The Campbell Island Teal *Anas aucklandica nesiotis*: history and review

MURRAY WILLIAMS and CHRISTOPHER J.R. ROBERTSON

We dedicate this paper to Ronald Walter Balham, friend, teacher and important contributor to the history of Campbell Island Teal.

A small flightless duck was collected from waters near Campbell Island in the New Zealand subantarctic in 1886 and remained unreported for 50 years. A second specimen was obtained in 1944 but it was not until 1975 that the existence of a tiny remnant population of Campbell Island Teal was confirmed on 23 ha Dent Island, an islet 3 km off Campbell Island's western shores. Formal descriptions of adult male and female, juvenile and duckling are given. Superficially, the species resembles two other teal from the New Zealand area, Brown Teal and Auckland Islands Teal, but is considerably smaller (mean male weight 371 g, female 301 g) and darker than either. On Dent Island the teal live terrestrially in a subantarctic tussock grassland and megaherb community wherein pairs appear to hold territories year-round in the damper sites. Neither nest, egg nor duckling has been seen in the wild but the breeding season is assumed to be November to January. The breeding component of the population is unlikely to exceed 25 pairs. To fuel the establishment of a second wild population, 15 birds are held in captivity (as at May 1996), resulting from the removal of seven males and four females from the wild population since 1984 and the raising of seven in captivity. Eradication of Norway Rats from Campbell Island is required before teal can be re-established on what was probably their former stronghold.

Key Words: Campbell Island Teal, Campbell Island, Dent Island, History, Population, Conservation.

When, in 1935, Royal Ontario Museum ornithologist J.H. Fleming described a small brown duck from subantarctic Campbell Island as a new genus and species *Xenonetta nesiotis* (Fleming 1935), he had before him a single worn and faded mounted specimen reportedly collected almost 50 years previously. Now, 60 years later, and more than a century after its first sighting, the duck remains something of an enigma. Although its existence has been confirmed, its egg, nest, duckling and juvenile have yet to be seen in the wild, its general ecology and diet remain unknown, its taxonomic rank and relationships are disputed, and its population status is uncertain. The Campbell Island Teal *Anas aucklandica nesiotis* could well lay claim to being the least known, least seen, geographically the most restricted, and one of the rarest of the world's waterfowl.

In this paper we seek to assemble what is known of the teal's discovery, scientific history, status, biology and conservation. By so doing we provide a vehicle for many relevant but unpublished file reports and records to enter the scientific literature and serve as the basis for further investigation of this small and isolated anatid.

Campbell Island

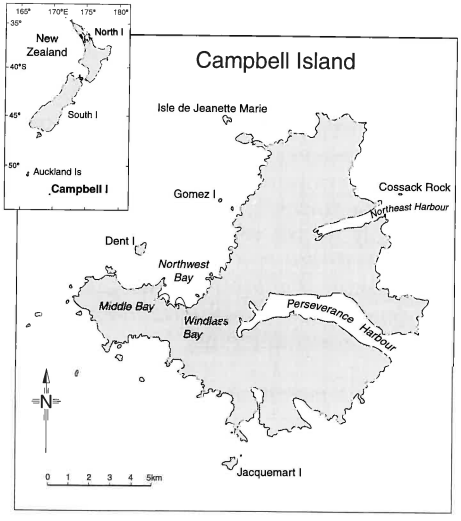
Events in the scientific history of Campbell Island Teal are, to a large extent, consequences of the history of discovery and biological modification of its presumed former stronghold, Campbell Island.

Geography and climate

Campbell Island (52°33'S, 169°08'E) lies approximately 740 km due south of Dunedin on New Zealand's South Island and 270 km southeast of Auckland Islands, home of another small and flightless anatid, Aucklands Island Teal *A. aucklandica* (**Figure 1**). It is a volcanic island, formed 5-10 million years ago as the Pacific tectonic plate of old granitic and sedimentary rocks passed over a linear hot zone in the Earth's mantle (Adams 1981). The present island, approximately 11,400 ha in area, is the remnant eastern slopes of the volcano, the westerly erosive forces of wind and sea having taken a spectacular toll over the millennia. In the process of that erosion, portions of the volcano have become isolated as small but physically spectacular islets, the most conspicuous (and in the context of this paper, the most important) of which is Dent Island, 3 km to the west of the main island (**Figure 1**).

Climatically, Campbell Island reflects its position midway between the Antarctic and subtropical convergences in that region most frequently referred to as "the roaring forties". It is cloudy, windy and bleak. Average annual sunshine hours are a mere 635, annual rainfall, although a moderate 1,440 mm (Sorensen 1955), falls on 325 days of the year (Anon 1983) and 30-40 days of snow annually are about usual. Mean annual temperature is 6°C and only rarely is the wind less than 15 knots. Indeed, strong winds are a feature of the island, averaging 30-40 knots and regularly gusting to 130 knots (240 km hr $^{-1}$). Sudden changes in weather are characteristic and brief southerly squalls with hail and plunging temperatures are common throughout the summer.

Figure 1. A. Location of Campbell Island in the New Zealand subantarctic region; B. Campbell Island, Dent Island and other nearby islets mentioned in the text.



Biological characteristics

Floristically, Campbell Island and its associated islets are dominated by the tussock *Poa litorosa* and the spectacular subantarctic megaherbs *Stilbocarpa polaris*, *Anisotome latifolia*, the *Pleurophyllum* daisies and the lily *Bulbinella rossi* (Meurk *et al.* 1994). On the lower slopes the native grass trees, *Dracophyllum longifolium* and *D. scoparium*, occur in scattered dense stands sometimes 2 m tall. The islands plants have, as a growing medium, a thick, poorly aerated, permanently saturated and strongly acidic peat (Foggo & Meurk 1983).

The macro-fauna of the island is dominated by sea creatures – birds and mammals. Small numbers of Hooker's Sea-lion *Phocarctos hookeri*, Elephant Seal *Mirounga leonin* and New Zealand Fur Seal *Arctocephalus forsteri* haul-out or breed there (Bailey & Sorensen 1962). Birds, on the other hand, are numerous and visually spectacular. Twenty-nine species breed and at least 42 other species have been recorded as stragglers (Kinsky 1969). Campbell Island is the main breeding

locality for the Southern Royal Albatross *Diomedea e. epomophora* and New Zealand Black-browed Mollymawk *D. melanophrys impavida* and for large numbers of Grey-headed Mollymawk *D. chrysosoma*. The ubiquitous Rockhopper Penguin *Eudyptes chrysocome* is present in summer in many noisy colonies, and numerous Light-mantled Sooty Albatross *Phoebetria palpebrata* speckle the island's cliffs. However, few petrels, prions or shearwaters now nest on the main island although formerly, Campbell Island was probably awash with them; they are now restricted to the islets where Sooty Shearwater *Puffinus griseus* and White-chinned Petrel *Procellaria aequinoctialis* are the most numerous.

Introduced mammals

The indigenous biological characteristics of Campbell Island have been modified significantly since human discovery, principally by the introduction of Norway Rat *Rattus norvegicus*, Sheep *Ovis aires*, Cattle *Bos taurus* and Cat *Felis catus*.

The rat is almost certainly a legacy of the sealing and whaling era, reaching the island shortly after its discovery in 1810. Although Armstrong (1868) was the first to document their presence on the island, and Filhol (1885), reporting on 1874 observations, referred to them as "...the scourge of Campbell Island", there is every likelihood of their earlier arrival. Inadvertent transfer of rats from ship to shore probably occurred many times in the early sealing years and the 1840 grounding of British Antarctic Expedition's ship *Terror*, which necessitated stores to be landed and water discharged in order to refloat the ship (Kerr 1976), would have provided a perfect opportunity.

Irrespective of how it arrived, the rat has been implicated in the island's dramatic faunal changes. Most small ground nesting birds and many terrestrial insects have been eradicated. For example, the local race of the New Zealand Pipit *Anthus novaeseelandiae aucklandicus* is common on Dent and Jacquemart Islands but is now only occasionally and rarely seen on Campbell Island; most local species or races of weevil (Curculionidae) are no longer encountered on Campbell Island but persist on all of the rat-free islets; and burrow-nesting petrels are virtually absent, a distinct contrast to the other nearby subantarctic islands such as Antipodes, The Snares and Auckland Islands, all of which are free of rats. In short, the presence of rats on Campbell Island for well over 150 years and their presence today in extremely high densities (approximately 9 ha-1, Taylor 1986), makes them a major influence on the ecology of the island.

Sheep were released on the island in 1895 and their farming persisted for 36 years, only to fall victim to the economics of the great depression. At times, their numbers reached almost 9,000. Abandoned to their fate in 1931, the sheep persisted in numbers of 1-3,000 (Wilson & Orwin 1964, Taylor *et al.* 1970) and their impact on the indigenous flora and fauna of the island became a hot topic of debate from the early 1960s. In 1970 the sheep were fenced out of half of the island to allow recovery of the flora and to provide time for genetic evaluation of the sheep. Behind the fence, sheep numbers increased to 4-5,000 by 1979 (Dilks & Wilson 1979) necessitating culling and their further confinement behind a second fence in 1984 and then final extermination in 1989-90.

A small number of cattle were also introduced at the time of the initial farming enterprise. The feral herd seems always to have been small (<30 animals, Taylor *et al.* 1970) with a restricted range and they were exterminated in 1984.

Cats and farm dogs were cohabitants of the shepherds. There are no records of dogs becoming feral but cats did so and persist on the island in unknown numbers. Their sign is periodically encountered all over the island and their scats reveal a diet predominantly of rats (Dilks 1979).

Biological expeditions to Campbell Island

The first recorded human encounter with Campbell Island was on 4 January 1810 when the brig *Perseverance*, under the

command of Captain Frederick Hasselburgh, was searching for new sealing grounds in the southern ocean. Fraser's (1986) summary of that encounter notes that seven men were landed with supplies for several months and that, because of the ship's subsequent discovery of Macquarie Island (a much richer sealing ground), they were not uplifted until late October, a stay of ten months.

Once news of the discovery of these southern islands got out there was a rush of sealing vessels from Sydney to Macquarie Island and almost certainly to Campbell as well. The sealing era was brief, within 20 years almost all the seals had been exterminated, but there seems little doubt that Campbell Island received numerous unrecorded visits during that time (Kerr 1976). Perhaps it is ironic that the *Perseverance* was wrecked at Campbell Island in 1828, the only ship known to have been wrecked there.

The first scientific expedition to Campbell Island was that of Sir James Clark Ross's British Antarctic Expedition. Ross's vessels *Erebus* and *Terror* anchored in Perseverance Harbour 13-17 December 1840, time enough for the expedition's enthusiastic botanist Joseph Hooker to collect more than half of the plant species now known from the island. The avifauna seems not to have been the subject of great interest. Gray (1844) reported on the birds encountered by the expedition in New Zealand waters and lists only three species from Campbell Island: *Anas superciliosa, Megadyptes antipodes* and *Catharacta antarctica.* It was Ross's (1847) account of the expedition that first referred to the presence of "albatrosses" and ship's surgeon Robert McCormick who, in an appendix to volume two of Ross's account, specifically identified the albatross and again referred to the presence of a skua.

Scientifically, Campbell Island was ignored for the next 30 years despite numerous visits and attempted settlement at nearby Auckland Islands during that period. The brig *Amherst* visited briefly in 1868 allowing Armstrong (1868) to record the presence of rats and albatrosses. The French expedition to Campbell Island in 1874 to observe the transit of Venus was the next dedicated scientific visit. The expedition's surgeon, Henri Filhol, was also a keen naturalist and his account (Filhol 1885) contains a list of 19 bird species encountered; the only waterfowl recorded was *Anas superciliosa.*

Soon after the French expedition, New Zealand's subantarctic islands were visited regularly by New Zealand Government ships (mostly commanded by Captain John Fairchild) to provision castaway depots and uplift any shipwrecked mariners. Campbell Island, it seems, was only rarely visited by scientists during these rounds. James Hector, then Director of the Colonial Museum (now Museum of New Zealand) visited Campbell Island in 1883 but added nothing to the existing list of avifauna. The Austrian collector, Andreas Reischek visited Campbell Island on board *Stella* in January 1888 and wrote (1889) "I was informed that the tui *Prosthemadera novaeseelandiae* and a wingless duck inhabited the island but I did not see any."

Thus, Reischek can claim the privilege of introducing the Campbell Island Teal to the scientific literature, presumably by way of reporting the comments of Captain Fairchild who, as master of *Stella*, visited Campbell Island in January-February 1886 and secured the first specimen (see below).

Visits to Campbell Island became more common thereafter and the island became a sheep run. The next list of the island's birds was compiled during an eight-day expedition of the Philosphical Institute of Canterbury in 1907. Its report contains Waite's (1909) listing of 22 species, but the only waterfowl was again *Anas superciliosa.*

Subsequent recorded visits to the islands, up to the Cape Expedition of 1940-45 (see below), tended to be brief landings and without serious research intent (see Westerskov (1960) for summary). Although such notable early New Zealand naturalists as H. Guthrie-Smith and Edgar Stead were amongst the visitors, their accounts make no reference to the presence of Reischek's "wingless duck".

History of Campbell Island Teal discovery and encounter

The first specimen

In his paper describing the first specimen, Fleming (1935) provides the following account of the bird's history:

> *"I am indebted to Capt. T.E. Donne, C.M.G., for the history of the type, it was taken on Campbell Island by Capt. Fairchild of the government ship Stella on his 1886 cruise to "The Islands" probably in January or February. On the return of Capt. Fairchild to Wellington, the bird was given to Capt. Donne who at once sent it to Mr. E. Jennings of Dunedin to be preserved.*
>
> *Capt. Donne has been good enough to go back through his correspondence and writes "I found a type-written copy of my letter of instructions to Jennings, written at Wellington, and sent to him at Dunedin, this clearly stated that the Nesonetta came from Campbell Island, his account for mounting it was also attached, and read "Flightless duck from Campbell Island". Jennings was meticulously careful in regard to marking localities on specimens that he preserved or mounted". On the bottom of the stand is written,"Flightless Duck, Campbell Island, 1886, ♂"."*

Fleming's narrative provides no detail of where on Campbell Island the bird was collected, nor of the specimen's history from the time of its preservation until its receipt by him.

In the interval between Fairchild's collection of the specimen and Fleming's (1935) description, there were two apparent references to the bird in the literature: Reischek's of 1889, which is presumably based on information supplied by Fairchild, and a rather curious reference in an account provided by one of New Zealand's early Governors-General, Lord Plunket. In an address read at a meeting of the Royal Colonial Institute, London, on 5 December 1911 (Plunket 1912), he gave an account of a journey, in January-February 1907, on the government steamer *Tutanekai* around New Zealand's outlying islands. He states, in a paragraph referring to his time on Campbell Island:

> *"On this island we came across the wandering albatross, a darker and smaller edition of his royal cousin. The land birds on all these islands hardly fly at all,but flutter, and then run along the ground or hop from bough to bough. There is something very canny in this, and the sight of the professors catching snipe with butterfly nets completely upset my Irish shooting notions. We came across the flightless duck, and I made a gallant attempt to catch one in the seaweed by the shore, backed up by a devoted and self-sacrificing staff. But this duck, though he never attempts to fly or to dive, is not as easy as the snipe to catch, and I soon found he could climb rocks (thanks to his strong, sharp claws) far better than I could. The disinclination or inability to fly amongst these land birds is said to be the result of the survival of the unfittest, the more energetic having been (by degrees) blown out to sea in the course of their flight, and only the lazy flutterers left. Somehow this does not seem to point a good moral, so I will hurriedly pass on!"*

Plunket's account needs interpretation on at least two grounds. First, he was accompanied by "..two University scientists, one taxidermist...". If it was on Campbell Island that the flightless duck was encountered, it is remarkable that a record of the encounter never made it into the scientific literature. Second, Plunket refers to the professors catching snipe. Snipe *Coenocorypha aucklandica* occur as identifiable races on Chatham, The Snares, Auckland, Antipodes and Stewart Islands but not on Campbell Island. It is our conclusion that, despite the structuring of Plunket's narrative, the above quotation describes events at the Auckland Islands, not Campbell Island, and his reference was to Auckland Islands Teal.

