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Birds of the Kermadec Islands, south-west Pacific

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Abstract Birds recorded on the Kermadec Islands, south-west Pacific, between 1967 and 1998 are summarised. Population estimates and distributions are given for the 24 breeding species. Brown noddy (*Anous stolidus*) is recorded breeding there for the first time. Information on breeding chronology for most breeding species is presented. Sightings of 53 non-breeding and vagrant species are summarised; 24 of these were new records since the last comprehensive review was published in 1970. The total bird list for the Kermadec Islands is now 80 species, including records of giant petrels (*Macronectes*), frigatebirds (*Fregata*) and oystercatchers (*Haematopus*) not identified to species. A further 16 species are included in a suspense list. The Kermadec Islands have only seven indigenous land birds, but retain a diverse seabird fauna, very similar to those of Norfolk and Lord Howe Islands. The land birds and seabirds of the largest island (Raoul) have been decimated by introduced cats (*Felis catus*) and rats (*Rattus exulans, R. norvegicus*). Introduced goats (*Capra hircus*) (since eradicated) drastically modified the vegetation of Raoul and Macauley Islands, and this also affected some bird species. Recommendations for restoration of the avifauna of these two islands are given.

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INTRODUCTION

The Kermadec Islands (Fig.1) are the summits of volcanic cones rising from the Kermadec sub-oceanic ridge between New Zealand and Tonga (Fleming 1979) and lie on a north-north-east to south-south-west axis between latitudes 29°S and 32°S. They have formed since the Pliocene and Raoul and Curtis Islands are active andesitic volcanoes. Their terrestrial history is no more than two million years old and this youth is reflected in low levels of faunal and floral endemism. The fauna and flora of the Kermadec Islands are derived mainly from New Zealand forms, but there is also a tropical Polynesian element.

The archipelago comprises six islands exceeding 5 ha in area and nine small islets supporting woody vegetation. All are nature reserves administered by New Zealand's Department of Conservation.

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Raoul Island and adjacent islands

Raoul Island (2938 ha; 29°16'S, 177°52'W), is the largest island (Fig 2) and is situated 995 km from the nearest part of mainland New Zealand (East Cape). The island is roughly triangular in shape, approximately 10 km long and 7 km wide and rises to 516 m at Mt Moumoukai. Its topography consists of a steep-sided central caldera with major ridges to the west and south from which run sharply dissected ridges and ravines.

A boulder and rock coastline flanked by cliffs up to 250 m high surrounds most of the island, though sand and gravel beaches occur at Denham Bay and to a lesser extent on the north coast in front of Low Flat and the Terraces. Flat to undulating land is essentially restricted to Denham Bay, Low Flat, the Terraces and to the floor of the caldera. Three lakes occur on the floor of the caldera, the largest being Blue Lake, followed by Green Lake, and Tui Lake. The lakes are periodically affected by volcanic activity and do not provide a consistently potable water source. Standing water also occurs in the

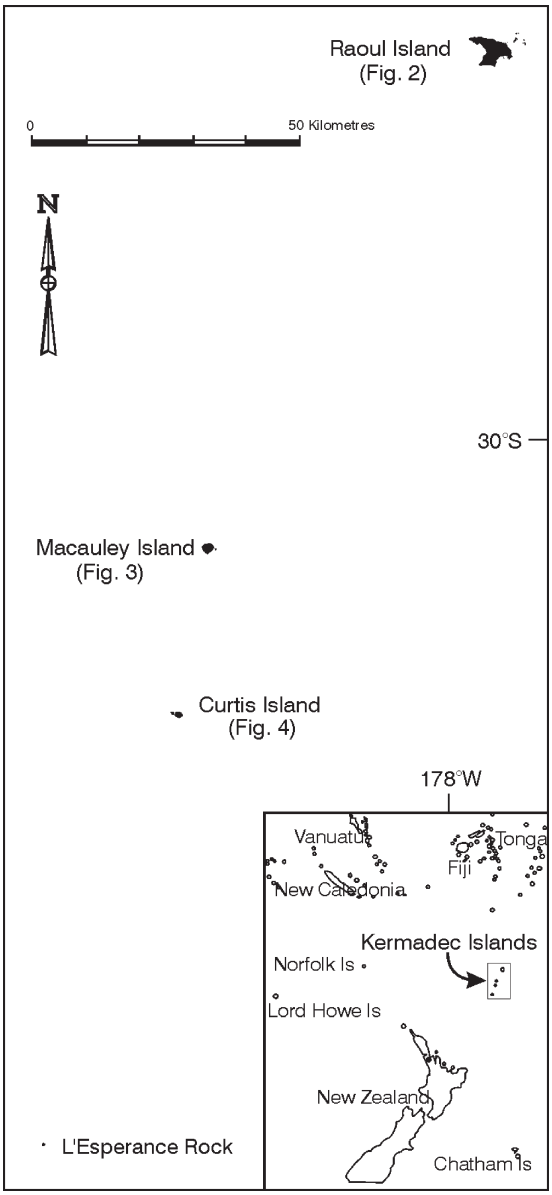

Figure 1 The Kermadec Islands.

centre of the Denham Bay flat while freshwater springs occur at the western end of the Terraces and on the coast north of Lava Point.

Raoul I. is the summit of a large and active volcano rising from the Kermadec Ridge. The Herald, Napier, Nugent, and Meyer Islands immediately north-east of Raoul are part of the same volcano and, together with the Sentinel at the south-eastern end of Raoul I., are erosion remnants of a formerly larger island. In its present form, Raoul I. is the result of five major volcanic events which occurred before 4000 BP (Lloyd & Nathan 1981). The soils of Raoul I. are derived mainly from basalt, andesitic ash and pumice with airfall deposits. The more recent soils are derived from volcanic ash with alluvial and colluvial derivatives (Lloyd & Nathan 1981).

Forest on Raoul I. is dominated by Kermadec pohutukawa (*Metrosideros kermadecensis*) with *Myrsine kermadecensis* and *Ascarina lucida* var. *lanceolata* as the predominant understorey. Other common species include mahoe (*Melicytus ramiflorus*), wharangi (*Melicope ternata*), kawakawa (*Macropiper excelsum* var. *majus*), karaka (*Corynocarpus laevigata*), the tree ferns *Cyathea kermadecensis* and *C. milnei*, and nikau palm (*Rhopalostylis cheesemanii*) (Sykes 1977).

The Kermadec Islands have no indigenous land mammals or herpetofauna. On Raoul I., Polynesian voyagers introduced Pacific rats (*Rattus exulans*), probably from the southern Cook Islands possibly earlier than A.D. 1250, and, presumably at a later date, from New Zealand (Matisoo-Smith *et al*. 1998, 1999). Cats (*Felis catus*) were established on Raoul by 1836 (Straubel 1954), and Norway rats (*R. norvegicus*) probably arrived when the schooner *Columbia River* was wrecked in 1921 (Ingram 1972; Merton 1968).

In the period between their introduction prior to 1836 (Straubel 1954) and their removal in 1972-85 (Parkes 1990), goats (*Capra hircus*) modified the vegetation considerably (Sykes 1969), removing almost all natural understory, allowing no regeneration of canopy species, and permitting dense stands of the introduced aroid *Alocasia brisbanensis*. Many coastal slopes became grasslands. The significant reduction of goat numbers from the early 1970s allowed extensive regeneration of vegetation to occur. However, the presence of rats and lack of seed-dispersing birds has probably inhibited seedling growth and species diversity in places.

Until the mid 1980s, the Terraces were grazed by sheep and cattle. For the most part, the old farm is now rank grass, which provides little food or habitat for birds. A small mown airstrip is utilised by a number of species. These major habitat changes have resulted in considerable changes in bird presence and abundance as noted below.

Raoul I. has a mild subtropical climate, with a mean annual temperature of 19°C and only small seasonal and daily temperature ranges. The maximum temperature recorded is 28.3°C, and the minimum 7.4°C; frosts are unknown. Rainfall averages 1535 mm. and is evenly distributed throughout the year (Anon 1979). South-easterly and easterly winds predominate in summer and north-westerlies at other seasons (Williams & Rudge 1969).

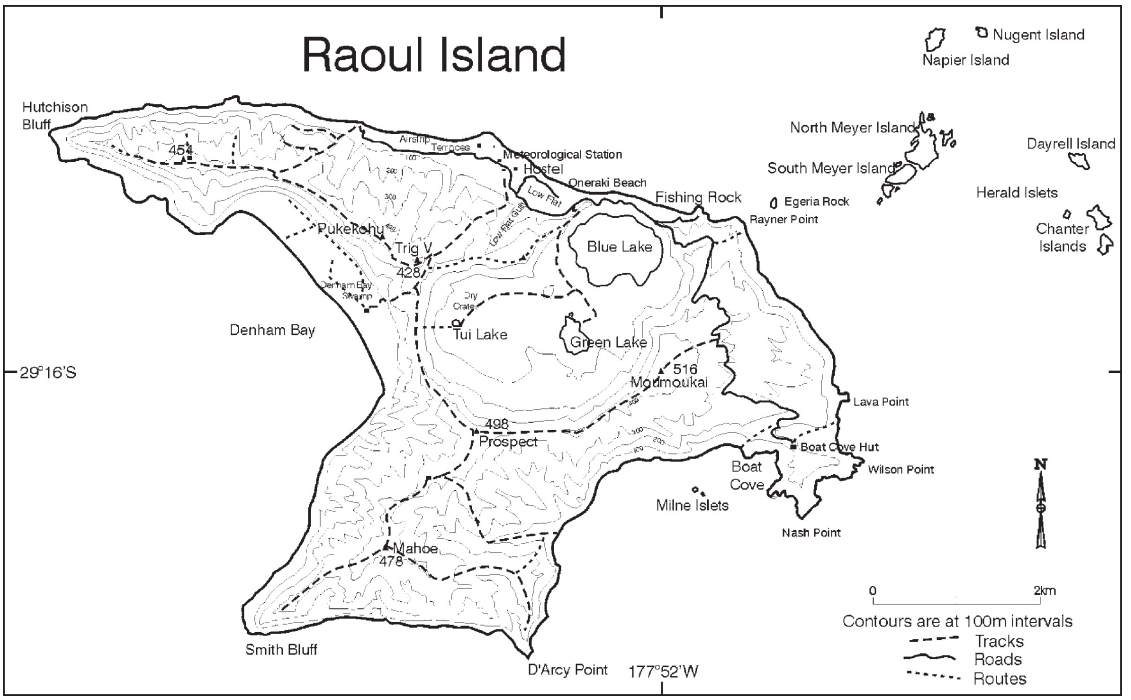

Figure 2 Raoul and adjacent islands showing locations mentioned in the text.

Adjacent to Raoul are eight islands large enough to sustain vegetation, and a number of smaller stacks. These lie off the north-east coast of Raoul, and in Boat Cove (Fig 2). These islands are all free of introduced predatory or browsing mammals and there are no signs that they have been subject to fire. Introduced weeds are present on the Meyer Islands.

Macauley Island

Macauley Island (306 ha; 30°15'S, 178°32'W) lies 108 km south-south-west of Raoul (Fig 1). It is the remnant of a volcano active in the Pleistocene and its rocks comprise subaerial basalts, acid pumice tuff, and fragments of gabbro (Brothers & Martin 1970). Macauley I. is a roughly circular plateau, sloping gently from Mt Haszard (238 m) to the south-east, and bordered on all sides by steep cliffs of pumiceous tuff usually in excess of 60 m (Fig 3). To the south of Mt Haszard is a roughly circular crater *c.* 230 m in diameter. The otherwise featureless surface of Macauley is cut by numerous erosion gullies, the largest, Grand Canyon, being up to 45 m deep. A basalt wave platform extends around most of the island, except below Perpendicular Cliffs and at Sandy Bay. The cliffs can be ascended at only four localities. There is no permanent water on Macauley I.

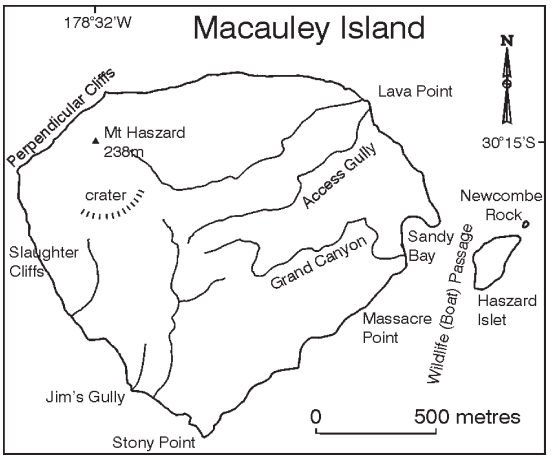

Figure 3 Macauley and Haszard islands showing locations mentioned in the text.

When discovered in 1788, Macauley I. was reported to be covered with "many trees, shrubs and grass" (Bowes 1787-89). The island was apparently fired prior to the arrival of goats (Sykes 1969), which were numerous in 1836 (Straubel 1954). D'Urville (1832) described Macauley as covered only with grass and scrub, without a single tree. Capt. W.B. Rhodes noted that, in 1836,

there were "...a few stunted trees and a little wild parsley [=*Cotula australis*, Sykes 1977] and other herbage...." (Straubel 1954). In 1887 Macauley was "...covered with a beautiful sward of natural grass...", the only woody plants being a few stunted bushes of *Columbium* [*Homalanthus polyandrus*] and ngaio (*Myoporum*) (Cheeseman 1888). The sedge *Cyperus ustulatus* fringed the edges of gullies (Smith 1887, Cheeseman 1888). The vegetation was in a similar state in 1908 (Oliver 1910). Many species were confined to cliffs inaccessible to goats. In 1966 the dominant plant was rice grass (*Microlaena stipoides*) with areas of *Vulpia bromoides* and *Rytidosperma racemosa*. Other prominent plants were *Cyperus ustulatus*, *Disphyma australe*, *Lobelia anceps*, *Polypogon monspeliensis* and *Isolepis nodosa* (Sykes 1969). A few Kermadec ngaio (*Myoporum kermadecensis*) clung to the cliffs, out of the reach of the goats, as did a few clumps of the Kermadec taupata (*Coprosma petiolata*) (Sykes 1977).

Captain Sever observed a "great number of rats and mice" (Watts 1789) when he landed on Macauley I. on 1 Jun.1788. These were undoubtedly Pacific rats, which still occur there. Pacific rats occur all over the plateau surface on Macauley, but are apparently absent from the flat behind Sandy Bay and the rest of the coast (Bell 1970). Although primarily herbivorous, signs of rats feeding on sooty tern (*Sterna fuscata*) eggs, corpses of black-winged petrel (*Pterodroma nigripennis*), and Kermadec parakeet (*Cyanoramphus novaezelandiae*) have been noted (Moors 1981).

When Rhodes landed on Macauley on 20 December 1836 (Straubel 1954) he noted that the island "abounds with goats and pigs" (the latter not reported since and now absent). Smith (1887) noted "over a hundred" goats, and a dog, which he considered responsible for a shortage of kids. The goats severely modified the vegetation of Macauley I. (Sykes 1969); in April 1929 the goats had so heavily grazed the grass that Guthrie-Smith (1936), from the deck of *Tutanekai,* noted ... "that when mustered by the blowing of the siren their hoofs were actually visible on the naked ground. The whole surface was grazed bare, no vestige of bush or tree remaining on it; the ground, moreover, seemed to have become set and compressed, otherwise these animals' hoofs would not have shown".

