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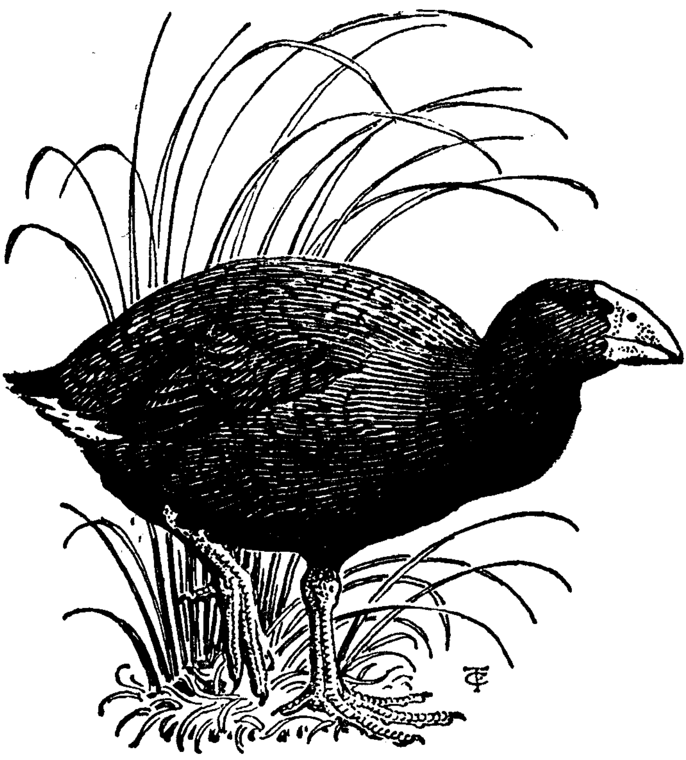

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BREEDING OF THE CHATHAM ISLAND WARBLER (Gerygone albofrontata)

By M. D. DENNISON, H. A. ROBERTSON and D. CROUCHLEY

ABSTRACT

The breeding of the Chatham Island Warbler was studied over five seasons on three islands in the Chatham Group. The breeding season is short, and only one brood is raised per year. On predator-free 'petrel islands', nests were low to the ground in dense vegetation, whereas on Chatham Island nests were high and in the open. Mean clutch size was 3.1 eggs (n=79). Incubation and nestling periods were both about 20 days. Density of breeding birds was highest in regenerating forest clumps on predator-free islands, with about 10 pairs per hectare. Comparisons are made with the breeding biology of the Grey Warbler *(G. igata)* of the New Zealand mainland and with other *Gerygone* species. Brood parasitism by the Shining Cuckoo *(Chrysococcyx lucidus)* and how vulnerable the Chatham Island Warbler is to extinction are discussed.

INTRODUCTION

The Chatham Island Warbler (*Gerygone albofrontata* Gray, 1844) is endemic to the Chatham Islands. It belongs to the genus of Australasian warblers, *Gerygone,* which contains about 18 species, extending from South-east Asia through New Guinea and Australia to the islands of the South-west Pacific, including New Zealand, where it is represented on the mainland and on many offshore islands by the Grey Warbler *G. igata* (Meise 1931, Gill 1982). Robertson & Dennison (in press) have suggested that the Chatham Island Warbler was derived from a warbler that has become extinct on the New Zealand mainland, and not from *G. igata,* a species whose breeding biology has been closely studied recently (Gill 1982, 1983a). The breeding of other *Gerygone* species has not been studied in depth; only approximate clutch sizes, some incubation and nestling periods and a few other details are known (e.g. McGill 1970, Courtney & Marchant 1971).

In recent years the Chatham Island Warbler has been used as a host for the eggs and chicks of Black Robins *(Petroica traversi)* in an attempt to save that species from extinction (Merton 1981).

STUDY AREAS

Chatham Island

Warblers on Chatham Island were observed mostly in the Tuku-a-Tamatea River valley (176° 37'W, 44° 05'S) and the forest to the west of it, between December 1977 and February 1978 and in November/December 1978. The vegetation has a 6-12 m canopy and is mainly composed of *Coprosma chathamica, Pseudopanax chathamica, Hymenanthera chathamica* and *Dracophyllum arboreum,* with the *Dracophyllum* dominant on the drier slopes and ridges. The understorey and ground layers are fairly open on the ridges and flat areas, reflecting the influence of feral pigs, sheep and cattle, but in the steep valleys, the forest is denser and supplejack *(Rhipogonum scandens)* and tree ferns (*Cyathea* spp.) are numerous.

South East Island

On South East Island (176° 10'W, 44° 20'S) observations were concentrated in 5.5 ha of the northern part of the island in December 1978, November/December 1979 and December 1981. The area consisted of clumps of coastal forest with *Olearia traversii, Myoporum laetum* and *Hymenanthera chathamica* predominating; a large area of old farmland which was clear until 1963 when stock were removed from the island, and which is now mainly bracken *(Pteridium esculentum)* and *Muehlenbeckia australis;* and an area of continuous forest of *O. traversii, H. chathamica, Coprosma chathamica* and *Plagianthus betulinus* var. *chathamica.* The forest edge and tree clumps were often partly covered by *Muehlenbeckia,* creating very dense thickets. The continuous forest had a canopy at 7-10 m, and the understorey and ground layer were open because of intensive petrel burrowing activity. Within this study area, 2.7 ha of reverting farmland, tree clumps and some continuous forest were used for an intensive study of warbler pairs.

Mangere Island

Nesting warblers on Mangere Island (176° 17'W, 44° 16'S) were observed in 4.2 ha of coastal forest at the north-eastern end of the island in September/December 1980 and 1981. The history of clearing, and current vegetation types are similar to those on South East Island. *Olearia traversii* is dominant, with *P. betulinus* var. *chathamica* and *H. chathamica* the other tree species in the bush remnant. Much of the forest edge and tree clumps is covered by

M. australis, creating the dense thickets which were the favoured habitat of warblers on South East Island.

METHODS

Standard (9 m x 2 m) 38-mm mesh mist-nets were erected in the forest understorey on South East and Mangere Islands. No artificial lures were used. We caught 42 adult and 33 juvenile Chatham Island Warblers in 420 net-hours in 1979 and five adult and six juvenile warblers in 80 net-hours in 1981 on South East Island; and four adult and four juvenile warblers in 27 net-hours in 1981 on Mangere Island. These birds were measured, weighed, aged, sexed (Robertson & Dennison, in press), and individually marked with a colour combination of celluloid bands and a numbered metal band, before being released. We plotted sightings of these banded birds and breeding pairs on 1:3500 aerial photographs of South East Island and 1:1750 grid maps of Mangere Island.

Nesting was studied most intensively on Mangere Island, where the Chatham Island Warbler was being used as a host in cross-fostering experiments with the Black Robin. Most observations of post-fledging behaviour came from the South East Island study area. We found nests by following birds or by searching trees where pairs were often seen. Nests were checked daily during the nest-building, laying, hatching and fledging stages, and periodically in between. If we found a nest during incubation or brooding, we checked it on most days until one of the above stages was reached.

RESULTS

Territories

Chatham Island Warblers nest solitarily and are monogamous. During the breeding season, territories were defended from all other warblers, other than their own dependent young. Boundary disputes, mainly by males, consisted of long chases interspersed with bouts of singing, not physical contact. Females occasionally joined in the chases. Throughout the breeding season some 1-year-old birds remained non-territorial and did not attempt to breed; these birds frequently trespassed into territories and induced chases. Towards the end of the breeding season flocks of up to 15 juveniles began to form in inter-territory gaps, and this may indicate that flocking occurs during the non-breeding season; however, nothing is known of the social system in autumn and winter. Some pairs defended the same territories for at least three breeding seasons on South East Island.

On Chatham Island, the density of warblers was about 0.3 pairs/ha in *Dracophyllum*-dominated forest, but it was lower in the pure broadleaf forest. On South East Island, from observations on territorial pairs and birds feeding nestlings or flying young, we mapped 28 warbler territories in the 2.7 ha intensive study area in 1979 and 22 territories in 1981. These were densities of 10.4 and 8.2 pairs/ha respectively and are minimum estimates since some of the area was open grassland, which the warblers did not use. In the 4.2 ha study area on Mangere Island, breeding densities of 9.3 and 10.5 pairs/ha were recorded in 1980 and 1981 respectively.

Breeding season

The breeding season of the Chatham Island Warbler was from September to early January, but timing varied from year to year. In 1980, warblers were occupying territories on Mangere Island in mid-September, but nest-building did not start until late September. Laying was from 3 October to 21 November. In 1981, however, laying began on about 13 September and continued until 6 December. Although renesting was artificially induced on Mangere Island in both years, nests with eggs were found in December on both Chatham and South East Islands, suggesting that there were also natural replacements. The peak of laying was in mid-October in both 1980 and 1981 on Mangere Island, and from extrapolation of nestling and fledgling data, also on South East Island in 1979.

The single peak of laying suggests that only one brood is normal for this species, although pairs can renest if the first clutch fails.

Nests

The enclosed pendant nest of the Chatham Island Warbler is very like that of the Grey Warbler. Dimensions of nests were ($\bar{x}$, n, range in cm): outside depth 14.3, 4, 8.0-10.5; outside frontal diameter 8.3, 4, 7.0-9.5; outside lateral diameter 9.1, 4, 8.0-10.5; width of entrance 3.2, 7, 2.5-3-8. These dimensions are similar to those given by Gill (1983a) for the Grey Warbler.

Nests were composed of rootlets, mosses, lichens, leaves, bark, small twigs, grass stems, feathers, *O. traversii* flower heads, and spider egg cases and webs. They were thickly lined with feathers.

On Chatham Island, four nests averaged 6 m above the ground (range 1.5-10.0 m). Three were in terminal branches of *D. arboreum,* and the fourth and lowest was on the trunk of a ponga *(Cyathea dealbata).* All these nests were freely hanging in the open or near a gap in the vegetation.

On South East Island, 17 nests averaged 2.1 m above the ground (range 0.5-8.0 m). Eight were in *M. australis,* five in sapling *H. chathamica,* two in *O. traversii,* one in *Myoporum laetum* and one in *C. chathamica.* Most nests were attached with lateral and basal connections in dense foliage. That is, they were not freely hanging.

On Mangere Island, 109 nests averaged 2.5 m above ground (range 0.2-6.0 m). Of these, 65 were in *O. traversii,* 39 in *M. australis,* three in *H. chathamica* and two in *P. betulinus* var. *chathamica.* In 1981, the average height (2.7 m) of 37 nests in *O. traversii* was significantly higher than the 2.1 m in *M. australis* ($t = 2.26$, $p<0.05$). Most nests were in dense foliage and had lateral and basal connections.

Nest-building

Only females constructed nests, although males often accompanied their mate to the nest, and once a male appeared to work at a partly built nest. The male often sang as the female collected material and worked on the nest.

Nests took up to 13 days to build, and 1-12 days (average 6.0, n=25) separated the completion of building and the laying of the first egg. The prelaying interval of first nests was 6.4 days (n=21) and that of renesting attempts was 4.0 days (n=4).

Eggs

The eggs of the Chatham Island Warbler are similar to those of the Grey Warbler, being white with reddish-brown speckles, usually concentrated towards the larger end. Average measurements of 25 eggs from Mangere Island, to the nearest 0.1 mm, were 18.09 mm long (SD 0.62, range 17.2-19.2) and 12.96 mm wide (SD 0.38, range 12.0-13.7), with a mean volume index (length x breadth^2) of 3043.1 (SD 237.1, range 2476.8-3429.6). If the relationship between the egg volume index and the fresh egg weight is the same as in the Grey Warbler (Gill 1982, 1983a), the fresh egg weight would be 1.82 g, which is 19.1% of the average weight of an adult female in the breeding season (9.51 g, Robertson & Dennison, in press). Like Grey Warblers, Chatham Island Warblers have much heavier eggs than would be expected for a passerine of their size, and a complete clutch represents, on average, 59% of the body weight of a female.

Clutch size and breeding success

Eggs were laid at 2-day intervals in all nests checked daily. The average clutch of 79 nests (all on Mangere Island) was 3.1 eggs, there being 11 2-egg clutches, 51 3-egg clutches and 17 4-egg clutches. Unfortunately breeding success could not be directly determined because most clutches were manipulated in the Black Robin cross-fostering programme. However, on South East Island in late November-early December 1979, the average number of fledged young in 31 family groups was 2.7, there being 1 group with 1 young, 10 with 2, 18 with 3, and 2 with 4 young. Although complete nesting failures are not represented by family parties, most pairs seemed to have fledged young with them. The breeding success on South East Island, therefore, seemed to be very high (87%), if we assume an average clutch of 3.1 eggs.

Incubation and care of young

Only female Chatham Island Warblers incubated, and they began when the last egg was laid. Brooding periods were recorded at three nests when nestlings were 3, 10, and 12 days old. Periods on the nest were generally short: $\bar{x}$ = 9 minutes (n = 10 periods), and the proportion of time spent brooding was 48% (58 minutes' observations), 49% (51) and 55% (69) for the three ages respectively.

The average incubation period (interval between the laying and hatching of the last egg — Skutch 1945) for 13 nests was 19.5 ± 1.3 days ($\bar{x} \pm$ SD), range 17-21 days.

Only the female brooded, but both parents usually fed the young in the nest and after fledging, except at three nests with well-grown chicks and only one adult in attendance. The nestling period in seven nests was 20.0 ± 1.5 days, range 19-23 days. One fledgling was still being fed by its parents 24 days after leaving the nest. Sometimes the fledglings were split between the parents, and these groups occasionally coalesced. Adults were occasionally seen with the small flocks of juveniles, but none of these juveniles was seen to be fed.

Cuckoo parasitism

The Shining Cuckoo is a brood parasite of the Chatham Island Warbler (e.g. Potts 1884). In many breeding pairs of warblers we found a very low rate of parasitism by cuckoos. On Chatham Island no cuckoos were seen or heard during the study, but on Mangere Island one was seen in November 1981 (D. V. Merton, pers. comm.). On South East Island we saw one or two cuckoos in two seasons, two Shining Cuckoo fledglings were seen in January 1981 (B. D. Bell, pers. comm.), and a nest with a well-grown cuckoo nestling was found on 14 January 1982 (W. F. Cash, pers. comm.).

DISCUSSION

The breeding of the Chatham Island Warbler has not been studied before. Of the genus *Gerygone,* only the Grey Warbler *(G. igata)* has been studied in depth (Gill 1982, 1983a). Table 1 compares the breeding systems of Chatham Island Warblers and Grey Warblers.