There was, however, one group of people aware of the Campbell Island Teal's existence prior to its description, and who had, probably on several occasions,

encountered and even eaten it. From 1909 to 1916 a group of whalers, from Tory Channel in New Zealand's Cook Strait, based themselves at Northwest Bay where they looked out directly towards Dent Island. The whalers periodically visited Dent Island to obtain a supply of muttonbirds (Sooty Shearwater chicks). In an interview in 1977, the last surviving Campbell Island whaler, Joe Timms, acknowledged the presence on the island of the flightless teal and added:

> *"....I can't remember much about them, but they're not very big,,. not as big as seagulls. They were lower down on the ground than the seagulls; they had shorter legs and, according to the boys, used to run down the muttonbird burrows when frightened". (N. Judd unpubl.ms., Kerr & Judd 1978).*

Fleming's original description provoked Stead (1938) to question the authenticity of the specimen's origin, and hence Fleming's erection of a new genus and species. Not unreasonably, Stead found it ".. incredible that no one should have heard of it (the specimen) for fifty years." He further expressed surprise that Buller's "Supplement to the Birds of New Zealand" (Buller 1905) in which the author "..constantly acknowledges information and gifts of southern birds which he had received from Captain Fairchild", contained no reference to the bird. "How can it be imagined" wrote Stead, "that Fairchild, if he had taken a flightless duck on Campbell Island, should never have mentioned the extremely interesting fact to Buller?"

Stead went on to cite the response of two shepherds who worked on Campbell Island; they reported only *Anas superciliosa* but no flightless duck. He referred to an engineer on Stella who was a collector of birds and eggs for Buller and others, and who was on Stella in early 1886 when the duck was supposed to have been collected; he had no recollection of the bird having been caught and transported back to Wellington.

There was clearly some correspondance about the bird between Fleming and the then Director of New Zealand's Canterbury Museum, R.A.Falla. Stead (1938) refers to "a hand-coloured figure of the type specimen sent by Mr Fleming to Mr Falla" (presumably the plate published in Mathews (1936)). The receipt of that figure stimulated both Falla and Stead to re-examine teal specimens from Auckland Islands, and led to them publishing a re-description of the species (Falla & Stead 1938) which, curiously, was made without any reference to Fleming's specimen.

Fleming responded to Stead's challenge with a letter to *Ibis* (Fleming 1938) in which he explained how he had obtained the specimen and that he was in no doubt that it had come from Campbell Island. He obtained the bird direct from his friend Captain T. E. Donne who in a letter to Fleming stated:

> *" This bird was given to me because it was regarded as a rara avis, as no other specimen had been secured in the waters of that island. Captain Fairchild told me that some of the crew gave chase to it in a boat and one of them killed it with an oar. It was sent to Jennings, the taxidermist, who resided at Ravensbourne, near Dunedin, to be mounted.....I always understood the distinction of this bird arose from the fact that it came from Campbell Island, and therefore I kept it for nearly half a century until you received it. I was not previously aware that it was of a different variety to the Flightless Ducks of the Auckland Islands.....You may rest assured that you possess a duck that was secured at Campbell Island."*

The second specimen

About a year after the outbreak of World War II, the New Zealand Government decided to station small coastwatching parties on both Campbell and Auckland Islands in order to detect enemy ships attempting to use the islands as bases for possible raids on New Zealand and Australian coastal shipping. On the advice of R.A. Falla and others, these parties included biologists, geologists, meteorologists and surveyors. Parties remained on the islands for a year at a time with some individuals returning for second

tours of duty and also serving in both island groups. The reports of these "Cape Expeditions", published as a series of bulletins by the New Zealand Department of Scientific and Industrial Research, laid the foundations for all modern scientific investigations on the islands. One young biologist/meteorologist who was on Auckland Islands during 1943 in a party led by Falla and who, the following year, went to Campbell Island, was Ron Balham. Falla had instructed him to keep a lookout for Campbell Island Teal and, on 28 May 1944, he and expedition leader Laurie Pollock saw their first bird. The following are references to teal in the diaries of the Cape Expedition (held as part of the Sorensen Collection by Department of Conservation, Wellington).

> May 28 1944.
> *Between northwest and Middle Bay – bird seen swimming near rocks – endeavoured for about an hour to secure specimen with stones but unsuccessful. (Duck) 'steamed' strongly on occasions. Another bird seen in water between Middle Bay and Windlass Bay. L. Pollock, R. Balham May 29 1944. Between northwest and Middle Bay – Shot specimen, the only one seen although a search was made of Windlass Bay. On both days it was after 3.30pm when birds were seen so they may not come out until late in the day. L. P, R. B.*
>
> July 20 1944.
> *Windlass Bay. One bird seen in the bay, landed on the beach (at about 1.30pm)*

Thus, Balham and Pollock unequivocally established the presence of a flightless teal in the Campbell Island area.

Subsequent references to the collection of the 1944 specimen have rather muddied the waters. Delacour (1956) quotes from a letter sent to him by R. A. Falla thus:

> *"All that I can tell about the Campbell Island bird is that in 1944 members of the party stationed at the island collected an adult male and female in North-west Bay. I have the skins and hope shortly to publish description and dimensions. I can detect no important difference from the Auckland Island bird except that the Campbell specimens are both slightly smaller than the corresponding sexes of* aucklandica *and they have the somewhat pinkish-brown tone Fleming drew attention to in his diagnosis of* Xenonetta. *The most that can be allowed is that the bird is a weak subspecies of* aucklandica, *for which* nesiotis *can be admitted as the subspecific name. It must be exceedingly rare. Campbell Island is over-run with* Rattus norvegicus *and no ground-nesting bird has a chance to breed. The outlying islets are steep and small, and my guess is that the whole population of flightless ducks exists on one known as Dent Island (the name is, I think, French, and not English, and may be gained by the resemblance of the rock to a tooth). Unfortunately, no one has had enough enterprise or luck to land on this islet to find out. An older sealer tells me that his party occasionally caught flightless ducks in North-west Bay about 1912, but apart from J.H. Fleming's unsatisfactory specimen and the two which I have here, I doubt that there are any others in existence."*

Westerskov (1960:36) mentions "...Dr R W Balham, who, with L. Pollock in 1943 (sic) collected the only recent specimen of the Campbell Island flightless teal" but later, (p.64), refers to Falla's letter in Delacour (1956). Westerskov followed this with:

> *"Dr Falla has kindly shown me the two specimens, and seeing them and comparing the Campbell Island teals with Auckland Island teals one cannot help agreeing with Dr Falla's caution. In effect, I wondered whether there may be any Campbell Island teal at all, i.e. that teals collected at Campbell Island (and only three have been collected altogether, in 1886 and 1944) could be teal blown south-east from the Auckland Islands"*

Bailey & Sorensen (1962:245) refer to "a pair" and "the two" collected by the 1944 coastwatchers but published measurements from only one specimen held in the Dominion Museum.

The final and definitive word on this has to be that of Ron Balham:

> *He confirmed (pers.comm. to MJW) that only one specimen was collected in 1944 but that two separate birds were seen (on 28 May 1944). Furthermore, one of us (CJRR) was able to discuss the "two" specimens with R A Falla in 1976 at which time he acknowledged his inadvertent assumption that an Auckland Islands Teal, initially used for comparative purposes and stored with the Campbell bird for 30 years in a box in his office, was a "second" 1944 Campbell Island Teal specimen.*

Subsequent sightings

Bailey & Sorensen (1962) reported a possible sighting of the bird by Sorensen in 1943; we have read Sorensen's diaries most carefully and can find no references to flightless ducks other than those referring to Balham and Pollock's encounters. However, in his 1945 diary (on 20 April) he records "saw a single grey duck take off from the back of Windlass bay". An annotation (by an unknown hand) in the margin alongside that entry says "Duck?, flightless".

Westerskov (1960:65) reported the sighting, on 31 January 1958 in northwest Bay, of "four dark birds sitting as low in the water as diving ducks.....They reminded me somewhat of New Zealand shoveler females, but were not so round in body, the head appeared smaller and the birds were sitting lower in the water. They were not muttonbirds, nor grey duck..... I am inclined to think that the birds observed on 31 January were the Campbell Island teal."

Modern field encounters

The first positive encounter with the duck, since the 1944 sightings, was on 12 November 1975. A party comprising Christopher Robertson, Rodney Russ and Gerry van Tets spent two hours on Dent Island, the first scientific party to do so. Shortly after landing, in the head of a shallow gully, they caught a glimpse of a small bird scuttling uphill with head and neck outstretched and low to the ground. It appeared to go down a petrel burrow at the base of a tussock but the burrow was empty when excavated. Shortly thereafter, Russ followed some rustling amongst the tussocks and, from a distance of only 2 m, had a clear view of a small dark-brown duck with a prominent pale eye ring. It too seemed to disappear down a burrow and eluded capture. An intensive traversing of the shallow gullies adjacent to this sighting was rewarded with another fleeting glimpse. Then, some 30 m above the sea level, not far above the lower limit of vegetation on the island, Russ's graceless swallow dive secured a small duck (**Figure 2E**). Within an equally graceless container (a knotted pair of overtrousers) the bird was taken off the island to be held in captivity on board ship for a week. This bird, a female, and the first of this sex to be encountered, was released at the site of capture weighing 244 g, only 20 g lighter than at capture. During their three two hour visits ashore, the party collected skeletal remains of six teal from skua middens (**Appendix 2**, van Tets 1980) and, on the basis of their sightings and the area traversed, estimated the population to be 30-50 individuals (Robertson 1976).

In February 1984, Murray Williams and Andrew Garrick completed the first known overnight stay on the island. Their attempt at a capture-recapture estimate of teal numbers (as undertaken on Auckland Islands Teal; Williams 1986) was bedeviled by the dense tussock cover and the infrequency of sighting and capture of the birds. Williams, Garrick and other members of the 1984 Campbell Island expedition spent, in all, three nights on Dent Island and 90 man-hours searching for teal on the island's southeastern face. That effort was rewarded with the capture of one bird, sightings of four (not necessarily all different birds), the possible disturbance of three and the absence of other sign to indicate their presence.

Williams & Garrick (1984) concluded that teal numbers might not be of the magnitude suggested by Robertson (1976) and that the quality of their island home may have been affected by recent erosion in three major gulleys, the result of unusually heavy rains in January 1976. As a consequence, the single adult male they captured was removed to the National Wildlife Centre in New Zealand pending a further visit to capture two pairs.

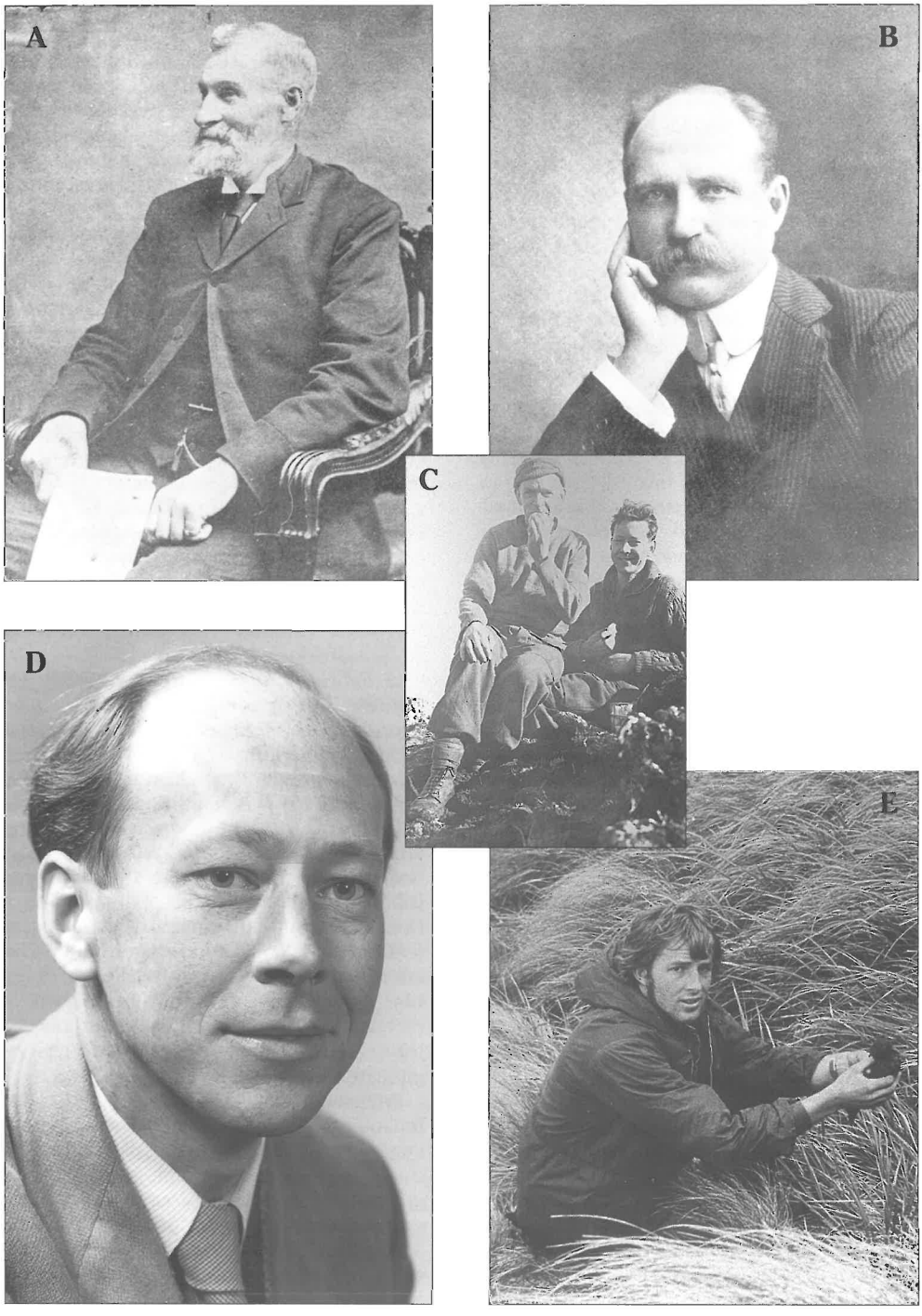


Figure 2. Key figures in the history of discovery of Campbell Island Teal:

Figure 2. *(opposite)* **Key figures in the history of discovery of Campbell Island Teal:** A - Captain John Fairchild (1835-1898), master of the New Zealand Government vessels *Hinemoa* and *Stella* who collected the first Campbell Island Teal specimen in 1886 and returned it to New Zealand in good order (photo R.M. Riddell collection, Alexander Turnbull Library); B - Captain T.E.Donne (1860-1945), c 1907, to whom Fairchild gave the first specimen. He worked as an agent of the New Zealand Tourist Department in United States and was responsible for securing several species of deer and Canada Geese *Branta canadensis* for release in New Zealand. Presumably he took the teal mount with him to United States and eventually passed it on to his friend J.H.Fleming at the Ontario Museum (photo Alexander Turnbull Library); C - Laurie Pollock (left) and Ron Balham (right), collectors of the 1944 specimen, photographed on Campbell Island in the same year (photo R.Balham); D - Ron Balham, c 1958, completed a PhD on Canada Goose at Delta Waterfowl Research Station in Manitoba, participated in the Commonwealth Trans-Antarctic Expedition of 1958 as a meteorologist, was the first waterfowl biologist with New Zealand's Wildlife Branch (later Wildlife Service) before joining the staff at Victoria University in Wellington where he taught ecology to the authors (photo A S Helm collection, Alexander Turnbull Library); E - Rodney Russ, then a trainee New Zealand Wildlife Service field officer, with the capture in 1975 that confirmed Dent Island as the location of a remnant population. He now conducts tourist expeditions to the New Zealand subantarctic islands and Antarctica (photo CJR Robertson).

