck. Destruction of habitat is the most serious threat. Four species have been successfully established and four others have been stragglers from Australia in European times.

Introduction

The depletion of New Zealand's avifauna since European settlement, from about 1800, has often been cited as an example of the ever-increasing effect of modern man upon natural ecosystems. Unfortunate though these effects may have been, the degree to which they have hastened the extinction of various species is frequently over-emphasised. I have recently reviewed the extent and timing of the known cases of extinction of land- and fresh-water inhabiting birds (Williams, 1962). The present paper discusses the past and present

status of all forms of the Anatidae known to have occurred in New Zealand, including stragglers and species introduced by man, with the object of putting into better perspective the recent changes in the status of the endemic species. 'New Zealand' is used here to include only the North Island (44,000 sq. m.), South Island (58,000 sq. m.), Stewart Island (670 sq. m.), the Chatham group (370 sq. m.), Auckland Islands (250 sq. m.) and Campbell Island (42 sq. m.). The small offshore islands of each of these subdivisions are considered part of the nearest mainland. Cook Strait, with a

minimum width of 15 miles, separates North and South Islands. Foveaux Strait, 20 miles wide, separates Stewart Island from South Island. The Chathams lie 400 miles east-south-east of the South Island, the Auckland Islands 200 miles to the south-south-west and Campbell Island 350 miles south.

The Anatidae of New Zealand may be conveniently divided into five categories: (1) species becoming extinct in pre-European times (i.e. before 1800 approximately), (2) those becoming extinct since, (3) stragglers and temporarily established invaders, (4) surviving native species and (5) surviving introduced species. These are listed separately in Table I.

Extinct in pre-European times

Four of the long extinct species belong to endemic genera. Virtually nothing is known about the ecology of these birds. *Pachyanas chathamica* is known only from a small amount of material from the Chatham Islands; the small Finsch's Duck has been found in comparative abundance at several places in the South Island and once in the North Island; *Cnemiornis* was large and flightless; and the Chatham Islands Swan, which was considerably larger than the Black Swan, has been abundantly found in the North and South Islands as well as in the Chatham group and was obviously exploited for food from the time Polynesians began the human occupation of New Zealand, perhaps 1500 years ago.

Because bones of all these species have been found associated with remains of early Polynesian activity, hunting has usually been assumed as the proximate cause of extinction.

Extinct since European times

Just one species of waterfowl has become extinct during European times. *Mergus australis*, the only merganser of the Australasian region, once occurred on at least the east coast of the South Island (Williams, 1962), on the Auckland Islands and, presumably, in some intermediate places as well. When Europeans arrived in the South Island it had already become extinct there and existed in presumably only small populations at the uninhabited Auckland Islands some 200 miles to the south-south-west. The first specimen was taken in 1840, the last in 1909 (Delacour, 1959) and only about twenty are considered to have been taken in all by collectors. Although the disappearance of the species from the South Island could perhaps be ascribed to predation by man (Fleming's (1962) general thesis for pre-European extinctions) this is not a satisfactory suggestion to account for the merganser's ultimate disappearance

from the Aucklands. Adams Island, the species' last refuge, has an area of 35 sq. m., and has not only never been inhabited but is still free of mammalian predators and is in virtually a virgin state. Nevertheless, the merganser had gone from there in about 70 years and it is hard to believe that the few specimens taken over this period by very rare visitors was a hunting pressure intense enough to destroy the species.

Man and introduced predators could have played a part on Auckland Island itself or on one or two of the other islands in the group. A general search made for the species by the Cape Expedition during the second world war was unsuccessful (E. G. Turbott, *pers. comm.*).

Little is known of the merganser's ecology. Its habitat was sheltered bays of the coast and the streams running into them.

Stragglers and temporarily established invaders

Of the six species in this category three are recent stragglers to New Zealand and two are known only from a few sub-recent remains. The fourth was a breeding resident for at least thirty years. All occur in eastern Australia and it is obvious that the prevailing westerlies of these latitudes were responsible for carrying them across the Tasman Sea.

Plumed Whistling Duck, *Dendrocygna eytoni*. This has been recorded three times (Oliver, 1955). One was shot on the Thames River, North Island in May 1871; in the same year a flock of fourteen was seen in the neighbourhood of Lakes Tuakitoto and Kaitangata, South Island; and between 1894 and 1896 two males and a female inhabited the lakes in the Ashburton Botanic Gardens, South Island.