Between 28 Jul. - 21 Aug.1966, 3200 goats were killed on Macauley I. (Williams & Rudge 1969) and the last 18 goats removed in November 1970 (Bell 1970). Following this eradication, *Microlaena* and *Rytidosperma* formed a dense mat *c.* 0.4 m deep on the island's plateau which was soft and tiring to walk in (Sykes 1977). By 1988, the cutty sedge *Cyperus ustulatus* was established over much of the surface of the plateau, from where it was formerly absent. Other common plant species on the plateau included *Isolepis nodosa*, *Scaevola gracilis*, *Solanum americanum*, *Sonchus kirkii* and *Cyperus brevifolius*. *Hypolepis dicksonioides* was abundant in the gully floors and Kermadec ngaio was regenerating on the cliff faces and cliff-tops. The *Microlaena* meadow had reduced to less than 30% of the plateau surface and *Disphyma* was largely restricted to the coastal fringe. The soil had become more friable and honeycombed with millions of petrel burrows (Taylor & Tennyson 1988).

Haszard Islet

This small islet (6 ha) is located about 250 m east of Macauley I., being separated from the larger island by Wildlife (Boat) Passage (Fig. 3). Originally named Roaches' Isle after a quartermaster on *Lady Penryhn* (Bowes 1787-89), Haszard Islet was renamed by Smith (1887) after his assistant, H.D.M. Haszard.

Haszard Islet gives some shelter to Sandy Bay, the best landing on Macauley I. Its steep slopes have not yet been scaled, but the small flat on the western side and the slopes immediately behind it were explored on 27 Nov.1970 and 19 Nov.1980.

The lavas exposed below tuffs near sea level on Haszard Islet dip to the west-south-west, suggesting that they may be related to an eruptive centre, the remnant neck of which remains as a columnar jointed stack (Newcombe Rock), lying just north-east of Haszard Islet (Brothers & Martin 1970). The lower western slopes of Haszard Islet are mainly covered in *Disphyma* with small patches of ngaio, *Cyperus ustulatus*, *Tetragonia tetragonioides*, *Isolepis nodosa* and *Scaevola gracilis* (Sykes 1977). The flat top is covered with *Cyperus*.

Rodents have not been recorded on Haszard Islet, or any of the islands further south in the Kermadec Group.

Curtis Island

Curtis Island (52 ha; 30°35'S, 198°36'W) lies 37 km south-south-west of Macauley I. (Figs 1, 4). Steep coastal cliffs rise to 100-130 m., and a gently undulating summit ridge surrounds the 6 ha crater. Curtis is an active volcano in the solfataric stage, with boiling mudpools and sulphur-encrusted fumaroles in the crater, and steam issuing from a few points on the upper slopes of the island. A stream of hot water enters the sea through a breach in the northern wall of the crater. The remainder of the crater is surrounded by steep cliffs exceeding 100 m, except for a low point of about 50 m on the eastern side (Sykes Gap; Fig 4). There is another smaller, inactive, crater on the south-east of the island.

Until at least 1929 it was possible to land from a small boat in Macdonald Cove, which penetrated the crater from the north. Recent uplift of both

Curtis and Cheeseman Islands has left the cove dry (Doyle *et al.* 1979) and the floor of the crater is now about 10 m above sea level. The 1970 expedition landed on the steep south-western coast, but had to traverse the rocky shoreline to the east before reaching the upper slopes near the south-east corner. The 1988 landing was also on the south-western coast. Other recent landings by boat (1969, 1974, 1975 and 1982) have been on the north-east coast, at the foot of Sykes Gap.

Curtis I. and neighbouring Cheeseman I. (Fig. 4) are composed predominantly of pumice and andesite cliffs (Doyle *et al.* 1979). Samples of andesite have also been obtained, but no identifiable flow-rocks have been observed (Oliver 1911b; Doyle *et al.* 1979).

The slopes above the shoreline and the broad summit ridge of Curtis I. are covered with *Disphyma australe* and *Cyperus ustulatus*. *Parietaria debilis* is common towards the summit, as are *Asplenium obtusatum, Sonchus kirkii, Solanum nigrum* and *Lachnagrostis littoralis* (Sykes 1977). All available soil is extensively honeycombed by petrel burrows (Taylor & Tennyson 1988). The crater floor is mainly bare of vegetation, but Cheeseman (1888) recorded *Disphyma* and *Lobelia anceps,* and the fern *Nephrolepis hirsutula* (elsewhere in New Zealand only known from Raoul I.) was recorded on the south wall of the crater in 1970 (Sykes 1977).

Cheeseman Island

Cheeseman Island, 7 ha, lies to the west of Curtis I., from which it is separated by the 570 m wide Stella Passage (Fig 4). Like Curtis I., Cheeseman I. is composed of pumice and andesite which has eroded to form inaccessible coastal cliffs, up to 60 m high. During the only recorded landing, on 19 Nov.1970, *Disphyma* and *Cyperus* were dominant on the upper slopes, in association with *Conyza bonariensis*, *Sonchus kirkii*, *Solanum nigrum*, *Parietaria debilis* and *Lachnagrostis littoralis* (Sykes 1977).

L'Esperance Rock

Also known as French, Brinds or Hope Rock, L'Esperance Rock, 5 ha, is an extinct volcano composed of scoriaceous lava rising to about 46 m. Lying at 31°26'S 178°55'W, 97 km south-south-west of Curtis I., L'Esperance Rock is the southernmost of the Kermadec Islands (Fig. 1).

There is only a small area of soil suitable for burrowing by petrels, and this is restricted to two small craters and an upper slope. The main vegetation is *Disphyma*, the only other vascular plants present being *Asplenium obtusatum*, *Senecio lautus*, *Lachnagrostis littoralis*, *Parietaria debilis*, and *Einadia trigonos* (Sykes 1977).

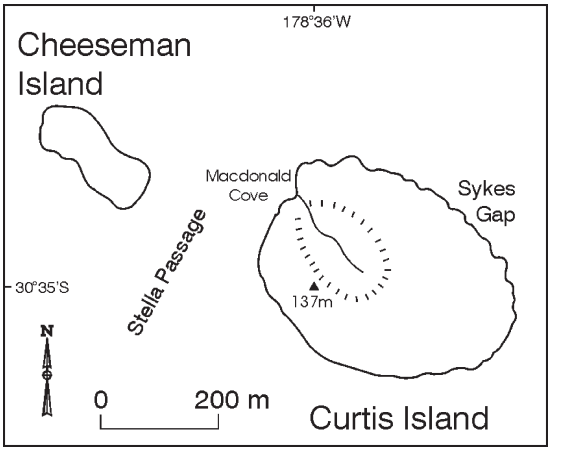

Figure 4 Curtis and Cheeseman islands showing locations mentioned in the text.

METHODS

This paper records observations of birds made by the authors during visits to the Kermadec Islands between 1967 and 1998. These observations are supplemented by those of other visitors and a summary of the entire bird fauna is presented. Only species which were recorded ashore or about the coast of the islands are included; species seen only in pelagic waters near the islands are not included. Many additional seabirds have been seen near the Kermadec Is. Dick Veitch (CRV) made visits to Raoul and adjacent islands on 13 Nov.1966 to 27 Jan.1967, 24 Aug.- 17 Oct.1972, 13 - 27 Sep.1991, 31 May - 24 Aug.1994, and 29 Jun.- 9 Jul.1998. Colin Miskelly (CM) landed on Curtis I. on 21 May 1982 and on Macauley I. on 22 May 1982. Graeme Taylor (GT) and Alan Tennyson (AT) landed for a few daylight hours on L'Esperance Rock and Curtis I. on 14 and 15 Sep.1988, respectively and stayed on Macauley I. during 15 - 24 Sep.1988. GT, AT and Paul Scofield (PS) visited Macauley I. on 23 Nov.- 6 Dec.1988. GT and AT visited Curtis I. during 13 Oct. - 12 Nov.1989. Grant Harper (GH) lived on Raoul I. from October 1993 to October 1994 and visited the adjacent islands on numerous occasions.

SYSTEMATIC ACCOUNT

Nomenclature and presentation order follow Turbott (1990), modified by Holdaway *et al.* (2001). Abbreviations, other than author initials, are: AM = Auckland Museum, Auckland; AMNH = American Museum of Natural History, New York; MNZ = Museum of New Zealand Te Papa Tongarewa, Wellington; OM = Otago Museum, Dunedin.

Wandering albatross (*Diomedea exulans*) *sensu lato*
Beach-wrecked wandering albatrosses, or parts thereof, were reported from Raoul in November 1907 (Iredale 1910, 1913; MNZ 1928), November 1962, November 1966, and June 1969 (Merton 1970). This species is regularly seen at sea around the Kermadec Is. (e.g., Cheeseman 1888; Merton 1970; R. Mayhill & G. Clark pers. comm.; AT & GT).

Buller's albatross (*Thalassarche bulleri*)
One found beach-wrecked on Denham Bay, Raoul I. in 1972 (Reed 1973).

Wedge-tailed shearwater (*Puffinus pacificus*)
Present in "immense numbers" on Raoul I. in 1908 (Iredale 1910) and were still breeding in large numbers in 1944 (Sorensen 1964). They were found on ridges behind the hostel and east of Fishing Rock in November 1964 (Edgar *et al.* 1965), but were rare in 1966/67 (Crockett 1975), being found in small breeding colonies on headlands and the tops of coastal cliffs (Merton 1970). They still persisted at scattered locations in 1973 and 1974 (Smuts-Kennedy 1973, 1975). The depredations of cats were noted by most observers. The headlands and cliffs referred to by Merton (1970) were not searched in 1993/94 but during extensive periods of weed control work over the same period on the ridges behind the Hostel and east of Fishing Rock, in the areas referred to by Edgar *et al.* (1965), no sign of wedge-tailed shearwaters was found. In April 1998 a single bird was found in a burrow above Rayner Point (C. Wickes pers. comm.).

Wedge-tailed shearwaters breed abundantly on North and South Meyer Islets, with smaller numbers on Napier, Dayrell and North Chanter Is. (Crockett 1975). The breeding population of the Meyer Is. was estimated to be 10,000 pairs (Merton 1970).

Wedge-tailed shearwaters were common on the plateau of Macauley I. in November 1970 and November 1980 (B.D. Bell pers. comm.). This species does not come down onto the coastal fringes like the black-winged (*Pterodroma nigripennis*) and white-naped petrels (*P. cervicalis*), and they tend to occur in groups of burrows rather than have a general coverage (Bell 1970). Bell estimated the Macauley population to be about 20,000 pairs in November 1970 and AT, GT & PS considered it to be 40,000 pairs in November-December 1988.

AT & GT estimated 2500 pairs to be on Curtis I. in October - November 1989. Wedge-tailed shearwaters were numerous on Cheeseman I. on 19 Nov.1970, but appeared to be restricted to basins where deeper soil was available for burrowing (Bell 1970). They were common and breeding on the southern and western sections of the crater ridge of Curtis I. on the same date.

About 50 pairs of wedge-tailed shearwaters were occupying burrows on L'Esperance Rock on 18 Nov.1970, but no eggs were seen (Bell 1970).

No wedge-tailed shearwaters were observed on Macauley I. in September 1988 (AT & GT). AT & GT observed wedge-tailed shearwaters returning from migration to Curtis I., with the first being seen on 19 Oct.1989 and thereafter numbers rapidly increased. Sorensen (1964) noted birds arriving at Raoul in early October, with egg-laying in early December. On North Meyer I. in 1966 Crockett (1975) recorded egg-laying during 12-28 December. In 1988, laying had not begun on Macauley I. by 6 December, but copulation was seen on 30 November (AT, GT & PS). Copulation was seen on Curtis I. on 30 Oct., 3, 4 and 10 Nov. 1989 (AT & GT). A chick close to fledging was seen on Curtis I. on 21 May 1982, and an adult was observed feeding another chick (CM). Fledglings were exercising their wings on Macauley I. on 22 May 1982 (CM). This agrees with Iredale's (1910) observations that fledging occurred "about the middle of May".

Sooty shearwater (*P. griseus*)
Three freshly dead sooty shearwaters were washed ashore on Denham Bay on 22 Nov.1966, 3 Dec.1966 and 24 Jan. 1967 (Merton 1970). A few sooty shearwaters were seen at sea around the Kermadecs in October 1988 (R. Mayhill & G. Clark pers. comm.) and October-November 1989 (AT & GT).

Short-tailed shearwater (*P. tenuirostris*)
One collected by T. Bell in 1890 is in the Auckland Museum (AM B5092) bearing the collection location of "Kermadec group" (see Hutton 1893). It is presumed that this was a beach-wreck from Raoul I. (Iredale 1910, 1913).

Christmas Island shearwater (*P. nativitatis*)
One caught on Curtis I. on 10 Nov.1989 was the first live individual recorded in the New Zealand region (Taylor & Tennyson 1994).

Kermadec little shearwater
(*P. assimilis kermadecensis*) (Fig. 5)
Long known to breed on the Meyer Is. (eg., Cheeseman 1888; Iredale 1913), and more recently found on the other Herald Is. (Merton 1970). They were possibly breeding on Raoul in 1964 and 1966 (Edgar *et al.* 1965; Merton 1970).

Little shearwaters were present and breeding on Macauley I. in November 1970 (Bell 1970), and possibly on Haszard Islet where a mummified

carcass was found in November 1980 (P.J. Moors pers. comm.). Suspected breeding locations on Macauley I. in September 1988 were cliff ledges behind Sandy Bay and along the south-eastern side of the island, suggesting a coincidence with areas where Pacific rats were absent. Several hundred pairs were estimated to nest on Macauley I. in 1988 (AT, GT & PS).

Little shearwaters were also present and breeding on Curtis and Cheeseman Is in mid-November 1970 (Bell 1970). In October - November 1989, AT & GT estimated *c.*100,000 pairs were present on Curtis I. There is no evidence that this species nests on L'Esperance Rock.

The little shearwater is a winter breeder in the Herald Group, the first arrivals being heard in the last week of April and laying occurring in late June and July (Iredale 1910, 1913; Oliver 1955). Young hatch in August - September (Iredale 1910; Oliver 1955; Sorensen 1964) and are still present until early December (Merton 1970). Birds on southern Kermadec islands breed at a similar time to those in the Herald Group (Yaldwyn 1970; CM, AT & GT). Courting pairs were found in burrows and under *Cyperus* on Curtis I. on 21 May 1982 (CM). In October 1989 many burrows had large chicks, and these began to fledge in late October (AT & GT). Most birds had apparently left Macauley I. before 7 Nov.1980, as the only individual seen during November was a feathered chick (P.J. Moors pers. comm.). On Macauley I., AT, GT & PS observed that the nesting season appeared to be nearly over by late November in 1988, as they saw no live birds, although freshly dead corpses of chicks were present.

Giant petrel (*Macronectes* sp.)
A wing found by CRV at Denham Bay, Raoul I. in September 1972 was of this genus and a beach-wrecked giant petrel was also found in Denham Bay in October 1995 (Clifford & Lawrie 1997). There were two sightings of live birds at sea around the Kermadecs in 1966 (Merton 1970) and one was seen near the Meyer Is. on 9 Sept.1972.

Thin-billed prion (*Pachyptila belcheri*)
One found as a beach-wreck on Raoul I. on 27 Jul.1944 (Sorensen 1964; MNZ 10473).

Antarctic prion (*P. desolata*)
A female was found at Denham Bay by R. Bell on 29 Jul.1910 and deposited in the Auckland Museum (Oliver 1913; AM B5496). Falla (1940) believed that this specimen may have been *P. salvini crozeti* but recent re-examination of the specimen shows it is closer to the size range of *P. desolata* (Brian Gill pers. comm.).

Figure 5 The Kermadec little shearwater is endemic to the Kermadec Is.

Blue petrel (*Halobaena caerulea*)
One found dead at Oneraki Beach, Raoul I. in October 1995 (Clifford & Lawrie 1997).

Black-winged petrel (*P. nigripennis*)
Iredale (1910, 1913) confirmed that black-winged petrels bred on Raoul I., although they were more numerous on the Meyer Is. In November 1964, Edgar *et al.* (1965) observed three birds entering the forest behind their camp immediately south of the Hostel. Small numbers of juveniles were reported to have left Raoul in March 1966 (Merton 1970). No occupied burrows were found on Raoul during the summer of 1966/67, although the abundance of cat-eaten remains suggested that these petrels were attempting to use their ancestral breeding grounds (Merton 1970). In April 1973, two cat-eaten corpses were found near Hutchison Bluff and an adult in a short burrow near Nash Point (Smuts-Kennedy 1973).