This subsequent visit took place on 21 June 1984 (Cheyne 1984). Eight persons spent a total of 44 man-hours searching for teal on the southeastern slopes of Dent Island, capturing three birds (two male, one female), and making seven other sightings (probably of five separate birds). These captives were also taken to the National Wildlife Centre together with four pairs of Aucklands Island Teal captured on the same journey south. This was the genesis of a captive breeding programme designed to found a second island population.

On 10 February 1985, the authors and Rowley Taylor camped overnight on the island and the following day, with the help of naval ratings from HMNZS *Monowai*, searched for teal, in all for 52 man-hours. In the evening there were three sightings and only one brief glimpse the following day (possibly of a duckling). As in February the previous year, the ducks were not at all conspicuous.

The history of field encounters with Campbell Island Teal requires reference to only one further visit to Dent Island. This was a Department of Conservation expedition in October-November 1990 which sought to remove up to four pairs of teal for an expanded captive breeding programme. This party, armed with traps and fyke nets and a recording of a female Campbell Island Teal decrescendo call, was able to visit Dent Island on six occasions, spending 120 man-hours there (Goudswaard 1991). Seven males and three females were caught. There were an additional 22 sightings and, on 11 occasions, birds were heard but not seen. Four males and three females were removed to the National Wildlife Centre.

Interpreting the historical record

The historical record, as we understand it, provides no reference to indicate that teal were resident on Campbell Island itself. But it seems inconceivable that they never occurred there prior to rat infestation. Auckland Islands Teal find the tussock-covered slopes of Adams and Disappointment Islands much to their liking, Campbell Island Teal occupy the same sort of habitat on Dent Island today, so why not Campbell Island in the past? Aucklands Island Teal are readily observed along sheltered sections of Adams Island shoreline in Carnley Harbour and on the shores of Enderby, Rose and Ewing Islands in Port Ross, habitat essentially the same as at the head of Campbell Island's three eastern harbours.

The absence of teal records from Campbell Island can reasonably be explained by the early arrival of rats along with the sealers and the late arrival of

biologists. The rat invasion rendered teal extinct on Campbell Island before there was a serious appraisal of the fauna and flora. That teal were not seen during the *Erebus* and *Terror* visit to Perseverance Harbour in 1840 could suggest they were already a rare species and implies that teal have been restricted solely to Dent Island for the past 150 years.

As it stands, the only positive "record" of teal being on the shoreline of Campbell Island is the observation of Balham and Pollock on 20 July 1944 when they saw a bird land on the beach in Windlass Bay on the island's western side.

The historical record also shows that Reischek's 1889 reference to Campbell Island's "wingless duck" either failed to be noticed or was not taken seriously. This is perhaps understandable given that teal were easily seen and collected at the Auckland Islands and no specimens or sightings were forthcoming from Campbell Island. The historical record also suggests that Captain John Fairchild did not appreciate the significance of his 1886 specimen. Given that he regularly took naturalists to the subantarctic islands on his ship, and that he was, as Stead (1938) commented, a contributor of information and specimens to Sir W.L. Buller, it seems strange that his specimen had to wait 50 years for recognition. Perhaps, in the absence of ever seeing another teal at Campbell Island, Fairchild and any person with whom he shared the information (like Reischek) simply assumed the 1886 specimen was a single, "lost" teal from the Auckland Islands and thought no more of the matter. T.E. Donne certainly expressed this opinion (Fleming 1938).

While Stead (1938) firmly believed the 1886 specimen did not come from Campbell Island, it seems his close friend R.A. Falla did not concur. Fleming's (1935) publication obviously stimulated both men to examine specimens from the Auckland Islands but whereas they jointly prepared a re-description of Auckland Islands Teal (Falla & Stead 1938), Falla did not join Stead in his public doubting of the geographic origin of Fleming's specimen. As his wartime instruction to Ron Balham implies, Falla thought a teal at Campbell Island was a distinct possibility and he even suggested then that islets like Dent Island were the most likely refuge (R. Balham pers.comm.). He was indeed correct!

Phylogeny

Taxonomic history

Fleming (1935) described the Campbell Island Teal not just as a new species but as a new genus – *Xenonetta*. He differentiated the specimen from the then *Elasmonetta chlorotis* (Brown Teal) and *Nesonetta aucklandica* (Auckland Islands Teal) by the narrowness of the bill, the reticulate tarsus and the bird's almost uniform coloration. Stead (1938) was less than convinced about the specimen's uniqueness and argued that the diagnostic characters that Fleming had used to erect the new genus were all shown by the Auckland Islands specimens that he was able to examine.

Delacour & Mayr (1945), in their extensive review of the family Anatidae, concurred with Stead (1938) and synonymised *Xenonetta* with *Nesonetta* and then synonymised *Nesonetta* with *Anas*. They erected two subspecies of *Anas aucklandica*; *chlorotis* (Brown Teal) and *aucklandica* (Auckland Islands Teal) but did not recognise Fleming's *nesiotis*. The first modern systematic list of New Zealand birds (Marples 1946) recognised the bird however, now that the 1944 specimen was to hand, declaring it (*nesiotis*) as a third subspecies of *A. aucklandica*.

On the basis of Falla's (1953) assertion that "*Anas chlorotis* is unquestionably a smaller, shorter-winged, more obscurely patterned derivative of *Anas castanea*", Fleming's (1953) checklist of New Zealand birds synonymised *Anas aucklandica* with *Anas castanea* thus combining, at the species level, all four dark plumaged teals in Australasia. However, Kinsky's (1970) checklist, and the later one of Turbott (1990) have retained Delacour & Mayr's trans-Tasman distinction at species level

and accepted Campbell Island Teal as one of the three subspecies of *aucklandica*. Most recently, however, Marchant & Higgins (1990) have upgraded *aucklandica's* three subspecies to separate species status, a view given support by morphological (Livezey 1990) and genetic studies (C. Daugherty, pers.comm. in Williams *et al.* 1991).

Relationships

As the above taxonomic history shows, there have been no modern suggestions that Campbell Island Teal is other than a member of Delacour & Mayr's (1945) "Austral teal". However, the issue of the origin of the flightless teal on Auckland Islands has been the subject of past speculation. Dumbell (1986) has summarised the history of suggestions that Auckland Islands Teal is an isolated derivative of Brown Teal, attributing the idea to Salvadori (1895). Generally this view has remained unchallenged, and given most recent support by Livezey (1990).

Falla's comments in Delacour (1956) imply that he considered *nesiotis* to be a recent derivative of *aucklandica*. Livezey (1990) has hypothesised a similar origin, and Westerskov (1960) presented arguments for considering the Campbell Island birds to be little more than recently wind-blown Auckland Island Teal. However, Turbott (1968) proposed an alternative by suggesting the possibility that Campbell Island received *chlorotis* stock rather than *aucklandica*. The most recent suggestion concerning origin and relationships, however, adds a further twist. Using gel-electrophoresis of blood proteins, C. Daugherty (pers. comm. in Williams *et al.* 1991), noted that while *castanea* and *chlorotis*

> *"were separated at a genetic distance most commonly associated with infra-specific variation in birds,* chlorotis *and the sub-Antarctic teals were further apart;* chlorotis *and* aucklandica *could be distinguished at one of the 14 loci examined and, although* chlorotis *and* nesiotis *also differed at one locus, this was different from that which separated* chlorotis *and* aucklandica. *Given that all 54* chlorotis *examined were homogeneous at all loci, and* castanea *were polymorphic at only one, these results suggest that the sub-Antarctic teal are the result of two quite independent colonisations at different times and, perhaps, from different sources and that flightlessness has evolved independently in both sub-Antarctic forms."*

Thus, the hypothesis that all three New Zealand teal represent independent colonisation events from an Australian (i.e. proto-*castanea* or *castanea*) source awaits critical evaluation.

Plumage

Fleming's (1935) description of the holotype (ROM 35406) was:

> *"Head and neck sepia, darker on the hind neck: back and upper tail-coverts sepia, with faint edgings of warm sepia, this colour predominant on the under tail-coverts.*
>
> *Under parts more Saccardo's umber than sepia, and without spots or vermiculations; lower breast and abdomen with faint edgings of light buff.*
>
> *Wings, dark sepia with no visible speculum, the primaries dark sepia on outer web and edged with sepia, the inner webs lighter; the shafts warm umber. Under wing coverts, umber with light buff edges producing a mottled effect; axillaries light buff with two centre spots of sepia.*
>
> *Tail feathers dark sepia with indistinct sepia edgings, the tail much shortened by wear, the shafts very stiff.*
>
> *Bill in dried skin, blackish brown, a large triangular patch of cinnamon buff extending from the base of the maxilla to a line drawn in front of the nostrils; the nail umber*
>
> *Tarsi and toes in dried skin, blackish brown with traces of cinnamon buff on the edges of the toes, the webs blackish brown"*

This description of a male collected about February is of a bird in eclipse or partial eclipse plumage. It is also a description based on a very worn and faded mount which, today, fails to show some diagnostic features, for example, the white eye ring and the green iridescence on the head or back.

All subsequent descriptions (e.g. Robertson 1985; Marchant & Higgins 1990) have been based upon that of Fleming, and amended slightly after reference to the 1944 specimen. However, none discriminate between male plumages nor describe females.

The following descriptions are based on two adult male study skins and one wing (NMNZ 14735, 24051, 24051/1) and one adult female wing (NMNZ 24826/1), observations of live birds in captivity, and colour photographs of live birds available for reference alongside the skins and wings (including **Colour plate 1**). The above museum specimens are here designated as PARATYPES which, together with the holotype (ROM 35406) form the type series of the Campbell Island Teal. Names and numbers of colours follow Smythe (1975) as far as possible.

Adult male - Breeding

HEAD, THROAT, NECK - Sepia 119 with strong green iridescence on crown and nape with clear demarcation line at top of breast. Throat paler. EYE - Dark brown, surrounded by narrow white feathered eye-ring. MANTLE, RUMP, UPPER TAIL COVERTS - Sepia 119 with moderate green iridescence and paler edges of Verona Brown 223B giving dappled appearance. TAIL - Sepia 219 with pale shafts. UPPER BREAST - Tips warm Chestnut 32. LOWER BREAST - Robin Rufous 340 with a regular speck of Sepia 119 as a central spot towards the distal end of each feather. SHOULDER, FLANKS - Fine vermiculations of alternating True Cinnamon 139 and Sepia 119. BELLY, ABDOMEN - Grading darker to light from breast to under-tail from Robin Rufous 340 to a pale Drab Grey 119D with barred vermiculations formed with a double pale band through darkest outer parts of feather and with pale outer edge. TAIL SPOT - Conspicuous pale patch of vermiculated white and Sepia 119. VENT - True Cinnamon 139 at base of feathers with distal half and edge Sepia 119 to give uniformly dark appearance. UNDER-TAIL - Sepia 119 with True Cinnamon 139 edges. SCAPULARS, UPPER WING COVERTS - Sepia 219 edged with Robin Rufous 340 producing a fine paler bar above secondaries. Scapulars of Sepia 219 predominantly edged with variable width of vermiculations of Sepia 119 and Cinnamon 39. UPPER WING - Secondaries Sepia 219 with green iridescence of speculum on outer vane of 4-9th secondaries and outer tertial. Outer edge and tips of secondaries 1-5 edged with Robin Rufous 340 narrower in 6-9th secondaries. Primaries with leading edge of narrow outer vanes Robin Rufous 340 backed by Sepia 219. Inner vanes paler with paler shafts of Raw Umber 223. Primary coverts Sepia 219. UNDER-WING - Primaries and secondaries and under-wing coverts a pale grey-brown approximating Drab 27. Rest of under-wing barred Natal Brown 219A and True Cinnamon 139 with tips palest. Axillaries pale Grey Brown 27 with darker shaft and central spot of Natal Brown 219A towards tip. LEGS, TOES, CLAWS - Dark blackish brown with steely sheen, webs steely black. BILL - Dark steely grey slightly paler towards base of culmen.

Adult male - Eclipse

As in breeding male except as described. HEAD, THROAT, NECK - Sepia 219 (paler than breeding) with no iridescence and appears faintly vermiculated especially on cheeks and at rear of head due to paler edges. EYE - Pale Horn Color 92 eye-ring. MANTLE, RUMP, UPPER TAIL COVERTS - Green iridescence considerably less intense. UPPER BREAST - Robin Rufous 340 interspersed with irregular specks of Sepia 119. LOWER BREAST - True Cinnamon 139 with irregular spotting of Sepia 119. BELLY & ABDOMEN - As in breeding, but overall paler. UNDER-TAIL - As in breeding but Sepia lacking. TAIL SPOT - indistinct. SHOULDER & FLANK - Vermiculations greatly reduced with overall darkening from breeding plumage.

Adult female - Breeding

As in breeding male except as described. HEAD, THROAT, NECK - Sepia 219, conspicuously lighter than male with occasional small pale grey flecks in nape and behind eye. MANTLE, RUMP & UPPER TAIL - As for male eclipse. BREAST - Uniformly Robin Rufous 340 with some barred effects due to light edges of feathers. No spotting as in male. SHOULDER & FLANKS - Strongly barred (not vermiculated) appearance of Sepia 219 with Robin Rufous 340 edges. BELLY & ABDOMEN - Grading darker to light from breast to under-tail from Robin Rufous 340 to Drab Grey 119D with some darker spotting and streaking. UNDER-TAIL - As in male eclipse. TAIL SPOT - None. UPPER WING - As for breeding male but no iridescent speculum and less pale tips of secondary coverts. Dark outer vane of tertials with slight iridescence. SCAPULARS - As in breeding male except for broad barring replacing fine vermiculations. UNDER-WING - similar to male but lacking cinnamon tones. Axillaries have greater area of Natal Brown 219A along shaft and spot near tip.

Adult female - Eclipse

Generally darker and duller than male eclipse with barred areas less prominently coloured.

Juvenile

Both male and female similar to adult female eclipse, but green iridescence less marked on back. On undersides feathers are Sepia 219 with darker edges. Paler than eclipse female on abdomen. Overall like a dark adult female.

Downy duckling

FOREHEAD, CROWN, NAPE, MANTLE, UPPER-WINGS, RUMP - Natal Brown 219A, more intense on crown and closer to Sepia 219. CHEEKS, BREAST, UNDERSIDES - Between Light Drab 119C and Drab Grey 119D. Vestigial supercilliary stripe most conspicuous behind eye. EYE -Dark brown. A hint of a pale eye-ring. LEGS, FEET, BILL - As in adult.

Comparison of the plumages of *chlorotis*, *aucklandica* and *nesiotis* shows the latter to be generally darker than the others. In nuptial plumage, *nesiotis* males more closely resemble *chlorotis* than *aucklandica* on account of their more conspicuously green head and more prominent tail spot but we have seen no hints of a vestigial white neck ring as on some *chlorotis* males. In dull light and at a distance, we perceive *nesiotis* males to resemble a small *castanea*. The females of all three species are very similar, but we consider *nesiotis* to be generally darker than the other two.