Maned Goose, *Chenonetta jubata*. There are four records from the southern half of the South Island (Oliver, 1955). One bird was shot at Lake Wanaka in 1910, one in the Orawia district, Waiau River in 1944 and two others at about the same time – one at Linwood and the other at Wairaki.

Australian Shelduck, *Tadorna tadornoides*. One was shot on Lake Ellesmere, South Island. Oliver gives no date.

Pink-eared Duck, *Malacorhynchus membranaceus*. This is known from a few sub-fossil remains found in Pyramid Valley, South Island and seems referable to the existing Australian species.

White-eyed Duck, *Aythya australis australis*. First recorded by Europeans on Lake Whangape, North Island in 1867 (Oliver), this species may have been present earlier, since the Maoris had a name for it. Buller (1888) remarked that it was common

Table I. Anatidae recorded from New Zealand

		endemic	
		genus	species
EXTINCT BEFORE EUROPEAN SETTLEMENT			
<i>Cygnus sumnerans</i> (Forbes) ¹	Chatham Island Swan		*
<i>Pachyanas chathamica</i> Oliver	Chatham Island Duck	*	*
<i>Cnemiornis septentrionalis</i> Oliver	North Island Goose ²	*	*
<i>Cnemiornis calcitrans</i> Owen	South Island Goose	*	*
<i>Eurynas finschi</i> Van (Beneden)	Finsch's Duck	*	*
EXTINCT SINCE EUROPEAN SETTLEMENT			
<i>Mergus australis</i> Hombron and Jacquinot	Auckland Island Merganser		*
STRAGGLERS AND TEMPORARY SELF-INTRODUCED INVADERS			
<i>Dendrocygna eytoni</i> (Eyton)	Plumed Whistling Duck		
<i>Tadorna tadornoides</i> (Jardine and Selby)	Australian Shelduck		
<i>Malacorhynchus membranaceus</i> (Latham)	Pink-eared Duck		
<i>Aythya australis australis</i> (Eyton)	Australian White-eye		
<i>Chenonetta jubata</i> (Latham)	Maned Goose		
<i>Biziura delautouri</i> Forbes ³			*
<i>Biziura lobata</i> (Shaw) ³	Musk Duck		
SURVIVING NATIVES			
<i>Tadorna variegata</i> (Gmelin)	Paradise Duck		*
<i>Anas gibberifrons gracilis</i> Buller	Grey Teal		
<i>Anas castanea chlorotis</i> G. R. Gray	Brown Teal		
<i>Anas castanea aucklandica</i> (G. R. Gray)	Auckland Island Teal		
<i>Anas castanea nesiotis</i> (Fleming) ³	Campbell Island Teal		
<i>Anas superciliosa superciliosa</i> Gmelin	Grey Duck		
<i>Anas rhynchotis variegata</i> (Gould)	Shoveler		
<i>Hymenolaimus malacorhynchos</i> (Gmelin)	Blue or Mountain Duck	*	*
<i>Aythya novaeseelandiae</i> (Gmelin)	Scaup, or Black Teal		*
SUCCESSFUL INTRODUCED SPECIES			
<i>Cygnus atratus</i> (Latham)	Black Swan		
<i>Cygnus olor</i> (Gmelin)	Mute Swan		
<i>Branta canadensis</i> (L.)	Canada Goose		
<i>Cereopsis novaehollandiae</i> Latham ³	Cape Barren Goose		
<i>Anas platyrhynchos platyrhynchos</i> L.	Mallard		

¹ Howard (1964).

² The problem of naming the species of *Cnemiornis* smaller than *calcitrans* is unsettled (Howard, 1964). In the meantime I have retained *septentrionalis* for this, and Dawson (1958) states this name is synonymous with Forbes's *gracilis*. The North and South Island forms may eventually prove to have been only subspecifically different.

³ Species of doubtful status.

on some of the lakes in the Waikato area, North Island, in the 1860s and Oliver added that it was abundant on the lower Waikato River itself, on some of the lakes of the Rotorua district, North Island and that it also occurred on other waters in the eastern and southern North Island and on Lake Ellesmere and in the Otago district of the South Island. Continuous occupation apparently ceased after 1895 and the only record since is of a sighting at Hamurama in the Rotorua district in 1934. One can only guess now at the reasons for the failure of this species to maintain itself.

Musk Duck, *Biziura lobata*. That bones of the existing Australian species have been found in New Zealand seems certain. What

does not seem certain is what other species, if any, of this genus are native to this country. Howard (1964) and Dawson (1958) revive Forbes' *B. delautouri* (= *B. lautouri*), 'a *Biziura* somewhat larger than *Biziura lobata*, the musk duck of Australia'.