Between December 1993 and February 1994, numerous birds were seen chasing and calling over Raoul I., in many cases coming very close to the canopy or beach (GH). This behaviour was attributed by Merton (1970) to unemployed adults. Several adults were also found on the ground, including two in shallow burrows, and the remains of three freshly cat-eaten birds were found both at the "Waterfall" site in Denham Bay (under Pukekohu) and on the north side of the island. Extensive searches of the lower northern slopes (where Edgar *et al.* (1965) saw them) during 1993/94 failed to find any burrows.

Black-winged petrels were recorded breeding on Napier, Dayrell and the Chanter Is. and in abundance on the Meyer Is. where thousands of birds were present (Merton 1970).

Bell (1970) found black-winged petrels to be simply everywhere on Macauley I. in late November 1970 and the population to number

hundreds of thousands. Six hundred individual birds were banded without effort on the flat behind Sandy Bay; this was by no means the total nor was it the most densely populated part of the island. The only place they were not found was where the ground was too hard or rocky for burrowing. By November 1980 numbers had increased significantly (B.D. Bell pers. comm.). P.J. Moors (pers. comm.) calculated that the island population exceeded 1.1 million in November 1980, based on mark and recapture of banded birds in a measured area. In November - December 1988, black-winged petrels were the most abundant bird on Macauley I., with an estimated population of 2-3 million pairs (Tennyson & Taylor 1990). Bell (1970) recorded this species breeding on Haszard Islet.

Black-winged petrels were also the most abundant birds on Curtis I. in October - November 1989 (AT & GT). They were returning from migration in late October, with numbers building rapidly to an estimated 300,000 pairs present by 12 Nov.1989. This is the main breeding petrel on Cheeseman I., where Bell (1970) found the ground honeycombed with their burrows on 19 Nov.1970.

On L'Esperance Rock, on 18 Nov.1970, Bell (1970) found about 200 pairs occupying burrows but no eggs were present.

No black-winged petrels were seen on Macauley I. in September 1988 (AT & GT). Abundant adults were noted ashore on North Meyer I. on 8 Oct. 1993 (GH) but egg-laying does not occur there until late December - early January (Iredale 1910; Oliver 1955; Sorensen 1964; Merton 1970). In 1989, on Curtis I., the first adult was found on the ground on 15 October and copulation was seen on 4 November (AT & GT). Between 21-30 Nov.1970 (Bell 1970) and 7-24 Nov.1980 (B.D. Bell pers. comm.), nesting had not begun, but courtship and burrow cleaning was in full swing. In 1988, egg-laying had not begun on Macauley I. by 6 December, but copulation was seen on 27 & 29 November and 5 December (AT, GT & PS). Fledging and departure occurs in April (Oliver 1955; GH) and May (CM), probably extending into June (based on large downy chicks seen on Curtis I. on 21 May 1982 and on Macauley I. on 22 May 1982; CM). One was seen off Raoul I. on 1 Jun.1973 (Ireland 1973)

White-naped petrel (*P. cervicalis*) (Fig.6)
This large gadfly petrel (also known as the Sunday Island, black-capped or white-necked petrel) was formerly thought to breed only on Raoul I. Cheeseman (1891) was given specimens and informed by Thomas Bell that "it was by no means common". Colonies were scattered over the higher ridges in 1908 but were not of any extent and the total number of birds was estimated at less than 500 pairs (Iredale 1910). Oliver (1930) reported that live white-naped petrels had not been recorded from Raoul I. since 1908, when they were decreasing due to the ravages of cats. Three eggs were collected on Raoul I. by R.S. Bell on 3 Jan.1909 (W. Oliver *in litt.*; MNZ 6863, MNZ 7048). Two skins (AM B3534, MNZ 1912) were collected by W.S. Bell on Raoul I. on 1 Jan.1914. Sorensen (1964) reported white-naped petrels as breeding on the higher levels of Raoul I., but he is thought to have been repeating historical records. There are no records of white-naped petrels on the Meyer or Herald Islands.

The existence of other breeding colonies of white-naped petrels was indicated by sightings at sea in the central north Pacific (King 1967, 1970) and near the Kermadecs (Jenkins 1970), and by single storm-wrecked birds on Raoul I. (Merton 1970) and the New Zealand mainland (Kinsky 1971). The provenance of these birds was probably Macauley I., where white-naped petrels were found to be common in late November 1970 (Bell 1970), although their presence was established through the collection of two skeletons in August 1966 which, at that time, were incorrectly identified as Kermadec petrels (Tennyson *et al.* 2003).

Finding white-naped petrels on Macauley I. in November 1970 was the "find" of the trip (Bell 1970). It appeared to be the second most numerous petrel there, following black-winged petrel. Most did not come ashore until dusk although the occasional bird was seen in daylight. Burrows were most common in the sides of gullies, but also occurred on the plateau surface and on the flat behind Sandy Bay. Bell (1970) estimated the population as *c.*10,000 pairs based on the number banded on the small flat behind Sandy Bay and the general distribution throughout the island. In November - December 1988, *c.*50,000 pairs were present (Tennyson & Taylor 1990).

Figure 6 The white-naped petrel was exterminated from Raoul I. by cats but continues to survive on Macauley I.

Although this species was seen offshore from Curtis or Cheeseman Is. on 18 Nov.1970, 21 May 1982, and 12 Nov.1989 (Bell 1970; CM, AT & GT) there is little evidence to suggest that it nests there. On Curtis I. in October - November 1989, AT & GT did not find white-naped petrels ashore.

No live white-naped petrels were seen on Macauley I. in September 1988 (AT & GT). On Raoul I. they were reported to return to their colonies in late September (Cheeseman 1891) or October (Iredale 1910). Egg-laying had not commenced on Macauley I. at the end of November in 1970 (Bell 1970) or in 1980 (B.D. Bell pers. comm.) but courtship and nest building were underway. Egg-laying had not begun on Macauley I. by 6 Dec.1988 but copulation was seen on 24 November (Tennyson & Taylor 1990). Fresh eggs were found on Raoul I. between 26 December and 2 January (Oliver 1930). The young became fully-fledged in May and departed in June (Iredale 1910; Oliver 1930). Fully-fledged young were seen on Macauley I. on 22 May 1982, and at sea on 24 & 27 May 1982 (Miskelly 2001).

Phoenix petrel (*P. alba*)
On 21 May 1982 a Phoenix petrel circled *Derwent* close to Curtis I. It then flew over the island and attempted to land on a north-east facing slope (CM & T.G. Lovegrove pers. comm.). Although the dark head, pale throat and white underparts gave this bird a similar appearance to an intermediate colour phase of the Kermadec petrel, it was distinguishable by the absence of a white area at the base of the primaries, and by having pale mottling in the centre of the underwing.

The Phoenix petrel is a tropical species that has only been recorded from the New Zealand region on one previous occasion: R.S. Bell collected one of four birds found under the forest on Raoul I. on 7 Mar.1913 (Matthews & Iredale 1914). A similar bird taken on Raoul on 20 Aug.1944 (MNZ 11376) is mentioned by Bourne (1975). According to this bird's label, R.A. Falla identified the specimen as "*P. alba* form". However, it has white upper primary shafts, as is seen on Kermadec petrels and not Phoenix petrels, and its measurements fall within the range for Kermadec petrels but outside the range for Phoenix petrels (Marchant & Higgins 1990; AT pers. obs.).

Kermadec petrel (*P. neglecta*)
Cheeseman (1891) referred to Kermadec petrels nesting on Raoul I. as *Oestrelata mollis* on the authority of Sir Walter Buller. Hutton (1893), working with specimens from Auckland Museum, reported two adults and a nestling, which Buller considered to be "*Œ mollis*" from Raoul I. These were almost certainly colour forms of the polymorphic *P. neglecta*. None of the *P. mollis* specimens now in Auckland Museum are listed as being collected on Raoul I. (B. Gill pers. comm.). A specimen of *P. neglecta* (AM 3895), listed as "Holotype of *Oestrelata leucophrys* Hutton, 1893.", is probably the specimen which Hutton (1893) identified as "Specimen no. 1 (*type*)" in his description of *Œ mollis*.

The breeding population of Kermadec petrels on Raoul I. was estimated by Iredale (1914) at "about half a million individuals" in 1908. In 1944, Sorensen (1964) recorded the Kermadec petrel as a common breeding bird on Raoul I. By 1966/67 they had all but gone, with only two nests being found at Denham Bay (Merton 1970). While detailed accounts of this species on Raoul I. have been few, it is clear that predation by cats and Norway rats were the major causes of decline (Merton 1970).

Kermadec petrels have not always been recorded on the Herald Islets. Iredale (1910) noted that only about half a dozen pairs bred on Meyer I., and in November 1908 (Iredale 1914) found no sign of these birds on Meyer I. They are now present on the Meyer Is. at all times of the year (Veitch & Harper 1998). Records of breeding, however, are few and, while most observers have given an indication of abundance, the statements are not comparable. About 6000 pairs were thought to be nesting on the Meyer Is. in 1966/67 (Merton 1970).

Two dead *P. neglecta* recorded from Macauley I. in Aug 1966 (O'Brien 1966) have been re-identified as *P. cervicalis* (Tennyson *et al.* 2003). Fewer than 50 pairs were present in November 1970 and nest sites were confined to caves and crevices on the western and northern faces (Bell 1970). Numbers and locations were similar in November 1980, and almost all birds observed were dark phase (B.D. Bell pers. comm.). In September 1988, this species was seen in flight only, and the ratio of dark to light phase birds was 6:4 (AT & GT). In November - December 1988, fewer than 50 pairs were present (Tennyson & Taylor 1990).

A single Kermadec petrel with an egg was found in the shelter of a beach boulder on Haszard Islet on 27 Nov.1970 (Yaldwyn 1970; Tennyson *et al.* 2003) and again on 19 Nov.1980 (P.J. Moors pers. comm.).

A.T. Pycroft collected a near-fledged Kermadec petrel on Curtis I. on 16 Apr.1929 (AM 1699), but there are no subsequent records from this island (Tennyson *et al.* 2003).

Nests, eggs and chicks may be seen on the Meyer Is. in varying numbers at all times of the year, with a peak of egg-laying in February - March (Veitch & Harper 1998). Previously, the population breeding on Raoul Is. did so mainly in summer (August - May, eggs October - February), in contrast to the birds on the nearby Meyer Is. (January - August, eggs February - May; Iredale 1914; Veitch & Harper 1998).

Figure 7 Kermadec storm petrel. The white rump is the key feature identifying this species.

Grey-faced petrel (*P. macroptera*)
Although not recorded as a breeding species, at least four specimens have been found beach-wrecked on Raoul I. (Ogilvie-Grant 1905; Oliver 1912; Iredale 1913; Sibson 1979) and it is frequently observed at sea nearby (e.g., O'Brien 1966; R. Mayhill & G. Clark pers. comm.; CM, AT & GT)

Kermadec storm petrel (*Pelagodroma albiclunis*)
Most records of this enigmatic bird are of sightings at sea, or of specimens collected from vessels at sea (Murphy & Irving 1951; Edgar *et al.* 1965; Edgar 1975; Jenkins 1980a; R. Mayhill & G. Clark pers. comm.; CM, AT & GT), or as beach-wrecks (Iredale 1910, 1913; Smuts-Kennedy 1975 (MNZ 18381)) during October and November. Its breeding grounds remain unknown (Imber 1984) despite early reports that it breeds on "Meyer Island and other outlying rocks" (Cheeseman 1891). However, an adult with a largely bare brood patch and soil on its bill was caught by AT on Macauley I. on 4 Dec.1988. This bird's condition strongly suggested that it was either breeding or attempting to breed close by. It may have come from either Macauley I. or nearby rat-free Haszard Islet. This bird (Fig. 7) was relatively large and square-tailed, like the Australian white-faced storm petrel (*P. marina dulciae*). Its rump was very worn, but appeared mainly white, unlike the New Zealand subspecies (*P. marina maoriana*) which has a grey rump. Four were attracted to a light and captured at Sandy Bay, Macauley I., in August 1990 (L. Johnson pers. comm.). One of the two beach-wrecked specimens from Raoul I. in October 1908 was a female with large ova (Iredale 1910).

White-bellied storm petrel (*Fregetta grallaria*)
A freshly dead specimen (MNZ 12693) was found on top of the southern cliffs of Macauley I. on 3 Aug.1966 (O'Brien 1966). The bird was almost fledged, with small portions of down still adhering to the feathers. This was the first record of this species breeding in New Zealand, and only the second specimen obtained in New Zealand (Oliver 1955). Another corpse was found at Sandy Bay, Macauley I. in November 1970 (Bell 1970; Yaldwyn 1970; MNZ 16071). In September 1988, a number of storm petrels were seen both on the ground and in flight over Macauley I. One, which landed in Sandy Bay on 21 September, was identified as this species (AT & GT). Single birds were seen at sea on 8 and 14 Oct.1988 between L'Esperance Rock and Curtis I. (R. Mayhill & G. Clark pers. comm.).

On 21 May 1982, a single downy chick, about three weeks old, was found in a rock crevice *c.*20 m above sea level on the north side of Curtis I. (CM). Although not accompanied by an adult, the chick was identified by its flattened, spade-like claws and black legs, toes and webs. In October - November 1989, AT & GT caught 23 adults on Curtis I. They did not seem to be nesting at this time, but a long-abandoned egg (MNZ 26417), thought to be of this species, was found in a cave above the north-east landing.

Red-tailed tropicbird (*Phaethon rubricauda*)
Many tropicbirds were reported on Raoul I. in 1788 (Merton 1970). Cheeseman (1891) reported that this species visited Raoul I. "in great numbers for breeding purposes". In 1908 Iredale (1910) observed them nesting on grassy ledges on the sea cliffs all around the coast of Raoul I. Neither he, nor subsequent observers, made any attempt to estimate their numbers. A few tropicbirds continue to nest in isolated, safe locations on Raoul I. e.g., two nests were noted on the north side of Hutchison Bluff on 16 Jan.1994 (GH).

Most tropicbird observations have been on the Meyer Is., but here too data are scant. Clark (1963) considered that there could easily be 200 breeding pairs on Meyer I. Merton (1970) reported 40 nests on South Meyer, nine on North Meyer and that the species was nesting on most islands of the Herald Group. Up to 60 birds were on North Meyer in March - July 1973 (Ireland 1973).

Bowes (1787-89) landed on Macauley I. on 1 June 1788 and recorded: "There were many Tropic Birds under the trees, some of which were asleep and these they took by hand and brot [sic] on board with them". Cheeseman (1891) reported them as breeding on Macauley I. In August 1966 a few adults were seen flying around the island (O'Brien 1966). In late November 1970 courtship flights were common and seen during most of the day (Bell 1970). Flight intensity seemed to increase shortly after mid-day and upwards of 50 birds could be seen over Sandy Bay and Grand Canyon, 20 near Stony Point and another similar number off Slaughter

Cliffs. The breeding population was estimated at 50-100 pairs (Bell 1970). Similar numbers were present in November 1980 (B.D. Bell pers. comm.). Up to 130 were seen in flight at one time in November – December 1988 (AT, GT & PS).

On Curtis I., in October - November 1989, AT & GT did not see any live birds, but found a single dead chick, indicating that a few pairs must nest there. A pair was seen flying over Curtis I. on 21 May 1982 (CM), and another on 15 Sep.1988 (AT & GT). One was seen around L'Esperance Rock on 7 Oct.1988 (R. Mayhill & G. Clark pers. comm.).