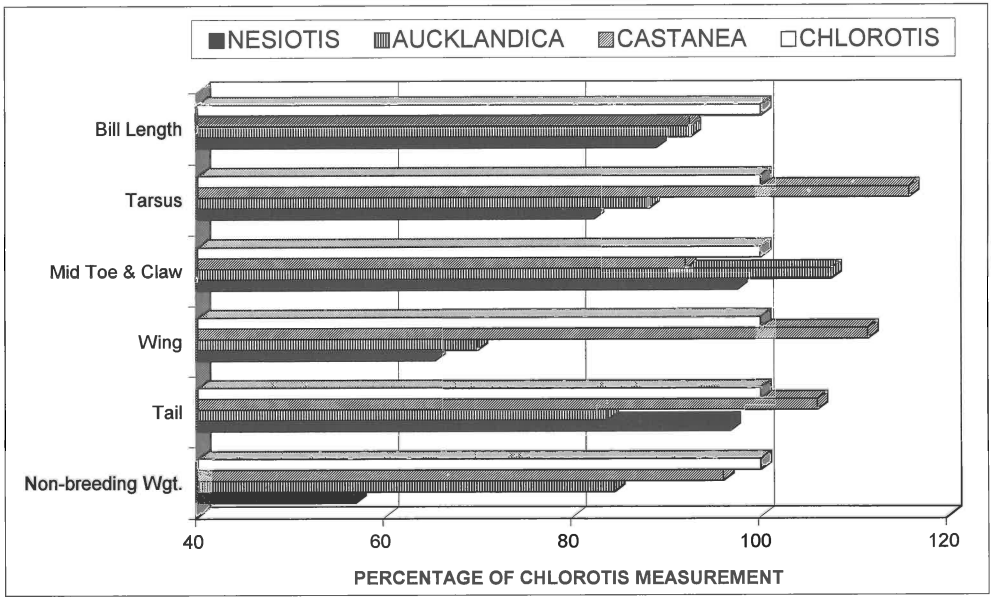
Measurements and weights

Because so few birds have been handled, and because there are considerable differences between field and captive weights, in dimensions of captive-raised and wild-caught birds, and between these and dried museum specimens, we have listed details of each bird separately in **Appendix 1**. Also in **Appendix 1**, data from all known Campbell Island Teal specimens are summarised and compared with the other three brown-plumaged Australasian teal. For this summary we have been careful to compare like with like and so present one set of data derived entirely from live wild birds, and another from dried museum specimens.

Campbell Island Teal are the smallest of the four species (**Figure 3, Appendix 1**). Their mean weights (male 371 g, female 301 g) are approximately half that of *chlorotis* and *castanea* and 70% that of *aucklandica*. Although tarsus length is only about 80% that of *chlorotis*, foot size, as measured by mid toe and claw length is almost the same, thus complementing the same trend in the equally cursorial *aucklandica* of having relatively shorter legs and larger feet.

Apart from weight, the most conspicuous difference from the other teals is in wing length and wing area. Campbell Island Teal have a wing length only slightly more than half that of the most strongly flighted of the four, *castanea*. Wing area is even more reduced; 114.5 cm^2 for one male, 96.5 cm^2 and 103 cm^2 for two females. Based on mean wild weights, wing loadings (body mass (g)/wing area (cm^2) are 3.25 (male) and 3.0

Figure 3. Relative size of *Anas castanea, A. chlorotis, A. aucklandica* and *A. nesiotis* males based on measurements summarised in Appendix 1. The measurements and weights of *A. chlorotis* are used as the basis of the comparison and relative size is expressed as a percentage of the *chlorotis* measurement.



(mean female). Using the capture weights of the birds measured, wing loadings were 4.37, 3.78 and 2.60 for the male and two females respectively. Livezey (1990, Table 3) records wing loadings of 2.17 and 1.24 for *aucklandica* and *chlorotis* respectively and <1.0 for a range of strongly flighted *Anas* species weighing less than 1 kg.

The lengths and length ratios of bones are tabulated in **Appendix 2**. They illustrate that: (i) differences between *nesiotis* and *aucklandica* are slight; and (ii) *chlorotis* differs markedly from the subantarctic forms on the one hand, and from *castanea* on the other.

These differences appear related to the ability or inclination to fly; absent in the subantarctic forms, poor in *chlorotis* and good in *castanea*. Hence the clines from *nesiotis* through *aucklandica*, *chlorotis*, to *castanea* in the relative total lengths of the wing bones and the ratios between proximal and distal elements in the wings and legs. The lack of volancy is thus accompanied by a foreshortening of the distal bones in both the fore and hind limbs. No species-specific differences in the shapes of the bones were noted.

Dent Island: the last refuge

At present, Dent Island is the only known natural location of Campbell Island Teal. Geologically, Dent Island is of massive intrusive columnar rock, probably the hard core of a dyke which has resisted the sea while the land that once surrounded it has been worn away (Fraser 1986). Measuring 650 m and 450 m at its longest and widest points respectively, it rises with twin peaks just above 200 m a.s.l. (**Colour plate 2**). Its more sheltered south to southeastern faces slope at 25-30° while the exposed and eroded northern and western faces are almost vertical and devoid of vegetation. At sea level, the 10 m surge zone is very steep and smooth with a narrow band of *Durvillea antarctica* kelp attached. At places, there is sufficient irregularity in the rock to allow adventurous sea-lions to struggle up into the tussock.

Floristically, the island is a slightly less diverse version of Campbell Island. While the island's species list includes 29 species of vascular plants arranged in about six obvious floral associations (**Appendix 3**), the dominant plant is *Poa litorosa* which forms an extensive tussock blanket exceeding 1 m tall over most of the slopes. The shallow moister gullies on the lower half of the island contain conspicuous mixed stands of *Poa foliosa, Stilbocarpa polaris, Bulbinella rossi* and *Anisotome latifolia* (**Colour plate 2**).

The conspicuous animals on the island are seabirds (**Appendix 4**), the most numerous of which are Sooty Shearwaters on the tussock covered slopes and White-chinned Petrels at wet sites in gullies.

The island lacks significant standing water but is generally moist underfoot. The shallow furrows or gullies on the south and eastern face create seepage zones in which, lower down, small rivulets descend often through a series of small (0.25-0.5 m^2), temporary impoundments where spent vegetation or an accumulation of peat impedes the flow. In the vicinity of the petrel burrows, there are conspicuous seepages and water may also impound in the entrances of the burrows. The island's upper slopes are drier and flatter with a thinner peat mantle and, above the 100 m contour, there are no obviously wet areas.

At intervals across the lower slopes erosion scars indicate where significant areas of vegetation have slipped from both gullies and steeper ridge sides. Three slips that occurred in January 1976 were, by 1990, still very obvious and only sparsely covered with vegetation (**Colour plate 2**).

Habitat of teal

Although teal have now been encountered over most of the island's accessible vegetated area, it seems that they are more numerous below the 100 m contour and in moister sites. **Figure 4** illustrates the approximate locations of all encounters made during the 1975, 1984, 1985 and 1990 expeditions. It highlights the conspicuous seepage channels running down the vegetated section of the island within or immediately adjacent to which most encounters have been made.

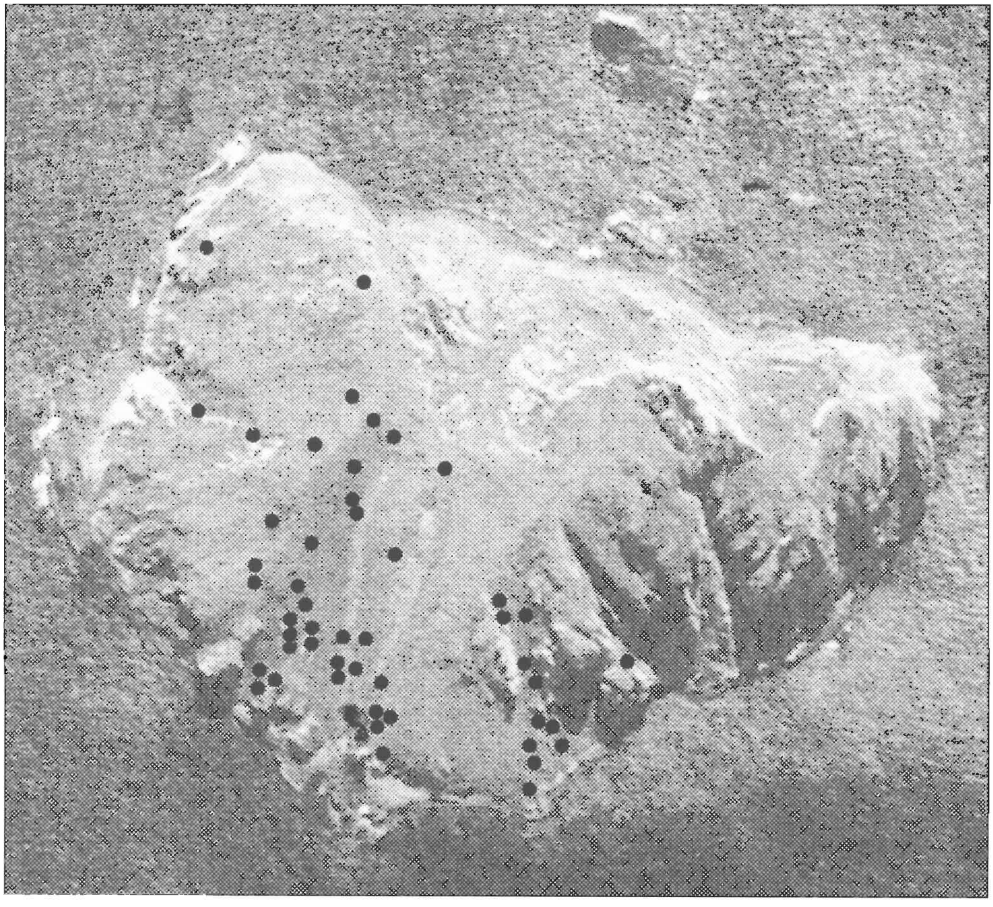
A feature of the seepage channels is the extensive ground disturbance caused by burrowing petrels. This has allowed *Stilbocarpa* to form extensive pure stands and, in summer, clumps of *Bulbinella* are conspicuous around their margins (**Colour plate 2**). Teal can move beneath the *Stilbocarpa* canopy with considerable ease relative to the tussock grassland. There is an abundance of burrows in which to hide, plenty of open space in which to bask on sunny days, a rich seabird guano to support an abundant invertebrate fauna, and periodic small areas of impounded water. By contrast, the pure tussock areas are considerably drier and generally without impounded water, have few open spaces, and the seabird burrows seem not so dense.

Adjacent to most of the channels are small rock outcrops. Members of all recent expeditions have observed teal on exposed rocks or on patches of bare ground viewing their surroundings. In captivity, the teal, especially the males, have clambered up on anything that would give then a view. Perhaps, in the occluded habitat of Dent Island, high points from which to watch for other teal are an important habitat component.

The vegetation in which teal have been encountered is similar to that occupied by Auckland Islands Teal on parts of Rose, Ewing, Ocean and, in particular, Disappointment and Adams Islands. *Stilbocarpa* patches in extensive areas of *Poa* grassland (see Williams 1995, Figure 11) were found to be favoured daytime roosting sites for adults and broods on Ewing and Ocean Islands.

Assuming that Campbell Island Teal did formerly occur on Campbell Island, a greater diversity of habitats would have been available. Streams and marine habitats, especially at the head of the island's three harbours, could have been occupied just as Auckland Islands Teal presently exploit similar habitats on Enderby and Adams Islands. Protected rocky shorelines, or shorelines upon which kelp accumulated in windrows could have supported resident teal, as similar areas on Rose and Ewing Islands do Auckland Islands Teal. Teal on Dent Island have limited habitat choice but, in the past, they may have exploited the wider range of subantarctic environments as now shown by Auckland Islands Teal.

Figure 4. Dent Island showing the approximate locations of all sightings of teal made in November 1975, February 1984,1985, and October-November 1990.



Foods and feeding

Teal have not been observed feeding on Dent Island. However, most expeditions to the island have located "signs" attributed to teal feeding in or about the seepage channels. Shallow, oval probings about 3 cm wide and 2 cm deep and clearly made by a blunt bill, have been found scattered in the soft peat alongside the seepage channels. In the channels themselves, dead tussock tillers are often worked in a circular fashion so as to create a tiny pool of clear water in the centre. Signs at the margins of these are suggestive of a bird sitting in the water probing and dabbling around the perimeter. Such behaviour has been observed in captive teal.

Some teal held in captivity at Campbell Island prior to removal to New Zealand were offered a range of invertebrate foods, all of which were eaten avidly. Piles of rotting seaweed, when provided to the captives, were fed over intensively and amphipods appeared to be particularly sought. Captives also readily consumed weevils and earthworms, the latter in preference to some bivalve molluscs offered at the same time, and also ate small pieces of seaweed (*Ulva* sp.).

In captivity in New Zealand, teal will dabble in soft ooze at the margins of their

ponds and have been seen stripping seed heads from *Juncus* plants. They are particularly fond of earthworms and insects.

Behaviour

Little is known of teal behaviour on Dent Island, but a general similarity with Auckland Islands Teal is likely.

All recent expeditions have encountered pairs of teal - in February, June and October/November - and, from this, year-round pair associations are inferred. The strong and prolonged territoriality shown by pairs in captivity (Preddey 1995a; b) and the ready response of wild pairs to broadcast taped calls (Goudswaard 1991) suggests that, like Auckland Islands Teal, Campbell Island Teal pairs defend small territories year-round.

Goudswaard (1991) reported " several sightings of different birds..... at the same site indicating that territories are ...flexible". He later explained (pers. comm. to MJW) that during the 1990 visits, nine teal encounters were recorded in or adjacent to one small gully and that five of these (including seeing three birds simultaneously) occurred after a pair had already been removed from the locality. He also recounted two other examples of males being replaced ten and 31 days after capture and removal and interpreted this as evidence of "demand for good territories".

In October/November 1990, teal responded readily to broadcast female calls (Goudswaard 1991). Usually it was the male that responded, either by calling or approaching the source of the sound. Females were more timid and only twice did a female call in response, although on several other occasions a female called after first hearing a male respond (Goudswaard pers.comm.). While taped calls broadcast in the seepage channels at lower altitude on the island induced a response or sighting of both males and females, responses in the grassland at higher elevations were solely of males.

In captivity, the introduction of a female to a small group of males induced intense male-male hostility (chases and fights), prolonged Trill calls like those of Auckland Islands Teal (Weller 1975) and several ritualised comfort movements (Preen-behind-wing, Bill-dip, Drink, Wing-flap (McKinney 1965)). Introduction of additional females to this group caused female-female chases and fights, Inciting and decrescendo calls from the females and numerous male-female chases and vigorous forced mountings (MJW pers. obs.). Preddey (1995b) has recorded a range of additional calls.

Breeding

No nests, eggs or ducklings have been observed on Dent Island. Although one of four sightings of teal (by MJW) in late February 1985 was recorded as "possibly a duckling", there has been no other encounter to suggest breeding. Presently the best guide to timing and duration of breeding is that of Auckland Islands Teal which lay in November to January with brood care extending into March (Williams 1995).

Nesting has occurred in captivity (Preddey 1995a). In early October 1994, a 1990-caught female laid a clutch of three and then commenced a second clutch of four eggs when her ducklings were 30 days old. In 1995, this female laid a first clutch of four in early October and a second of three, starting her second clutch when her ducklings were 44 days old. In 1995, a captive-bred female, laying in her first season, left a single egg in a nest on 13 November, abandoned it following inadvertent human disturbance, immediately created another nest and by 22 November had laid and commenced incubating three eggs. When this nest failed, she laid another two eggs but did not incubate them.

Laying interval has been recorded for one of the three-egg clutches; there was a two-day interval between the first two eggs and five days between the second and third.

In all, 20 creamy/pale fawn eggs have been laid. Mean (±sd) dimensions of eight eggs, all laid by the same female, were 61.8 (1.4) x 44.0 (0.7) mm. No egg has been weighed when fresh, but the mean (Ösd) calculated weight is 65.4 (1.6) g (formula from Williams 1995, Table 8). Using these measurements from eggs laid in captivity, and the mean

weight of wild females at capture (**Appendix 1**), each egg is approximately 21% of the female's body weight. However, as the contributing female weighed about 500 g during winter and up to one month prior to laying, the mean egg weight was approximately 13% of her body weight.

Incubation period, the time elapsing between the laying of the last egg and the hatching of the first duckling, was 31 and "at least" 30 days for the two 1994 clutches. In 1995 both successful clutches were incubated for a minimum of 30 days (S.O'Connor pers. comm.). This is the same as for Auckland Islands Teal (Williams 1995).