However, R. J. Scarlett (*pers. comm.*) believes that at least some of the bones attributed to this alleged species could quite well belong to *B. lobata*. The issue is complicated by the fact that he has found bones of a *Biziura* apparently smaller than the Australian species. Until the situation is clarified it is probably better to include the Australian Musk Duck as a vagrant and leave other possible species of *Biziura* on the suspense list.

Surviving native species

There are seven in this category of which three are endemic. One of the latter belongs to an endemic genus. Since European settlement all but two of these seven species have been reduced either in numbers or range or both.

New Zealand Shelduck, Paradise Duck, *Tadorna variegata*. Though now absent from areas in which it once occurred previous to heavy settlement, the endemic Paradise Duck is still widespread throughout North, South and Stewart Islands in open country near water from high on the mountains down to the seashore and is still locally abundant in many places. Buller in 1888 remarked that it did not then occur north of 39°S, and in 1905 added that it was becoming rare in Marlborough and had 'disappeared' from the Nelson district as a result of predation by mustelids and the taking of poisoned grain laid for rabbits. (Mustelids – stoats, polecats and weasels – were introduced into New Zealand in the early 1880s in an unsuccessful attempt to control the introduced rabbit, *Oryctolagus cuniculus*.) The Paradise Duck still occurs in Marlborough and Nelson and, in the North Island, has gradually spread beyond 39°S. This occupation of new range in the north has been a partial compensation for shrinkage in range and numbers elsewhere, particularly in the South Island. Destruction or alteration of habitat aside, man has had less detrimental effect upon the Paradise Duck than upon any of the other four species that have become reduced in recent times. Neither introduced mammalian predators nor an annual open season (at present of about four weeks) in most parts of New Zealand seem to be important in the species' ecology.

Grey Teal, *Anas gibberifrons gracilis*. A recent invader from Australia, the Grey Teal has spread throughout New Zealand, aided by the protection from hunting it enjoys, though a few are shot each year in mistake for female Shovelers.

First recorded by Buller in 1866 it may well have occurred earlier for it was known to the Maori as *tete*. Though apparently rare in the 1860s it was taken in other parts of the country in the next 25 years; and, according to Buller (1888), became comparatively plentiful on some of the lakes of the Rotorua district. Now it is found widespread but only locally common on the three main islands, and only south of Auckland in the North Island. Stragglers have reached the Chathams, 400 miles east of the South Island (Oliver, 1955). Of its present status Miers writes (*in litt.*): 'The species seems to have already occupied all suitable

habitat, especially since the 1957 invasion. I consider the main reason for the decline since 1958-59 to have been the lack of suitable nesting sites. The nests we find are atypical, 99% of Australian nests are found in trees'.

Brown Duck, Brown Teal, *Anas castanea chlorotis*. I have followed the *Checklist of New Zealand Birds* (Fleming *et al.* 1953) rather than Delacour (1956) in regarding the races of Brown Duck as endemic subspecies of the Australian Chestnut Teal rather than as races of a species, *Anas aucklandica*, endemic to the New Zealand region. After the Merganser, this is the species that has suffered most in European times and there can be no doubt that its present dangerous situation results primarily from destruction of its habitat. Originally Brown Duck were abundant throughout New Zealand and the Chatham Islands. Buller (1888) related that they were to be met with on every inland lake and often in the deep freshwater streams running into them. Habitat also includes intertidal streams, mangrove swamps and quiet inlets of the sea. Nocturnal and crepuscular in activity, during the day Brown Ducks tend to retire to thick cover along the water's edge. Their chief haunt used to be the once-extensive swamp forests of kahikatea, *Podocarpus dacrydioides*, but these have been almost totally destroyed by draining and felling or burning. As a result Brown Ducks are very reduced in both numbers and range throughout New Zealand and are common only in a few places in Northland and Great Barrier Island. Small numbers occur in the eastern part of the Volcanic Plateau in the North Island, in Fiordland in the south-west of the South Island and on Stewart Island and its two largest adjacent islands. They became extinct on the Chathams, presumably as a result of human interference, about 1915 (Williams, 1962).

A subspecies with only weak powers of flight, *A. c. aucklandica*, persists at the Auckland Islands. It, too, has been reduced in range and numbers and is now very rare on Auckland Island proper but locally abundant on other islands in the group. The reasonable assumption is that cats and pigs established on the main island have been responsible for its destruction there; this island has otherwise been but little affected by man.