Early records suggest that this species was absent from Raoul I. in winter. Cheeseman (1888, 1891) did not see any but was informed by Bell that tropicbirds arrived about the end of October and left again in June or July. Iredale (1910) confirmed this seasonal pattern by noting their absence in June and July 1908, birds returning in early August, and eggs and chicks present in both January and April 1908. Davison (1938), present on Raoul I. from July in 1937, first saw tropicbirds in the second week of October. In April and early May 1973, Smuts-Kennedy (1973) recorded near-fledged young on Raoul I., although he commented that all succumbed to predation or natural disaster.

On the Meyer Is., the bulk of egg-laying occurred in December (1966) (Merton 1970). In 1994, adults were noted on eggs, and chicks were in a variety of stages of development from downy to fledgling on 10 April whereas only chicks were present on 19 July (GH). Well-grown chicks were seen on 14 Apr.1929 (Guthrie-Smith 1936). Ten adults on nests on the south cliff of North Meyer were counted in mid-July 1994 but the nest contents could not be determined (CRV). Large to well-feathered chicks were present on 20 Aug.1994, but no adults were seen on the ground (CRV). A near-fledged chick was seen on 4 Oct.1974 on North Meyer I. (Smuts-Kennedy 1975).

On Macauley I., four single well-grown chicks were observed in August 1966 (O'Brien 1966). On Macauley I. in November 1970, Bell (1970) observed nesting in deep burrows running in from ledges near the top of the cliffs around the coast and in the major gully systems. Nesting did not occur along the northern coast between Perpendicular Cliff and Lava Cascade. The chicks that were seen in the burrows were feathered (Yaldwyn 1970). Only a small portion of the birds present in November 1980 appeared to be nesting; of four nests recorded, two had no eggs and two had one egg (P.J. Moors pers. comm.). In November - December 1988, AT, GT & PS considered that laying had not yet begun. On 22 May 1982, breeding ranged from courting pairs through a small downy chick to a fully feathered fledgling (CM).

Brown booby (*Sula leucogaster*)

Oliver (1912) recorded a dead brown booby found by R.S. Bell on Raoul I. There is an undated juvenile skin (MNZ 1097) labelled "Kermadecs". Clark (1963) saw a single bird in Boat Cove, Raoul I. on 21 Aug.1963. An immature flew around the *Derwent* between Curtis and Cheeseman Is. on 21 May 1982 (CM), an immature was seen off Curtis I. on 16 Oct.1989 (GT & AT), and one was also seen there on 28 Jul.1966 (Merton 1970).

Masked booby (*S. dactylatra*)

Although no masked boobies were breeding on the Meyer Is. in 1966/67 (Merton 1970), they had been noted there in the past (eg., Cheeseman 1891; Iredale 1910, 1913; Sorensen 1964) and were breeding on Dayrell I., the Chanter Is. and a stack off North Meyer. They have been recorded nesting in low numbers on the Meyer Is. subsequently (Smuts-Kennedy 1975; Morrison 1979; GH, CRV). Up to 50 pairs nest on the Herald Is. (Merton 1970). There are no records of masked boobies on Raoul I.

O'Brien (1966) recorded about 30 pairs nesting on Macauley I. Bell (1970) observed that about 75 pairs used the island for nesting. Nests were mainly on the south-east sector and did not extend higher than 150 m level. On 17 Oct.1972, 62 birds were on nests visible from the summit of Mt Haszard (CRV). In November 1980, birds were banded at 57 of the *c.*100 nests present, and there was a "club" of up to 25 young birds (P.J. Moors pers. comm.). In November -December 1988, AT, GT & PS observed about 100 pairs nesting. During this visit, 11 birds were captured that had been banded on Norfolk I. Cheeseman (1891) recorded this species nesting on Haszard I.

Cheeseman's (1888) statement that black-browed albatrosses (*Thalassarche melanophris*) bred on Curtis I. is certainly erroneous (Sorensen 1964), and probably refers to the masked booby. Cheeseman (1889) observed this species to be breeding in some numbers on the top of Curtis I. and noted that Captain Fairchild took four live specimens from Curtis I. to New Zealand during the captain's previous visit. Bell (1970) estimated that 25 pairs were nesting on Curtis I. on 19 Nov.1970. About 24 adults were sitting on the higher slopes of the island on 21 May 1982 (CM). On 15 Sep.1988, and in October - November 1989, about 70 pairs were present (AT & GT). Two breeding birds recaptured in October 1989 had been banded on Norfolk I. (AT & GT).

Bell (1970) observed one chick and roosting adults on Cheeseman I., so more nests may have been present. Three adults were seen there on 21 May 1982 (CM). Two adults (viewed from Curtis I.) were ashore on 15 Sep.1988, and one on 7 Nov.1989 (AT & GT). There are no confirmed breeding records from L'Esperance Rock, although

four birds were seen around it on 7 Oct.1988 (R. Mayhill & G. Clark pers. comm.).

The nesting season at the Kermadec Is. is long, and chicks may be present throughout the year. In 1994, on the lower slopes of North Meyer I. a pair occupying a potential nest site on 13 June had no eggs, but on 22 July an egg was being incubated at this site; another pair that had no eggs on 19 June had one egg on 22 Jul (CRV). An adult on 12 Jul.1994 had two eggs that had hatched by 20 Aug. (R. Collen pers. comm.). On 8 Aug.1977, one adult on North Meyer I. was incubating two eggs (Morrison 1979). In September 1944 Sorensen found birds on "well incubated eggs" on Meyer I. (Sorensen 1944). On 5 Sep.1972, one was incubating two eggs on North Meyer (CRV). On 12 Oct.1977 an adult had a downy chick (Morrison 1979). A downy chick was found on North Meyer on 8 Oct.1993 (R. Collen pers. comm.). On 9 Nov.1974, two pairs were incubating on North Meyer (Smuts-Kennedy 1975). On 26 Dec.1966, Merton (1970) found a newly-hatched chick on a nest on Dayrell I., while another nest had an almost fully-fledged juvenile. On the Chanter Is at this time, Merton (1970) recorded nests containing chicks at all stages from naked young to flying age, but no eggs were being incubated. A flying chick was on Meyer I. on 23 Apr.1908 (Iredale 1910).

Egg-laying was just beginning on Macauley I. on 22 Aug.1966 (O'Brien 1966) but a "recently fledged juvenile" was also present (Merton 1970). In September 1988, most nests contained eggs but there were some new hatchlings (AT & GT).

The nests observed in mid-October 1972 contained eggs to large downy young (CRV). There were fresh eggs on 12 Nov.1908 (Iredale 1910). Both eggs and fledged young were present in November 1970 (Bell 1970). Of 57 nests recorded 7-24 Nov.1980, four were empty, 20 had two eggs, seven had one egg and one chick, three had one naked chick, two had two naked chicks, 10 had one downy chick and two had two downy chicks (P.J. Moors pers. comm.). In November - December 1988 some nests contained fresh eggs and others well-grown chicks (AT, GT & PS).

Nests on Macauley I. in November 1970 appeared to start with two eggs and end with one chick (Yaldwyn 1970). However, a few three-egg clutches and some nests containing half-grown twin chicks have been found here (AT & GT).

Guthrie-Smith (1936) recorded that breeding had finished and adults were courting on Curtis I. on 16 Apr.1929. On Curtis I., nests contained eggs and chicks up to three weeks old on 15 Sep.1988 and contained eggs through to half-grown chicks in October - November 1989 (AT & GT). There were fresh eggs on 12 Nov.1908 (Iredale 1910).

Black shag (*Phalacrocorax carbo*)
Two seen on Newcombe Rock, off Macauley I., on 10 Nov.1980, and a single bird was at the same location the next day (R. Taylor pers. comm.).

Frigatebird (*Fregata* sp.)
There have been several sight records of unidentified frigatebirds at Raoul I. (Cheeseman 1888, 1891; Sorensen 1964; Edgar *et al*.1965; Merton 1970).

White-faced heron (*Ardea novaehollandiae*)
Two "blue cranes" seen from Low Flat in October 1944 (Sorensen 1964) may have been this species. Single white-faced herons were present on Raoul I. in March and April 1965, and April - June 1969 (Merton 1970). One was in the Blue Lake area August - October 1972 (CRV). On Raoul I. in 1973: one from 9 March to 3 April and from 7 May and through June, two in mid-July and a corpse found on 23 April (Ireland 1973; Smuts-Kennedy 1973; Clunie *et al*. 1978). A single bird was seen on the hostel lawn on 9 Mar.1994 (GH). A single bird was present on Macauley I. during August 1966 (O'Brien 1966) and again during November 1970 (R. Taylor pers. comm.).

White-necked heron (*A. pacifica*)
One seen on Macauley I. on 11 Nov.1980 (R. Taylor pers. comm.).

Little egret (*Egretta garzetta*)
Two were seen together in the farm area of Raoul I. during October - November 1974 (Smuts-Kennedy 1975). They were very shy and could not be approached closely, but from a distance of *c*.200 m appeared to have black bills and legs. They did not associate with the cattle.

Cattle egret (*Bubulcus ibis*)
One seen on Raoul I. on 15 May 1994 was joined by a second bird two days later (GH). They associated mainly with the four cattle then present, but occasionally were seen with the sole pig and the hens. They were last seen in Jun 1994.

Royal spoonbill (*Platalea regia*)
One seen flying toward Blue Lake over Boat Cove Road in April 1996 (J. Ballantyne pers. comm.).

Canada goose (*Branta canadensis*)
A skeleton (MNZ 23745) found behind Denham Bay on 18 Nov.1980 by P.D. Gaze was later identified by AT as a Canada goose. One was seen in the "pool paddock" near the hostel on Raoul I. on 5 Jun.1994 and seven seen later that month flying over the hostel in a V-formation (GH). During the last week of June,

five birds were noted feeding on the sward between the beach and the pohutukawa forest at Denham Bay (N. Torr pers comm.) and five birds were still present at Denham Bay in mid August (CRV).

Paradise shelduck (*Tadorna variegata*)
A male was observed on Blue Lake, Raoul I. in October 1995 (Clifford & Lawrie 1997).

Chestnut-breasted shelduck (*T. tadornoides*)
A pair of chestnut-breasted shelducks was seen on Blue Lake, Raoul I. on 28 Mar.1994, and a single bird was seen with 11 grey ducks in the same area the next day (GH). A single male inhabited the airstrip throughout July - August 1994 (CRV).

Mallard (*Anas platyrhynchos*)
Two ducks and two drakes were present on Raoul I. in August 1972 (CRV) and at least three drakes in April - July 1973 (Smuts-Kennedy 1973). A female was seen on the island's north side on 28 Jan., 1 Feb. and during June 1994 (GH, CRV).

Grey duck (*A. superciliosa*)
Grey ducks occur on all fresh water areas of Raoul I. throughout the year, and were recorded breeding by Oliver (1913), Bell (1955) and Merton (1970).

Australasian harrier (*Circus approximans*)
Many observers have recorded harriers on the Kermadec Is. (Raoul, Meyer, Macauley and Curtis Is), even noting that they were plentiful (summarised in Merton 1970). None was seen during the three-month long 1966/67 OSNZ expedition (Merton 1970) but they have been recorded since on Raoul I. at all times of the year (GH, CRV). Nesting has not been recorded but the frequency of observations by GH and CRV suggests permanent residency. Single harriers were seen on Curtis I. on both 21 May 1982 (CM) and 15 Sep.1988 (AT & GT), and two on Macauley I. in September 1988 (AT & GT).

Spotless crake (*Porzana tabuensis*)
This secretive species is sometimes seen by visitors to the Meyer Is. currently its only known location in the Kermadec Is. Spotless crakes were present and nesting on Raoul I. prior to 1911 (Oliver 1913), but have not been recorded there since. Soper (1969a) recorded crakes from only the two Meyer Islets, where he considered fewer than 40 individuals to be present. Ireland (1973) noted one on North Meyer I. on 11 Mar.1973. Morrison (1979) recorded one on North Meyer I. in October 1977.

Pukeko (*Porphyrio p. melanotus*)
Pukeko records have increased over time on Raoul I., where a breeding population is now established. Cheeseman (1888, 1891) and Oliver (1913) recorded single specimens, while Iredale (1913) and Sorensen (1964) did not record pukeko during their visits in 1908 and 1944 respectively. A skin (MNZ 1900) was collected by W.S. Bell on Raoul I. in March 1913, six were seen on Raoul I. in 1954 (Bell 1955), and two were seen in 1964 (Edgar *et al.* 1965). A small breeding population was present in 1966/67 (Merton 1970) but in September 1972, none could be found despite searching with a trained bird dog (CRV). A pukeko was seen looking "very tired" on Low Flat beach on 28 Apr. 1973 (Ireland 1973, Smuts-Kennedy 1973). A four-person Wildlife Service team spent 11 weeks on Raoul in 1975 and did not record pukeko (Smuts-Kennedy 1975).

A substantial pukeko population now exists at both Denham Bay and Blue Lake (GH, CRV). In 1994, 27 adults were counted in Denham Bay during February and 46 in July, and others were present on the dune vegetation behind Denham Bay in July. Pukeko may have benefited from the improvement of wetland vegetation following goat eradication. In July 1998 they were estimated to have declined to just 25% of the 1994 numbers due to high water levels in all wetlands (CRV).

A dead pukeko was found on L'Esperance Rock on 14 Sep.1988 (AT & GT, MNZ 23979).

Oystercatcher (*Haematopus* sp.)
Three "pied" oystercatchers, probably *H. finschi*, were on Raoul I. from February to May 1969 (Merton 1970).

Oriental pratincole (*Glareola maldivarum*)
An oriental pratincole, present on Raoul I. 28-31 May 1976, was identified by S. Bartle (pers. comm.) from a photograph taken by L. Andrews (Sibson 1978).

Banded dotterel (*Charadrius bicinctus*)
R.S. Bell collected a male on Low Flat Beach, Raoul I. on 11 Sep.1913 (Oliver 1955, *in litt*.).

Oriental dotterel (*C. veredus*)
One was collected on Raoul I. on 22 Apr.1908, and a further three birds, apparently the same species, were seen on the Meyer Is (Iredale 1910, 1913). An immature female was collected by M. Fraser on Raoul I. on 15 Sep.1982 (MNZ 22731).

Pacific golden plover (*Pluvialis fulva*)
Although not seen by Cheeseman (1891), Mr Bell informed him that golden plovers sometimes visited Raoul I. Several were in Denham Bay in 1908 (Iredale 1910, 1913). Specimens were collected from Raoul I. in 1908 (AM B2752), 1909

(Museum of Vertebrate Zoology, Berkeley, 100501; Falla 1936) and 1912 (Oliver *in litt*.). All subsequent bird lists for Raoul have included this species, with numbers present varying with time of year and available habitat. Numbers peak in November when, possibly, birds are stopping on their southward migration. Two were seen on North Meyer I. on 25 Jan.1967 (Merton 1970).

High numbers were present when there were extensive mudflats around Blue Lake following the 1964 eruption, with 36 in November 1964 (Edgar *et al.* 1965) and 34 in November 1966 (Merton 1970). The total count for the farm and Blue Lake in October 1972 was 80 birds (CRV). A maximum of 34 was noted on Raoul I. during March - July 1973 (Ireland 1973). The Blue Lake mudflats are now covered in vegetation, and the farm has reverted to rank grass. The small mown airstrip now appears to offer a feeding area similar to the larger grazed area of the previous farm. Up to 17 birds were noted during November 1993, mainly on the airstrip (GH). They remained present in low numbers (6) through the winter of 1994 (GH), and similar numbers were present in the winter of 1998 (CRV).

Iredale (1910, 1913) reported a flock of 13 waders, mainly golden plovers, on Macauley I. in November 1908. Three were seen there on several occasions in August 1966 (O'Brien 1966), 3-6 in November 1970 (Bell 1970; Yaldwyn 1970), similar numbers in November 1980 (B.D. Bell pers. comm.), and three on 17 Oct. 1972 (CRV). Up to four were seen in September, November and December 1988 (AT, GT & PS). These frequented both the coast and grassland of the upper plateau.

A maximum of five golden plovers were present on Curtis I. in October - November 1989 (AT & GT).