Thomas (1974) drew attention to some adaptations for breeding in Australian passerines: (1) small clutches (usually 2-3 eggs). (2) 48-hour laying intervals, (3) delayed laying after nest building, (4) high longevity, (5) helpers at the nest, and (6) nomadism outside the breeding season. Gill (1982) found that points 1-4, but not 5 and 6, applied to Grey Warblers, except that their clutch of 3.9 eggs was higher than that of Australian relatives and that delay in laying was up to 8 days in Grey Warblers compared with several weeks in Australia. Points 1-4 apply even better to the Chatham Island Warbler. The clutch size of 3.1 eggs is much nearer the usual range of 2-3 eggs in Australian *Gerygone* (McGill 1970, Pizzey 1980), and the delay before laying was up to 12 days, and on average about 2 days longer than for the Grey Warbler. It is likely that Chatham Island Warblers are long-lived, judging by resightings of banded birds on South East Island over four years after capture. Helpers were not recorded at nests or in family parties. The lack of records of warblers outside forest areas, and their limited distribution, on the Chatham Islands (Robertson & Dennison in press) indicate that nomadism is unlikely.

TABLE 1 — Comparison of breeding systems of Chatham Island Warbler (**Gerygone albofrontat**) and Grey Warbler (**G. igata**) (Gill 1982).

	albofrontata	igata
Solitary/colonial	Solitary	Solitary
Monogamous/polygamous	Monogamous	Monogamous
Density (pairs/ha)	0.3-10.5	1.1-2.2
Period of egg-laying	10 weeks	16 weeks
Broods/year	1	2
Nest	Pendant	Pendant
Nest building by	Female	Female
Pre laying interval	6.0 days	4.3 days
Laying interval	48 hours	48 hours
Clutch size	3.1	3.9
Incubation by	Female	Female
Incubation period	19.5 days	19.5 days
Brooding by	Female	Female
Feeding by	Both adults	Both adults
Nestling period	20.0 days	17.2 days
Breeding cycle[1]	44.5 days	43.7 days
Eggs/season	3.1	7.8
Breeding success[2]	87%	38%
Young/pair/year[3]	2.7	2.9

1 Days required to lay a clutch plus incubation and nestling periods

2 Proportion of eggs that yielded fledglings

3 Eggs/season x breeding success

On Mangere and South East Islands, two different methods gave similarly high estimates of the breeding density of Chatham Island Warblers. Both islands have similar habitat of regenerating forest clumps with dense thickets formed by the vine *Muehlenbeckia,* and both are predator free. Continuous forest on South East Island had lower densities than the forest clump habitat. The continuous forest on Chatham Island, where rats and cats are present, had an even lower density of warblers, and of other forest birds too. Predation pressure may also have affected nest sites. On Chatham Island, nests were higher and in terminal branches, which probably made them less accessible to rats and, especially, to cats. On predator-free Mangere and South East Islands, a wider range of nest sites could be used. On these islands, however, nest siting may be influenced by the high numbers of nesting seabirds in the forest areas and the need to protect nests from petrels landing.

The shorter single-peaked laying season of the Chatham Island Warbler compared with the extended bimodal season of the Grey Warbler on the New Zealand mainland (Gill 1982) parallels the differences between the Chatham Island Fantail *(Rhipidura fuliginosa penitus)* and the two mainland subspecies of Fantail, and between the Chatham Island Tomtit *(Petroica macrocephala chathamensis)* and Black Robin and their mainland counterparts (Dennison & Crouchley, in prep.; Dennison *et al.* 1979). As climate and hence food supplies on the Chathams are probably suitable for a much shorter time than on the mainland of New Zealand, which Gill (1982) considers to show some characteristics of the tropics, a contracted breeding season with a more pronounced laying peak can be expected on the Chatham Islands. An additional factor affecting timing of the breeding season of the Chatham Island Warbler may be the need to avoid nest-parasitism by the Shining Cuckoo. The single peak of laying by the Chatham Island Warbler occurs before the cuckoos are ready to breed. Most of the cuckoo eggs in Grey Warbler nests at Kowhai Bush, on the New Zealand mainland, were laid in November (Gill 1983b), when most Chatham Island Warbler eggs would be well incubated or hatched. Gill (1983b) had only one record of a Shining Cuckoo laying an egg in mid-October, but he considered this record exceptional as it was 2-3 weeks earlier than any others. The three recent records of cuckoo parasitism of Chatham Island Warblers were of nestlings or newly fledged juveniles in January. By extrapolation, based on an incubation period of 15 days and a nestling period of 19 days (Courtney & Marchant 1971, Gill 1983b), parasitism occurred in late November-early December, right at the end of the Chatham Island Warbler's laying season; this may explain why so few Shining Cuckoos are in the Chatham Islands.

The similar figures for annual productivity of Chatham Island Warblers and Grey Warblers shown in Table 1 are achieved by different methods: the Chatham Island Warbler lays one small clutch and has a high breeding success because of low predation and parasitism rates (on Mangere and South East Island, at least). The Grey Warbler lays two larger clutches but has a much lower breeding success, due mainly to predation by introduced mammals and nest parasitism by Shining Cuckoos (Gill 1982, 1983b). The Chatham Island Warbler can therefore be described as a 'k-selected' species, whereas the Grey Warbler is 'r-selected' by comparison. Moors (1983) has argued that in New Zealand, which lacked mammalian predators until recently, 'k-selected' species are much more at risk of extinction caused by exotic predators than 'r-selected' species. Therefore, the Chatham Island Warbler, with its low annual rate of egg production, may be vulnerable to extinction if mammalian predators reach the few islands in the Chatham Group where the warbler is still numerous.

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M. D. DENNISON, *Dept Zoology, University of Toronto, Toronto M5S 1A1, Ontario, Canada;* H. A. ROBERTSON, *Edward Grey Institute of Field Ornithology, Dept Zoology, South Parks Road, Oxford, England*;* D. CROUCHLEY, *Wildlife Service, Department of Internal Affairs, Private Bag, Wellington, New Zealand*

* Present address: *Ecology Division, DSIR, Private Bag, Lower Hutt, New Zealand*

PLUMAGE, MORPHOLOGY AND HYBRIDISATION OF NEW ZEALAND STILTS *Himantopus* spp.

By R. J. PIERCE

ABSTRACT

New Zealand has experienced two invasions of stilts, the first giving rise to the endemic Black Stilt *(Himantopus novaezealandiae)* and the second being that of the Pied Stilt *(H. himantopus leucocephalus)*. The geographical separation of these forms was of insufficient duration for reproductive isolation to become complete, and introgressive hybridisation has occurred. Hybrids are usually intermediate in plumage and morphology between their parents and are distinguishable from immature Black Stilts. There was no evidence of hybrid infertility or lack of vigour. Through hybridisation, the Pied Stilt has become distinguishable from the Australian population of Pied Stilts by several characteristics, including shorter tarsus, longer tail, and variable plumage markings. Selective mating and a different wintering area have helped keep the small remnant population of Black Stilts from being absorbed into the much larger Pied Stilt population. On the basis of aspects of its morphology, ecology and behaviour, the Black Stilt merits its status as a full species.

INTRODUCTION

Repeated invasions of an ancestral form are a feature of island systems, the descendants of an early invasion adapting with time to the new environment and further invasions occurring much later (Mayr 1970). In New Zealand, double invasions have been postulated to account for the occurrence of closely related species of rails, oyster-catchers, stilts and flycatchers (Fleming 1962, Heather 1966, Baker 1975). The first stilt invasion gave rise to the Black Stilt *(H. novaezealandiae)*, while the second invasion — that of the Pied Stilt *(H. h. leucocephalus)* may have occurred as late as the early 19th century. Since the mid-19th century the Pied Stilt has greatly increased in numbers and range, but the Black Stilt is now an endangered species, the remaining 10-15 pairs breeding entirely in the Upper Waitaki River Basin (Pierce 1984).

In addition to its entirely black plumage, the Black Stilt has long been known to differ morphologically from the Pied Stilt by a longer bill and shorter tarsus. How far the two stilts differ in these and other morphological features, however, has not been shown conclusively. Consequently the Black Stilt has been variously considered as, for example, a " seasonally dimorphic species " (Buller 1882), a " mutant form of the White-headed (Pied) Stilt " (Oliver 1930), a " subspecies " (Mayr & Short 1970), and a " full species " (Potts 1869, Kinsky 1970).

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Moreover, birds in various intermediate plumages have caused much confusion in the literature. In the 19th century, birds exhibiting unusual plumages were often placed in separate species: since 1841 no fewer than ten species names have been applied to New Zealand stilts in attempts to account for several common plumage forms. The situation was well summed up by Buller's (1875a) comment that the stilts are " probably the most puzzling group of birds we have in New Zealand . . ." In the 20th century, birds in intermediate plumage have continued to cause confusion and still do. Three terms, " hybrid " (Hutton & Drummond 1905, Oliver 1930, 1955), " intermediate " (Stead 1932) and, more lastingly, " smudgy " (Stead 1932, OSNZ Recording Scheme) were commonly used to embrace all those birds that did not fit the known plumage forms.

In this paper I shall describe from field observations the plumage patterns of birds of known parentage, compare morphological features and breeding behaviour of Pied, Black and hybrid Stilts, and review the early literature.

METHODS

Plumage characters and the timing and duration of moult were observed for colour-banded birds in the Cass River Valley (see Pierce 1983) and in several other parts of South Canterbury from 1977 to 1982. During the last two weeks of the fledgling period, several young were captured and given individual combinations on the tarsi of coloured plastic bands and numbered stainless steel band (size Y) issued by the Wildlife Service. For biometric data, nesting adults were trapped with a self-release drop trap with a wire frame and nylon netting. To avoid nest desertions, adults were trapped only at nests in which young were hatching or about to hatch. All adult birds seen in the field were classified into one of ten plumage nodes. See Fig. 4. Birds in nodes A-C ("Pied Stilts") and birds in node J ("Black Stilts") have formed the basis for other studies (e.g. Pierce 1983). Stilt skins were examined at the Otago, Canterbury, National and Auckland Museums, using the procedures outlined by Heather (1966). Equivalent measurements of Pied and Black Stilts were provided by the British, Australian and Bishop Museums, the National Museum of Victoria, the American Museum of Natural History and the CSIRO Museum in Canberra.

BLACK AND PIED STILTS

Plumages

Nestling: Nestlings closely resemble those of other forms of *Himantopus* (Bent 1927, Cramp & Simmons 1983). The forehead is buff with one or two black spots on the midline. Upper parts are pale grey, buff or fawn (and usually darker in Black Stilts), interrupted by black spots, smaller on the crown. The spots are in four to six longitudinal lines with the middle two having the largest spots, which sometimes overlap. A horizontal black line extends from the base of the upper mandible through the eye to the hind neck. The under surface is white or off-white, except for a dark grey patch on the thigh, larger in Black Stilts. In nestlings of both species, the iris is brownish; bill black or brownish black, often with a paler base; tibia bluish grey to brownish grey; tarsus and toes bluish grey to orange-grey, the soles of the toes orange.

Juvenile Pied: At fledging, Pied Stilts have a white forehead and forecrown, off-white to grey cheeks and grey over the eye. Most birds have a grey or dark grey hind crown, paling to light grey on the nape, hind neck and forepart of the mantle. Exceptional birds have no dark markings anterior to the mantle. The feathers of the hind mantle and wings are greyish black, tipped with pale grey to buff, giving a spotted appearance. The rump and tail are off-white, and the tail has a broad (5-30 mm) terminal band of grey or brownish grey. The underparts, except for the tail band, are white. About 2-4 weeks after flying, the pale tips to the wing- and back-feathers are lost, leaving those parts uniform greyish black. The iris is brownish; bill greyish black with a fleshy base, legs pale pink.

Juvenile Black: At fledging, Black Stilts are mainly dark above and white below. The forehead is white, the cheeks are grey, and the crown is dark grey to greyish black, which usually extends in a paler vertical band to and encircling the eye (Fig. 1a). The hind crown and nape are off-white with variable amounts of grey flecking, becoming more continuous grey on the hind neck and forepart of the mantle (Fig. 2). The wings and hind part of the mantle are smooth greyish black with variable greenish gloss, lacking the pale feather-tips of Pied Stilt juveniles. The rump and tail are white with a broad (20-50 mm) dark grey terminal band on the tail. The underparts, except for the tail band, are white. Iris and bill are as for Pied Stilt juvenile, but the legs are reddish pink.

First-winter Pied: This plumage resembles that of juvenile Pied, except that the nape, foreneck and hind crown are darker. Iris brownish red, bill black, and legs pink.

First-winter Black: Early-flying birds (November-December) began to develop greyish black blotches or streaks on the sides in late December. By late March or April, visible moult (which lasted 8-14 weeks per bird) had ceased and these markings had extended over much of the sides and flanks. Very rarely were these side and flank markings laterally symmetrical and there was great variation between individuals, including siblings (Fig. 1b, 1c). Of ten birds studied, two had small greyish black markings extending forward to the breast, but in all others the breast was white. In all birds a dark, fragmented band, usually incomplete, extended from the flank to the cloacal region, giving the impression of linking the two flanks (Fig. 3). The legs were darker than in juveniles.