Status of the population

Three of the recent expeditions to Dent Island made assessments of, or commented upon, the size of the teal population. Robertson (1976), reporting on the historic November 1975 encounter, suggested the population was "possibly 30 - 50 individuals". The basis of this assessment was the sighting of teal on each of three two hour-long visits to the island, the presence of "fresh" remains of six teal in skua middens, and the confinement of sightings to the wetter gully areas on the leeward side of the island.

Williams & Garrick (1984), visiting the island in February 1984 achieved only four positive and two probable sightings of teal during 90 man-hours of searching, and including three overnight stays on the island. They interpreted this to imply a lower population than was present in 1975 (rather than a reduction in relative conspicuousness) because, additionally, they failed to find any teal bones in skua middens, found no typical feeding sign or feathers, heard only one call, and noted that, despite searching the entire accessible slopes of the island, all of their encounters were limited to small gullies in a confined area on the lower third of the island. This, together with evidence of recent and extensive landslips, led them to express real concern for the status of the population and to promote an active conservation programme.

The 1990 expedition landed on Dent Island six times during October and November (McClelland 1991, Goudswaard 1991). Members of this expedition saw birds 32 times, catching ten, and hearing another 11 during 120 man-hours ashore. From the distribution of their encounters (**Figure 4**), expedition members concluded that between 60 (Goudswaard 1991) and 100 (McClelland 1993) teal persist, scattered over the accessible vegetated portion of the island.

These assessments are not based on statistically supported procedures and uncertainty remains about the number of Campbell Island Teal on Dent Island. Assessment is helped neither by the island's terrain and vegetative cover nor by an apparent change in teal conspicuousness at different times of year. Visits to Dent island in February (1984, 1985) had low visual encounter rates (one per 15 and 13 man-hours respectively), whereas in June (1984) and November (1975, 1990) visual encounters were more frequent (one per 4.4, 3.0, and 3.75 manhours resp.).

Interpretation of encounters may be helped by appraising where each occurred and comparing findings with data for Auckland Islands Teal inhabiting similar subantarctic grassland habitat (Williams 1995). The encounters of the 1990 expedition were not scattered over the island's slopes but tended to be concentrated in seepage courses and at lower elevations (**Figure 4**). Furthermore, sightings in the seepage areas were clumped and some were confirmed as of the same individual. Both Robertson (pers. obs.) and Williams & Garrick (1984) encountered their birds in seepage areas at low elevations on the island and at the same locations (so far as can be judged) as some of the 1990 encounters. In other words, the conspicuous birds, which we interpret as likely to be the vigilant territory-holders, were generally in the damp seepage areas and spaced along these at about 30-50 m intervals.

Williams (1995) found that in grassland habitat on Ewing Island, Auckland Islands Teal pairs occupied ranges of 1,000-3,700 m^2 but, where food was very abundant e.g. adjacent to a beach, this was reduced to 200-500 m^2. Shoreline territories, where birds had access to a superabundance of

food amongst windrows of kelp, were smaller still. On Rose and Disappointment Islands, teal pairs have been encountered at 50-100 m intervals throughout the grassland but are more readily and frequently encountered in the moister sites (MJW, CJRR, unpubl.); on Rose Island four pairs were encountered within an area of approximately 1,700 m^2 in the wettest part of the island's grassland (MJW unpubl.).

Our interpretation is that territorial (and, most likely, breeding) pairs of Campbell Island Teal will account for the majority of sightings. Furthermore, we suspect that the upper grassland slopes will hold some birds, not all of whom are paired or defending territories i.e. the equivalent of the solitary-living Auckland Islands Teal reported by Williams (1995). Given (i) the general restriction of sightings in or close to seepage channels, (ii) the small area of the island covered by seepages and stands of *Stilbocarpa*, (iii) the likelihood of pairs being spaced not less than 30 m apart along these seepages, and (iv) the absence of pairs seen or heard in the upper grasslands in 1990, we suspect that the reproductive component of this population may not exceed 25 pairs.

Not all of the vegetated areas of Dent Island have been surveyed. The northeastern segment of the island is very steep and much of it is bare rock. However, there are small patches of tussock and *Stilbocarpa* in some of the erosion channels that may offer a refuge to, at best, an additional five pairs.

Conservation plans

The restriction of a tiny population of this identifiably different little duck to a single small island a mere 3 km away from an island with one of the world's densest field populations of Norway Rat poses more than a few conservation challenges. The rats prevent any realistic attempt to (re-) establish teal on Campbell Island. Although an obvious long-term conservation goal, rat eradication must wait until improved techniques can ensure success for such a daunting and expensive operation. In the meantime, conservation of Campbell Island Teal has to proceed by a series of short-term objectives.

A conservation programme established by the New Zealand Department of Conservation (McClelland 1993) has three objectives for its first five years of operation: 1. to resurvey other islets adjacent to Campbell Island to determine whether teal are present; 2. to assess the size of the Dent Island population; and 3. to establish and operate a captive breeding programme for the purpose of establishing a second wild population.

Other islets

Are Campbell Island Teal restricted to Dent Island? On present evidence it would appear so. However, there are four other islets around Campbell Island worthy of investigation. Members of the 1984 expedition landed briefly on Cossack Rock, Gomez Island, Jacquemart Island, and Isle de Jeanette Marie but failed to encounter teal. However, given that so few teal were encountered on Dent Island at that time, it is likely that any teal present would have remained undetected. Cossack Rock and Gomez Island, both less than 2 ha in size and within 500 m of Campbell Island are, perhaps, the least likely of the four, while the towering cliffs of Jacquemart Island may have always prevented teal reaching the island's crown. However, Isle de Jeanette Marie remains a credible "long shot".

Population assessment

Given the dense vegetation on Dent Island and the island's general inaccessibility, accurate assessment of the population will prove particularly difficult. On the assumption that the population may be structured as pairs occupying territories year-round a territory mapping exercise using taped calls and a dog would seem the only practical approach to obtaining an "order of magnitude" assessment. This can be supported by assessments of Auckland Islands Teal pair densities in similar grassland and megaherb habitat.

Captive breeding

As at May 1996, 15 teal are held in captivity. These originate from three males and one

female captured in 1984, and four males and three females in late 1990. The initial female, a juvenile at capture, failed to pair with any of the three males and died in 1991 without having laid an egg.

At capture, the 1990 birds comprised one definite and one probable pair and these associations were retained throughout their first two years in captivity. The third 1990 female was given a choice of two males and the resulting association was retained through the first three breeding seasons. All pairs were held in separate pens but none of the females laid.

In 1991, one of the two surviving 1984 males was paired with an Auckland Islands Teal female and they produced three ducklings, confirming the male's fertility. In 1992 and 1993 the three 'surplus' Campbell males were paired with Auckland females in a single large pen to test a different captive management technique as well as the males' fertility. Fertile eggs were laid and some ducklings raised (later deliberately destroyed) by most hybrid pairings, thus confirming the fertility of all but one of the Campbell males and, importantly, showing that multiple pair aviaries, by providing a high level of social stimulus, facilitated breeding.

Three pairs of Campbell Island Teal were co-housed in 1994 and one female laid, producing two clutches and four fledglings (three males, one female). The productive pair was placed in a single aviary in 1995 and produced two clutches and three fledglings (one male, two females). The 1994 captive-raised female laid while in the multiple pair aviary but hatched no progeny.

Thus, captive breeding efforts have a long and frustrating history with the first egg coming only after 19 pair-years of captive confinement. To date, only one of the four wild-caught females, and one of her daughters, have laid and only one of the seven wild males has contributed to the captive gene pool. One male and one female caught in 1984, and one captive-raised male have died in captivity while the other two 1984 males, both adults at capture, must be nearing the end of their lifespans. On the positive side, however, has been the rearing of three females and the knowledge that they can lay in their first year.

Conservation prognosis

Most likely, Dent Island has been the sole home of Campbell Island Teal for the past 150 years. There is, thus, a reasonable expectation that this isolated and bleak island, on the windward side of Campbell Island, will remain rat-free for the immediate future and so allow teal to persist until rehabilitation of Campbell Island becomes practicable, perhaps in the first two decades of next century.

Apart from the rat "threat", Dent Island is unlikely to suffer modification that would threaten the survival of teal. In 1976, a burst of abnormally heavy rain caused visible erosion on the island, denuding some of the small gullies and undoubtedly impacting upon birds with territories in those places. A repeat of this phenomenon is possible but it is hard to imagine the island being rendered uninhabitable. Perhaps the most immediate danger to teal is from well-meaning humans attempting conservation activities in the absence of vital knowledge e.g. removing birds without knowing population size, or blundering carelessly around the island during the summer breeding period attempting exploratory work. These dangers are well recognised in the species' recovery plan (McClelland 1993).

Campbell Island Teal are fortunate in having a more numerous close relative at the Auckland Islands. Auckland Islands Teal are dispersed over several small islands of differing character (Williams 1986) not only demonstrating their ecological plasticity (and hinting at the same for Campbell Island Teal) but also providing an ideal surrogate for testing management strategies. The testing of field census techniques, captive male fertility by deliberate cross breeding, and new aviary designs, all outlined above, are examples of their value.

Perhaps the only contentious issue looming, assuming the captive breeding programme does progress, is where to establish another wild population - the immediate insurance policy. Should it be within the subantarctic zone where most of the selective forces that have shaped the bird's evolution will continue to operate? If so, then should it be on another (and

pristine) subantarctic island in the New Zealand region (e.g. Antipodes Island, The Snares) or should the hunt extend beyond the New Zealand region (e.g. to the Falkland Islands)? Or should it be on a predator-free island close to the New Zealand mainland, outside of the subantarctic zone but where there is ready human access and ease of management? Alternatively, is total retention in captivity sufficient on its own? These issues are not unique to Campbell Island Teal conservation (Williams In press) but apply to several of the world's rarer waterfowl endemic to small islands (e.g. Andaman Teal *A. albogularis*, Laysan Duck *A. laysanensis*) and desecrated larger ones (e.g. Madagascar Teal *A. bernieri*, Brown Teal).

Subantarctic island waterfowl

But for the serendipitous survival of a tiny remnant population on the one islet too far from Campbell Island for rats to reach by swimming, the past existence of the Campbell Island Teal would have gone undetected. No bones have been found on Campbell Island and there are no writings to indicate the bird's former presence. Yet its existence could almost be predicted.

Small anatids are known from several subantarctic islands (Weller 1980), testimony to the dispersal abilities and generalised ecology of Anas ducks (Lack 1970). Descendants of successful island colonists have become smaller and darker than their continental forbears, have reduced flying ability, and have adopted a more sedentary and terrestrial lifestyle, the latter associated, in some instances, with some obvious skeletal modifications (Livezey 1990; Olson & Jouventin 1996).

Similar yet distinguishable small ducks exist on nearby subantarctic islands. The Crozet and Kerguelen archipelagos, about 1,000 km apart in the southern Indian Ocean, have their endemic pintails *A. (acuta) drygalskii* and *A. (acuta) eatoni* (Marchant & Higgins 1990) and, according to Stahl *et al.*(1984), isolation between different island populations within the same archipelago is common. Olson & Jouventin (1996) have suggested there is no reason to suppose that the extinct flightless Amsterdam Island Duck *A. marecula* was precisely the same as that thought to have occurred on St. Paul Island only 80 km away (Bourne *et al.* 1983). In the New Zealand region, differentiation of island forms has been extensive. Apart from the three teal presently recognised, the extinct Chatham Island form of *A. chlorotis* showed sufficient reduction in wing bone length to be separable from North Island, New Zealand specimens (P. Millener pers comm.) while Mathews (1937) presented a case for recognising South Island Brown Teal as a separate subspecies *peculiaris*.

Thus, had Campbell Island Teal failed to persist on Dent Island, an interpretation of teal distribution in the New Zealand region, and of ducks elsewhere in the subantarctic, could have led to the suggestion that Campbell Island had its own endemic anatid. It also begs the question of whether Macquarie Island also used to have its own race of teal.

Clearly, differentiation of distinguishable island "races" of teal in the New Zealand region has occurred rapidly. But how rapidly and by what routes are among the many scientific challenges posed and opportunities provided by the fortunate survival of this smallest of the Australasian teal.

The preparation of this review has been facilitated by many who have shared their subantarctic teal experiences with us. We particularly thank Ron Balham, John Cheyne, Andrew Garrick, Ron Goudswaard, Peter McClelland and Murray Willans in this regard. We also acknowledge Norm Judd's kindness in bringing details of the Marlborough whaler's experiences to our attention. Sue Anderson, Martin Bell, John Gill, Shaun O'Connor and Jeannie Preddey, all of whom have cared for the captive teal over the past decade, and Colin Miskelly, have freely shared information with us and it is a pleasure to record their contribution. We pay special respect to Rodney Russ, the late Gerry van Tets, Colin Meurk and Alex Black, skipper of m.v. Acheron, for their contributions on the 1975 expedition, and we acknowledge the various and numerous Wildlife Service, Department of Conservation and Royal New Zealand Navy personnel who have facilitated visits to Dent Island.

References

Adams, C.J. 1981. Migration of late Cenozoic volcanism in the South Island of New Zealand and the Campbell plateau. *Nature* 294:153-155.

Anon. 1983. *Management plan for the Campbell Islands nature reserve.* Management plan series NR13, Department of Lands and Survey, Wellington.

Armstrong, H. 1868. Official report on cruise of the Brig *Amherst. New Zealand Government Gazette, Province of Southland.* 11 April 1868, Vol. 6, No. 9.

Bailey, A.M. & Sorensen, J.H. 1962. *Subantarctic Campbell Island.* Denver Museum of Natural History Proceedings 10. 305 pp.

Bourne, W.R.P., David, A.C.F. & Jouanin, C. 1983. Probable Garganey on St. Paul and Amsterdam Islands, Indian Ocean. *Wildfowl* 34:127-129.

Buller, W.L. 1905. *Supplement to the Birds of New Zealand.* 2 vols. Privately published, London.

Cheyne, J. 1984. *Capture of Campbell Island Teal and Auckland Islands Teal for captive breeding at the National Wildlife Centre. Wildlife Service file 33/5/74.* Lodged with National Archives, Wellington. Accession no. W3832.

Delacour, J. 1956. *Waterfowl of the world. Vol.II.* Country Life, London.

Delacour, J. & Mayr, E. 1945. The family Anatidae. *Wilson Bulletin* 57:3-55.

Dilks, P.J. 1979. Observations on the food of feral cats on Campbell Island. *N.Z. Jl. Ecol.* 2:64-66.

Dilks, P.J. & Wilson, P.R. 1979. Feral sheep and cattle and royal albatrosses on Campbell Island: population trends and habitat changes. *N.Z. Jl. Zoo.* 6:127-139.

Dumbell, G.S. 1986. The New Zealand Brown Teal: 1895-1985. *Wildfowl* 37:71-87.

Falla, R.A. 1953. The Australian element in the avifauna of New Zealand. *Emu* 53:36-46.

Falla, R.A. & Stead, E.F. 1938. The plumages of *Nesonetta aucklandica* Gray. *Trans. Roy. Soc. N.Z.* 68:37-39

Filhol, H. 1885. Oiseaux. In: *Mission de L'ile Campbell.* Acadamie de France, Paris. Pp. 35-64

Fleming, C.A. 1953. *Checklist of New Zealand birds.* A.H. & A.W. Reed, Wellington.

Fleming, J.H. 1935. A new genus and species of flightless duck from Campbell Island. *Occasional papers of the Royal Ontario Museum of Zoology*, No.1.

Fleming, J.H. 1938. Letters: A new genus and species of flightless duck from Campbell Island. *Ibis*, ser 14,II:590-1.

Foggo, M.N. & Meurk, C.D. 1983. A bioassay of some Campbell Island soils, *N.Z. Jl. Ecol.* 6:121-124.

Fraser, C. 1986. *Beyond the roaring forties.* Government Printing Office, Wellington, 214pp.

Goudswaard, R. 1991. The search for the Campbell Island Flightless Teal *Anas aucklandica nesiotis. Wildfowl* 42:145-148.