Grey plover (*P. squatarola*)
One was seen on North Meyer I. on 18 Dec.1966 (Merton 1970), and a possible sighting was made on the summit plateau of Macauley I. on 28 Nov.1988 (AT).

Spur-winged plover (*Vanellus miles*)
One was in the paddocks on Raoul I. during September - December 1981 and a carcass, apparently cat-eaten, was found there in January 1982 (Dave Rees pers. comm.). A pair was noted in early October 1993 and was resident around the hostel and airstrip throughout 1994, and another pair was seen occasionally throughout this period fighting with the first pair (GH). In October 1995, David Lawrie and Hugh Clifford (pers. comm.) observed two at Denham Bay swamp, one on Denham Bay beach, and two at Green Lake. In the winter of 1998 none was present in Denham Bay, but four were using the hostel/airstrip and Green Lake areas (CRV).

Turnstone (*Arenaria interpres*)
A turnstone was reported from North Meyer I. on 20 Nov.1964 (Edgar *et al.* 1965). Up to nine were present on the extensive mudflats at Blue Lake in 1966/67 (Merton 1970). One was on the Blue Lake mudflats from 28 Sep. to 2 Oct. 1972 (CRV). Other sightings were: one on Oneraki Beach on 1 Nov.1993, one on South Meyer I. on 1 Jan.1994, three on Egeria Rock on 8 Mar.1994, and one on the tide line at North Meyer I. on 13 Mar.1994 (GH). The location and frequency of these sightings suggest that turnstones might be present each summer on the northern Kermadec Is., occupying habitats rarely visited by observers.

Most recent visitors to Macauley I. have recorded small numbers of turnstones on the rock platforms and parts of the summit plateau (O'Brien 1966; Bell 1970; CM, AT, GT & PS). On 10 Nov.1980 there were 30 birds on the rock platform (Rowley Taylor pers. comm.).

One turnstone was seen in flight off Curtis I. in July 1973 (Smuts-Kennedy 1973). Two were present on Curtis I. on 21 May 1982 (CM), and two were there in October - November 1989 (AT & GT). Three were on Cheeseman I. on 19 Nov.1970 (Bell 1970).

Lesser knot (*Calidris canutus*)
A probable sighting was made in September 1908 at Denham Bay (Iredale 1913; Sorensen 1964). A knot was collected by Roy Bell at Denham Bay on 17 Oct.1910 (Oliver 1913, AM 2813) and a dead bird was found on the Blue Lake mudflats in 1966 (Merton 1970). One was seen with a turnstone on Oneraki Beach on 1 Nov.1993 (GH), and another observed in Denham Bay swamp in October 1995 when there was virtually no surface water in the swamp (Clifford & Lawrie 1997).

Sharp-tailed sandpiper (*C. acuminata*)
There are four sharp-tailed sandpiper records from Raoul I.: one was collected on 25 Oct.1908 (Iredale 1910, 1913), one was shot by R. Bell on 29 Oct.1910 (Oliver 1913), one was collected by M. Fraser on 17 Oct.1982 (MNZ 22730), and a juvenile was seen at Green Lake on 26-27 Oct.1995 (Clifford & Lawrie 1997). A record of a pectoral sandpiper (*C. melanotos*) from the Kermadecs (Falla 1936) was based on a specimen (AM 75.1, missing since 1977), later re-identified as a sharp-tailed sandpiper (B. Gill pers. comm.). This specimen was collected by R. Bell in "? 1910" (B. Gill pers. comm.), so is probably the 1910 bird referred to by Oliver (1913).

Eastern curlew (*Numenius madagascariensis*)
One was seen and heard calling in flight at North Meyer I. on 4 Oct.1974 (Smuts-Kennedy 1975).

Asiatic whimbrel (*N. phaeopus variegatus*)
Oliver collected one of four-five whimbrels seen on Raoul I. in 1908 (Iredale 1910, 1913). One was on North Meyer I. in 1964 (Edgar *et al.* 1965) and at least two were present on Raoul I., North Meyer I. and Egeria Rock in 1966/67 (Merton 1970). Five were present on Raoul I. in September 1972 (Veitch 1974) and one was seen on Low Flat 2 -10 Mar.1973 (Ireland 1973). A whimbrel, thought to be this species, was disturbed feeding on D'Arcy Point on 20 Nov.1993; it flew quickly out to the south east (GH).

An Asiatic whimbrel was present on Macauley I. during November 1970, where it frequented the wave platform to the south and east, and was seen to visit Haszard Islet (Bell 1970). A whimbrel was again present in November 1980 (B.D. Bell pers. comm.).

A mummified corpse of an Asiatic whimbrel was found on Curtis I. on 6 Nov.1989 (GT; MNZ 24048). A whimbrel was heard on L'Esperance Rock on 18 Nov.1970; it is presumed to have been the same bird that picked up the ship 25 km south of L'Esperance and flew alongside until the rock was reached (Bell 1970).

Bristle-thighed curlew (*N. tahitiensis*)
The first New Zealand record for bristle-thighed curlew was from Macauley I., where one was seen in August 1966 (O'Brien 1966). The dried corpse of a female was found on North Meyer I. in 1972 (MNZ 17615), and a single live bird was present on Raoul I. in September 1972 (Veitch 1974).

Bar-tailed godwit (*Limosa lapponica*)
While not noted by all who have recorded the birds of Raoul I., bar-tailed godwits appear to be present every year, particularly in spring. Bell collected 12 in October and November 1909 and 1910 (Oliver 1913). Up to 12 were present in both October 1937 (Davison 1938) and October 1972 (CRV). There is a skeleton from Raoul I. collected on 13 Oct.1983 by M. Fraser (MNZ 22943). A single godwit was on Oneraki Beach and the paddocks from 31 Oct. - 16 Nov.1993, where it usually associated with golden plovers (GH).

Wandering tattler (*Tringa incana*)
A wandering tattler was collected at Fishing Rock, Raoul I. by W.S. Bell on 7 May 1913 (Oliver 1930, *in litt*.). Single birds were recorded on Raoul I., the Milne and Meyer Is. during the 1966/67 OSNZ visit (Merton 1970). Single tattlers, thought to be this species, were seen on Raoul I. in April and June 1973 (Ireland 1973). Smuts-Kennedy (1975) recorded seven on the farm on 18 Oct.1974 and a single bird, probably of this species, on North Meyer I. in October 1974.

Two wandering tattlers (one in breeding plumage) were seen on Macauley I. in August 1966 (O'Brien 1966). Two or three tattlers frequented the wave platforms there in November 1970 and 1980; the only call recognised was that of the wandering tattler, although the only specimen collected proved to be a Siberian tattler (Bell 1970; B.D. Bell pers. comm.).

At least two wandering tattlers were present on the southern shoreline of Curtis I. on 19 Nov.1970 (Bell 1970).

Siberian tattler (*T. brevipes*)
One was seen on the northern coast of Raoul I., west of the farm, on 18 Sep.1972 (CRV). A tattler collected on Macauley in 1970 (Bell 1970) proved to be an adult female Siberian tattler (MNZ 15977). Single tattlers on Macauley I. on 21 and 24 Sep.1988 gave the two-syllable call typical of Siberian tattler – one of these also visited Haszard Islet (AT & GT). In November - December 1988 at least two tattlers were present, and at least one gave the two-syllable call (AT & PS).

A bird giving a two-syllable call, probably a tattler, was seen briefly on the shoreline of Curtis I. on 7 Nov.1989 (AT).

Arctic skua (*Stercorarius parasiticus*)
One was flying south of Denham Bay on 23 Nov.1964 (Edgar *et al*. 1965).

Southern black-backed gull (*Larus dominicanus*)
A juvenile female was collected by W.S. Bell on Raoul I. on 3 Jan.1914 (AM B3001). Oliver (1930) and Fleming (1953) listed this species as straggling to the Kermadecs. The 1966/67 expedition recorded a single adult on three occasions (Merton 1970). In August 1972, two birds of differing juvenile age classes were seen at Raoul Is. (CRV).

Red-billed gull (*L. novaehollandiae*)
Sorensen (1964) made the first reference to red-billed gulls on the Kermadec Is, when he referred to "one or more gulls in the Otago Museum". A search of the Otago Museum collection by CRV revealed one small gull (OM AV339) with an attached label "*Bruchigavia jamesonii* Silver Gull". An accompanying, unattached, paper label bearing the word "Kermadecs" was written by AT in 1983 based on an entry in a register (now missing). L. Gurr (pers. comm. to Sorensen 1964) believed this specimen to be *Larus gunnii* of Tasmania. A "red-billed gull" frequented Raoul during November - December 1963, a probable juvenile was present at Denham Bay on 15-16 Nov.1966

(Merton 1970) and a possible red-billed gull was seen from the Terraces on 21 May 1973 (Ireland 1973).

Sooty tern (*Sterna fuscata*)
Early records noted sooty terns as being present seasonally, in great abundance, at Denham Bay, and also on the Meyer Is. (e.g., Iredale 1910). The first census of this population, made by the 1966/67 OSNZ expedition, estimated 40,000 pairs at Denham Bay, about 40,000 along the southern side of Hutchinson Bluff, 2500+ pairs on North Meyer, 4000+ pairs on South Meyer and up to 3000 pairs on Dayrell (Merton 1970).

The largest colony on Raoul during the 1993/94 summer was confined to the tip of Hutchinson Bluff, where several thousand birds were noted on 3 Jan.1994 (GH). The colony that was on the south side of Hutchinson Bluff in 1967 (Merton 1970) does not now exist. What appears to be a new colony has established on the north side of Hutchinson Bluff, with possibly 5000 adults present and nesting (GH). No terns were noted here in 1966/67 (Merton 1970) or 1978 (Taylor 1979).

The massive Denham Bay population has been destroyed, apparently by cat and rat predation. The numbers of chicks had dropped from 8500 in 1967 (Merton 1970), to 2801 in February 1978 (Taylor 1979), to 300 fledging chicks on 5 Feb.1994 (GH). Only 1300 adults were counted in Denham Bay at the height of the nesting season on 9 Jan.1994; numerous carcasses were found, and cat tracks were observed over the length of Denham Bay beach (GH). Jenny Steven (pers. comm.) reported 2230 birds present at Denham Bay on 12 Dec.1995, with chicks and eggs present. On 13 Dec.1997 the entire island coastline was checked by helicopter: no sooty terns were nesting on Denham Bay beach, but a flock of about 60 was on a rocky area between Hutchinson Bluff and Denham Bay (CRV).

Sooty terns were not common on Macauley I. 21-30 Nov.1970, but a small group of *c.*50 pairs was settling in to nest (the first eggs had just been laid) on the plateau at Stony Point (Bell 1970). On 13 Nov.1980 there were two colonies just north of Slaughter Cliffs, with a total of 500 pairs (P.J. Moors pers. comm.). Sooty terns were present in increasing numbers at Macauley I. from 15-23 Sep.1988, but none was seen on the ground (AT & GT). In November - December 1988, AT, GT & PS found nine colonies and counted about 10,000 eggs.

Cheeseman (1891) recorded that Captain Fairchild took live sooty terns from Curtis I., and Iredale (1910, 1913) recorded that eggs were "very abundant" on Curtis I. on 13 Nov.1908. On 19 Nov.1970, Bell (1970) observed that breeding on Curtis I. was confined to the main crater, where some 10,000 nests were found on every available piece of ground which was not too hot to settle on. AT & GT found sooty terns nesting over much of Curtis I. and counted 5500 eggs on 10-12 Nov.1989.

More than 5000 pairs were present on Cheeseman I., nesting in groups all over the island, on 19 Nov. 1970 (Bell 1970). In 1989, several were seen from Curtis I. flying about Cheeseman I. on 15 October and two were seen ashore there on 21 October (AT & GT).

Iredale (1910) recorded sooty terns arriving at Raoul I. from 31 July with laying starting in late October/early November. Iredale (1910) described the slow process from their first appearance to night time landings, to birds finally staying on the beach all day. Laying seemed to have just begun on Curtis I. on 16 Oct.1989 and was still in progress when the first chick hatched on 10 Nov.1989 (AT & GT). Taylor (1974) recorded laying beginning at Denham Bay shortly after 30 Oct.1974, with chicks from the end of November. P.J. Moors (pers. comm.) observed that 40% of the birds present on Macauley I. on 13 Nov.1980 had laid. Edgar *et al.* (1965) believed that laying at Denham Bay had recently begun on 20 Nov.1964. Laying began on 1 December in 1966 at Denham Bay (Merton 1970). There were eggs and chicks in the Denham Bay colony on 27 Dec.1954 (Bell 1955). By February on Raoul I. some chicks were able to fly (Sorensen 1964). On North Meyer I. fledglings were still present on 13 Mar.1994 (GH) and 23 Mar.1973 (Ireland 1973). The last chicks leave Raoul I. in April and the last adults were heard on 14 May (Iredale 1910, Lindsay 1929).

Of 14,600 sooty tern chicks banded at Denham Bay on Raoul Island between 1961 and 1969, 145 have been recovered on Raoul I. and one as a breeding adult on Aride I. in the Seychelles (Cossee 1995).

Little tern (*S. albifrons*)
A tern skeleton (MNZ 22440) collected from Macauley I. by B.D. Bell in Nov 1980 was identified as a little tern by AT. A possible little tern was seen feeding off South Meyer I. on 13 Oct.1974 (Smuts-Kennedy 1975).

Crested tern (*S. bergii*)
A male crested tern was collected by K. Bell at Denham Bay, Raoul I., on 1 Apr.1910 (Oliver 1913, AM B4928).

Brown noddy (*Anous stolidus*)
In October - November 1989, AT & GT found about 25 scattered pairs of brown noddies nesting on Curtis I. Most birds were on eggs, although a few chicks were present. This was a new breeding record for New Zealand. This species may be a recent colonist at the Kermadec Is. (Holdaway *et al.* 2001).

Black noddy (*A. minutus*)
Black noddies breed abundantly on the Meyer Islets, where 1000 pairs were present in early 1967 (Merton 1970). They have not been recorded breeding on Raoul I., although they do roost along the coast (Merton 1970, GH, CRV).

Iredale (1913) recorded a flight of black noddies at Macauley I., but in the absence of trees, did not think that they bred there. O'Brien (1966) and Bell (in Merton 1970) recorded 20-40 pairs on Macauley I. in August 1966. During 21-30 Nov.1970, Bell (1970) found black noddies nesting in small groups around the eastern and southern shores of the island. As there were no trees for nesting, all nests were built on ledges on the steep cliff faces. Nests were made of seaweed and *Cyperus* sedge. There were about eight - ten groups each with an average of 10-12 nests, and the breeding population was estimated at about 100 pairs (Bell 1970). Similar numbers were present in November 1980 (B.D. Bell pers. comm.). On 23 Sep.1988 there were about 25 nests in Quadrat Gully (AT & GT), and in November - December 1988, there were about 40 nests around the eastern coast (AT, GT & PS).

Bell (1970) observed large numbers of black noddies roosting on Haszard I. in late November 1970.

About 40 black noddy nests, mainly in small colonies, were found by AT & GT on Curtis I. in October - November 1989. About 70 birds were seen around the shore of Curtis I. by CM on 21 May 1982. Bell (1970) found some 30 pairs nesting on L'Esperance Rock on 18 Nov.1970 and estimated that there were fewer than 20 pairs on the western end of Cheeseman I. on 19 Nov.1970. On 14 Sep.1988, five pairs were nesting on L'Esperance Rock (AT & GT) and on 7 Oct.1988, seven nests were noted (R. Mayhill & G. Clark pers. comm.).