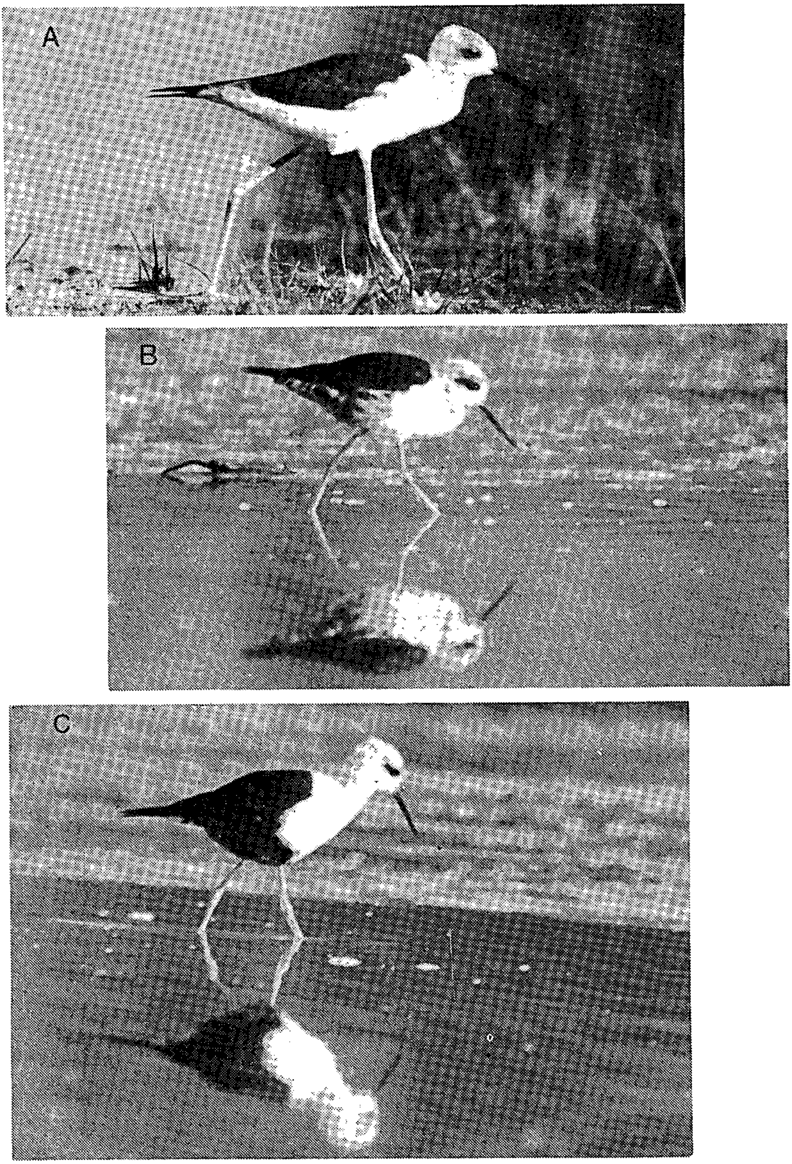
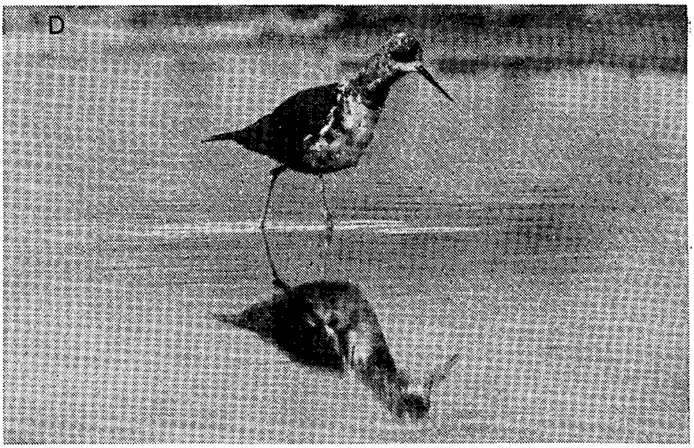


FIGURE 1 — Immature plumages of Black Stilts. A: Juvenile, December. B, C: First winter, June (siblings). D: Second-summer moult, September. E: Second-summer moult, October. F: Second-summer plumage, January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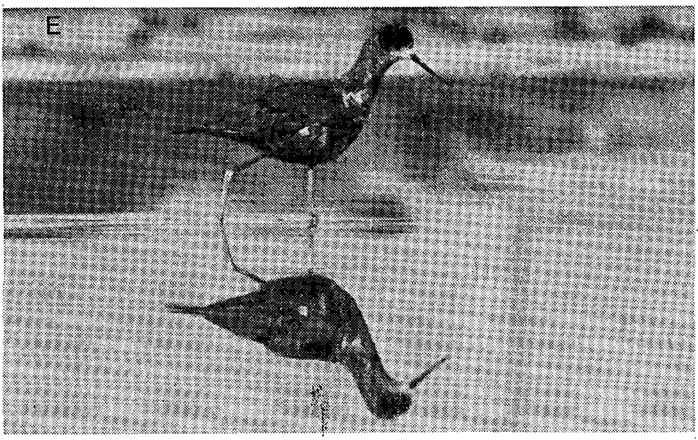
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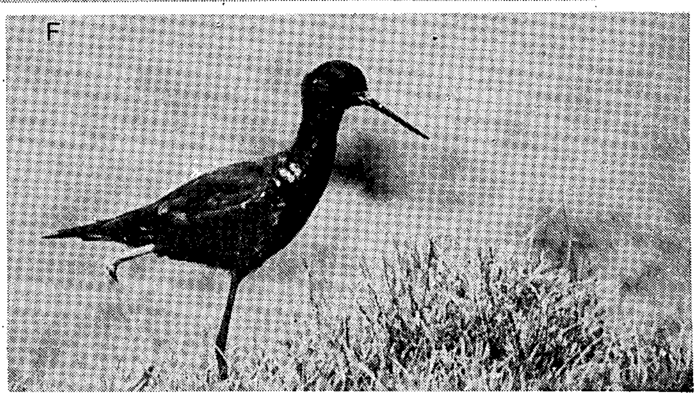
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Second-summer Pied: Some birds were indistinguishable from adults, but the hind neck of most retained a small amount of fine flecking, and there were greyish markings about the ear coverts.

Second-summer Black: The second summer moult of Black Stilts occurred from late June to October, lasting 8-12 weeks per bird. Early in this moult the crown and hind neck developed scattered greyish black blotches followed by uniform darkening of the areas between the blotches. After nearly one month, this pattern had extended to the foreneck (Fig. 1d), and finally, after a further month, to the breast and sides (Fig. 1e). The largest patches of white in the second summer plumage were on the abdomen and undertail, with smaller patches on the breast, foreneck, sides of neck, chin and forehead (Fig. 1f). Iris crimson, bill black, legs crimson.

Second-winter (adult) Pied: Adult plumage was mainly white with black hind neck, nape, mantle and wings. The black areas of the male in particular had a greenish gloss. A narrow white mantle band, often with black mottling, usually separated the black of the nape from the black of the mantle. The boundary between black and

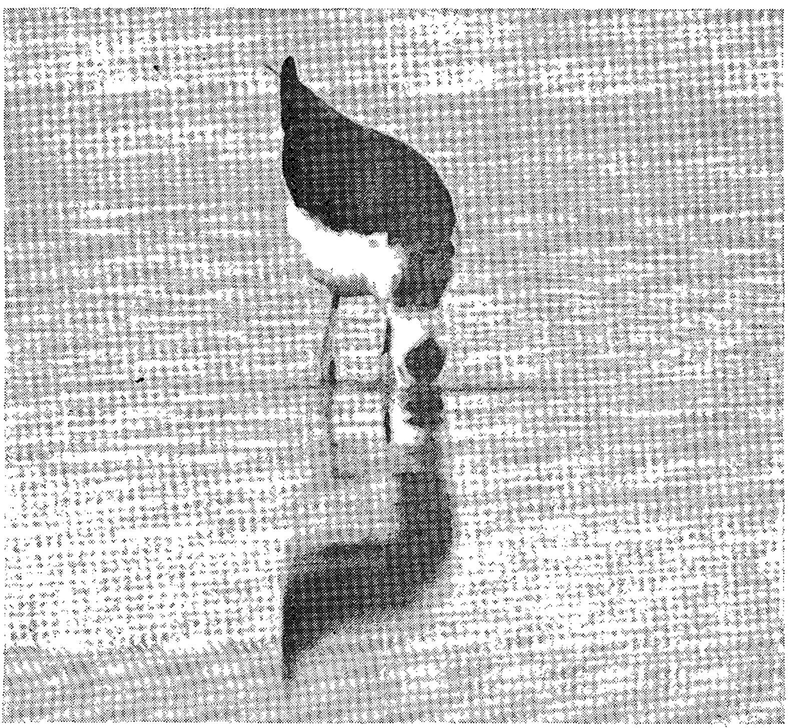


FIGURE 2 — Juvenile Black Stilt, January

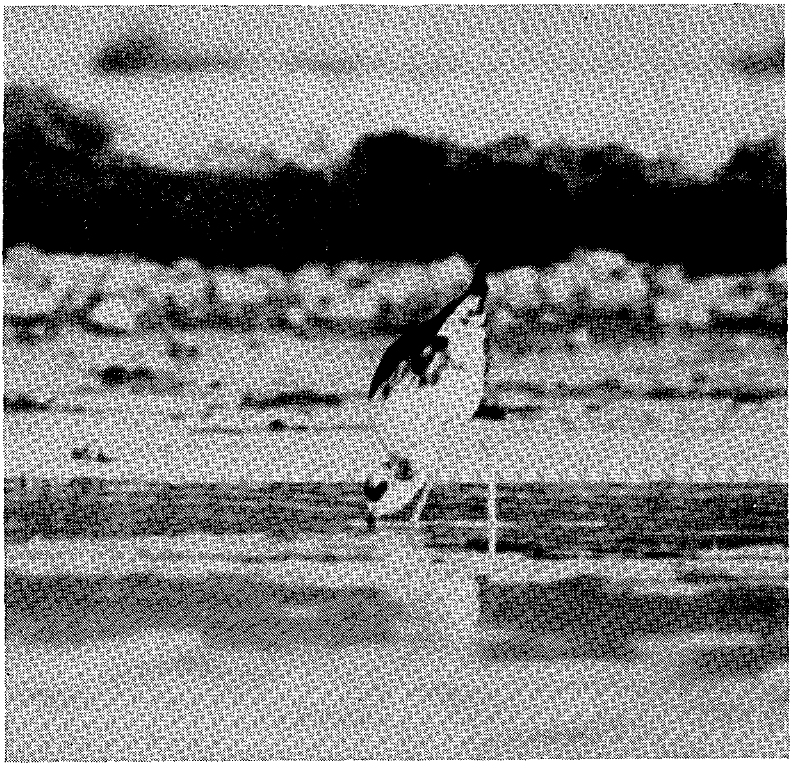


FIGURE 3 — Underparts of a first-winter Black Stilt, July

white on the sides of the neck was very variable in both position and extent of black mottling. On the tail of all birds was a terminal band of light grey to greyish brown, sometimes extending 50 mm up the tail.

Second-winter Black: The second-winter moult occurred between December and April. After moult, birds were black above with a greenish gloss to the hind neck, mantle and wings. The underparts were dark brownish black. In some birds a small amount of white mottling on the abdomen was retained until the next summer moult, beginning about June, at the age of 17-20 months. This white was usually less clearly defined than the white of nodes H or I hybrids (Fig. 4).

Third-summer (adult) Black: As for second-winter Black, but without white abdominal markings. During periods of moult, adults may have grey to off-white forehead and chin.

TABLE 1 — Comparative morphology of adult Pied and Black Stilts

Measurement	Sex	n PA	n PNZ	n B	$\bar{x}$ PA	$\bar{x}$ PNZ	$\bar{x}$ B	sd PA	sd PNZ	sd B	p[1] PA	p[1] B	$\bar{x}$PA/$\bar{x}$PNZ	$\bar{x}$B/$\bar{x}$PNZ
Bill length (mm)	M	18	42	3	62.1	62.0	66.6	2.3	2.7	0.8	NS	-	1.00	1.07
	F	14	31	7	60.7	61.3	65.7	3.0	2.4	1.8	NS	-	0.99	1.07
	M + F	32	73	27	61.5	61.7	66.2	2.8	2.5	2.5	NS	+++	1.00	1.07
Bill width (mm)	M + F	34	34	34	6.0	6.1	6.8	0.7	0.5	0.5	NS	+++	0.98	1.11
Bill depth (mm)	M + F	..	35	15	..	6.7	6.9	..	0.6	0.5	-	NS	..	1.03
Tarsal length (mm)	M	19	47	4	114.3	100.3	90.8	6.3	6.4	2.3	+++	-	1.14	0.91
	F	15	45	9	109.0	93.0	85.6	7.8	3.8	5.8	+++	++	1.17	0.92
	M + F	34	92	32	112.0	96.6	88.1	6.7	8.5	4.9	+++	+++	1.16	0.91
Tail length (mm)	M	19	40	4	72.9	76.9	79.8	2.7	3.4	2.5	+++	-	0.96	1.04
	F	15	37	8	73.4	75.1	78.6	5.4	3.5	4.8	NS	+	0.98	1.05
	M + F	34	77	33	73.1	76.0	78.5	4.1	3.4	4.3	+++	++	0.96	1.03
Wing length (mm)	M	19	44	4	228.6	230.3	235.5	8.4	12.1	3.7	NS	-	0.99	1.02
	F	15	39	9	220.1	220.5	237.5	6.7	13.3	8.7	NS	+++	1.00	1.07
	M + F	34	83	37	224.8	225.5	236.3	8.7	13.5	11.0	NS	+++	1.00	1.05
Fresh weight (g)	M	6	15	2	176	193	219	12.4	10.2	-	-	-		
	F	12	14	2	176	192	227	20.8	18.2	-	-	-		
	M + F	18	29	4	176	193	223	18.0	20.9	8.3	-	-	0.91	1.16

NOTES:

[1] t - test with New Zealand Pied Stilts, NS = not significant; +, ++, +++ significant at the p = 0.05, 0.01 and 0.001 levels respectively; - = not tested.

PA = Australian Pied Stilts, PNZ = N.Z. Pied Stilts, B = Black Stilts; M + F includes some unsexed specimens; Except for weight, measurements are of dried specimens

Morphology of Pied and Black Stilts

Table 1 compares Black Stilts, New Zealand Pied Stilts and Australian Pied Stilts. Black Stilts differed from New Zealand Pied Stilts by having longer bills ($p<0.001$), broader bills ($p<0.001$), shorter tarsi ($p<0.01$ for females, $p<0.001$ for sexes combined), longer tails ($p<0.01$ for sexes combined), and longer wings ($p<0.001$). New Zealand Pied Stilts differed from Australian Pied Stilts mainly by having shorter tarsi ($p<0.001$), by being heavier ($p<0.01$) in an equivalent season's comparison, and by having longer tails ($p<0.001$ for sexes combined) as well as by having variable plumage markings.