Gray, G.R. 1844. Birds of New Zealand. In *Zoology of the voyage of HMS Erebus & Terror, under the command of Capt. James Clark Ross, RN,FRS during the years 1839 to 1843.* The Admiralty, London. Pp 1-20.

Gurr, L. 1947. Measurements of birds. *Notornis* 2:57-61.

Kerr, I.S. 1976. *Campbell Island: a history.* A.H. & A.W. Reed, Wellington, 182 pp.

Kerr, I.S. & Judd, N. 1978. *Marlborough whalers at Campbell Island 1909 - 1916.* Department of Lands & Survey, Wellington. 76 pp.

Kinsky, F.C. 1969. New and rare birds on Campbell Island. *Notornis* 16:225-236.

Kinsky, F.C. 1970. *Annotated checklist of the birds of New Zealand.* A.H. & A.W. Reed, Wellington.

Lack, D. 1970. The endemic ducks of remote islands. *Wildfowl* 21:5-10.

Larson, J.S. & Taber, R.D. 1980. Criteria of sex and age. In: S.D. Schemnitz (Ed.). *Wildlife management techniques manual.* The Wildlife Society Inc. Pp. 143-202.

Livezey, B.C. 1990. Evolutionary morphology of flightlessness in the Auckland Islands Teal. *Condor* 92:639-673.

McClelland, P. 1991. *Teal: a report on the capture of Campbell Island Teal on Dent Island.* Unpublished report, file BIR009, Southland Conservancy, Department of Conservation, Invercargill. 8 pp + map.

McClelland, P. 1993. *Subantarctic teal recovery plan.* Threatened Species Recovery Plan No. 7, Department of Conservation, Wellington.

McKinney, D.F. 1965. Comfort movements of the Anatidae. *Behaviour* 25:120-220.

Marchant, S. & Higgins, P.J. (Eds). 1990. *Handbook of Australian, New Zealand and Antarctic birds.* Vol.1. Part B. Oxford University Press, Melbourne.

Marples, B.J. 1946. List of the birds of New Zealand. *New Zealand Bird Notes* 1:i-vii (supplement).

Mathews, G.M. 1936. *Supplement to the birds of Norfolk and Lord Howe Islands, to which is added those birds of New Zealand not figured by Buller.* Witherby & Co., London.

Mathews, G.M. 1937. Notes on New Zealand ducks. *Emu* 37:31-32.

Meurk, C.D., Foggo, M.N., & Wilson, J.B. 1994. The vegetation of subantarctic Campbell Island. *N.Z. Jl. Ecol.* 18(2):123-168.

Olson, S.L. & Jouventin, P. 1996. A new species of small flightless duck from Amsterdam Island, southern Indian Ocean (Anatidae:*Anas*). *Condor* 98:1-9.

Plunket, Lord. 1912. The outlying islands of New Zealand. *United Empire*, London, January 1912, Pp.18-25.

Preddey, J. 1995a. Campbell Island Teal *Anas aucklandica nesiotis* bred in captivity. *Wildfowl* 46:69-71.

Preddey, J. 1995b. *The behaviour of the Campbell Island Teal Anas aucklandica nesiotis in captivity at Mt Bruce.* Unpublished M.A. thesis, Victoria University of Wellington.

Reischek, A. 1889. A note on the islands to the south of New Zealand. *Trans. N.Z. Inst.* 21:384-5.

Robertson, C.J.R. 1976. The Campbell Island Teal. *Wildlife - a review* 7:45-46 (New Zealand Wildlife Service, Wellington).

Robertson, C.J.R. 1980. Birds on Campbell Island. In: *Preliminary reports of the Campbell Island expedition 1975-76.* Reserve Series No.7. Department of Lands & Survey, Wellington. Pp.106-109.

Robertson, C.J.R. (Ed.). 1985. *Reader's Digest Book of New Zealand Birds.* Reader's Digest Pty Ltd., Surrey Hills.

Ross, J.C. 1847. *A voyage of discovery and research in the southern and antarctic regions during the years 1839-43.* London, John Murray.

Salvadori, T. 1895. *Catalogue of the birds of the British Museum*, London: 27:287-90.

Sorensen, J.H. 1955. Ecology of the subantarctic islands: Botanical factors. *Proc. N.Z. Ecol. Soc.* 2:17-18.

Stahl, J.C., Mougin, J.L., Jouventin, P. & Weimerskirch, H. 1984. Le canard d'eaton *Anas eatoni drygalskii* des iles Crozet: Systématique, comportement alimentair et biologie de reproduction. *Le Gerfaut* 74:305-326.

Stead, E.F. 1938. The supposed flightless duck from Campbell Island. *Trans. Roy. Soc. N.Z.* 68:100-1.

Smythe, F.B. 1975. *Naturalists color chart.* American Museum of Natural History, New York.

Taylor, G.A. 1986. *The ecology of Norway Rats on Campbell Island.*, Unpublished report, DSIR Ecology Division, Nelson. 174 pp.

Taylor, R.H., Bell, B.D., & Wilson, P.R. 1970. Royal albatross, feral sheep and cattle on Campbell Island. *N.Z. Jl. Sci.* 13:78-88.

Turbott, E.G. 1968. *Buller's Birds of New Zealand.* Whitcombe & Tombs, Wellington.

Turbott, E.G. 1990. *Checklist of the birds of New Zealand.* Random Century, Auckland.

van Tets, G.F. 1974. A revision of the fossil Megapodiidae (Aves), including a description of a new species of *Progura* De Vis. *Trans. Roy. Soc. S. Austr.* 98:213-224.

van Tets, G.F. 1980. Bird bones collected at Campbell Island. In: *Preliminary reports of the Campbell Island expedition 1975-76.* Reserve Series No.7. Department of Lands & Survey, Wellington. Pp. 120-1.

Waite, E.R. 1909. Vertebrata of the subantarctic islands of New Zealand. In: Chilton, C. (Ed.) *The subantarctic islands of New Zealand.* Vol. II. Philosphical Institute of Canterbury, Christchurch. Pp. 542-600.

Weller, M.W. 1975. Ecological studies of the Auckland Islands Flightless Teal. *Auk* 92:280-297.

Weller, M.W. 1980. *The island waterfowl.* Iowa State University Press, Ames.

Westerskov, K. 1960. *Birds of Campbell Island.* Department of Internal Affairs, Wellington. 83 pp.

Williams, M. 1986. The numbers of Auckland Islands Teal. *Wildfowl* 37:63-70.

Williams, M. 1995. Social structure, dispersion and breeding of Auckland Islands Teal. *Notornis* 42:219-262.

Williams, M. In press. Conservation dilemmas with island waterfowl: a perspective based on the New Zealand experience. *Gibier Faune Sauvage - Game and Wildlife.*

Williams, M. & Garrick, A. 1984. *The status of Campbell Island Teal on Dent Island: a report from the 1984 Campbell Island expedition.* Unpublished report, N.Z. Wildlife Service file 33/5/74. Lodged with National Archives, Wellington. Accession no. W3832.

Williams, M., McKinney, F. & Norman, F.I. 1991. Ecological and behavioural responses of Austral teal to island life. *Acta XX Congressus Internationalis Ornithologici*: 876-884.

Wilson, P.R. & Orwin, D.H. 1964. The sheep population of Campbell Island. *N.Z. Jl. Sci.* 1:460-90.

Murray Williams and **Christopher J.R.Robertson**, Department of Conservation, P.O.Box 10-420, Wellington, New Zealand.

APPENDIX 1: Weights and measurements of Campbell Island Teal

This Appendix provides a comparison of standard measurements and weights of live specimens of the four brown-plumaged Australasian teal, Chestnut Teal from Victoria in southern Australia, Brown Teal from Northland and Great Barrier Island, New Zealand, Auckland Islands Teal from Enderby, Ewing and Rose Islands, Auckland Islands and Campbell Island Teal. In addition we provide a comparison of measurements derived from dried museum specimens of the four species.

The number of wild Campbell Island Teal handled, weighed and measured to date are few: 11 males and five females. Records for all of these birds are provided.

Live birds

External measurements (mm) of wild, live brown-plumaged Australasian teal are presented according to sex (m=male, f=female). Measurements of *A. castanea* provided by F.I. Norman, those of *chlorotis* and *aucklandica* made by MJW. See below for details of origin of *nesiotis* measurements. Weights (g) are given as "breeding" (br) when collected during the breeding season, and "non-breeding" (nb) when collected outside of main breeding period (mostly obtained February-May); those for *castanea* are all from March. All data are presented as mean ± standard deviation, sample size.

		castanea	*chlorotis*	*aucklandica*	*nesiotis*
Bill length	m	40.5±1.3,41	42.9±1.6,49	39.7±1.3,33	38.1±0.9,7
	f	38.1±1.5,43	39.8±2.0,39	36.6±1.0,30	34.4±1.1,5
Tarsus	m	47.7±1.7,41	41.4±2.1,47	36.3±0.9,33	34.0±1.6,7
	f	45.3±1.9,44	38.7±1.9,21	33.4±1.1,30	31.1±1.2,5
Mid toe & claw	m	48.1±2.3,41	52.3±1.8,42	56.2±2.8,18	51.0±2.0,3
	f	45.3±2.0,44	49.6±2.0,25	51.3±2.8,11	46.6,2
Wing	m	225±5.6,40	202±6.2,38	141±6.7,21	132±3.6,7
	f	212±8.6,43	189±4.5,37	126±5.0,23	118±4.6,5
Tail	m	no data	92±5.6,37	77±7.7,25	89±7.6,7
	f		81±4.6,26	68±8.9,21	72±2.6,4
Weight br	m		719±59,57	560±31,11	
nb	m	627±46,41	653±49,60	551±38,33	371±56,9
br	ff		697±88,44	478±34,9	
nb		541±49,43	634±77,38	409±32,30	301±38,5

Museum specimens

External measurements (mm) of museum specimens of brown-plumaged Australasian teal are presented according to sex (m=male, f=female). Data are from Livezey (1990, Table 1) and presented as mean ± standard deviation, sample size. Note that our measurements for the same two *nesiotis* specimens (ROM 35406 and NMNZ 14752) are listed below and tail and tarsus measurements differ from Livezey's.

		castanea	*chlorotis*	*aucklandica*	*nesiotis*
Bill	m	41.5±2.0,78	43.3±1.9,58	39.8±1.3,74	36.0,2
	f	39.3±1.7,21	40.4±1.7,47	37.0±1.5,47	
Tarsus	m	39.9±2.2,81	41.5±1.9,59	36.0±1.9,74	33.5,2
	f	38.9±1.7,21	39.6±1.6,50	33.9±1.6,48	
Middle toe	m	42.8±2.3,81	43.7±1.8,58	43.7±1.9,74	41.0,2
	f	41.3±2.8,21	41.7±2.3,49	41.0±2.1,48	
Wing	m	212±6.6,80	200±6.6,57	137±7.2,74	127,2
	f	200±7.2,20	186±6.6,57	123±31,50	
Tail	m	86.0±6.6,80	88.6±7.5,57	80.7±12.7,73	69.0,2
	f	81.0±6.2,21	78.8±7.6,50	66.1±8.4,48	

APPENDIX 1: Weights and measurements of Campbell Island Teal

This Appendix provides a comparison of standard measurements and weights of live specimens of the four brown-plumaged Australasian teal, Chestnut Teal from Victoria in southern Australia, Brown Teal from Northland and Great Barrier Island, New Zealand, Auckland Islands Teal from Enderby, Ewing and Rose Islands, Auckland Islands and Campbell Island Teal. In addition we provide a comparison of measurements derived from dried museum specimens of the four species.

The number of wild Campbell Island Teal handled, weighed and measured to date are few: 11 males and five females. Records for all of these birds are provided.

Live birds

External measurements (mm) of wild, live brown-plumaged Australasian teal are presented according to sex (m=male, f=female). Measurements of *A. castanea* provided by F.I. Norman, those of *chlorotis* and *aucklandica* made by MJW. See below for details of origin of *nesiotis* measurements. Weights (g) are given as "breeding" (br) when collected during the breeding season, and "non-breeding" (nb) when collected outside of main breeding period (mostly obtained February-May); those for *castanea* are all from March. All data are presented as mean ± standard deviation, sample size.

		castanea	*chlorotis*	*aucklandica*	*nesiotis*
Bill length	m	40.5±1.3,41	42.9±1.6,49	39.7±1.3,33	38.1±0.9,7
	f	38.1±1.5,43	39.8±2.0,39	36.6±1.0,30	34.4±1.1,5
Tarsus	m	47.7±1.7,41	41.4±2.1,47	36.3±0.9,33	34.0±1.6,7
	f	45.3±1.9,44	38.7±1.9,21	33.4±1.1,30	31.1±1.2,5
Mid toe & claw	m	48.1±2.3,41	52.3±1.8,42	56.2±2.8,18	51.0±2.0,3
	f	45.3±2.0,44	49.6±2.0,25	51.3±2.8,11	46.6,2
Wing	m	225±5.6,40	202±6.2,38	141±6.7,21	132±3.6,7
	f	212±8.6,43	189±4.5,37	126±5.0,23	118±4.6,5
Tail	m	no data	92±5.6,37	77±7.7,25	89±7.6,7
	f		81±4.6,26	68±8.9,21	72±2.6,4
Weight br	m		719±59,57	560±31,11	
nb	m	627±46,41	653±49,60	551±38,33	371±56,9
br	ff		697±88,44	478±34,9	
nb		541±49,43	634±77,38	409±32,30	301±38,5

Museum specimens

External measurements (mm) of museum specimens of brown-plumaged Australasian teal are presented according to sex (m=male, f=female). Data are from Livezey (1990, Table 1) and presented as mean ± standard deviation, sample size. Note that our measurements for the same two *nesiotis* specimens (ROM 35406 and NMNZ 14752) are listed below and tail and tarsus measurements differ from Livezey's.

		castanea	*chlorotis*	*aucklandica*	*nesiotis*
Bill	m	41.5±2.0,78	43.3±1.9,58	39.8±1.3,74	36.0,2
	f	39.3±1.7,21	40.4±1.7,47	37.0±1.5,47	
Tarsus	m	39.9±2.2,81	41.5±1.9,59	36.0±1.9,74	33.5,2
	f	38.9±1.7,21	39.6±1.6,50	33.9±1.6,48	
Middle toe	m	42.8±2.3,81	43.7±1.8,58	43.7±1.9,74	41.0,2
	f	41.3±2.8,21	41.7±2.3,49	41.0±2.1,48	
Wing	m	212±6.6,80	200±6.6,57	137±7.2,74	127,2
	f	200±7.2,20	186±6.6,57	123±31,50	
Tail	m	86.0±6.6,80	88.6±7.5,57	80.7±12.7,73	69.0,2
	f	81.0±6.2,21	78.8±7.6,50	66.1±8.4,48	

All wild Campbell Island Teal handled up to May 1996.

Individual teal are identified by leg band number (for those captured and held in aviaries; records kept by the New Zealand Bird Banding Office, Wellington), or by their later museum specimen number. Data from live birds were obtained under field conditions (on Dent Island or in captivity) using vernier callipers for measurement (mm) and 0-1000 g spring balance for weights (g). Bill measurements are listed sequentially as length (of exposed culmen), width (at base) and depth (at base) but where only one figure is given it refers to length. Abbreviations are Ta (tarsus), MT&C (mid toe and claw), Wg (wing), Tl (tail) and Wt (weight). All linear measurements of live birds were made by MJW (except those of the 1975 female (by CJRR) and those dated 10.5.1995 (by C.Miskelly)), of museum specimens by CJRR, and all follow the method of Gurr (1947). Where ages are given at capture, they were determined by cloacal examination (Larson & Taber 1980). Weights recorded as x hours after capture indicate the bird was held in confinement without food or water for the stated time during which interval they were transported from Dent Island to Campbell Island.