Up to three were flying off Raoul I. in June 1973 (Ireland 1973). No black noddies were seen on the Meyer Is on 22 Jul. or 20 Aug.1994, although they were present at sea nearby (GH, CRV). On 8 Aug.1977, Morrison (1979) recorded birds resting in ngaio trees and on the ground on the Meyer Is. On Macauley I., Bell (in Merton 1970) recorded laying beginning about mid-August 1966. Of five nests with birds present on L'Esperance Rock on 14 Sep.1988, one had two eggs and another, one egg. In late September 1988 most nests on Macauley I. were empty, suggesting that laying had just begun (AT & GT). Adults were on eggs on North Meyer I. on 8 Oct.1993 (GH). On 12 Oct.1974 & 1977, birds were incubating on North Meyer I. (Smuts-Kennedy 1975; Morrison 1979). At the same location on 16 Oct.1972, there was a considerable amount of courtship flying, displaying on the ground and in the trees but no eggs had been laid (CRV). In late November 1970, most young were already fledged on Macauley I. but some eggs were still present; between 21 & 30 November most of the colonies broke up and remaining eggs were deserted (Bell 1970). During 7-24 Nov.1980 on Macauley I. some nests had large chicks while others had eggs (P.J. Moors pers. comm.). On 20 Nov.1964 on Meyer I. eggs but no chicks were seen (Edgar *et al*. 1965). On 22 Nov.1966 on North Meyer I., Soper (1969b) found two nests with newly hatched chicks and 32 with eggs, but the majority of nests were still under construction. Eggs and well-grown chicks were present on Curtis I. in November 1989 (AT & GT). In November - December 1988 on Macauley I., nests contained eggs through to well-grown chicks (AT, GT & PS). On 25 Jan.1967 on South Meyer I. most nests contained eggs but chicks of all ages were present (Merton 1970). On 29 Feb.1908 fully feathered chicks were on Meyer I. (Iredale 1910). A few well-grown chicks have been seen on North Meyer I. in March-April (Guthrie-Smith 1936; Ireland 1973; Smuts-Kennedy 1973).

Grey noddy (*Procelsterna cerulea*)
The Meyer and Napier Islets are major breeding grounds for the grey noddy, with lesser numbers on other islands of the Herald Group (Soper 1969c). Merton (1970) estimated the breeding population of the Meyer Is. to exceed 2000 pairs, while Napier I. had many thousands of birds breeding.

Iredale (1910) found grey noddies breeding "very sparingly" on the cliffs at each end of Denham Bay, Raoul I. In 1966/67 the OSNZ expedition found a colony at Smith Bluff, where the cat-eaten remains of 87 fresh and semi-fresh birds, mainly juveniles and nestlings, were found as evidence of breeding there (Soper 1969c; Merton 1970). A nesting pair, with a chick, was at D'Arcy Point on 3 Oct.1974 (Smuts-Kennedy 1975). A colony was seen on Smith Bluff in late 1993, and roosts were apparent on Egeria Rock and Wilson Point (GH).

Cheeseman (1891) found grey noddies to be plentiful on Macauley I., and Iredale (1910, 1913) recorded them breeding there. In August 1966 the species was common there (O'Brien 1966), but in November 1970 numbers appeared to be less than during the 1966 visit, perhaps because some dispersal had already occurred (Bell 1970). Numbers similar to 1970 were present in November 1980 (B.D. Bell pers. comm.), but the birds were not confined to their nesting territories – they were still extremely numerous around the coastal strip, and to a lesser degree up the main gullies. In late September 1988 this was the most abundant breeding species on the island, being widespread around the entire coastline and also nesting on the sides of the steeper inland gullies (AT & GT). About 10,000

pairs may nest on Macauley I. (AT & GT). More than 2000 were feeding off Macauley I. on 22 May 1982 (CM).

Grey noddies roosted in large numbers on Haszard I. in 1970 and 1988 and are presumed to nest there (Bell 1970; AT & GT). They frequently roosted on Newcombe Rock in September 1988 (AT & GT).

Grey noddies nest abundantly on Curtis I., with about 5000 pairs present in October – November 1989 (AT & GT). About 1500 were feeding about the coast on 21 May 1982 (CM). Bell (1970) recorded them breeding in large numbers around the outer coastal fringe of Cheeseman I. in November 1970. From Curtis I., many were seen ashore on Cheeseman I. on 15 Oct. 1989 (AT & GT).

About 5000 grey noddies were present on L'Esperance Rock on 18 Nov.1970 (Bell 1970). AT & GT estimated 1000-1500 nests there on 14 Sep.1988.

Flocks of up to 30 birds were seen around Raoul and North Meyer Is. in March - April 1973 (Ireland 1973). In 1994 low numbers were present on North Meyer I. on 13 June, with no indication of any nesting or courtship taking place (CRV); on 22 July some were courting and visiting prospective nest sites (CRV). On Macauley I. in August 1966 nesting was in full swing, with the first chicks predicted to hatch in the last week of August (O'Brien 1966). On Meyer I. on 3 Aug.1908, laying had not begun (Iredale 1910). On L'Esperance Rock on 14 Sep.1988, 80% of nests had eggs, while 20% had young chicks mostly one-three days old. All 35 nests checked on Macauley I. on 16-17 Sep.1988 had one egg, and by 24 September the first chick was present (AT & GT). On 24 Sep.1944, laying "had just commenced" on Meyer I. (Sorensen 1944). In early October 1974 there were eggs and chicks on North Meyer I. (Smuts-Kennedy 1975). Adults were on eggs on 8 Oct.1993 on North Meyer I. (GH). On 16 Oct.1972 on North Meyer I. there were many nests with eggs, and a few with small chicks (CRV). On 17 Oct.1972 nests on Macauley I. ranged from eggs to fledged young (CRV). In 1989 on Curtis I. the earliest fledglings were seen in late October but some eggs (<5%) were still being incubated on 12 November (AT & GT). Iredale (1910) found hard-set eggs on Curtis I. on 13 Nov.1908. Soper (1969c) found eggs and flying young to be present on the Meyer Is. in mid-November 1966. On L'Esperance Rock breeding had virtually finished by 18 Nov.1970, with only a few late young and addled eggs present (Bell 1970). Nesting on Cheeseman I. was mainly completed, but the odd late fledged chick was still present on 19 Nov.1970 (Bell 1970). On 20 Nov.1964 eggs, a small chick and fledglings were found on Meyer I. (Edgar *et al*. 1965). In late November 1970 on Macauley I. nesting had nearly been completed with only an occasional late chick, with the last of its down remaining, found (Bell 1970). In early December 1988 well-grown chicks and fledglings were common on Macauley I. (AT, GT & PS). On the Herald Is. on 2 Jan.1967, the last hatching was noted but most chicks were already flying (Merton 1970).

White tern (*Gygis alba*)

The white tern is one of the rarest breeding species in the New Zealand region, with Raoul I. its only known nesting site. On Raoul I. they nested in the forest behind Denham Bay (e.g., Sorensen 1964; Merton 1970), the forests behind Low Flat and the Terraces and other coastal areas (e.g., Bell 1912). Recent observations suggest a more restricted distribution, but this may be due more to the localities visited by observers than the presence/absence of birds (GH).

Eggs are found on Raoul I. from October to January (Sorensen 1964). Three pairs were seen frequenting the Norfolk pines near the Meteorological Station and Low Flat during November 1993 - February 1994 (GH). A nest about 5 m above the ground with an egg was found on 11 Nov.1993 but the nest was not successful. Up to 16 were seen flying at Raoul Island in October 1974 (Smuts-Kennedy 1975). Ten birds were noted flying around the canopy in Low Flat Gully on 24 Mar.1994 (GH). Up to 20 were seen in flight in March - May 1973 (Ireland 1973; Smuts-Kennedy 1973).

The nesting habits of white terns make eggs, chicks and adults prone to predation by rats and cats. Smuts-Kennedy (1973) recorded a group of five birds trying to drive his dogs off by diving at them. Such activity makes this species prone to predation by cats, as recorded by Bell (1912) who found as many as eight pairs, eaten by cats, beneath one tree.

New Zealand pigeon (*Hemiphaga novaeseelandiae*)

Early settlers on Raoul I. found a large fruit pigeon, which exactly resembled the New Zealand species, to be abundant (Straubel 1954). It was exterminated, partly by the settlers themselves and partly by the wild cats before any specimens were obtained (Cheeseman 1891). This record has been substantiated by the finding of a pigeon bone on Raoul I. in 1998 (Worthy & Brassey 2000).

Kermadec parakeet (*Cyanoramphus novaezelandiae cyanurus*) (Fig. 8)

Kermadec parakeets were plentiful and, presumably, breeding on Raoul I. in 1836 (Straubel 1954) but were exterminated by cats (Cheeseman 1888). There have been no records that include or suggest permanent residency or breeding on Raoul since 1836. No live birds were seen on Raoul I. in 1967, but evidence was found of one vagrant parakeet eaten by a cat (Merton 1970).

One was on Raoul I. in June - August 1973 (Smuts-Kennedy 1973). In 1994 a pair was seen behind the Meteorological Station on 1 April, and five single birds were seen or heard on Raoul I. in late summer and autumn (GH). They were occasionally heard in many locations on Raoul I. in the winter of 1994 (CRV). Since the removal of goats, more parakeets appear to be residing on Raoul I. for short periods, although breeding has not been proven.

On the Meyer Is., parakeets appear to be common but there may not be more than 100 birds in the Herald Group (Merton 1970; CRV).

Bowes (1787-89) recorded that on 1 June 1788 a party from the *Lady Penrhyn* landed on Macauley I. and "knock'd down some Parroquetts, several of which they brot [sic] on board". Cheeseman (1888) found parakeets on Macauley I. to be in great numbers, going about in flocks from 12 to 50. Iredale (1910, 1913) noted them in "fair numbers" on Macauley I. In August 1966 O'Brien (1966) considered parakeets to be the most common land bird on Macauley I., with numbers exceeding 1000. They were observed to be continuously feeding on the goat carcasses resulting from the goat eradication in progress at that time. By November 1970 Bell (1970) considered them to be twice as abundant as in 1966 and they were seen to visit Haszard I. Taylor (1985) estimated the population on Macauley I. in November 1980 to be 10,000 birds. In September 1988 the population was estimated to be between 17,000 and 20,000 birds, with flocks of up to 400 individuals being seen and birds were also present on Haszard I. (AT & GT). In November of that year AT, GT & PS noted that parakeet numbers on Macauley had declined to 5 to 10% of their previous numbers, and many corpses were found. This was possibly caused by an extremely dry period in October/November 1988.

Parakeets do not appear to be resident on Curtis I., Cheeseman I. or L'Esperance Rock, but there are two records of single birds on Curtis I. Buller (1905) recorded that Mr Ernest Bell brought a caged bird from Curtis I., and Pycroft (1929) reported seeing one bird on Curtis I. on 16 Apr.1929.

Most eggs are laid in October - November and fledging occurs mainly in late December - early January (Taylor 1985). On Macauley I. egg remains were found on 24 & 25 Nov.1988 (AT).

Shining cuckoo (*Chrysococcyx lucidus*)
Bell informed Cheeseman (1888, 1891) that shining cuckoos were occasional visitors to Raoul I. One was heard near Low Flat, Raoul I., on 17 Nov.1966 (Merton 1970).

Long-tailed cuckoo (*Eudynamys taitensis*)
In some years, at least, long-tailed cuckoos may be present on Raoul I. throughout the year. Iredale (1910, 1913) recorded birds in every month except December, and Sorensen (1964) sighted them in most of the winter months of 1944. Small numbers were present on Raoul in the summer of 1966/67 (Merton 1970). From March to July 1973, Ireland (1973) and Smuts-Kennedy (1973) occasionally noted long-tailed cuckoos. Meteorological Station staff reported that at least one bird was present on the island during the winter of 1972 (pers. comm. to CRV). On 18 Oct.1993 a long-tailed cuckoo was being mobbed by five tui (*Prosthemadera novaeseelandiae*) (GH). Similar activity was noted on Low Flat on three occasions in April 1994 (GH). A single bird was observed in early July 1998 (W. Cook pers. comm.).

A long-tailed cuckoo was seen on Macauley I. on 17 Oct.1972 (CRV).

Figure 8 Kermadec parakeet. An endemic sub-species of the red-crowned parakeet.

Sacred kingfisher (*Todiramphus sanctus*)
Early observers recorded kingfishers as being common all over Raoul I. (Cheeseman 1888; Iredale 1910, 1913; Sorensen 1964). Available feeding habitat for this species has been reduced

considerably, with the removal of goats and farm animals allowing rank vegetation to grow. Kingfishers continue to be present where the grass is mown, along the more open parts of the roads and on areas of rocky shore (CRV).

There are a few records from North Meyer I. (eg., Merton 1970). In 1994 kingfishers were seen fishing in the sea from the Milne Islets and South Meyer I. in winter, and others were seen at North Meyer I. during each visit (CRV, GH).

One kingfisher was seen on Macauley I. in November 1980 (P.J. Moors pers. comm.).

Skylark (*Alauda arvensis*)
Cheeseman (1891) did not see any skylarks on Raoul I., although Bell informed him that they were occasionally seen. Sorensen (1964) was informed by Oliver that this species was present in 1908, and Sorensen saw three-four in 1944 and collected one (MNZ 7780). One was seen on Raoul I. on 18 Nov.1964 (Edgar *et al*. 1965). Two skylarks reported in January 1967 were not confirmed by the 1966/67 OSNZ expedition (Merton 1970). In 1973, one was seen on Raoul I. on 9, 16 & 19 April (Ireland 1973; Smuts-Kennedy 1973). Two birds, seen on L'Esperance Rock on 14 Sep.1988, were recorded as either pipits (*Anthus novaeseelandiae*) or skylarks, but they are considered more likely to have been skylarks as this species is more common in northern New Zealand and the Kermadec Islands (AT & GT).

Welcome swallow (*Hirundo tahitica*)
A swallow was seen on Raoul I. in September 1972 (CRV). Up to 13 were seen between March and July 1973 (Ireland 1973; Smuts-Kennedy 1973), one was at North Beach on 13 Oct. 1974 (Smuts-Kennedy 1975), one was collected on Raoul I. on 25 Apr.1983 (MNZ 22971), and Craig (1984) considered the species firmly established in the Kermadec Is. in March 1984. Swallows were in moderate numbers in early October 1993, but none was seen through the summer (GH). Individuals were again seen in increasing numbers from 12 Mar.1994, with up to 20 birds seen in the Meteorological Station and Blue Lake areas (GH). There is no evidence that welcome swallows have bred on the Kermadec Is.
At least two swallows were seen on Macauley I. in September 1988 (AT & GT). Two were on Curtis I. on 15 Sep.1988, and three dead birds and up to seven live birds were on Curtis I. in October - November 1989 (AT & GT).

New Zealand pipit (*Anthus novaeseelandiae*)
Pipits were occasionally recorded on Raoul I. (Cheeseman 1891; Sorensen 1964), Macauley I. (Cheeseman 1888, 1891) and Curtis I. (Lindsay 1929; Pycroft 1929; Guthrie-Smith 1936) between 1887 and 1944, but there are no recent confirmed records.

Blackbird (*Turdus merula*)
Blackbirds were first recorded as firmly established on Raoul I. in 1908 by Iredale (1910), and have since been considered common there (Merton & Veitch 1986). Counts in 1967 showed them to be less abundant than starlings (*Sturnus vulgaris*), song thrushes (*Turdus philomelos*) and tui in the forest, but mist-netting at low altitudes caught more blackbirds than thrushes (Merton & Veitch 1986). Observations during the winters of 1994 and 1998 indicate that blackbirds have maintained their abundance in the forest habitat and they are now second in relative abundance after tui (Veitch 2003).

Blackbirds are also present on the Meyer Is. (Sorensen 1964; Morrison 1979; Merton & Veitch 1986) but they have not been recorded from other islands in the Herald Group.

At least one female blackbird was on Macauley I. in August 1966 (O'Brien 1966) and another present in November 1970 (Bell 1970) and on 17 Sep.1988 (AT & GT). Pycroft (1929) and Guthrie-Smith (1936) recorded one blackbird on Curtis I. on 16 Apr.1929. Two were on L'Esperance Rock on 14 Sep.1988 (AT & GT).