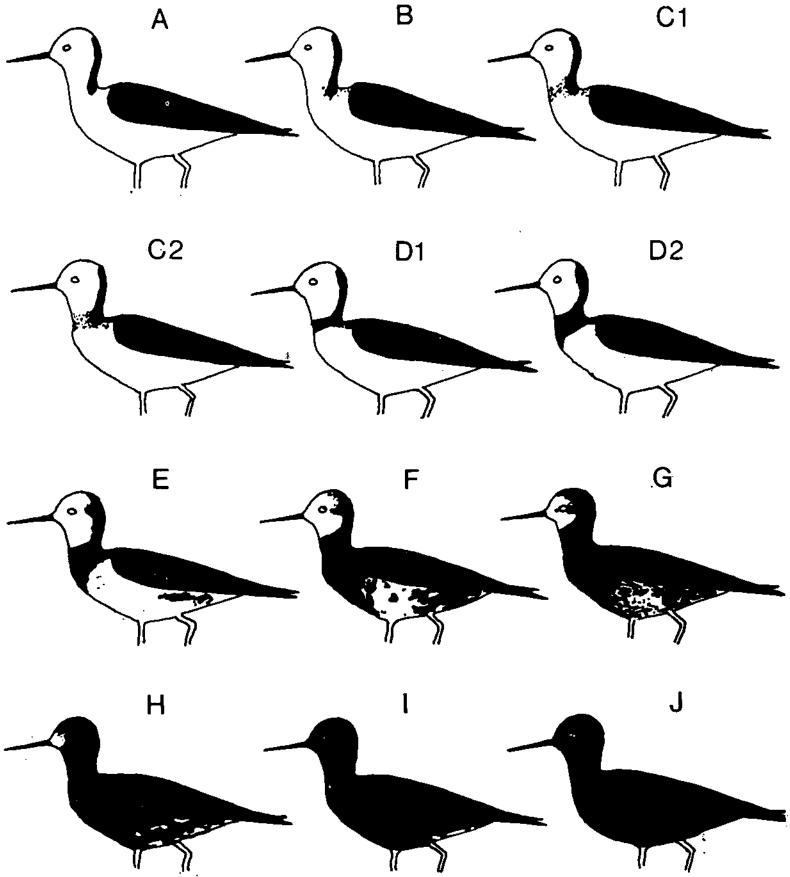


FIGURE 4 — Plumage classification of adults. Not all birds fitted into one node exactly, but each was allocated to whichever node it most closely resembled

HYBRIDS

Plumages and morphology

The categories or nodes of adult plumage are shown in Figure 4. The validity of using these particular nodes lay in an approximately linear relationship between lengths of appendages and proportion of black and white on the underparts. For example, tarsal lengths decreased linearly with increasing blackness of the birds. Table 2 presents plumage forms of offspring from various pairings. Pairs of node A birds ("pure" Pied Stilts) produced node A offspring (n=2), and pairs of node J birds ("pure" Black Stilts) produced node J offspring (n=10). The offspring from backcrossing intermediate nodes with "pure" nodes, however, were generally intermediate in markings between their parents. Some variations occurred within each category of backcrossing, but no throwbacks to either parental phenotype (nodes A or J) were found and there was no evidence of sex linkage. The two 'approximate' F1 hybrids (nodes B x J) observed both had node E plumage. The plumage markings of individual adult stilts were approximately similar from year to year. Only one bird changed nodes (from being node H at 2 and 3 years to being node I at 4 years).

Bivariate plotting of morphological features revealed that Pied and Black Stilts could best be distinguished from hybrids by tarsal and bill analyses and by tarsal and wing analyses. See Fig. 5. The continuous variation between extremes of plumage and body measurements, however, indicates that inheritance of these traits is controlled by several genes (Anderson 1953). In a simple two-gene system, back-crossing of an F1 hybrid with a parental phenotype, for example, would give a plumage ratio of 1 parent : 1 F1 hybrid : 2 intermediates. But of 20 progeny recovered so far from various hybrid backcrosses, 19 have been intermediate, and one similar to the hybrid parent.

The immature plumages of hybrids were not easily followed because few were resident in the Upper Waitaki River Basin. I had

TABLE 2 — Plumage nodes of mature offspring resulting from matings between pure stilts and various hybrids. Number of birds in parentheses

Node of one parent	Pied A	B	C	Hybrids D	E	F	G	H	I	Black J
Node of other parent										
Pied A	A(2)	B(1)	C(2)	C(3)	D(1)					
Pied B		B(4)	B(1)	C(1)	D(2) E(1)		E(2)			
Black J		E(2)			I(1)	G(1) H(4)	I(1)			J(10)

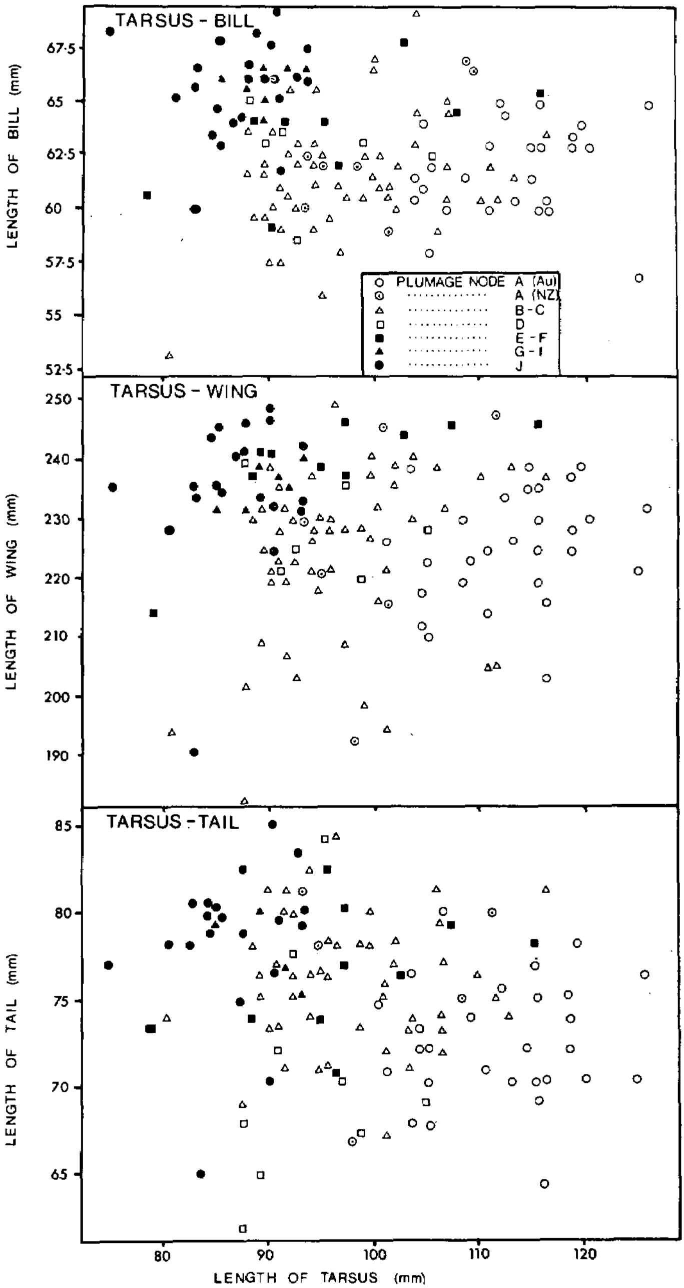


FIGURE 5 — Morphology of New Zealand and Australian stilts. Bivariate plots of tarsal length against lengths of bill, wing and tail for birds in different plumage nodes

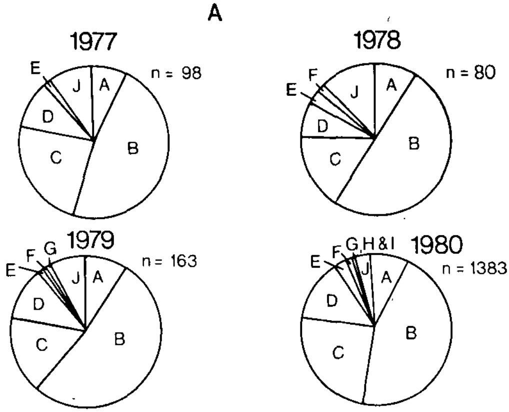
complete observations of nodes D, E (four) G and H (two) birds. The juvenile plumage of these birds was similar to that of juvenile Black Stilts. In first-winter plumage, however, the flank and side markings of all hybrids except one of the node H birds were not as extensive or as dark as those of Black Stilts in first-winter plumage, the markings on the node E birds being particularly faint. In second-summer plumage, the flank, side, and abdominal markings of all hybrids reached their maximum extent, but the nape, hind neck, sides of the neck and much of the foreneck were mainly black with greyish streaking. These streakings (indicative of immatures) were lost during the second-winter moult. Immature Black Stilts were, therefore, best distinguished from immature hybrids by more extensive body markings both in first-winter plumage and in second-summer plumage. The variation among immature Black Stilts, however, means that it is probably not possible to distinguish safely between second-summer Blacks and second-summer nodes H and I birds. The identification of juvenile and first-winter plumages of Black Stilts is simplified by the fact that family parties remain associated for the duration of these plumages.

Although I regarded node A and node J birds as "pure" Pied Stilts and "pure" Black Stilts respectively, they need not necessarily be genetically pure. Four out of seven node A birds had tarsal lengths below the range of Australian Pied Stilts (Fig. 5), indicating that there may be very few genetically pure Pied Stilts in New Zealand. Thus, true F1 hybrids are unlikely to occur, and some node J birds may not be genetically pure. In view of this it would be just as legitimate to regard nodes H and I birds as Black Stilts as to regard only node J birds as Black Stilts. To date I have had no recoveries of offspring of H x J or I x J pairings, which would shed some light on this problem.

Frequency and distribution of hybrids

During each breeding season the stilt population of the Cass River Valley and the Upper Waitaki River Basin as a whole was dominated by birds in nodes B and C plumage and not node A plumage (Fig. 6A). The distribution of hybrids was centred on the Upper Waitaki River Basin (Fig. 6B) where they accounted for 17.5% of adult stilts in 1980-81 (n=1372). Away from this area, per cent frequency of hybrids was consistently lower, including 3.4% (n=442) in coastal Otago. Lake Wainono was the coastal locality with the highest hybrid frequency (14.9%, n=295), which was consistent with that area being used as a feeding ground by at least some stilts from the Upper Waitaki River Basin (Pierce 1983).

About 90% of the Black Stilt population winters in the Upper Waitaki River Basin. Most hybrid stilts, however, followed the Pied Stilt migration pattern, leaving the Upper Waitaki River Basin after nesting and moving northwards. Regular wintering grounds include



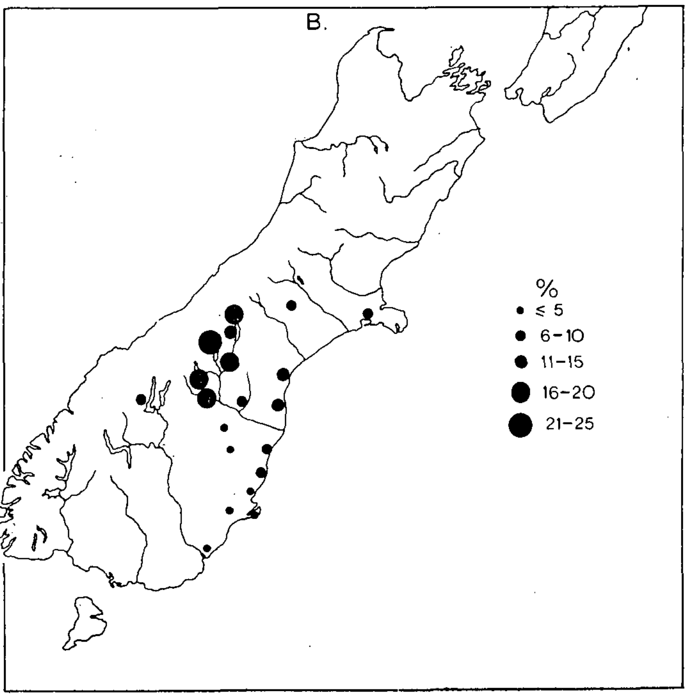


FIGURE 6 — Frequency and distribution of hybrids.

A. Percent frequency of plumage nodes (Fig. 4) of stilts in the Cass River Valley in 1977, 1978 and 1979, and in the Upper Waitaki River Basin as a whole in 1980

B. Frequency occurrence of hybrid stilts (nodes D-I) as percent total stilts, Nov 1980 to Jan 1981, in some Canterbury and Otago sites

Kawhia and Manukau Harbours, where associations with Black Stilts are often noted (OSNZ Recording Scheme; B. H. Seddon, pers. comm.). One node I bird, colour-banded as a juvenile on the Cass River Delta on 8 January 1980, was seen in the Manukau Harbour on 7 October 1981 (C. R. Veitch, pers. comm.) and returned to the Cass River Valley to breed in the 1982-83 season. Small numbers of hybrids overwintered in the high country, particularly at Lake Benmore: approximately 50% of these hybrids were apparently paired to Black Stilts, some of which were accompanied by young.

Hybrids returned early to the Cass River Valley, at a date corresponding to the general period of arrival of Black Stilts. In August of each year hybrids accounted for 28-37% of the stilt population in the valley, but by December, when Pied Stilts had become common, they accounted for about 11% of the population. Hybrids not only arrived early like Black Stilts but also, like Black Stilts, had the ability to probe for aquatic invertebrates which were hidden beneath the stones during periods of low water temperature. Nodes F to I hybrids used the lateral probing of Black Stilts (Pierce, in prep.) and so were able to maintain consistently high feeding rates during the morning. Birds in nodes D and E plumage had variable feeding patterns: all early arrivals used lateral probing extensively, but many later arriving birds used this method very little or not at all, like Pied Stilts.

Breeding biology and behaviour of mixed pairs

The formation of pair bonds involving at least one Black Stilt was seen on ten occasions in the Cass River Valley (Table 3), nine of them between late July and October. All ten pairings included a male Black Stilt, four of them when unmated female Black Stilts were in the valley, and Black-Black pair bonds were formed in three of the four cases. In the other six pairings, no unmated females were available locally: each male was approached on separate occasions by female Pied Stilts and/or hybrids. The females attempted contact by assuming the soliciting posture (e.g. Goriup 1982, Cramp & Simmons 1983), thus inviting the attention of the Black males. Five of the six males eventually mated with hybrids in nodes D-G plumage.

The preference of Black Stilts for black or near-black birds concurred with pairing choices throughout the Upper Waitaki River Basin. Although Black Stilts comprised only 3% of the stilts in this area (Fig. 6A), 70% of them occurred in Black-Black pair bonds (Table 4). This positive assortative mating was highly significant ($x^2=222.5$, 1 df, $p<0.001$, $n=24$ pairs). In addition, Black Stilts preferred hybrid mates to Pied Stilt mates ($x^2=29.5$, 1 df, $p<0.001$, $n=11$). Similarly, hybrids preferred hybrid or Black Stilt mates more than Pied Stilt mates ($x^2=52.4$, 1 df, $p<0.001$, $n=57$).