Another subspecies, *A. c. nesiotus*, has been claimed for Campbell Island. Of this, only about a dozen have ever been seen and about four of these collected and Bailey and Sorensen (1962) have suggested that all these were, in fact, stragglers from the Auckland Islands population some 150 miles away to the south-east. However, a

comparison between some of the measurements they give of a very small sample of birds belonging to the two alleged subspecies is not quite in harmony with this opinion so the question remains undecided. Should the Campbell Island race prove valid it must be extremely rare and was apparently not noticeably commoner when Campbell Island was uninhabited and unmodified by man. The almost inaccessible offshore Dent Island may be its last stronghold.

Grey Duck, *Anas s. superciliosa*. This is the most common and most widespread of all New Zealand waterfowl though it is often second in abundance to the introduced Mallard in settled areas and interbreeds with it. In spite of a steady decline in numbers that goes hand in hand with the advance of agriculture and urbanization, Grey Ducks are still to be found wherever there is water, 'by mountain streams, lakes and lagoons, tidal estuaries and inlets, and sometimes . . . on the sea off the coast' (Oliver, 1955). Their range extends from the Kermadec Islands, 550 miles north-north-east of the North Island, to the Chatham Islands and the subantarctic islands where, however, they are not common, though they have been reported from Macquarie Island, 550 miles south-south-west of New Zealand proper.

Grey Ducks are the main game species among waterfowl. They are decoyed more readily than Mallards and ringing studies have shown that they are subject to a much more intense hunting pressure. Consequently there has been a tendency over many years to shorten season lengths and decrease the daily bag limit as one contribution towards conservation. However, there is little doubt that, until now, habitat destruction has been the most potent factor reducing their numbers.

Grey Ducks disperse widely. Recoveries of ringed birds over hundreds of miles are frequent and birds ringed on the New Zealand mainland have been shot in the Chatham Islands and in inland New South Wales in Australia (Balham and Miers, 1959).

New Zealand Shoveler, *Anas rhynchotis variegata*. Buller (1888) considered that this species was uncommon and absent from the extreme north of the North Island. Oliver (1955) reported it to be present in numerous localities throughout both main islands but not in large numbers. Miers (*in litt.*) sums up the present distribution as follows, 'On the coasts and lowlands where there are satisfactory swamps and lakes this species is often the second most abundant native duck. This is certainly so in Waikato, where there is some evidence of increase,

and in the Bay of Plenty and perhaps in Otago too. It is absent from the south-west of the South Island'. The very moderate amount of hunting to which the species is subject is not important and indications are that Shoveler have not appreciably been reduced in either range or numbers over the last 75 years. Settlement and the advance of agriculture may in fact have favoured them. However, they have not been recorded from the Chathams since 1925 though they occasionally straggle to the Auckland Islands.

Blue Duck, *Hymenolaimus malacorhynchos*. Originally common in forested mountain ranges from about 37°S' in the North Island and throughout similar areas in the South Island the endemic and taxonomically puzzling Blue Duck is nowadays to be found only in remote and relatively unmodified localities. Here, under legal protection, moderate remaining populations are in no immediate danger of extinction. Though hunted by early European settlers and Maoris the main reason for the present reduced state of the species is doubtless the destruction of habitat following upon the clearing or damaging of the native forests. This, in turn, accelerated the natural processes of erosion and filled up many clear and swift-flowing mountain streams with rock debris. It is in the pools and rapids of unaggraded streams that Blue Ducks are chiefly found.

New Zealand Scaup, *Aythya novaeseelandiae*. 'About a century ago the Scaup was, to quote Buller, "freely distributed over the country, frequenting most of the rivers and lagoons, but seldom being met with in the bush creeks and never on the open sea shores". Now you may expect to see it, in the North Island, in parts of Northland, Waikato, the volcanic plateau and Hawke's Bay but only rarely in this island's south and west. In the South Island the species occurs on the western high country lakes from one end of the mountain chain to the other, occasionally on the eastern side of the Alps and rarely in the south-east. There is a record from D'Urville Island. It is absent from Stewart Island.' (Williams, 1963.) In 1934 Scaup were removed from the game list and any recent tendency to increase (Newcombe, 1959) may be ascribed to absolute protection plus the creation of some new habitat, as in the lakes of the hydro-electric system of the Waikato River. K. H. Miers (*in litt.*) has stated that Scaup proved very vulnerable to shooting until they were protected and has drawn my attention to the rather similar history of the Canvasback, *Aythya vallisneria*, in north America where the problems of maintaining a shootable popu-

lation have now led to the Canvasback's protection.