Song thrush (*T. philomelos*)
Recorded as firmly established on Raoul I. in 1908 by Iredale (1910), they have since been considered plentiful and widespread there (Sorensen 1964; Merton & Veitch 1986). In January 1967, thrushes were widespread and were the second species in order of relative abundance in the forest on Raoul I. (Merton & Veitch 1986). During the winters of 1994 and 1998, similar counts placed it fourth, but none was recorded during the counts in higher altitude forests (Veitch 2003). This change in abundance could be due to forest recovery since goat eradication – an effect similar to changes noted after goat eradications on other islands (Diamond & Veitch 1981). However, the conspicuousness of thrushes and blackbirds does vary throughout the year. In the summer of 1967 song thrushes were more vocal than blackbirds (Merton & Veitch 1986), whereas during winter counts thrushes become silent and blackbirds give alarm calls when disturbed (CRV).

On Macauley I. in August 1966 up to four thrushes were seen at any one time (O'Brien 1966), and in September 1988 one live and one dead thrush was recorded (AT & GT). Pycroft (1929) and Guthrie-Smith (1936) recorded one thrush on Curtis I. on 16 Apr.1929 while two were seen there on 15 Sep.1988 (AT & GT). One live and one dead thrush (MNZ 23959) were on

L'Esperance Rock on 14 Sep.1988 (AT & GT) and there is a probable sighting from there in July 1969 (Merton & Veitch 1986).

Silvereye (*Zosterops lateralis*)
Silvereyes were recorded as "not plentiful" on Raoul I. by Smith (1887) and Cheeseman (1888), and as a vagrant by Cheeseman (1891) and Iredale (1910). They were not recorded in 1966 (Merton 1970), but were heard and seen in low numbers in September 1972 (CRV) and 1973 (Smuts-Kennedy 1973).

Silvereyes were "not plentiful" on Macauley I. in August 1887 (Smith 1887; Cheeseman 1888, 1891), and they were present in August 1966, when two flocks of about 30 birds each were observed from time to time (O'Brien 1966). In September 1988, silvereyes were observed on different parts of Macauley I., with the largest flock being 45 birds (AT & GT).

Three silvereyes were on Curtis I. on 15 Sep.1988 (AT & GT) and four on L'Esperance Rock on 14 Sep.1988 (AT & GT).

Tui (*Prosthemadera novaeseelandiae*)
Tui have always been described as abundant on Raoul I. (eg. Cheeseman 1888; Iredale 1913), but prior to the 1966/67 OSNZ expedition there were no data to indicate abundance. Cheeseman (1888, 1891) and Sorensen (1964) referred to tui as being preyed on by wild cats. While birds were noticeably less important than rats in the diet of cats on Raoul I. (Fitzgerald *et al.* 1991), tui were the bird most frequently eaten. In 1967, tui were third in the order of bird abundance in the forest, being seen at about one third of the frequency of starlings, on slightly fewer occasions than song thrushes and slightly more frequently than blackbirds (Merton & Veitch 1986). Now they are quite clearly the most abundant forest bird, despite their regular silence during surveys (Veitch 2003). Tui have never been recorded on the Herald Islets or any of the southern Kermadec Is.

Yellowhammer (*Emberiza citrinella*)
Yellowhammers were first recorded at the Kermadec Is. in 1944 when they were moderately plentiful on Raoul I. (Sorensen 1964). Yellowhammers were sufficiently widespread in 1967 to feature in forest bird counts, albeit as the least abundant of the five species recorded (Merton & Veitch 1986). Since goat eradication, yellowhammers no longer occur in the forest on Raoul I. (Veitch 2003), but they do occur along the roads and on mown grass, as well as seeking crumbs on the Hostel verandah (CRV).

Two yellowhammers were on Curtis I. on 15 Sep.1988, and two on L'Esperance Rock on 14 Sep.1988 (AT & GT).

Chaffinch (*Fringilla coelebs*)
A female on Macauley I. in November 1970 (Bell 1970) is the only record from the Kermadec Is.

Greenfinch (*Carduelis chloris*)
R. Bell collected three greenfinches on Raoul I. on about 23 June 1910 (AM B4640-42). Greenfinches were recorded by the 1964 OSNZ party (Edgar *et al.* 1965), but were not seen in 1966/67 (Merton 1970). Some were present in 1972 (CRV) and they were regularly seen during the winter of 1973 (Ireland 1973; Smuts-Kennedy 1973). There is a skeleton from Raoul I. collected on 11 May 1983 by A.W. Blundell (MNZ 23020). An adult male was seen at the hostel on 26 Apr.1994 (GH), and a female was present on a number of occasions in mid July 1994 (CRV). A freshly dead greenfinch was found on Macauley I. on 13 Nov.1980, but no live birds were seen (P.J. Moors pers. comm.). Two were on L'Esperance Rock on 14 Sep.1988 (AT & GT).

Goldfinch (*C. carduelis*)
Prior to Sorensen's (1964) record of three on Raoul I. in 1940, the records were sparse, second-hand, and of single birds (Merton & Veitch 1986). None was recorded by the 1964 or 1966/67 OSNZ parties (Merton 1970). In the winter of 1972, a few small flocks of goldfinches were seen in the vicinity of the farm and Low Flat (CRV), and up to two occasionally visited the hostel garden in May-June 1973 (Ireland 1973; Smuts-Kennedy 1973). There is a skin from Raoul I. collected on 18 May 1983 by A. Harper (MNZ 22970). In 1994 a single male was seen in the station grounds on 7-9 June, and two were noted fighting on the hostel lawn on 17 June (CRV). A goldfinch was on Macauley I. in August 1966 (O'Brien 1966), and two were on Curtis I. on 15 Sep.1988 (AT & GT).

Redpoll (*C. flammea*)
Redpolls have probably been present on Raoul I. since at least 1887 if Smith's (1887) record of "Linnets" is correctly interpreted as redpolls (Merton & Veitch 1986). However, Oliver and Iredale (who spent 10 months on Raoul in 1908) did not record them. Redpolls were noted on Raoul I. in 1909 (Sorensen 1964). One specimen was collected by King Bell in May 1910 (Merton & Veitch 1986, AM B4502). A flock was seen on Raoul I. in May 1944 (Sorensen 1964). Redpoll calls were heard on Raoul I. in November 1964 (Edgar *et al.* 1965). None were seen during the 1966/67 visit, but flight calls were heard over D'Arcy Point Ridge (Merton 1970). A flock of 20+ were seen near Mt Prospect on 3 Oct.1972 (CRV). The 1973 Meteorological Station team reported

Table 1 Distribution and estimated numbers (pairs) of breeding birds on the Kermadec Is. Legend: X = locally extinct, ? = breeding suspected, (I) = species introduced to mainland New Zealand that have subsequently colonised the Kermadec Is. Macauley includes Haszard Islet, * = large population fluctuations occur.

	Raoul	Herald Is.	Macauley	Curtis	Cheeseman	L'Esperance
Wedge-tailed shearwater	X	10,000+	40,000	2500	<500	50
Little shearwater	X	100+	500	100,000	<1000	-
Black-winged petrel	X	1000+	2,500,000	300,000	10,000+	200
White-naped petrel	X	-	50,000	-	-	-
Kermadec petrel	X	6000+	<50	X	-	-
Kermadec storm petrel	-	-	?	-	-	-
White-bellied storm petrel	-	-	<200	<500	-	-
Red-tailed tropicbird	<50	200	<100	<20	-	-
Masked booby	-	<50	100	70	<20	-
Grey duck	<50	-	-	-	-	-
Spotless crake	X	<50	-	-	-	-
Pukeko	<50	-	-	-	-	-
Sooty tern	<5000	<10,000	10,000	5500	5000+	-
Brown noddy	-	-	-	25	-	-
Black noddy	-	1000	50	40	-	30
Grey noddy	<100	5000+	10,000	5,000	1000	<1500
White tern	<10	-	-	-	-	-
New Zealand pigeon	X	-	-	-	-	-
Kermadec parakeet	X	50	10,000*	-	-	-
New Zealand kingfisher	50	<10	-	-	-	-
Blackbird (I)	>1000	<100	-	-	-	-
Song thrush (I)	<500	-	-	-	-	-
Tui	>1000	-	-	-	-	-
Yellowhammer (I)	?	-	-	-	-	-
Starling (I)	<500	<100	?	<50	-	-

scattered sightings of up to five redpolls on Raoul I. (Merton & Veitch 1986). They were occasionally heard and seen in 1974 and a nest was found behind Denham Bay (Taylor 1974; Smuts-Kennedy 1975). A flock of five was seen in the top paddock on 30 April - 1 May 1994 (GH). There are no records of redpolls from any of the other islands in the Kermadec group.

Starling (*Sturnus vulgaris*)
First recorded on Raoul I. by Iredale (1910), who considered them to be firmly established. The 1966/67 OSNZ expedition confirmed their presence and breeding on most of the Herald Islets (Merton & Veitch 1986).

In 1967, flocks of up to 1500 starlings were feeding on the mudflats which had been created around the shores of Blue Lake during the 1964 eruption. There were also flocks on the farm, and starlings were by far the most abundant bird recorded in forest bird counts (Merton & Veitch 1986). The shores of Blue Lake are now densely vegetated, the farm is covered in rank grass, and starlings are less numerous in the forest (being third on the order of relative abundance; Veitch 2003). In the higher altitude forests, starling foraging appears to now be limited to the foliage and the upper surfaces of broad branches of emergent pohutukawa.

In 1966/67 many thousands of starlings flew to the Meyer Is. to roost each evening and the species was present on many of the Herald Is. (Merton & Veitch 1986). Counts in June 1994 at Ngaio Point and North Meyer I. suggested that fewer than 500 birds may now be making this evening roost flight (CRV).

Low numbers of starlings were present on Macauley I. in August 1966, with the most seen at any one time being eight (O'Brien 1966). In November 1970 small numbers were present and presumed to be breeding (Bell 1970). Low numbers (usually single birds) were seen on most days in September 1988, and they were also seen to fly to Haszard I. (AT & GT). Small numbers were also seen there in November - December 1988 (AT, GT & PS).

Guthrie-Smith (1936) saw 10-12 starlings on Curtis I. in 1929, and Bell (1970) saw a flock of 12-20 birds there on 19 Nov.1970 which included birds in juvenile plumage. Three starlings were seen on Curtis I. on 21 May 1982 (CM) and 15 September 1988 (AT & GT), and, in October – November 1989, at least 40 birds including two juveniles, and broken eggshell (AT & GT). One starling was on L'Esperance Rock on 18 Nov.1970 (Bell 1970).

Table 2 Comparison of the original known pre-human breeding seabird faunas of Kermadec, Norfolk, Lord Howe and Tonga Is. Australia and New Zealand, based on the breeding seabird species of the Kermadec Is. (●) = possibly part of the original fauna. Distributions based on Hermes *et al*. (1986); Hutton (1991); Marchant & Higgins (1990); Meredith (1991); Moore (1999); Holdaway *et al*. (2001); Watling (2001) and pers. obs.
Note: the brown noddy is considered a recent colonist.

Kermadec	Norfolk	Lord Howe	Tonga	Australia	New Zealand
Wedge-tailed shearwater	●	●	●	●	
Little shearwater	●	●		●	●
Black-winged petrel	(●)		(●)		(●)
White-naped petrel	(●)				
Kermadec petrel	●	●	●		
Kermadec storm petrel	(●)	(●)			
White-bellied storm petrel	(●)	●			
Red-tailed tropicbird	●	●	●	●	
Masked booby	●	●	●	●	
Sooty tern	●	●	●	●	
Black noddy	●	●	●	●	
Grey noddy	●	●	●		
White tern	●	●	●		

DISCUSSION

Biogeography of the breeding birds of the Kermadec Islands

Based on our limited understanding of their original avifauna, the Kermadec Is. had a naturally depauperate indigenous land and freshwater bird fauna. Of the seven known species, one (New Zealand pigeon) no longer occurs there (Table 1). Resident indigenous land birds are completely absent from the southern Kermadec Is. apart from the Kermadec parakeet on Macauley I. This depauperate avifauna is probably due to the relatively young age of the islands (less than 2 my; Brothers & Searle 1970) and the effects of catastrophic volcanic eruptions (Brothers & Searle 1970; Sykes 1977). Other factors that may have affected the ability of colonists to establish are the low botanical diversity (Sykes 1977), low insect diversity (Watt 1975), and the absence of potable surface water on the southern islands.

It is possible that additional landbird species were lost to introduced predators before naturalists were able to record their presence. For example, the former existence of New Zealand pigeon on Raoul I. has only recently been confirmed (Worthy & Brassey 2000) and banded rail may have been present (Cheeseman 1891). Cheeseman's (1891) intriguing account of a megapode occurring on Raoul I. until a volcanic eruption (Appendix) remains uncorroborated. One plausible way for a megapode to reach the Kermadec Is is via human intervention (Guthrie-Smith 1936), e.g., by Polynesians translocating *Megapodius pritchardi* from Tonga. However, *Megapodius* are strong fliers and regularly fly from one island to another (Jones *et al.* 1995), so they may have arrived by themselves.

The indigenous land and freshwater birds that succeeded in colonising the Kermadec Is. include some of the most successful colonisers of the south-west Pacific (*Anas superciliosa, Porzana tabuensis* and *Porphyrio*) and the New Zealand region (*Hemiphaga, Cyanoramphus* and *Prosthemadera*). Species that are unexpectedly absent include snipe (*Coenocorypha*), kaka (*Nestor*), morepork (*Ninox*), tomtit (*Petroica*), fantail (*Rhipidura*), warbler (*Gerygone*), bellbird (*Anthornis*) and pipit, although the latter was occasionally recorded between 1887 and 1944. The silvereye is surprisingly absent as a resident at the Kermadecs.

In contrast to the land birds, the Kermadec Is. have a diverse breeding seabird fauna (14 species) typical of the sub-tropical south Pacific (Table 2, Fig 9). For 11 taxa (including the Kermadec storm petrel and brown noddy), the Kermadec Is. are the only New Zealand breeding location. The original pre-human seabird fauna is most similar to those of Norfolk I. (1360 km to the west) and Lord Howe I. (2220 km to the west-south-west) (Fig. 1), both of which share at least nine species with the Kermadec Is. (Table 2). Seabirds that originally bred on one or both of Norfolk I. (NI) and Lord Howe I. (LHI) that are absent from the Kermadec Is. are the providence petrel (*Pterodroma solandri*; NI & LHI), Pycroft's petrel (*P. pycrofti*; NI & LHI), and flesh-footed shearwater (*Puffinus carneipes*; LHI). Note that we follow Holdaway *et al*. (2001) in not recognising *Sula tasmani* (van Tets *et al*. 1988) as being distinct from *S. dactylatra*.