In the Cass River Valley, 10 nests of Black Stilt x hybrid or Black x Pied pairings were found in the five seasons 1977-81. Except

TABLE 3 — Pairing by ten male Black Stilts

Bird	Month	Plumage node of potential mates[1] A-C	D	E	F	G	H	I	J	Partner chosen
1	Aug. 1978	2	0	1	0	0	0	0	0	E
2	Aug-Sep 1978	3-4	0	1	0	0	0	0	0	E
3	July-Aug 1979	2+	4	0	0	1	0	0	1	J
4	Aug 1979	2-3	4	0	0	1[3]	0	0	1[4]	D
5	July-Aug 1979	2-3	4	0	0	1	0	0	1[4]	G[2]
6	Aug 1980	..	..	..	..	..	..	..	1	J
7	Oct 1981	..	..	..	..	..	..	..	1	J
8	Feb 1982	..	..	..	..	1	..	..	1	G
9	Aug 1983	0	0	0	1	0	0	0	0	F
10	Aug-Sep 1983	2+	0	0	0	0	0	0	0	C

Notes: [1] Potential mates refer to female stilts at the same locality in the study area.

[2] Bird 5 was with a node G bird on 31 July and 1 August, but on 9 August it was with a node A bird. It eventually mated and nested with the node G bird.

[3] The node G bird was already forming a pair bond with bird 5, and so it was not readily available to bird 4.

[4] The node J potential mate was already forming a pair bond with bird 3, and so it was not readily available to birds 4 or 5.

.. = no data

TABLE 4 — Pair composition of Black Stilts in the Upper Waitaki River Valley, November to December 1979

Plumages of pair	JxJ	JxI	JxH	JxG	JxF	JxE	JxD	JxC	JxB	JxA
No. of occurrences	13	1	0	2	3	1	2	1	1	0

for one of the 1979 pairs, all mixed matings involved male Black Stilts. None of the pairs occurred in the study area for two consecutive years, and at least two pair bonds were broken after unsuccessful nesting and each bird remated with a new bird the following year. One pair (including the only female Black Stilt) kept their pair bond for at least three seasons, nesting at Lake McGregor (5 km south of Cass River) in 1977 and 1978 and on the Cass River Delta in 1979. The scarcity of Black Stilt females may have been caused by their susceptibility to predation (Pierce, in prep.) because several were preyed on during the incubation period (along with the eggs) and during the chick-rearing stage. The selection of nesting habitat by mixed pairs was in three cases strongly influenced by the Black Stilt partner: in 1977, 1978 and 1980, pairs consisting of Black Stilt males and nodes E, D and C females respectively were found along streams in the middle reaches of the valley where Black Stilts, but not Pied Stilts, nested regularly. Reverse examples were a Black Stilt male and a node C Pied Stilt in 1978 and a Black Stilt female and a node F male in 1979 nesting in Pied Stilt colonies.

Eight of the above ten nests of mixed pairs contained 3-4 fertile eggs out of a clutch of 4, but the other two clutches were preyed on, one by a ferret *(Mustela furo)* and one by a Norway rat *(Rattus norvegicus)*. Seven of 16 clutches of hybrids x Pied Stilt pairs contained fertile eggs, but the rest were preyed on or, more often, flooded. The limited data on nesting success of hybrids suggest that those nesting with Pied Stilts fared better (17% of 64 eggs produced flying young) than those nesting with Black Stilts in which 3 (11%) of 32 eggs produced flying young. This can be attributed to several life history patterns of Pied Stilts, such as colonial nesting in swamps and effective distraction displays, which alleviate the potentially heavy predation that affects the Black Stilt (Pierce, in prep.). The fledgling period of hybrid juveniles seemed to be intermediate (35-43 days, $\bar{x}=39$, $n=3$) between those of Pied Stilts (30-37 days, $\bar{x}=34$, $n=17$) and Black Stilts (41-55 days, $\bar{x}=47$, $n=12$).

PREVIOUS INTERPRETATIONS OF STILT PLUMAGES

Table 5 summaries interpretations of stilt plumages over the last 140 years. Black Stilts were described as species in 1841 by Gould (1841) and by Hombron & Jacquinot (1841) with the names of *H. novaezealandiae* and *H. melas* respectively, the former eventually being retained on grounds of priority. Australian Pied Stilts had meanwhile been described as *H. leucocephalus* (Gould 1837) and this name was applied, after some dissent (Ellman 1861), to New Zealand specimens also (Buller 1865). Most of the confusion in the early literature was caused by the enigmatic hybrid and immature plumages. Hutton (1871) recognised correctly that birds with very pale hind necks were juveniles, but he recognised three species, *H. leucocephalus* (Pied Stilts), *H. melas* (Black Stilts) and *H. novae-zealandiae* (probably intermediate nodes). Hutton's main error was to regard first-winter Black Stilts as the young of his *novaezealandiae*, but this was later corrected (Hutton & Drummond 1905). Potts (1872) added a fourth species, *H. spicatus*, from Canterbury, which was a hybrid in node E plumage, but this was later incorporated into the species *H. picatus* (Buller 1905, Hutton & Drummond 1905), which included nodes C-F birds.

Hutton's fundamentally correct views on stilt plumages were opposed by Buller and others, who had a rather more complex interpretation. From 1875 to 1905 Buller believed that at least three species of stilt were in New Zealand, *H. leucocephalus* (adult Pied Stilt), the seasonally dimorphic *H. novaezealandiae* (adult Black Stilt, hybrids, some juveniles, and first-winter Black Stilts), and *H. albicollis*

TABLE 5 — Nomenclature of stilts in New Zealand, 1841-1970

Author	Adult Pied	Adult Hybrid (Nodes D-F)	Juvenile	First-winter Black	Adult Black
Gould 1841					*novae*
Hombron & Jacquinot 1841					*melas*[1]
Ellman 1861	*albus*[1]	*picatus?*[1]		*picatus?*[1]	*niger*[1]
Gray 1862			*melas*		*melas & syn.*
Buller 1865	*novae*				*novae*
Buller 1868	*leuco*				
Finsch 1868	*novae?*			*novae*	*novae*
Potts 1869	*novae*				*melas*
Travers 1871	*novae*				
Hutton 1871	*leuco*	*novae?*	*spp.*	*novae*[2]	*melas*
Potts 1872	*leuco*	*spicatus (varius)*			*melas (novae)*
Finsch 1872	*leuco*				*melas (novae)*
Buller 1873	*leuco*				*novae*
Buller 1875a		*novae*[4]	*albicollis B*		*novae*[5]
Buller 1875b			*novae B*[3]		*novae*
Buller 1878	*leuco*				*novae*
Buller 1882	*leuco*	*novae?*[4]	*novae B*	*novae?*[4]	*novae*[5]
Buller 1882 (contd)			*albicollis P*		
Buller 1888	*leuco*	*novae*	*novae B*	*novae*	*novae*
Buller 1891 & 1892					*novae*[6]
Buller 1905	*leuco*	*picatus*	*albicollis*		*melas*
Hutton & Drummond 1905	*leuco*	*picatus*[7]	spp.	*melas*	*melas*
Matthews & Iredale 1913	*albus*[1]	*picatus*[1]			*novae*[1]
Stead 1927	*leuco*				*melas*
Oliver 1930	*leuco albus*	"hybrids"		"hybrids"	*novae*
Stead 1932	*leuco albus*	"intermediates"		"intermediates"	*novae*
Peters 1934	*him leuco*	"mutants"		"mutants"	*him novae*
Fleming 1953	*him leuco*				*novae*
Oliver 1955	*leuco*	"hybrids"		"hybrids"	*novae*
Kinsky 1970	*him leuco*				*novae*

Notes: *leuco* = *leucocephalus*; *novae* = *novaezealandiae*; *him* = *himantopus*;
B = Black Stilt; P = Pied Stilt; spp. = juveniles of unknown parentage;
? the descriptions given by the author are insufficient to enable a positive identification;
& syn. = synonyms given also
1 of the genus *Hypsibates*
2 Hutton considered this to be the young of his *novae-zealandiae* which was a category possibly of hybrids
3 The specimen was a partial albino
4 Buller considered this to be the winter plumage of Black Stilts
5 Buller considered this to be the summer plumage of Black Stilts
6 Includes specimens in second summer plumage
7 Hutton and Drummond considered Potts' (1872) *spicatus* to be a variety of *picatus* and that both *spicatus* and *picatus* ought to be conspecific with *leucocephalus*.

(very pale juveniles). Buller's *H. novaezealandiae* was supposedly black in summer plumage and black and white in winter plumage, while the juveniles were pale with dark crown, mantle and wings (Buller 1882, 1888). His description of winter adults was sooty black crown, sides of head, hind neck and abdomen, glossy greenish-black wings and tail, and mainly white underparts: this description may correspond to adult hybrids, but the abdominal markings and lack of greenish gloss on the hind neck suggest first-winter Black Stilt. This plumage was later (Buller 1905) noted as being very variable. It is very likely that many of these "adult winter Blacks" were in fact first-winter Black Stilts, which would also account for Buller's interpretation of a seasonally dimorphic adult plumage. Adult hybrids, by contrast, would have been in "winter" plumage throughout the year and so would not have fitted the seasonal pattern. Buller's allotting of some juveniles to species status is not altogether surprising because he relied heavily on specimens received by the Colonial Museum, rather than on field observations.

Hutton & Drummond (1905) produced an accurate assessment of stilt plumages, reducing the number of species to three: *H. leucocephalus* (adult and juvenile Pied Stilts), *H. melas* (adult, juvenile and first-winter Black Stilts) and *H. picatus* (nodes C-E birds), and they further suggested that *H. leucocephalus* and *H. picatus* might be conspecific. Surprisingly, authors in the mid-20th century did not distinguish between plumages of hybrids and first-winter Black Stilts. For example, Oliver (1930, 1955) stated "Stilts having their plumage intermediate in colour between the Black and the Pied species are undoubtedly hybrids", and Peters (1934), in his checklist of world birds, considered that stilts in New Zealand have "a tendency to melanism resulting in the production of a certain proportion of melanistic mutants of varying intensity". Oliver and Peters were either unaware of, or doubted, the precise descriptions given by Hutton & Drummond (1905). Stead (1932) on the other hand, was aware of hybrid juveniles and first-winter plumages, as is shown by his correct labelling of museum skins.

DISCUSSION

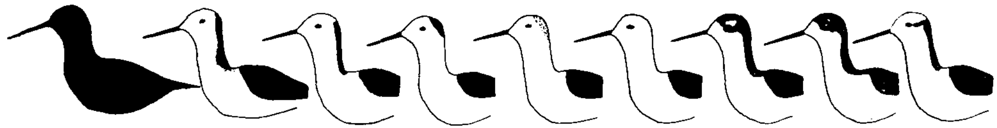
The extent of hybridisation in the 19th century is hard to assess. Node D or E hybrids were recorded by Hutton (1871), Potts (1872), Buller (1875a, 1888), and possibly by Ellmann (1861). In about 1880, A. Reischek collected a node D bird from Mt Selwyn, Canterbury, and this specimen is in the Vienna Museum (K. E. Westerskov, pers. comm.). Buller (1888) found that Pied Stilts varied considerably in size. Of 24 pre-1900 Pied Stilt skins in the British, Canterbury, Otago and Auckland Museums, seven only are in node A plumage. Despite these records, actual instances of inter-breeding between Pied and Black Stilts may have been relatively few. For example, Potts (1869) stated " . . . we have never once found the two species breeding together or using the same or even similar situations for their nesting place," and Buller (1882, 1888) endorsed Potts' observations.

Records in the 20th century suggested that the interbreeding increased wherever Black Stilts were rare or on the edge of their main range. On the bed of the Waipara River (North Canterbury) in 1904, Stead found several pairs of " pure Pied Stilts," along with several pairs of Black Stilts, one Pied x Black pair and several " intermediates," one of which was a " Potts type " bird (node D or E) nesting with a Pied Stilt. In 1907, Stead found no Black Stilts on the Waipara River bed, but in other parts of Canterbury he observed hybrids and " several instances of Blacks breeding with Pied mates " (Stead 1932). Stead suggested that Black Stilts interbred with Pied Stilts owing to a shortage of potential mates. This opinion is supported by my observations of selective mating at Lake Tekapo, where male Black Stilts greatly outnumbered females. Similar observations to Stead's are available for the Marawhenua River in North Otago, where M. Keioller (pers. comm.) found several pairs of Pied Stilts and several pairs of Black Stilts in the 1950s. In later years, Mr Keioller found only Pied Stilts and " smudgies " nesting at the river. In recent years some mixed pairs have been found nesting outside the normal Black Stilt breeding range, including the Routeburn River in 1958 (M. F. Soper, pers. comm.), near Hawea in 1966 (P. Child, pers. comm.), and along the Hakataramea River in 1971 and at Lake Wainono in 1979 (pers. obs.).

Interbreeding is currently contributing to the decline of Black Stilts. Introgression alone, however, could not have been responsible for the dramatic decline of Black Stilts in the late 19th and early 20th centuries. In the mid-19th century, Black Stilts were widespread and common in New Zealand, whereas Pied Stilts were uncommon and may have arrived only recently from Australia. Reproductive isolation would have remained largely intact during this period owing to selective mating by Black Stilts. Moreover, had a total breakdown in reproductive isolation occurred, it would have resulted in the then-rarer Pied Stilt being incorporated into the large Black Stilt population.

In my opinion the Black Stilt declined because it could not adapt to man-induced changes in the environment, particularly increased predation pressure and habitat alteration (Pierce 1982). However, the Black Stilt has maintained a very small population for about the last 25 years without being absorbed into the large Pied Stilt population. In part, at least, this has probably been helped by separate wintering grounds and habits, by which Black Stilts form pair bonds before Pied Stilts return inland. Pied Stilts were very rare in the Upper Waitaki River Basin in winter and early spring, when unpaired resident Black Stilts were usually forming pair bonds. If all Black Stilts had wintered alongside Pied Stilts in scattered coastal localities, mixed pairings would have been more likely than they are.