Surviving introduced species

Of the many species introduced (Thomson, 1922) only four now survive. The Cape Barren Goose, *Cereopsis novaehollandiae*, included in the official checklist (Fleming *et al.* 1953), is now probably extinct. Four were liberated in 1915 at Lake Hawea in western Otago and in 1936 some were reported here and at Lake Thompson, further south in Fiordland. According to Miers (*in litt.*) there has been no report of the species breeding in New Zealand for almost forty years and there are no recent sight records.

Black Swan, *Cygnus atratus*. The main reason for the liberation of this common Australian species in the South Island in the early 1860s was the hope that it would successfully control water weeds in the Avon River at Christchurch (Williams, *in press*). Secondary considerations were its potential as a game bird and its ornamental qualities. Liberations in other parts of New Zealand, including the Chatham Islands, soon followed and establishment and spread occurred virtually at once. Now the Black Swan is abundant throughout the country wherever there are large, shallow, fresh or brackish bodies of water carrying extensive beds of aquatic plants. The greatest concentrations are found on Lake Ellesmere, where flocks numbering tens of thousands are not uncommon in good years. At Lake Ellesmere eggs are exploited, both commercially and directly for food, and many thousands are taken in a good season without any detriment to the population. In fact, the idea is to exert some control over the swan numbers by large scale exploitation of their eggs. In some years when the population is very high and water levels are above normal, the swans suffer heavy losses arising at least in part from aspergillosis. The disease is no doubt aided in its spread by the birds' poor condition which, in turn, is caused by much of their food becoming inaccessible in the deep water.

Thousands also lived on Te Whanga Lagoon in the Chatham Islands, but K. H. Miers has recently informed me that the Lagoon has now been joined to the sea by a man-made cut. As a result of the increased salinity the weed beds have been destroyed and thousands of swans have died. The survivors are now largely confined to streams and estuaries.

Mute Swan, *Cygnus olor*. Introduced for its aesthetic appeal the white swan is widely distributed throughout the more heavily settled parts of both main islands. It exists in a semi-feral state and is nowhere abund-

ant except on Lake Ellesmere in Canterbury.

Canada Goose, *Branta canadensis*. Since 1876 Canada Geese have been imported on a number of occasions, and these birds or their progeny have been liberated in both North and South Islands until fairly recent times, especially in Otago and Canterbury. Though they have been reported from various parts of the North Island south of Auckland, Canada Geese have so far bred only in the South Island, so these records are merely of stragglers and establishment in the North Island is yet to come, if at all.

In the South they are particularly numerous on lakes and rivers in Canterbury and Otago though they do occur in moderate numbers elsewhere, mainly east of the main chain of the Southern Alps. There is a seasonal movement from the back-country lakes and valleys where they breed to lowland waters. In late summer, for example, Lake Ellesmere, a very large shallow and brackish body of water on the east coast south of Christchurch, carries many thousands of birds and after the post-nuptial moult most will return to their breeding areas with the coming of spring.

Where most common in agricultural areas Canada Geese are considered a pest by many farmers. Flocks form in winter and closely crop pastures which they may foul to such an extent that stock will not graze them. Consequently the geese are regarded as vermin and large scale campaigns are arranged to reduce their numbers. Elsewhere in the South Island they are subject to the usual waterfowl shooting season of about one month with daily bag limits. Because of their wariness Canada Geese are not exploited to anything like the extent their populations would allow.

Mallard, *Anas p. platyrhynchos*. In common with most of the introduced birds of New Zealand, the first attempts to establish the Mallard were made during the 1860s. These early attempts were not very successful but importations were persisted with and locally-bred birds continually liberated until success was achieved. Now Mallards are well established in the North and South Islands and do best in the improved agricultural districts where they tend to replace Grey Ducks or hybridize with them. In the Wellington and Hawke's Bay provinces of the North Island and over most of the eastern side of the South Island, Mallards now predominate over Greys; elsewhere the latter still hold their own. In an attempt to conserve Grey Ducks, Mallards are not now being liberated in localities where they are not already established and sportsmen are encouraged to shoot them rather than Greys whenever possible. Ringing studies

have shown that Mallards not only sustain a much lighter hunting pressure than Greys but seldom disperse beyond 25 miles from the ringing station (Balham 1952, Balham and Miers 1959). A Mallard has, however, been recorded from Campbell Island, 350 miles south by east of the South Island (Bailey and Sorensen, 1962).