The statistical summary given above comprised measurements of wild-caught birds only and used the initial set of measurements given for each bird below. Where more than one set of measurements is given for an individual bird, data from 10.5.1995 were excluded, and the mean of other measurements used in the summary calculation. Only field weights were used.

Live birds

(i) Males

Band S-44043: *Bill* 39.6, 15.0, 16.8; *Ta* 32.6; *MT&C* 49.0; *Wg* 132; *Tl* 77; *Wt* 500. *Comment:* Weight at capture (21.6.1984), measurements (4.2.1986). Wing and tail measured 15.6.1992 as 133 and 96 resp. Subsequent captive weights: 550 (4.7.1984), 660 (28.7.1984), 570 (3.9.1984), 420 (4.2.1986). Adult at capture. Died October 1989. Skin lodged as specimen NMNZ 24051, skeleton as NMNZ 24051/1.

Band S-44044/S-48600: *Bill* 37.9, 15.6, 16.8; *Ta* 35.3; *MT&C* 53.0; *Wg* 128; *Tl* 76; *Wt* 400. *Comment:* Weight at capture (21.6.1984), measurements (4.2.1986). Also measured 3.5.1985 and (10.5.1995) - *Bill* 37.7 (37.4), *Ta* 34.8 (33.2), *Wg* (132), *Tl* 76 (78). Captive weights: 590 (4.7.1984), 640 (28.7.1984), 540 (3.9.1984), 490 (4.2.1986), 590 (10.5.1995). Juvenile at capture.

Band S-44045: *Bill* 36.6, 15.4, 17.1; *Ta* 33.5; *MT&C* 51.0; *Wg* 130; *Tl* 80 (worn); *Wt* 380. *Comment:* Weight 5 hrs after capture (13.2.1984), measurements (4.2.1986). Also measured 22.3.1984 and (10.5.1995) - *Bill* 37.2 (34.8), 15.3, - ; *Ta* 33.7 (33.8); *Wg* 124 (137); *Tl* 90 (86). Captive weights 420 (13.3.1984), 490 (25.6.84), 400 (6.9.1984), 490 (4.2.1986), 494 (10.5.1995). Adult at capture.

Band S-71043: *Bill* 38.8, 15.9, -; *Ta* 37.0; *Wg* 133; *Tl* 96; *Wt* 340. *Comment:* Weight at capture (17.10.1990), measurements (15.6.1992). Also measured 10.5.1995 - *Bill* 36.3; *Ta* 33.1; *Wg* 132; *Tl* 91. Captive weights 410 (26.10.90), 385 (12.11.1990), 525 (15.6.1992), 586 (10.5.1995). In adult breeding plumage at capture.

Band S-71044: *Bill* 37.7; *Ta* 32.2; *Wg* 132; *Tl* 96, *Wt* 325. *Comment:* Weight at capture (5.11.1990), measurements 10.5.95. Captive weight 600 (10.5.1995). Dull plumage at capture.

Band S-71045: *Bill* 38.3, 16.1, -: *Ta* 34.0; *Wg* 133; *Tl* 96; *Wt* 290. *Comment:* Weight 3 hrs after capture (16.10.1990), measurements (15.6.1992). Also measured 10.5.1995 - *Bill* 37.7; *Ta* 32.7; *Wg* 131; *Tl* 89. Captive weights 355 (16.10.1990), 385 (12.11.1990), 525 (15.6.1992), 625 (10.5.1995). In adult breeding plumage at capture.

Band S-71035/S-48565: *Bill* 37.8; *Ta* 33.8; *Wg* 138; *Tl* 91; *Wt* 385. *Comments:* Weight at capture (15.11.1990), measurements 10.5.1995. Captive weight 539 (10.5.1995). Dull breeding plumage at capture.

Band S-71030: *Wt* 350 at capture. Dull dark plumage. Sexed by plumage and call. Released on Dent Island.

Unbanded: *Wt* 370 at capture (15.11.1990). Released on Dent Island. Sexed by plumage.

Captive-raised. Band S-48570: *Bill* 38.9; *Ta* 33.7; *Wg* 133; *Tl* 90; *Wt* 522. *Comments*: Weight and measurements 10.5.1995. Hatched November 1994.
Captive-raised. Band S-48594: *Bill* 38.8; *Ta* 34.4; *Wg* 138; *Tl* 60 (not fully grown); *Wt* 476. *Comments:* Weight and measurements 10.5.1995. Hatched January 1995.

Captive-raised. Band S-48595: *Bill* 35.5; *Ta* 32.0; *Wg* 117 (not fully grown); *Tl* 50 (not fully grown); *Wt* 564. *Comments:* Weights and measurements 10.5.1995. Hatched January 1995.

(ii) Females

Unbanded 1975: *Bill* 33.4, 14.1, -; *Ta* 29.8; *MT&C* 47.5; *Wg* 116; *Tl* 63 (worn); *Wt* 268. *Comment:* weight and measurement 4 hrs after capture (12.11.1975); Weight 244g after 24 hrs confinement with access to food and water. Released on Dent Island.

Band S-44042: *Bill* 34.1, 14.4, 14.6; *Ta* 30.5; *MT&C* 45.1; *Wg* 114; *Ta* 68; *Wt* 365. *Comment:* Weight at capture (21.6.1984), measurements (4.2.1986). Also measured at death (6.2.1991) - *Bill* 33.4, 14.0, 15.0; *Ta* 29.5; *MT&C* 46.3, *Wg* 113,Tl 68. Captive weights 460 (4.7.1984), 540 (28.7.1984), 480 (3.9.1984), 330 (4.2.1986). Juvenile at capture. Lodged as specimen NMNZ 24826/1 (wing) and 24826 (skeleton)

Band S-71038/S-48569: *Bill* 35.4, 15.0,-. *Ta* 32.2, *Wg* 119, *Tl* 71, *Wt* 305. *Comment:* Weight 6 hours after capture (5.11.1990), measurements 15.6.1992. Also measured 10.5.1995 - *Bill* 35.5; *Ta* 31.9; *Wg* 122; *Tl* 82. Captive weights 380 (15.6.1992), 428 (10.5.1995). Not aged at capture.

Band S-71047: *Bill* 35.9, 15.6, -. *Ta* 32.4, *Wg* 125, *Tl* 74, *Wt* 280. *Comment:* Weight 5 hrs after capture (16.10.1990), measurements (15.6.1992). Also measured 10.5.1995 - *Bill* 34.3; *Ta* 31.4; *Wg* 119; *Tl* 79. Captive weights 345 20.10.1990), 430 (15.6.1992), 500 (10.5.1995). Prior to egg-laying on 8.10.1994, weights were 506 (5 Aug.), 525 (2 Sept.), 560 (16 Sept.) and 645 (30 Sept.). Not aged at capture.

Band S-48564: *Bill* 34.1; *Ta* 31.1; *Wg* 114; *Tl* 73; *Wt* 290. *Comments:* Weight 2 hrs after capture (17.11.1990), measurements 10.5.1995. Captive weights 410 (19.7.1991), 515 (5.8.1994), 500 (10.5.1995). Not aged at capture

Captive-raised. Band S-48571: *Bill* 36.5; *Ta* 34.0; *Wg* 122; *Tl* 82; *Wt* 464. *Comments:* Weight and measurements 10.5.1995. Hatched November 1994.

Museum specimens.

ROM 35406 (Type specimen), male: *Bill* 35.0, 12.0, -; *Ta* 30.0; *MT&C* 46.0; *Wg* 133 (right),127 (left); *Tl* 64 (worn).

NMNZ 14752, male: *Bill* 36.5,12.5,-; *Ta* 33.0; *MT&C* 54.0; *Wg* 126; *Tl* 77; *Wt* 15 oz(420g). *Comment:* Weight presumed taken on day of death (29.5.1944). Measurements of specimen given in Marchant and Higgins (1990) are: *Bill* 36.7, *Ta* 32.8, *MT* 48.1, *Wg* 128, *Tl* 78, while those on the specimen's label are *Bill* 38, 15, -; *Ta* 33; *MT&C* 55; *Wg* 126; *Tl* 77.

APPENDIX 2: Comparative osteology of Australasian Teals. Contributed in 1979 by the late G. F. van Tets, Division of Wildlife Ecology, CSIRO, Lyneham, ACT, Australia.

When Campbell Island Teal were encountered on Dent Island in November 1975, a skull and five incomplete post-cranial skeletons of the teal were found in middens of Brown (Subantarctic) Skua. This skeletal material (now lodged as NMNZ 18953-7, 19170) was compared with that of *A. nesiotis, A. aucklandica, A. chlorotis* and *A. castanea* in the collections of: Canterbury Museum, Christchurch (CM); CSIRO-Wildlife, Canberra (CS); National Museum of Victoria, Melbourne (NMV); Royal Ontario Museum, Toronto (ROM); National Museum of New Zealand, Wellington (NMNZ); and Tasmanian Museum, Hobart (TM). The material included X-ray photographs of the residual bones in the (then) only two skin specimens of *nesiotis* and in three skins of *chlorotis*. Bones were measured as illustrated in van Tets (1974). The length of the maxilla was measured from the tip to the fronto-nasal hinge and to the front of the nasal opening. The cranium was measured from the fronto-nasal hinge to the back of the skull. Sample sizes were limited by the incompleteness of many of the skeletons (skins contained only skulls and distal wing and leg bones). Bones of the following specimens were measured:

nesiotis skins: ROM.35406(type), NMNZ 14752
skeleton: NMNZ.18953-57, 19170
aucklandica skeleton: CM.AV.5172,5445-49,5802,27279-80, CS.BS.1477-83, NMNZ.885,901-2,15907,17613-14,17620
chlorotis skins: TM.2133-4,6
skeleton: NMNZ.14978,15628,15935,18898
castanea skeleton: CS.BS.1460, NMV.B.5015,10385-5, NMV.W.5347-50,4843

The reader is referred to Livezey (1990, Table 5) for a similar comparative analysis. However, we draw attention to substantial differences in recorded lengths of some bones e.g. coracoid, presumably resulting from different methods of measurement. The tabulation below presents the range of lengths (mm), sample size. Measurements are rounded to nearest millimetre. Sexes of sampled birds not recorded.

Bone/species	*castanea*	*chlorotis*	*aucklandica*	*nesiotis*
maxilla from hinge	35-44,3	39-43,7	34-41,8	35-36,3
maxilla from nares	24-31,9	27-30,4	22-26,8	22-25,2
cranium	45-54,9	47-52,7	43-48,8	44-46,2
coracoid	41-47,8	40-41,3	30-35,13	28-30,4
humerus	69-77,8	69-73,5	49-54,10	47-50,4
ulna	59-66,7	56-60,7	36-43,10	35-40,4
carpometacarpus	41-49,8	37-42,7	26-31,8	24-29,4
femur	39-44,7	43-44,4	40-46,7	39-42,4
tibiotarsus	69-77,8	72-78,7	65-75,8	68-71,5
tarsometatarsus	37-42,7	38-41,7	31-37,12	31-35,5
3 wing bones	**169-189,7**	**166-175,5**	**112-131,8**	**107,1**
3 leg bones	146-158,7	158-162,4	137-152,7	135-144,3

The table below records bone length ratios, sample size, of the four brown-plumaged Australasian Teal. Data are derived from the table above. Wing:leg ratio for *A.nesiotis* derived from wing bones of one specimen and leg bones of three others.

Bones/species	*castanea*	*chlorotis*	*aucklandica*	*nesiotis*
ulna:humerus	0.85-0.89,7	0.82-0.83,5	0.75-0.77,8	0.75,2
carpometacarpus:humerus	0.59-0.62,8	0.57-0.59,5	0.53-0.55,8	0.52,2
tibiotarsus:femur	1.71-1.77,7	1.73-1.77,4	1.63-1.71,7	1.64-1.65,3
tarsometatarsus:femur	0.88-0.94,6	0.93-0.94,4	0.77-0.82,7	0.81,3
humerus:femur	1.75-1.83,7	1.61-1.66,4	1.22-1.29,7	1.21-1.23,3
carpometacarpus: tarsometatarsus	1.14-1.21,7	0.98-1.06,7	0.83,0.88,7	0.82-0.83
3 wing bones:3 leg bones	1.12-1.23,7	1.05-1.08,4	0.80-0.86,7	0.74-0.79,3

APPENDIX 3: The botanical characteristics of Dent Island. Contributed in 1976 by C.D. Meurk, Landcare Research NZ Ltd, PO Box 40, Lincoln, New Zealand.

Six floristic associations are identifiable on the island, some of which are successionally related or exist in dynamic equilibrium with erosional forces and the disturbance of nesting seabirds. Above the fringe of writhing kelp, principally *Durvillaea antarctica*, are zones of smaller seaweeds, lichens and mosses, above which the vascular vegetation begins with a discontinuous band of the red-tinged *Tillaea moschata* cushions clinging to rocky crevices. Above this is an irregular ecotonal association of *Tillaea, Cotula plumosa* and small *Poa foliosa* plants which extend up to the tussock grasslands - established on peats up to 1 m deep and from about 5 m a.s.l.

For up to two-thirds of the island's altitude there are three main associations. In the gullies or furrows, recognisable from a distance by darker green vegetation, are mosaics of *P. foliosa* and various mixes of *Bulbinella rossi, Anisotome latifolia, Stilbocarpa polaris*, and young *P. foliosa*. The glaucous *P. foliosa* stands form reasonably dense, almost flattened looking sheets often without associated species. Although the tussock habitat is not well developed here, perhaps because of gentle slopes, there is some resemblance to the maritime tussock formations of Macquarie Island. The remaining association is of *P. hamiltoni* (and replaced by *P. ramossissima*) with *Bulbinella* and *Anisotome* elements added. Any of these species may form pure communities of a few square metres; *Bulbinella rossi* tends to become most important on more level ground.

The dominant species on the island is *Poa litorosa* which forms an almost pure tussock community over 1 m tall on the interfluves becoming continuous above this. Associated species include *Polystichum vestitium, Bulbinella rossi, Stellaria decipiens*, and occasionally, scattered individuals of most of the remaining recorded species (see below). Where there has been rejuvenation of the site due to bird nesting many of the following species may colonise: *P.ramossissima, Epilobium confertifolium, Acaena minor, Cotula plumosa, Marchantia heteroana*, bryophyte cushions, *Bulbinella rossi, Stellaria decipiens, Blechnum durium, Stilbocarpa polaris* seedlings and sometimes *Gentiana antarcticus* seedlings.

The relationship between the associations described appears to be the opening of vegetation and rejuvenation of soil by bird disturbance, slumping and/or slightly greater supply of nutrients from runoff enabling the various small herbs, bryophytes, and seedlings of the large herbs to establish which, if no further disturbance occurs, progresses through *P. foliosa* to a *P. litorosa* climax. The position of the scattered *Chionochloa antarctica* in these successions is uncertain but may be the ultimate climax.

The remaining association is confined to the exposed ridges and rocky summit ledges. The species involved are *Cardamine depressa var. stellata, Lycopodium varium, Hebe benthamii, Ranunculus pinguis, Gentiana antarcticus, Coprosma ciliata, Colobanthus muscorellia, Damnamenia vernicosa, Abrotanella rosulata* and *Stellaria decipiens*.

In view of the rather depauperate flora, with its notable absence of *Pleurophyllum* spp., *Carex* spp. and perhaps some cushion and mat herbs, it would seem that the flora of Dent Island is not a remnant from a true larger land mass previously continuous with the main island but has arisen by wind and bird dispersal perhaps after the original ancient flora had been decimated during the last glaciation. The *Poa foliosa* alliance is almost absent from Campbell Island indicating different conditions and different contending species for the niche it fills on both Dent and Macquarie Islands, and the (then) sheep predation on these most palatable species.