TABLE 6 — Plumage and biometric comparisons within the genus **Himantopus**

Form		*novaezealandiae*[1]	*leucocephalus*[2] (N.Z.)	*leucocephalus*[3] (Aust.)	*himantopus*[4]	*ceylonensis*[5]	*meridionalis*[6]	*mexicanus*[7]	*knudseni*[8]	*melanurus*[9]
Plumage	M									
	F	Similar	Similar	Similar	Back brown	Back brownish	Back brownish	Back brown	Back browner	Similar
Plumage variability		Moderate Head, abdomen	High Neck, collar crown	Low -	High Crown hind neck	..	..	High Crown	High Neck	High Crown, collar
Bill length (mm)	n	27	73	32	63	..	14	36	36	28
	$\bar{x}$	66.2	61.7	61.5	63.6	..	63.5	64.4	74.11	62.0
	sd	2.5	2.8	..	..	..	..	..	..	2.9
Tarsus M (mm)	n	4	47	19	43	4	14	18	43	13
	$\bar{x}$	90.8	101.3	114.3	124.7	117	115	113	123.9	114.5
	sd	2.3	6.4	6.3	..	..	..	6.0	6.1	6.0
Tarsus F (mm)	n	9	45	15	32	3	..	21	45	16
	$\bar{x}$	85.6	93.0	109.0	111.8	113.5	..	103.2	116.9	107.6
	sd	5.8	5.2	7.8	..	..	..	4.1	5.9	6.9
Wing (mm)	n	37	83	34	76	7	14	39	88	29
	$\bar{x}$	236.3	225.5	224.9	237.5	239.5	226	219.5	235.0	220.5
	sd	11.0	3.3	..	..	..	..	..	..	13.0
Tail (mm)	n	33	77	34	..	7	14	39	88	29
	$\bar{x}$	78.5	76.0	73.1	..	79	80.9	67.7	76.1	76.2
	sd	4.3	3.4	..	..	..	..	..	..	4.4
Weight (g)	n	4	29	18	..	..	..	18	85	..
	$\bar{x}$	223.1	192.7	176.4	..	..	..	166	202.6	..
	sd	..	19.9	..	..	..	..	..	..	..

Notes: .. = no data; M = male, F = female

Source of data:

1 British, Auckland, National, Canterbury and Otago Museums: field data
2 As for *novaezealandiae* with the addition of data from B.F. McConkey (pers.comm).
3 Australian Museum, National Museum of Victoria, CSIRO
4 Prater *et al.* (1977), Goriup (1982)
5 Ali & Ripley 1980 ($\bar{x}$ = mid point of range)
6 McLachlan & Liversidge (1972). Tarsal measurements are for male and female combined.
7 Hamilton (1975), Prater *et al.* (1977)
8 Coleman (1981)
9 American Museum of Natural History

For geographical ranges of individual taxa see Fig 7

As a result of introgressive hybridisation, Pied Stilt plumages throughout New Zealand are highly variable. Node A birds accounted for only about 9% of the stilt population in the Upper Waitaki River Basin, and in the North Island, McConkey (1971) found that only 18 (13%) of 140 stilts had the white mantle band of node A birds. In addition, the tail of most node A birds in New Zealand is tipped grey to dark grey, whereas the tail of Australian birds is tipped light grey.

The introgression has contributed not only to plumage variations, but probably also to a shortening of the tarsus in Pied Stilts. Two of three measurements given in the early literature (Hutton 1871, Buller 1888, Hutton & Drummond 1905) list nodes A or B Pied Stilts as having tarsi of 4.5 inches (about 115 mm) in length. (The same authors list 90-95 mm for Black Stilt tarsi, consistent with this study). The Pied Stilt tarsal measurement is within the range of Australian birds, but outside the present-day range of New Zealand stilts. Of 195 stilt tarsi measured in New Zealand since 1970, only one of 115 mm, a male measured by B. F. McConkey (pers. comm.), has been of similar length to birds of the same sex in Australia. In addition, the tail is longer in New Zealand Pied Stilts than it is in Australian birds (Table 1). It is apparent that these variations in plumage and morphology began while Pied Stilts were still expanding their population in New Zealand.

The morphological differences between New Zealand and Australian Pied Stilts are comparable to those used to distinguish several world taxa of *Himantopus* (Table 6). Recent workers (Cramp & Simmons 1983), however, have considered that subspecific recognition of *meridionalis* and *ceylonensis* is not warranted and that the other forms, except perhaps the species *H. novaezealandiae*, are only subspecies of *Himantopus himantopus*. Nevertheless, the present morphological divergence of Pied Stilts in New Zealand may indicate a transitional stage in the speciation process, but it is too early to speculate on the outcome of this process. In South America, hybridisation between *H. h. mexicanus* and *H. h. melanurus* has given rise to variations in plumage (Blake 1977).

Black Stilt morphology has not changed noticeably since the 19th century, probably because the positive assortative mating of the original large population continued during the 20th century, even as the population declined. But now that they are rare and have a very low rate of population recruitment, they are very likely to acquire some Pied Stilt traits through interbreeding.

The presence of two forms of stilts in New Zealand probably represents a double invasion from Australia, but speciation of the Black Stilt was not complete when reinvasion occurred. The nomenclature of the Black Stilt is therefore not straightforward. Pied and Black Stilts exhibit a combination of specific and subspecific characteristics (Table 7), which places them in the "semispecies" category

TABLE 7 — Characters which (A) promote reproductive isolation and (B) reduce reproductive isolation between Pied and Black Stilts

	A. Isolating mechanisms	B. Unifying mechanisms
Morphology	Plumage and lengths of appendages differ	
Behaviour	Selective mating	Precopulatory behaviour and copulation alike
Voice	Black Stilt higher pitched	Responsive to pre-copulatory calls
Physiology	Chick growth rate differs	
Ecology	Mainly sedentary versus migratory; habitat partitioning; feeding differences	High overlap in habitat and foraging at certain times
Genetic		Hybrids are viable and fertile and so introgression occurs
Abundance		When rare Black Stilts cannot find Black mates

of some authors (Short 1969, Mayr 1970). In the literature, semispecies have been treated taxonomically as either species or subspecies. The apparently high level of interbreeding between Pied and Black Stilts suggests conspecificity (L. L. Short, pers. comm.). In some recent studies of interbreeding in birds, however, the criterion for species status has been the proportion of mixed pairs in the zone of contact, which may bring about reversal in nomenclatural decisions (E. Mayr, pers. comm.). Black Stilts show positive assortative mating, most breeding birds being paired Black-Black. The proportion of mixed pairs is clearly made higher by Black Stilts being locally and totally rare, one of several factors which encourage interbreeding between different species (Mayr 1970). The chances of a Black Stilt finding a suitable Black Stilt mate become less as the population decreases, and the potential for reproductive isolation between the two species also decreases. Because Black Stilts select other Black Stilts for breeding if they can, and because of their morphological and ecological differences from Pied Stilts (Pierce, in prep.), I recommend that Black Stilts retain their full specific status.

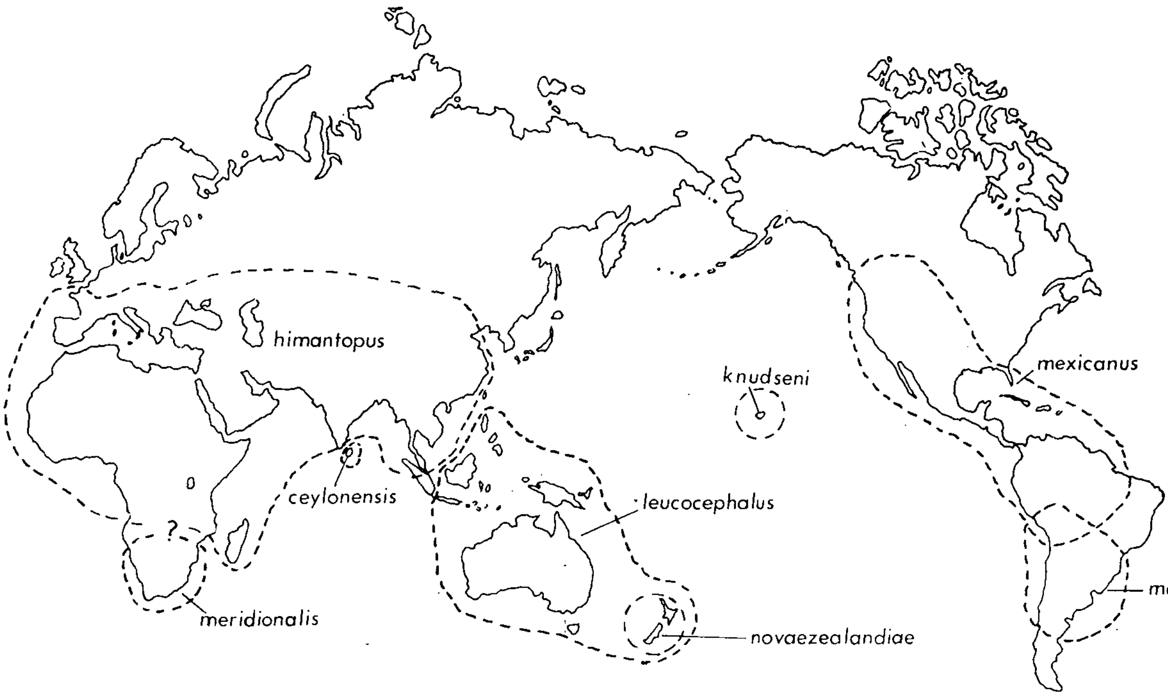


FIGURE 7 — World distribution of the genus **Himantopus**. Data from the references cited in Table 6. Most forms are considered to be subspecies of **H. himantopus** (e.g. Cramp & Simmons 1983), but the American Ornithologists' Union recognises **knudseni, mexicanus** and **melanurus** as subspecies of **H. mexicanus** (Coleman 1981), and the New Zealand checklist (Kinsky 1970) recognises **H. novaezealandiae** as a full species.

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R. J. PIERCE, *Department of Zoology, University of Otago, Dunedin*

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SHORT NOTE

CORRECTION: NORTH ATLANTIC SHEARWATER TO PINK-FOOTED SHEARWATER

First sightings of the North Atlantic (Cory's) Shearwater Calonectris diomedea **(Scopoli, 1769) in Australasian seas** (Notornis **29: 85-91, 1982**).

Overseas correspondence I have received in response to my report on the sightings of Cory's (North Atlantic) Shearwater, *Calonectris diomedea,* off the east coast of the South Island, has convinced me that my identification was incorrect. Indisputable evidence has been presented in support of Pink-footed Shearwater, *Puffinus creatopus.*

In May 1983 the OSNZ Rare Birds Committee met and reappraised the colour transparencies which featured as Figures 1, 2 and 3 in *Notornis* 29: 85-91 (1982). The Committee sent colour prints of the transparencies to Professor R. Schlatter, Universidad Austral de Chile, and Dr F. Roux, Museum of Natural History, Paris; both confirmed the birds in the photographs as Pink-footed Shearwater.

This is the first record of Pink-footed Shearwater in New Zealand.

I would like to acknowledge the constructive comments I received in correspondence from J. B. Cox, D. Eades, Kimball L. Garret, and John Izzard (and colleagues M. Carter and G. Holmes), and the OSNZ Rare Birds Committee, who acted promptly to my request that they meet and reconsider my *Notornis* report.

G. A. TUNNICLIFFE, *Canterbury Museum*

THE NORTH ISLAND KOKAKO (*Callaeas cinerea wilsoni*) IN THE WESTERN KING COUNTRY AND TARANAKI

By COLIN F. J. O'DONNELL

ABSTRACT

The distribution of the North Island Kokako *(Callaeas cinerea wilsoni)* in the western King Country and Taranaki was recorded during summer 1980-1981. The survey confirmed that the Kokako was widespread in the study area but showed that its range is continuing to shrink. The status of many populations is still uncertain. Kokako appear to have disappeared recently from large forest tracts in south-eastern and inland Taranaki and from large isolated forests in the north. Within large forest tracts Kokako were not recorded in some locations where they had been present before 1970.

Most Kokako were in unmodified rimu-tawa dominant forest and habitat deterioration appears to be an important factor in their decline.

INTRODUCTION

Although the North Island Kokako is still widespread in the northern half of the North Island (Lavers 1978, Falla *et al.* 1979), its populations are limited and localised, often being confined to fairly discrete forest areas (Crook *et al.* 1972). In a review of the distribution of the North Island Kokako, Lavers (1978) found that its range has changed markedly since European colonisation of New Zealand. Although the Kokako probably had a widespread distribution in pre-European times, its range has contracted since and populations have become isolated. Destruction of forest habitat is the most important factor in the decline of the Kokako (Imboden 1978). The species had already decreased greatly by 1880 (Falla *et al.* 1979) and populations have declined steadily since 1900 (Lavers 1978). Today the status of most populations is uncertain. The densest populations known now are in Puketi State Forest (SF) (Anderson 1979), Pureora Forest Park (Crook *et al.* 1972, Hay 1981) and Mapara Forest (Coker 1978, Hay 1981).

This report provides information on the distribution of the Kokako in the western King Country and Taranaki and discusses the status of various populations. The data in this report were collected by the Fauna Survey Unit (FSU) of the Wildlife Service between 14 October 1980 and 25 March 1981. Detailed studies of distribution and ecology of the Kokako in the eastern King Country have been made by Hay (1981).

References in the literature to Kokako in the study area have been few and brief. Imboden (1978) summarised the distribution of the Kokako through the Raglan-Waitomo-Taranaki region as " frequent, widespread reports. Populations little known but said to be declining in northern part of the area associated with goat damage to the forests." Falla *et al.* (1979) gave locations as " near Raglan; Mt Pirongia, south of Kawhia; some parts of the King Country; North and South Taranaki;". Lavers (1978) stated that forests to the east and west of Te Kuiti have not changed much since before settlement and that sightings since 1960 show that Kokako still occur widely. In Taranaki, one of the largest areas of forest cover in the North Island remains in the Matemateaonga Range and mid-Wanganui River catchments. Kokako were once present throughout this area and Lavers' information indicated that Kokako were still widespread, although declining, in the 1960s.

STUDY AREA

The study area covered those parts of the western King Country, Waikato and Taranaki which are enclosed by dashed lines in Figures 2-4. More specifically, the study area was that land within the 19 NZMS 290 map sheets, P19, 20, 21; Q18, 19, 20, 21; R14, 15, 16, 17, 18, 19, 20, 21 and S15, 16, 17, 18. This land contains extensive forest remnants from Raglan through the Pirongia, Taumatatotara, Waitomo and Whareorino districts, to the Mokau River and the Taranaki forests, including the Waitaanga, Whangamomona, Wanganui River and Matemateaonga tracts (Figure 1).

Forests in the east of the study area include areas of the Rangitoto and Hauhungaroa Ranges. Because extensive surveys have been made of these forests recently (Crook *et al.* 1971, 1972, Coker 1978, Imboden 1978, Hay 1981), no formal surveys were undertaken during this study. These forests will be briefly mentioned in the text.