Discussion

Because of (1) the physiological peculiarity of the total moult of the primaries, (2) the relative ease with which accessible habitat may be permanently damaged or destroyed and (3) the value of waterfowl as a source of food, the Anatidae are potentially very vulnerable to man and his works.

Though man introduced mammalian predators to New Zealand he alone has generally been the most important predator both of the waterfowl themselves and of their habitats. This is especially true of European times and during this period habitat destruction by forest clearance, swamp drainage and the consequences of accelerated soil erosion and agricultural practices have almost certainly far exceeded the results of hunting and of predation by such species as the Norwegian and Black Rats, mustelids and so on. (It is impossible to assess the ultimate effect, if any, of introduced bacterial and other parasites.) Indications are that competition between native and introduced waterfowl is appreciable only with Mallard and Grey Ducks and then only in the most modified habitats.

No doubt the Polynesians relied very considerably on waterfowl for food during

their thousand and more years of sole occupation and we know that they took full advantage of the post-breeding moult to capture the species they fed upon. They brought with them a frugivorous and insectivorous rat, *Rattus exulans*, and a dog, but neither is likely to have been an important predator of waterfowl. Destruction of waterfowl habitat seems to have been only on a very minor scale, especially when compared with that wrought by Europeans. The flightless North Island and South Island Geese must have been especially sensitive to hunting and so the assumption that they were finally exterminated by Polynesian man is reasonable; so too is the assumption that man was at least the proximal cause of extinction of the geographically very restricted Chatham Island Duck. About Finsch's Duck, the widely-distributed Chatham Island Swan and the mainland populations of the Auckland Island Merganser we can be less sure at present that human predation was both the ultimate and proximate cause of extinction. The disappearance of the Merganser from Adams Island is one in which man does not seem to have played the major part.

Establishment of the four extant introduced species is easy to understand: each occupies either a newly-created niche or habitat (Mute Swan, Mallard) or else what was at the time at least a temporarily empty one (Canada Goose, Black Swan).

I am indebted to Mr. K. H. Miers of the New Zealand Wildlife Service for supplying information which I have incorporated in this paper.

References

- BAILEY, A. M. and J. H. SORENSEN. 1962. Sub-antarctic Campbell Island. *Proc. Denver Mus. Nat. Hist.* 10.
- BALHAM, R. W. 1952. Grey and mallard ducks in the Manawatu District, New Zealand. *Emu* 52: 163-191.
- BALHAM, R. W. and K. H. MIERS. 1959. Mortality and survival of grey and mallard ducks banded in New Zealand. *N.Z. Dept. Internal Affairs Wildl. Bull.* 5.
- BULLER, W. L. 1888. *A history of the birds of New Zealand*. 2nd Edition. London.
- BULLER, W. L. 1905. *Supplement to a history of the birds of New Zealand*. London.
- DAWSON, E. W. 1958. Re-discoveries of the New Zealand sub-fossil birds named by H. O. Forbes. *Ibis* 100: 232-237.
- DELACOUR, J. 1956, 1959, 1964. *The Waterfowl of the World*. Vols. 2, 3 and 4. Country Life Ltd., London.
- FLEMING, C. A. 1962. The extinction of moras and other animals during the Holocene period. *Notornis* 10:113-117.
- FLEMING, C. A. et al. 1953. *Checklist of New Zealand birds*. Ornithological Society of New Zealand. A. H. and A. W. Reed Ltd., Wellington.
- HOWARD, H. 1964. Fossil Anseriformes. In Delacour (1964), pp. 259-280.
- NEWCOMBE, F. L. 1959. The conservation of waterbirds and their habitat in New Zealand. *Wildfowl Trust 10th Ann. Rep.*: 78-88.
- OLIVER, W. R. B. 1955. *New Zealand birds*, 2nd Edition. A. H. and A. W. Reed, Wellington.
- THOMSON, G. M. 1922. *The naturalisation of animals and plants in New Zealand*. Cambridge Univ. Press.
- WILLIAMS, G. R. 1962. Extinction and the land and freshwater-inhabiting birds of New Zealand. *Notornis* 10: 15-32.
- WILLIAMS, G. R. 1963. *Birds of New Zealand*. A. H. and A. W. Reed, Wellington.
- WILLIAMS, G. R. in press. Introduced birds. In *The Natural History of Canterbury*, 2nd Edition. N.Z. Royal Society.