Several seabird species typical of the northern North Island of New Zealand do not breed at the Kermadec Is., including grey-faced petrel, Cook's petrel (*Pterodroma cookii*), Pycroft's petrel, flesh-footed shearwater, fluttering shearwater (*Puffinus gavia*), common diving petrel (*Pelecanoides*

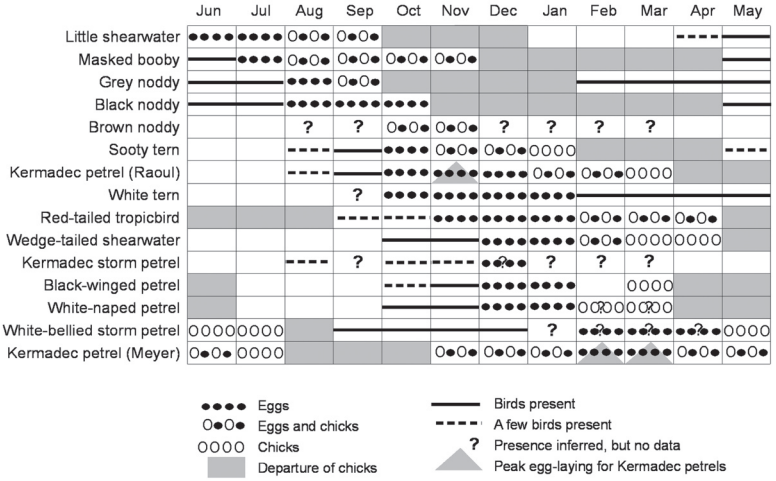

Figure 9 The breeding seasons of seabirds nesting on the Kermadec Islands. See text for additional information on occasional early or late breeding records. Compare with table on p. 23 of Hutton (1991) for a comparison with breeding seasons on Lord Howe I.

urinatrix), little penguin (*Eudyptula minor*), Australasian gannet, five species of cormorant and shag (*Phalacrocorax* and *Stictocarbo*), southern-black backed gull, red-billed gull and white-fronted tern (*Sterna striata*). Seabird species breeding in the Tonga Is. to the north, but not at the Kermadec Is. include herald petrel (*Pterodroma arminjoniana*), Audubon's shearwater (*Puffinus lherminieri*), white-tailed tropicbird (*Phaethon lepturus*), red-footed booby (*Sula sula*), brown booby, frigatebirds, crested tern, bridled tern (*Sterna anaethetus*) and black-naped tern (*S. sumatrana*) (Jenkins 1980b; Watling 2001).

Vagrants and recent colonists

Although the native breeding birds on the Kermadec Is. are currently limited to about 20 species, at least 61 species have visited or colonised the islands over the last 200 years. Based on the most likely country or region of origin, 26 (43%) came from New Zealand, 15 (25%) were holarctic migrants or vagrants, 6 (10%) came from the tropical Pacific, and 5 (8%) came from each of Australia and the subantarctic (Table 3). Four species (royal spoonbill, harrier, pukeko, and red-billed gull) are of uncertain origin, although probably had a greater probability of arriving from New Zealand. At least two of the subantarctic species (and possibly all of them) came from beyond the Pacific sector. The Kermadec Is. provides the only records from the New Zealand region for Phoenix petrel and bristle-thighed curlew.

Impacts of humans and introduced mammals

Humans, their camp followers, and deliberate introductions have decimated the birds of the Kermadec Is. Until 1970 goats, cats, and Pacific and Norway rats were present on Raoul I., and goats and Pacific rats were present on Macauley I. The tide is now turning, with goats eradicated from Macauley I. by 1970 and Raoul I. by 1985, and eradication of cats and both rat species attempted on Raoul I. in 2002. If these latter operations prove successful, then the only introduced mammal remaining on the Kermadec Is. will be Pacific rats on Macauley I. However, these actions have come too late for at least some land bird species and the vast seabird colonies formerly present on Raoul I.

The early settlers on Raoul I. collected and preserved large numbers of fledgling Kermadec petrels, with over 12,000 being collected during the spring of 1889 alone (Cheeseman 1891). Cheeseman also attributed the extinction of the pigeon "partly [to] the settlers themselves and partly by the wild cats introduced by them". The 1908 expedition also consumed "immature" Kermadec petrels, and noted that 2000 - 3000 were preserved by the islanders that year (Iredale 1914). While human hunting may have contributed to the decline of several species, there is little doubt that the main agents responsible for the extinction, or near extinction, of most bird species on Raoul I. were cats and Norway rats. These two species alone can be blamed for the local extinction of white-naped petrel plus a further four species that still occur on the Herald Islets close offshore (wedge-tailed shearwater, black-winged petrel, Kermadec petrel and spotless crake; Table 1). Other species never or rarely recorded from Raoul I. may also have been eliminated there by cats and rats (little shearwater, storm petrels, masked booby, noddies). Predation by cats and Norway rats has also nearly eliminated the formerly huge sooty tern colonies on Raoul I. (Taylor 1979 and data herein). After local breeding populations had been destroyed, cats continued to prey on black-winged petrels and Kermadec parakeets that attempted to recolonise Raoul I. (Merton 1970). Kermadec parakeets disappeared from Raoul I. before Norway rats colonised, and

Table 3 Vagrants and recent colonists listed by their possible source of origin.

New Zealand	Holarctic	Tropical Pacific
Buller's mollymawk	Oriental pratincole	Christmas I. shearwater
Sooty shearwater	Pacific golden plover	Phoenix petrel
Grey-faced petrel	Grey plover	Brown booby
Black shag	Oriental dotterel	Frigatebird *sp.*
White-faced heron	Turnstone	Crested tern
Canada goose	Lesser knot	Brown noddy
Paradise shelduck	Sharp-tailed sandpiper	
Mallard	Eastern curlew	**Australia**
Oystercatcher sp.	Asiatic whimbrel	
Banded dotterel	Bristle-thighed curlew	Short-tailed shearwater
Spur-winged plover	Bar-tailed godwit	White-necked heron
Black-backed gull	Wandering tattler	Little egret
Shining cuckoo	Siberian tattler	Cattle egret
Long-tailed cuckoo	Arctic skua	Chestnut-breasted shelduck
Skylark	Little tern	
Welcome swallow		
NZ pipit	**Subantarctic**	**Uncertain**
Blackbird		
Song thrush	Wandering albatross	Royal spoonbill
Silvereye	Giant petrel sp.	Harrier
Yellowhammer	Thin-billed prion	Pukeko
Chaffinch	Antarctic prion	Red-billed gull
Greenfinch	Blue petrel	
Goldfinch		
Redpoll		
Starling		

Cheeseman (1888), quoting a resident, attributed this to cat predation but this was probably assisted by the removal of understory vegetation and leaf litter by goats (Veitch & Bell 1990).

The impact of the Pacific rat on the birds on Raoul I. has been masked by the presence of cats and Norway rats. However, Bell (1911) reported Pacific rats killing up to 80% of Kermadec petrel chicks on Raoul I. in some years. This record notwithstanding, it is apparent from historical accounts from Raoul I. and recent observations on Macauley I. that most Kermadec bird species can survive in the presence of Pacific rat. Notable exceptions to this are little shearwater and the two storm petrel species. Little shearwaters and white-bellied storm petrels in the Kermadec Is. are now confined to rat-free islands and probably also only rat-free sites on Macauley I. The breeding grounds of the Kermadec storm petrel have yet to be discovered, but are almost certainly rat-free sites.

The impact of cats and rats on the birds of Raoul I. is striking (Table 1). Raoul I. is the largest island in the archipelago and should have the most abundant and diverse birdlife. It is the only island with freshwater habitats, and it has the only remaining substantial tract of forest in the archipelago. However, of the 20 remaining indigenous bird species still breeding on the Kermadec Is. only grey duck, pukeko, white tern, kingfisher and tui are more secure on Raoul I. than elsewhere in the group (note that all five species are confined to Raoul I. within the Kermadec Is.). Of these five species, white terns are critically endangered on Raoul I., and there are few grey ducks present. Tui, kingfisher and pukeko are the only indigenous bird species that can be considered secure on Raoul I. in the presence of cats and rats, and prior to goat removal the pukeko population seemed unable to establish permanently, probably due to inadequate food availability.

While goats may have displaced many surface-nesting seabirds and trampled many burrows, their impact on the birds of the Kermadec Is. has also been indirect through modification of vegetation (Sykes 1969). There is no record of whether tui, New Zealand pigeon or white tern originally occurred on Macauley I., but the complete destruction of woody vegetation by goats eliminated any potential habitat there for these species. On Raoul I. there is direct evidence that the removal of goats has led to population increases in tui (Veitch 2003) and pukeko. On Macauley I., wedge-tailed shearwaters, black-winged petrels, white-naped petrels, sooty terns and Kermadec parakeets all appear to have increased markedly since goat eradication, but there have been few estimates of breeding populations over time to confirm this.

Priorities for research and management

Although cats and rats have wrought terrible havoc on the birds of Raoul I., no species are known to have become globally extinct as a result, and all but one species remain elsewhere in the Kermadec Group (three if the megapode and banded rail are included). If the recent eradication of rats and cats on Raoul I. is successful, most of these species should recolonise naturally from the nearby Herald Islets. Black-winged petrels are known to frequently visit Raoul I., and the other more-nocturnal species may be doing the same. This process could be aided by installing solar-powered sound systems broadcasting calls of, particularly, Kermadec petrel, black-winged petrel, wedge-tailed shearwater and little shearwater. The return of some surface-nesting and tree-nesting seabirds could potentially be enhanced by placement of models at suitable nesting sites (eg. Kermadec petrel, red-tailed tropicbird, masked booby and noddies).

Species that are less likely to recolonise Raoul I. without direct translocation include white-naped petrel and New Zealand pigeon. Following confirmation of cat and rat eradication, white-naped petrel chicks from Macauley I. should be transferred to Raoul I. using techniques currently being trialed on Pycroft's petrel (*Pterodroma pycrofti*) and Chatham petrel (*P. axillaris*) (G. Taylor unpubl.) and Gould's petrel (*P. leucoptera*) (Priddle & Carlile 1999, 2001). The New Zealand pigeon is an important disperser of seeds in New Zealand forests (Clout 1990) and its reintroduction to Raoul I. is being investigated (M.N. Clout pers. comm.) using knowledge from mainland studies and lessons learnt from current attempts to (re)establish them on the Three Kings. Is (M. Thorsen pers. comm.).

Eradication of Pacific rats from Macauley I. should be a priority to improve the security of Kermadec storm petrel, white-bellied storm petrel and little shearwater. At least the latter two species survive on Macauley I. in low numbers, but their re-establishment could be enhanced by installation of solar-powered sound systems playing their calls or those of related taxa. Care should be taken to safeguard the Kermadec parakeet population on Macauley I. during rat eradication. The dramatic population crash that we recorded between September and November 1988 suggests that this population is subjected to severe natural fluctuations at times, and, if food shortages contribute to these fluctuations, the birds may prove more susceptible to consuming toxic cereal baits than has been found for populations of the nominate subspecies of the red-crowned parakeet (*Cyanoramphus novaezelandiae*) elsewhere (Spurr & Powlesland 1997). There are no data on whether there is any genetic differentiation between Kermadec parakeets on Macauley I. and those on the Herald Islets.

All vagrant mallards should be eliminated to prevent hybridisation with the grey duck population.

The location of the breeding site of the Kermadec storm petrel is one of the greatest remaining mysteries of bird distribution in the New Zealand region. Any opportunities to survey rat-free sites in the Kermadec Is. from late winter to summer should be taken, with particular priority given to Haszard Islet. Our knowledge of the original avifauna of both Raoul and Macauley Is is also rudimentary, and efforts should be made to locate subfossil bone deposits to guide restoration efforts. In particular, confirmation of the former presence of a megapode on Raoul I. would provide a novel challenge for New Zealand conservationists.

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Appendix: Suspense list

This list includes unverified or second-hand sightings not supported by specimens or only supported by specimens of dubious origin.

Fairy prion (*Pachyptila turtur*)
Oliver (1930) listed fairy prion as occurring at the Kermadecs but he did not repeat this record in his 1955 book (Oliver 1955). Perhaps the record is supposed to refer to the Antarctic prion (AM B5496), which is not mentioned in his 1930 book. A dead prion found on Oneraki Beach, Raoul I., on 5 June 1994 was identified as probably a fairy prion (GH).

Pycroft's petrel (*Pterodroma pycrofti*)
Although there are no accounts of this species occurring at the Kermadecs, we have located three museum skins labelled "Kermadecs": MNZ 305, Jan. 1896; AMNH 528249, 1898; MNZ 338, no date, exchanged to Kanagawa Museum, Japan.

Cook's petrel (*Pterodroma cookii*)
Oliver (1930, 1955) recorded Cook's petrel as occurring at the Kermadecs but there is no good evidence that nesting has ever occurred at the Kermadec Group. Five museum skins are labelled as being from the Kermadec Is. (MNZ 312, Jan. 1896; MNZ 303, Dec. 1901; MNZ 314, no date, exchanged to Kanagawa Museum, Japan; AMNH ex Buller no. 137c; AMNH ex Buller no. 137d). Two eggs in the Auckland Museum (AM 123, AM 125) labelled *Pterodroma cookii* from Curtis Is are presumed to be eggs of *P. nigripennis*. Guthrie-Smith (1936) recorded Cook's petrels burrowing on Meyer I. in April 1929 but this record has not been corroborated by any other observer.

Mottled petrel (*Pterodroma inexpectata*)
A louse is recorded as being collected from a mottled petrel from the Kermadec Is. (Palma & Pilgrim 2002). The louse is in the collection of the British Museum of Natural History as part of the Thompson Collection (B.M. 1980-40)(R. Palma pers. comm.) but no further evidence has been found in the British Museum to substantiate the petrel record (J. Cooper pers. comm.).

Providence petrel (*Pterodroma solandri*)
Hutton (1893), working with specimens from Auckland Museum, recorded three "*Œstrelata phillipi*" collected from Raoul Island by R.S. Bell in 1887-1891. Hutton referred to several colour forms of *P. neglecta* as separate species, and it is likely that these three birds were Kermadec petrels, which can appear similar to *P. solandri*. Hutton (1904) apparently retracted the identification, but it was accepted by Buller (1905). Iredale (1910, 1913, 1914) considered these birds to be *P. neglecta*, but he does not mention whether he sighted the specimens. None of the *P. solandri* specimens now in Auckland Museum are listed as being collected on Raoul I. (B. Gill pers. comm.).

Australasian gannet (*Morus serrator*)
Mr Bell reported to Cheeseman (1891) that gannets visited Raoul I. infrequently.

Little black shag (*Phalacrocorax sulcirostris*)
Oliver (1912) was informed by R.S. Bell that a small number of little black shags "stayed for some years" on Raoul and Macauley Is.

Striated heron (*Ardea striata*)
A specimen labelled "*Nycticorax caledonicus*" (nankeen night heron) from the Kermadecs (OM AV217) appears to be a striated heron (AT). This species has not otherwise been reported from New Zealand and the record requires further investigation.

Reef heron (*Egretta sacra*)
Mr Bell reported to Cheeseman (1891) that reef herons were occasionally seen at the Kermadec Is. A "white heron" possibly of this species was seen on the Meyer Is. in September 1964 (Merton 1970).

Banded rail (*Gallirallus philippensis*)
Cheeseman (1891) recorded banded rail to be on Raoul in the "vicinity of the lagoon in Denham Bay, but by no means common" based on a report from Mr Bell. There are no other records.

Megapode (*Megapodius* sp.)
A species of megapode was reported to be present on Raoul I. until wiped out by an eruption in 1876 (Cheeseman 1891).

Curlew sandpiper (*Calidris ferruginea*)
All reports of this species occurring at the Kermadec Is. (Fleming 1953; Oliver 1955; Merton 1970) refer back to Oliver (1930). The basis for this record is "A specimen in the Auckland Museum from Kermadec Is. Coll. R. Bell" (Oliver archives, Te Papa). This specimen cannot be found.

Franklin's gull (*L. pipixcan*)
A Franklin's gull in breeding plumage was photographed in Green Lake, Raoul I., by Mike Fraser, in July 1988. The details of this potential first record for New Zealand have not been assessed by the Rare Birds Committee of the Ornithological Society of New Zealand.

Caspian tern (*Sterna caspia*)
Cheeseman (1891) recorded Caspian tern as occurring at Raoul Island, based on a report by Mr Bell.

Australian tree martin (*Hylochelidon nigricans*)
There were two unconfirmed sightings of a tree martin on Raoul I. in September 1966 (Merton 1970).

House sparrow (*Passer domesticus*)
The only record of house sparrows at the Kermadec Is is of two specimens, one male and one female, lodged in the Auckland Museum (AM B4898 & B4899) and labelled as collected by R. Bell, Kermadec Is., dated *c*.25 June 1910. The labels attached to the specimens and cards in the card index were written by G.A. Buddle who was at the museum from 1943 to 1951. Roy Bell's diary (CRV pers. obs.) for the period 12 November 1908 to April 1911 (Bell 1911), makes no reference to house sparrows and he did appear to note most collections and new bird sightings.