METHODS

All forest tracts were visited by FSU personnel, often several times. Particular efforts were made to locate Kokako from line transects which, when practicable, followed leading ridges, tracks, roads, and other routes. Tape recordings were played, usually about every 500 m, to attract Kokako. The calls used included the apparently non-dialetical "mew" call, and also songs (Rotoehu and Puketi dialects). The "mew" call was used much more later in the survey, when its effectiveness had been proven. Several reliable reports were received from local residents. No quantitative assessment of population size was made; stated inferences about the Kokako's status depended on the wide experience of the observers. The survey was extensive rather than intensive and the assessments are preliminary only.

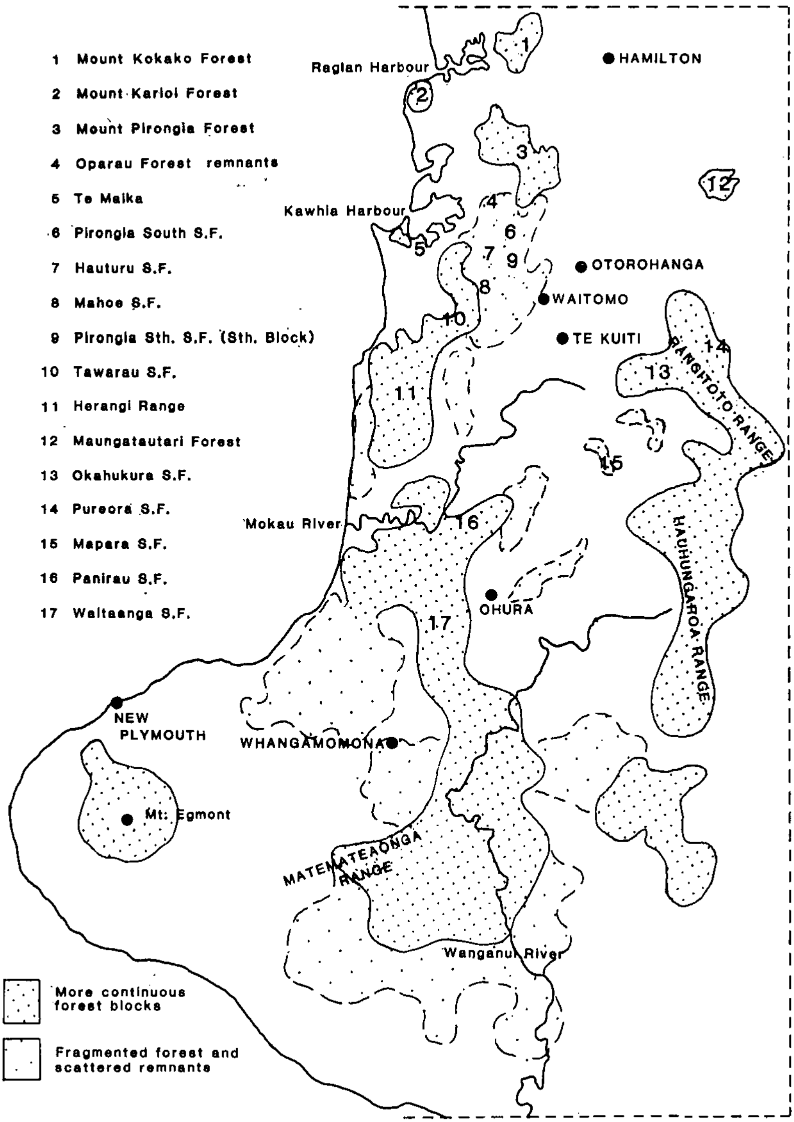

FIGURE 1 — Locality map showing general distribution of remaining forest in the King Country-Taranaki region.

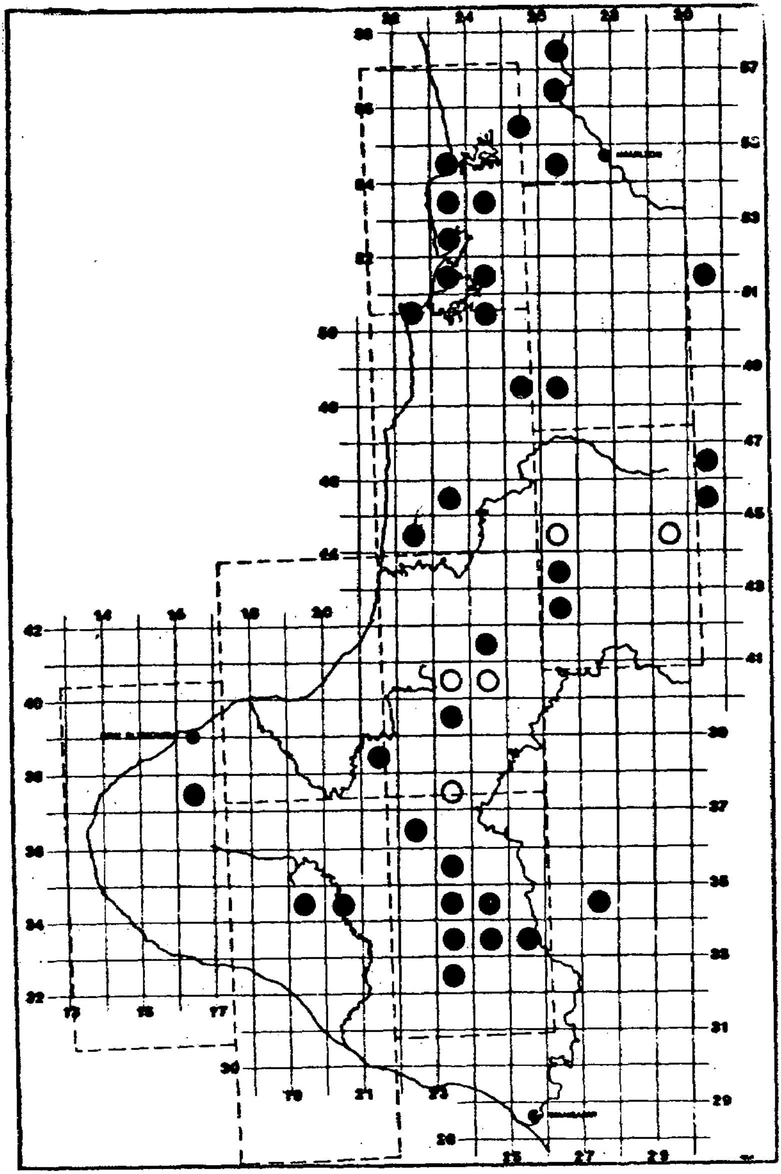

FIGURE 2 — Distribution of the Kokako in the western King Country and Taranaki before 1960
Closed circles: records from Appendix 1, Lavers (1978) pp. 179-181
Open circles: records from other sources

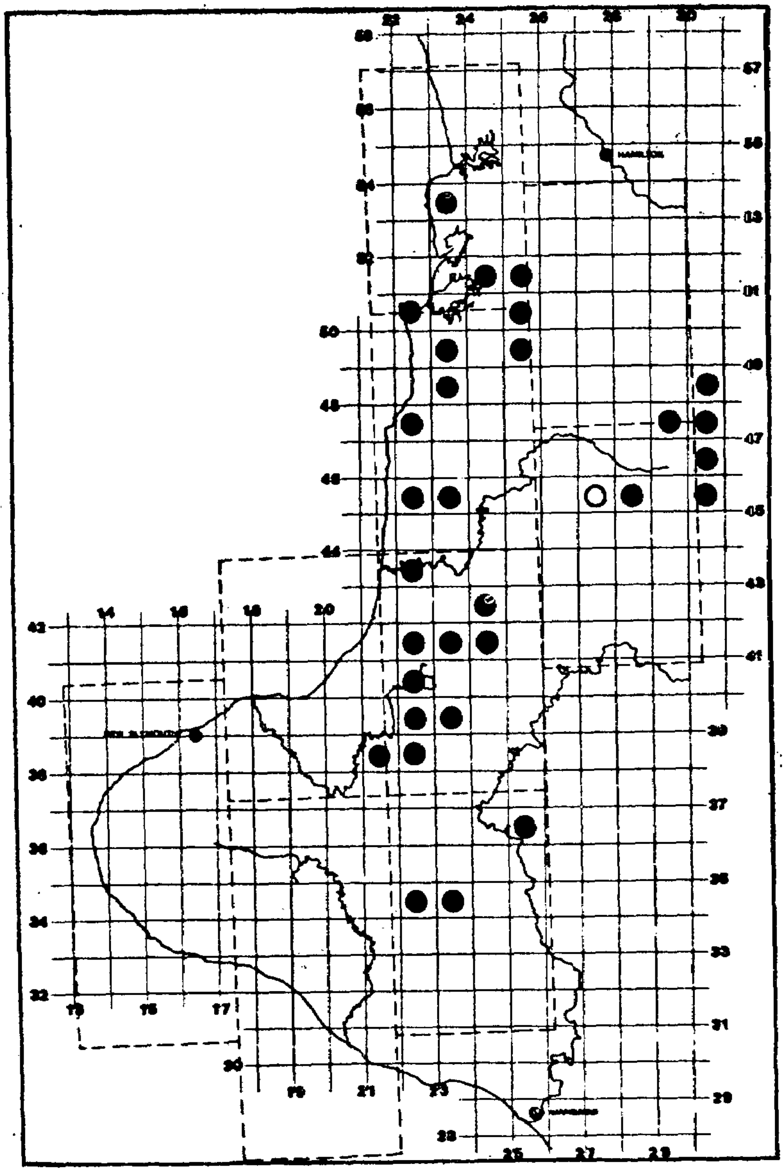

FIGURE 3 — Distribution of the Kokako in the western King Country and Taranaki, 1960-1970
Closed circles: records from Appendix 1, Lavers (1978) pp. 179-181
Open circle: record from other source

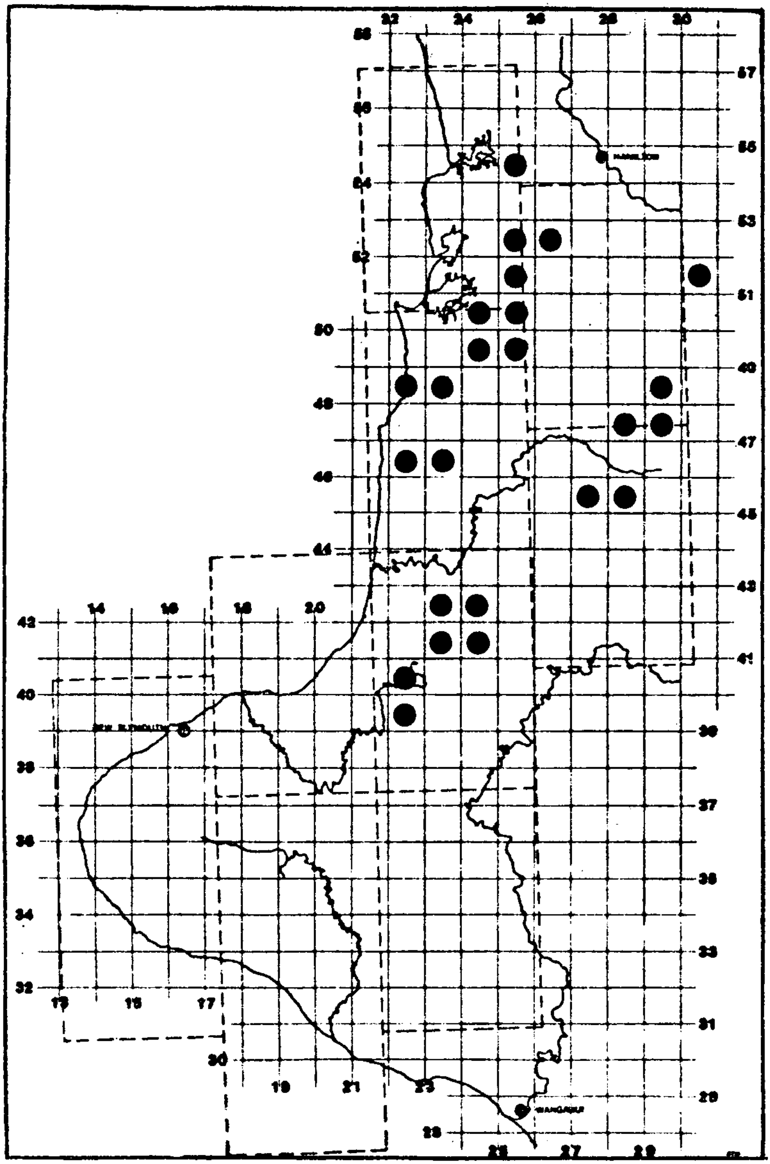

FIGURE 4 — Distribution of the Kokako in the western King Country and Taranaki, 1977-1981

Results are summarised for each 10 000-yard grid square (Fig. 4) and details of all sightings are given in Appendix 1.

DISTRIBUTION AND STATUS

Western King Country

Forests of this region comprise those west of the Waikato Plains, Otorohanga and Te Kuiti, from Raglan in the north to the Mokau River (Fig. 1), which extend to the western coast of the North Island.

Mount Kokako Forest

Before 1960, Kokako had been reported in various locations in forests on and about Mount Kokako, east of Raglan Harbour (Fig. 2), but there were no records between 1960 and 1970. (Five records cited by Lavers referring to Kokako Trig, supposedly from this area, actually refer to a trig of the same name near Ohura, much further south).

The presence of Kokako in unmodified forest was confirmed in 1978 and 1979 (Fig. 4) north of the Tumunui Stream (photographed by A. H. Grootegoed, Henderson). None was located in 1980. About 70% of the forest has been logged; the remaining 30% is unmodified podocarp-mixed hardwood forest. The Kokako population is of uncertain status but it is likely to be very small.

Mount Karioi Forest

Mount Karioi forms part of Pirongia Forest Park and is on the western coast between Raglan and Kawhia Harbours (Fig. 1). Kokako were present in the 1950s (Fig. 2) and 1960s (Fig. 3), but none was found in 1980 despite intensive searching. It is now either very rare or absent. In recent years, the forest (coastal podocarp-hardwood) has been seriously modified by logging, burning and browsing.

Mount Pirongia Forest

Kokako have been reported since the 1800s in the unmodified lower-altitude forest surrounding Mount Pirongia (Pirongia Forest Park). In 1980, birds were recorded north of the mountain (Kaniwha-niwha Track) by R. Schoefield (NZFS Ranger) and in the south by FSU (Fig. 4). The population is probably small to moderate and scattered. It is believed to have declined steadily during the last 25 years.