Species status list

I. *At low - mid altitude*

Chionocloa antarctica: scattered large tussocks to 120 cm tall most common at southeast end of island; mixed with *Poa foliosa*.
Poa litorosa: dominant on ridge crests at lower elevations and more or less continuous at higher elevations on more gentle slopes - also rock ledges. None taller than mainland, c 100-130 cm
Poa foliosa: dominant pure stands in fluves and gullies up to 100 cm tall. Has flattened appearance rather than tussock form. Not common above two-thirds altitude.
Hebe benthamii: flowering 13-18 November. Clumps in tussock openings c 50 cm across and to 30 cm tall; on exposed cliffs.
Polystichum vestitium: common with *P.litorosa*.
Lycopodium varium: scattered amongst tussock openings, more common on higher ridges.
Acaena minor: common throughout - both var. and exposure forms especially on old nest sites
Epilobium confertifolium: common throughout amongst tussocks and on old nest sites.
Marchantia berteroana: common throughout on old nest sites.

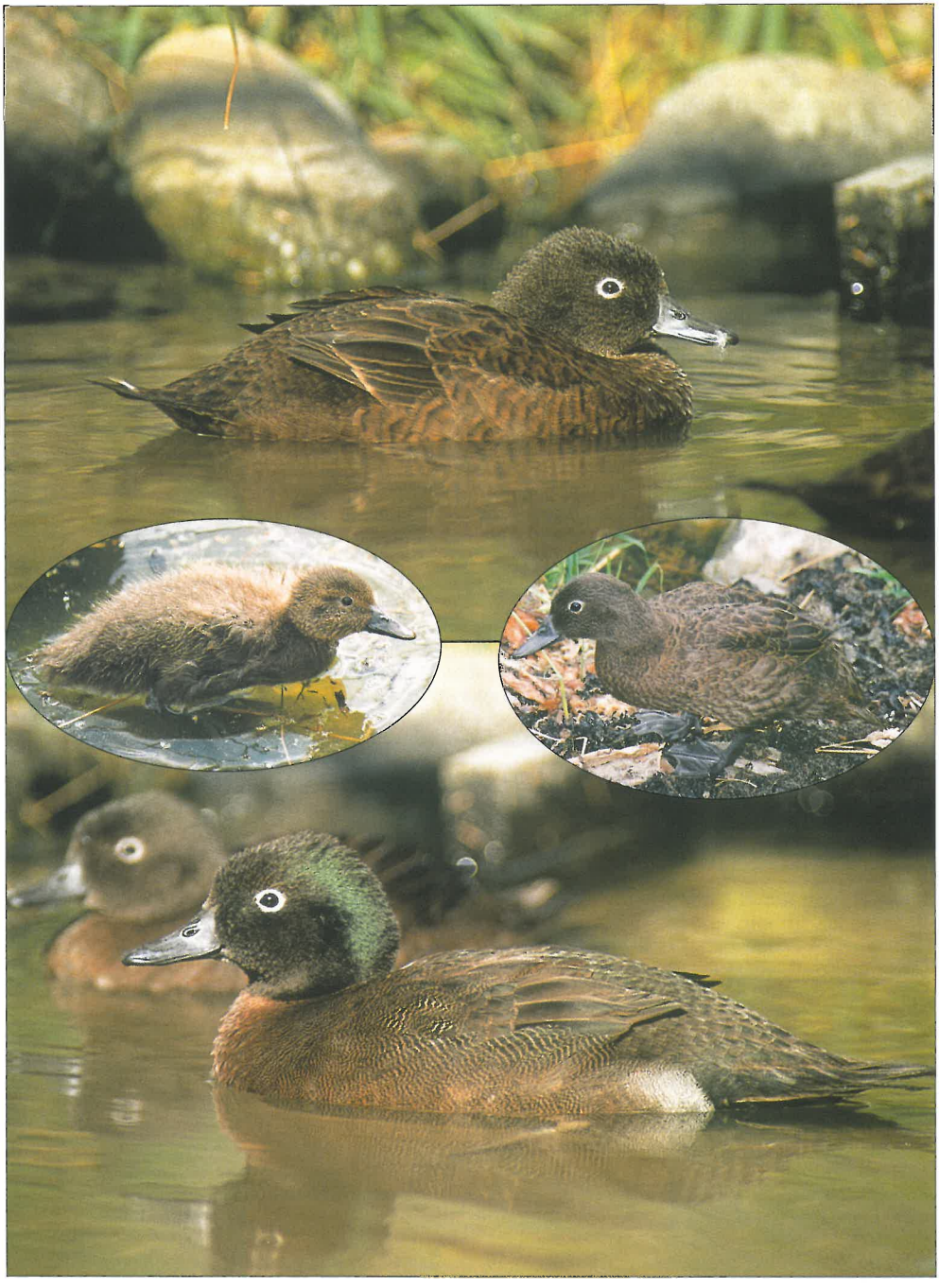
Stellaria decipiens: common as one of the few associated with dense tussock
Leafy liverwort: common throughout under tussocks on wet banks, in openings (old nests) and some large cushions.
Stilbocarpa polaris: common locally dominant in gullies up to 50 cm tall with *Bulbinella rossi.*
Tillaea moschata: common littoral rock species.

II. High altitude near exposed summit

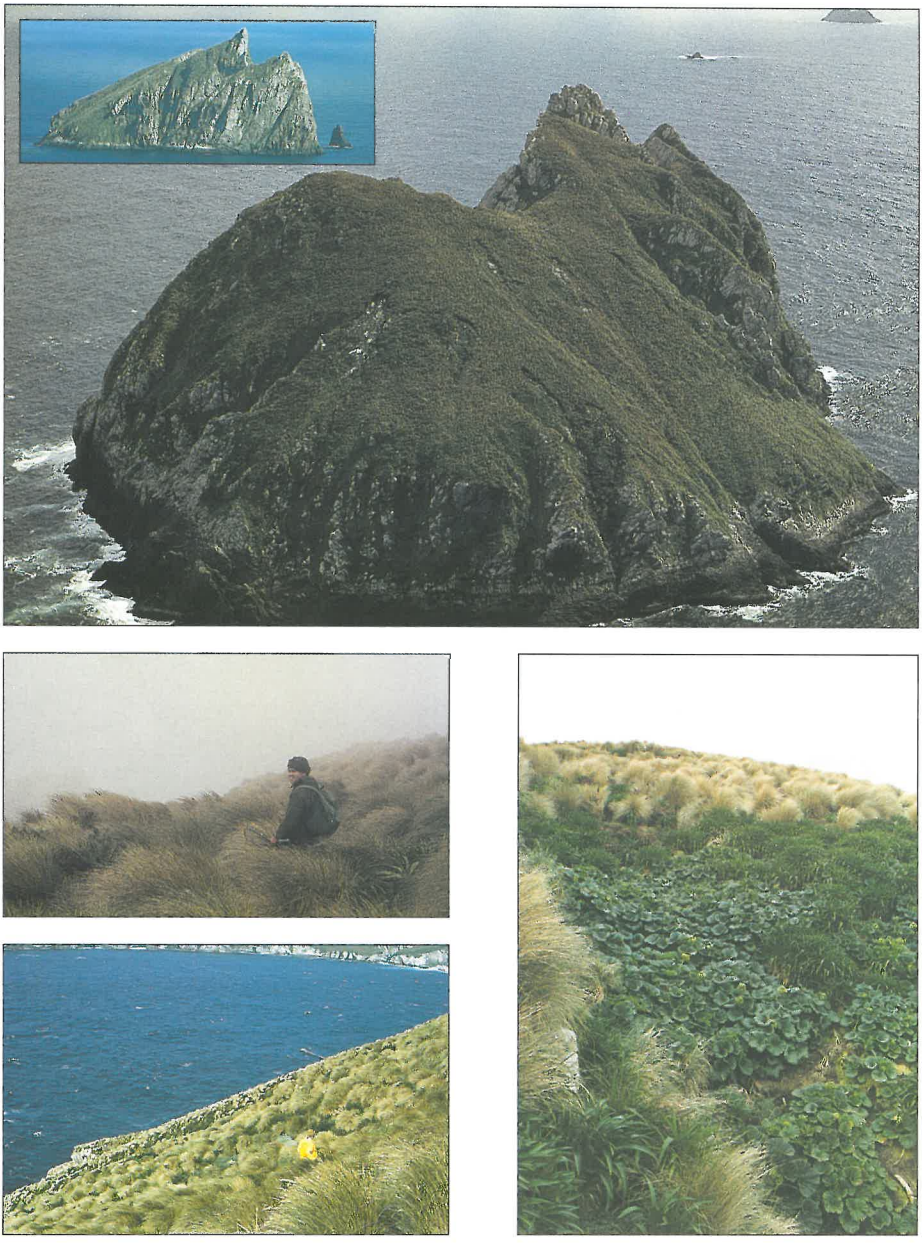
Bulbinella rossi: common throughout associated with *Poa litorosa* and *P. foliosa* on peaty ledges in gullies. Some pure stands.
Visula crinita: throughout, more common on exposed cliffs.
Ranunculus pinguis: scattered plants amongst summit rocks on bare peat.
Gentiana antarctica: mostly at higher elevations, particularly on bryophyte cushions.
Epilobium confertifolium: present.
Stellaria decipiens: present.
Trisetum spicatum: more or less confined to summit turfs on rock ledges.
Poa foliosa: occasional on exposed cliffs.
Poa litorosa: short.
Poa ramossissima (pro hamiltonii): common throughout often draped on peat banks & around old nest sites.
Damnamenia vernicosa: occasional on exposed cliffs.
Cardamine depressa var. *stellata*: common along summit ridges.
Colobanthus muscorelia: (small form) common along summit ridges. Also on littoral rocks.
Coprosma ciliata: a few depressed shrubs on summit ridges.
Coprosma cuneata: one bush seen in upper *Poa litorosa.*
Anisotome latifolia: common throughout and more particularly co-dominant with *Bulbinella rossi* and *Stilbocarpa polaris* on rock ledges.
Blechnum durium: scattered throughout openings in tussock - not common.
Abrotanella rosulata: a few plants amongst summit rocks.
Uncinia hookeri: some patches on bryophyte cushions - not common.
Scirpus aucklandicus: occasional small populations on bryophyte cushions.

APPENDIX 4: Birds recorded on Dent Island. Data are from November 1975 (Robertson 1980) and February 1984 (M. Williams & A. Garrick).

White-chinned Petrel *Procellaria aequinoctialis*: breeding, burrows most commonly encountered in wet sites in the gullies.
Sooty Shearwater *Puffinus griseus*: breeding, extremely abundant, nests all over tussock slopes.In burrows but without eggs in Nov., Dec.
Subantarctic Diving Petrel *Pelecanoides urinatrix exsul*: breeding, burrows encountered in tussock bases on lower half of island.
Grey-backed Storm Petrel *Garrodia nereis*: one caught Feb., breeding not confirmed. Not encountered Nov.,Dec.
Brown (Subantarctic) Skua *Catharacta skua lonnbergi*: breeding, 12 pairs counted Feb.; seen flying to main island to forage there, active hunting of petrels at night. Middens contained bones of all four petrels listed above plus Black-bellied Storm Petrel *Fregetta tropica*, Campbell Island Teal, Norway Rat, sheep wool, seal fur, egg shell, and Rockhopper Penguin feathers in regurgitations (van Tets 1980 (1975 material); M J Imber pers comm (1990 material)).
Light-mantled Sooty Albatross *Phoebetria palpebrata*: breeding, mostly at northern and southern end of the island.
Campbell Island Shag *Leucocarbo c.campbelli*: breeding, scattered pairs on lower ledges.
Campbell Island Teal *Anas nesiotis*: breeding presumed, more frequently encountered in gullies than on tussock slopes.
Starling *Sturnus vulgaris*: occasional small (5 - 10) flocks on bared slips and amongst lower rocks and ledges. Breeding not confirmed.
Dunnock *Prunella modularis occidentalis*: several birds seen feeding on island, at both lower and upper elevations (Feb.).
New Zealand Pipit *Anthus novaeseelandiae aucklandicus*: breeding, common all over island.

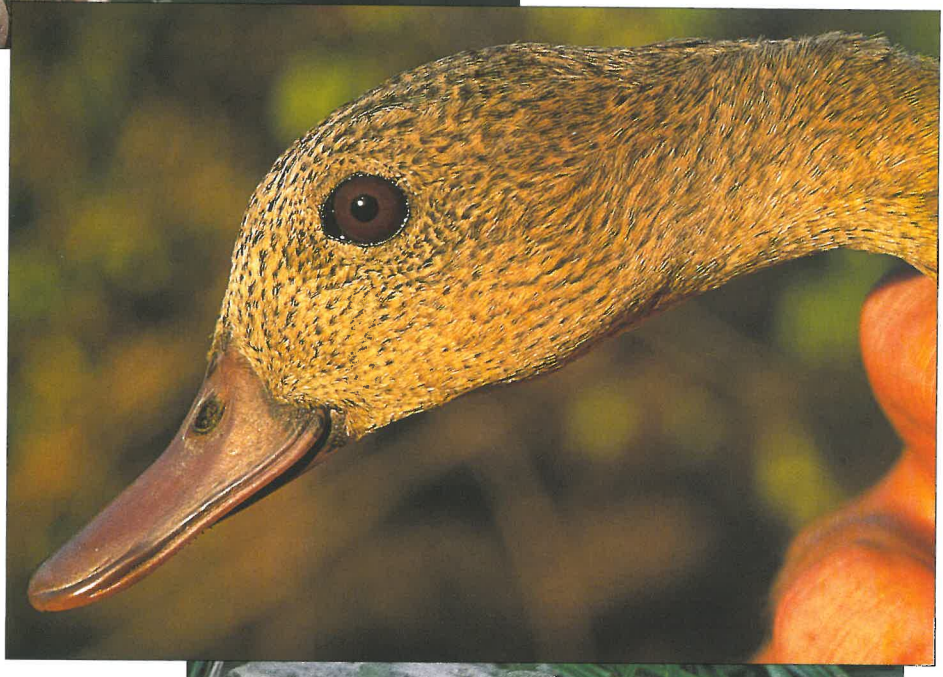


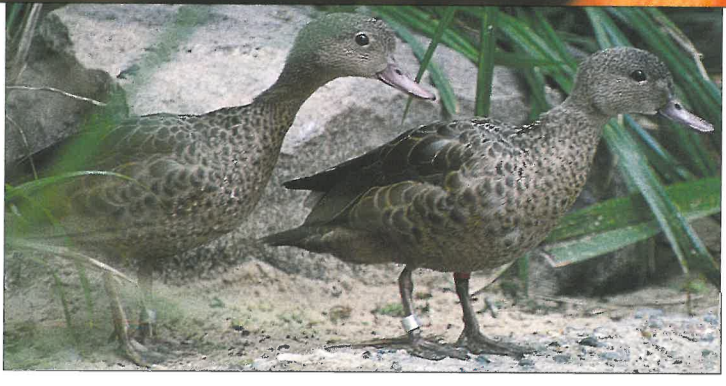
Colour plate 1. Campbell Island Teal: Upper - female in breeding plumage (photo G Norman); Lower - male in breeding plumage (photo G Norman); Insets - Downy duckling (photo H G Young) and juvenile (photo M Williams).



Colour plate 2. Views of Dent Island: Upper left - Dent Island viewed from Campbell Island and showing the 'tooth' shape that gives the island its name (photo CJR Robertson); Upper - aerial oblique view of Dent Island showing the vegetated southeastern face of the island in 1984. The 1976 erosion scars are clearly visible (photo M Williams); Lower left - The upper slopes of Dent Island are mostly covered with dense stands of tall *Poa litorosa* (photos M Williams); Lower right - *Stilbocarpa polaris* and other megaherbs in the seepage channels, apparently the preferred habitat of Campbell Island Teal (photo Ron Goudswaard).

Colour plate 3. Holocene Wildfowl. Alopchen *(Mascarenechen)* Kervazoi with Grey Teal *(Anas theodori)* from Reunion Island, Mascarenes.





Colour plate 4. Madagascar Teal: *Anas bernieri:* Left - female (photo H G Young/QMC Bloxam); Main - male (photo R Safford/HGY); Bottom - pair (photo HG Young/QMC Bloxam).