Oparau Forest Remnants

Large forest remnants are immediately east of Kawhia Harbour, including Te Rauamoa, Te Kauri Reserve, Te Kauri Park and private forests surrounding the Te Awaiti Stream. These remnants are south of Mount Pirongia. Kokako were recorded throughout the 1970s

(OSNZ Recording Scheme 1974, 1977, 1978, 1979). High numbers were present in the mid-1960s, when breeding birds were studied (McKenzie 1975). Kokako were not recorded in Te Kauri Reserve by FSU in October 1980, and the last bird was seen in the reserve by the ranger, R. Vale, at the beginning of 1980. The population has been declining slowly for some time. Only two birds were recorded in the whole area by FSU, on a ridge near Te Awaiti Stream.

Te Maika

In this large forest remnant immediately south of Kawhia Harbour, Kokako were recorded in the past (Fig. 2 and 3) but not since 1962. In searches in 1980 none was found.

Pirongia South SF, Hauturu SF and surrounding private forest

These are large but fragmented forests between Mount Pirongia and Waitomo (Fig. 1). Kokako have been recorded in these forests since the 1800s (Fig. 2 and 3) but the importance of these Kokako populations was not realised until this survey. In our 1980 survey seven Kokako were recorded in Pirongia South SF (north block) and eight in Hauturu SF (east block). These sightings indicate the presence of moderate to large populations. Small numbers were also located in private forests north of Mahoe SF and in Pirongia South SF (south block). In Pirongia South, the seven birds were recorded on nine listening stations, a density comparable with that in some West Taupo and Rotorua forests.

Tawarau SF

Three Kokako were recorded here, a forest from which Kokako were not known previously. These sightings indicate a small or moderate population in the least-modified forest to the east of the Puaroa River. The rest of the forest is highly modified by goat and possum browsing and some logging.

Herangi Range (Whareorino Forest)

This very large forest block north of the Mokau River includes Whareorino SF. Kokako used to be throughout the forest (Fig. 2 and 3), but our survey found them only in unmodified forest in the north and central areas (Fig. 4). They seem to have disappeared from the south, where the forest has been highly modified by logging. Areas peripheral to the whole block are being cleared steadily. Populations seem to be small to moderate and localised. Single birds have been reported from the north (immediately south of Marakopa), for example, by R. Shaw in 1980. Kokako seem more numerous in the headwaters of the Awakino River than in other parts of the Herangi Range, but there too they are restricted to several leading ridges.

Eastern King Country

Mangatautari Forest

This large isolated forest is just outside the study area in the north-east. Kokako were found in three parts of it in 1977 (Johnson & Saunders 1977), but none was found in 1980.

Rangitoto Range

This lies east of Te Kuiti on the boundary of the study area and includes Okahakura SF and margins of Pureora SF. This area was intensively surveyed by the Wildlife Service in the 1970s and more recently by Hay (1981). A brief survey by the FSU in December 1980 showed that Kokako were still widespread, and in one area (Okahakura SF) the population seemed to be dense as seven birds were recorded in two hours of survey. The numbers recorded may have given a false picture of abundance because large areas of forest have been, and still are being, logged and converted to farmland about Rangitoto and the headwaters of the Waipa River, while the State Forest has had much of its tawa *(Beilschmiedia tawa)* and podocarps removed. Kokako may have retreated into the area as a result of surrounding habitat destruction. This population needs to be watched closely.

Mapara state and private forest

This forest has been surveyed in recent years (Coker 1978, Hay 1981) and has been shown to have a moderately dense Kokako population. A brief visit in February 1981 revealed five Kokako in a small area of unmodified forest margin. High numbers remain throughout (Hay 1981). Kokako were found at two stations where they had not been recorded by Coker.

Taranaki

Mokau River forests

Kokako were recorded during the 1960s (Fig. 3) but not during the 1981 survey. Logging continues in some parts.

Mangakara catchment

One Kokako was recorded in this catchment, north-west of Ohura near the edge of Panirau SF. An extensive area was searched in some detail in January 1981 but no other birds were found. In recent years, the forest area has been logged extensively.

Waitaanga Forest

This very large mainly unmodified forest block immediately west of Ohura contains state and private areas. Kokako were once widespread throughout the district (Fig. 2 and 3) and, despite shrinkage of range in 1970-81 period (Fig. 4), the most dense Kokako population found during the whole survey was on the Waitaanga Saddle near Kokako Trig. A total of 23 birds was found here on two days of survey. On one occasion, eight birds were recorded from a single survey station. Kokako were present in unmodified podocarp-tawa forest. The population seemed to be localised because only single birds were found in other parts of the forest (the Mohakatino Catchment and forests extending southwards to, but not including, Tangarakau Gorge). Kokako were present in the Tangarakau Gorge 40 years ago but now seem to be in very small numbers or absent.

Forests north-west of Whangamomona

Kokako once seemed to be widespread in this region (Fig. 2 and 3) but very few birds were found during this survey (Fig. 4). No Kokako have been seen in forests close to Whangamomona since 1976. Localised populations of uncertain status still exist near the Rerekapa Track and Skinners Hill, Tahora. The species may be more widespread but, if so, numbers are probably very low. These forests have been fragmented gradually by both logging and farm development.

Matemateaonga Range, Wanganui River forests

Kokako were once widespread in these forests (Fig. 2) but seem to have declined this century (Fig. 3). Today, Kokako seem to be either very rare or absent (Fig. 4). The last confirmed report from this region was of a bird near the Tangahoe Stream (grid ref. 2480-3590) in 1974 (J. Ombler, Department of Lands and Survey, pers. comm.). A total of c.34 man-days were spent searching the forest proper, and additional days on the forest margins, but no Kokako was found. Most of the forests in the Matemateaonga Range remain unmodified by logging and seem to be suitable Kokako habitat. Forests of the mid-Wanganui River (e.g. Mangatete Stream and near Pipiriki), where Kokako were known in the past, are now in poor condition because of intensive goat browsing and erosion.

Mount Egmont

Kokako once inhabited Egmont's forests but the last probable record is from 1938 on the Mangorei Track in the Pouakai Ranges. It is unlikely that the species still occurs (D. Medway, pers. comm.). Records by Lavers (1978) citing the occurrence of Kokako in the 1960s have not been confirmed. They were of calls only suspected of being from Kokako.

TABLE 1 — Habitat of Kokako

Forest Type	n	%
Unmodified rimu-tawa dominant	71	69.6
Unmodified tawa dominant	4	3.9
Unmodified mixed podocarp	18	17.7
Cutover tawa	8	7.8
Secondary kamahi-tawheowheo	1	1.0
Total	102	100.0

HABITAT

Habitat type was recorded (Table 1) for 102 of the Kokako found by the survey. Most Kokako (91.2%) were in unmodified rimu-tawa dominant forest. None was found in beech forest (black and hard beeches, *Nothofagus solandri* and *N. truncata,* widespread in the Taranaki forests). Typical Kokako habitat was characterised by dominant emergent rimu *(Dacrydium cupressinum),* miro *(Podocarpus ferrugineus),* Hall's totara *(P. hallii)* and northern rata *(Metrosideros robusta),* and canopy plant species included tawa (dominant), hinau *(Elaeocarpus dentatus),* kamahi *(Weinmannia racemosa),* tawheowheo *(Quintinia* spp.*),* rewarewa *(Knightia excelsa),* pukatea *(Laurelia novae-zelandiae)* and mangeao *(Litsea calicaris);* and in the north, kohekohe *(Dysoxylum spectabile),* puriri *(Vitex lucens),* tanekaha *(Phyllocladus trichomanoides).* All Kokako were found on ridges and valley sides, mainly ridges. Records ranged in altitude from 175 m to 850 m a.s.l., but most were between 300 and 500 m (Table 2, Appendix 1). Thus Kokako were normally restricted to low-altitude forest.

TABLE 2 — Altitudinal range of Kokako records

Altitude (m)	n	%
100 - 299	3	2.8
300 - 499	48	44.9
500 - 699	53	49.5
700 - 899	3	2.8
Total	107	100.0

As was discussed for the Rangitoto Range, the presence of Kokako in cutover forest may be misleading. Kokako still survive in remnants of tawa and rata forest as small as 0.5 ha in Okahakura SF, where gaps of 10-20 m were often present between the remnants. A survey of Okahukura in October 1980 (Hay 1981) located 13 Kokako. Eleven of these birds were in undisturbed forest along stream edges, not in logged areas. Kokako have poor flight and thus poor dispersal ability (Imboden 1978). Whether the Okahukura population will breed or remain stable in this apparently suboptimal habitat is open to question.

DISCUSSION

Because Kokako populations seem to be very localised, surveys have to be intensive searches. Furthermore, although birds respond quickly to tapes on one day, they may not on the next (as was found in Waitaanga and Rangitoto forests). In some areas surveyed in 1980 the presence of Kokako was strongly suspected but not confirmed. Subsequent visits in 1981 did confirm their presence, e.g. Pirongia

South SF (south block). For these reasons a lack of Kokako records for a forest cannot be taken to mean that Kokako are not present.

This survey confirmed that Kokako are widespread in the western King Country and North Taranaki. However, the trend of shrinking distribution and declining numbers of Kokako reported by Lavers (1978) seems to be continuing. Kokako seem to have disappeared over the last 10-15 years from large tracts of forest in south-eastern and inland Taranaki (Matemateaonga Range) and from large insular forests in the north (Te Maika, Mount Kariori and perhaps Mangatautari). Within the large forest blocks in the north, Kokako were not recorded from many of the places where they had been known up to the 1960s.

The status of most of the observed populations is uncertain, but most seem small and are probably declining. Lavers' (1978) suggestion that remaining populations in extensive unmilled areas may now be fairly stable seems unlikely, in the light of the species' apparent disappearance from South Taranaki. Kokako populations outside the study area in the Hunua Ranges, Rotoehu SF and Horohoro SF have declined steadily over at least the past 10 years (Imboden 1978) and probably longer.

Historically, the Kokako has been steadily declining in numbers and contracting in range since European colonisation. Birds persisted in many of the smaller bush remnants in the King Country until the 1940s but gradually disappeared. For example, one pair was present for many years in a 15-ha remnant surrounded by farmland (K. Sinclair, pers. comm.). Populations may persist for a long time because the birds themselves are long lived, but productivity is very low

Reduction in range has been attributed to habitat loss and the decline in habitat quality from intensive browsing damage, mainly by goats (Imboden 1978). Certainly goats are modifying forest structure throughout the study area. Hay (1981) found considerable overlap in foods eaten by Kokako and possums and suggested that important competition may occur. In addition, continued fragmentation and isolation of bush areas, especially on privately owned land, are destroying the continuity of forest tracts in the study area. Breeding success is very low, probably because of predation by mustelids and cats and competition from possums (Hay 1981).

The continuing decline of the Kokako over its range gives cause for concern. Positive steps such as habitat protection are needed before numbers reach such low levels that they may not recover, even with the best available management practices.

APPENDIX 1 — Locations of N.I. Kokako in the western King Country and central Taranaki, 1977-1981

Location	Grid Ref.	Date	Number	Dominant Forest Type (u.m.=unmodified) 2°=secondary	Altitude (m) a.s.l.
Mount Kokako	2550 - 5585	1978,1979	-	u.m. rimu-tawa	175
Pirongia Forest Park	2595 - 5265	1980	3	u.m. rimu-tawa	300
Pirongia Forest Park	26 - 52	1979	-	u.m. rimu-tawa	-
Pirongia Forest Park	2589 - 5197	30.10.80	1	u.m. rimu-tawa	850
Priongia Forest Park	2580 - 5195	30.10.80	1-2	u.m. rimu-tawa	800
Mangatautari	3047 - 5199	Jan. 1977	1	u.m. rimu-tawa	500
Mangatautari	3048 - 5198	Jan. 1977	1	u.m. rimu-tawa	500
Mangatautari	3049 - 5196	Jan. 1977	1	u.m. rimu-tawa	500
Te Kauri Reserve	2520 - 5130	1980	-	u.m. rimu-tawa	-
Te Kauri Park	2477 - 5110	1980	-	u.m. rimu-tawa	-
Te Awaiti Stream	2495 - 5070	2.11.80	2	u.m. tawa	275
Pirongia South	2570 - 5043	1.11.80	2	u.m. rimu-tawa	450-550
Pirongia South	2560 - 5039	1.11.80	1	u.m. rimu-tawa	"
Pirongia South	2553 - 5036	1.11.80	1	u.m. rimu-tawa	"
Pirongia South	2548 - 5053	1.11.80	2	u.m. rimu-tawa	"
Pirongia South	2549 - 5047	1.11.80	1	u.m. rimu-tawa	"
Pirongia South	2554 - 4975	March 1981	2	u.m. tawa	500
Hauturu	2514 - 5014	22.11.80	1	2° kamahi-tawheowheo	350
Hauturu	2485 - 5015	22.11.80	1	u.m. mixed podocarp	300-480
Hauturu	2485 - 5010	22.11.80	1	u.m. mixed podocarp	"
Hauturu	2495 - 5010	22.11.80	1	u.m. mixed podocarp	"
Hauturu	2503 - 5020	22.11.80	1	u.m. mixed podocarp	"
Hauturu	2510 - 5020	22.11.80	1	u.m. mixed podocarp	"
Hauturu	2527 - 5018	22.11.80	1	u.m. mixed podocarp	"
Hauturu	2541 - 5016	22.11.80	1	u.m. mixed podocarp	"
Hauturu	2515 - 4997	June 1981	2	u.m. mixed podocarp	500
Hauturu	2514 - 5027	June 1981	2	u.m. rimu-tawa	500
Hauturu	2523 - 5022	June 1981	2	u.m. rimu-tawa	500
Mahoe forest	2500 - 4955	20.11.80	2	u.m. rimu-tawa	550
Tawarau	2382 - 4816	17.11.80	2	u.m. rimu-tawa	300
Tawarau	2379 - 4810	17.11.80	1	u.m. rimu-tawa	275
Otuatakahi	c.2505 - 4985	15. 1.79	11	mixed podocarp	300-480
Whareorino	2273 - 4810	4.12.80	-	u.m. rimu-tawa	200
Whareorino	2299 - 4809	May 1980	-	u.m. rimu-tawa	550
Whareorino	?	19 April 1980	-1	u.m. rimu-tawa	?
Whareorino	2275 - 4688	5.12.80	2	u.m. rimu-tawa	500
Whareorino	2266 - 4683	5.12.80	3	u.m. rimu-tawa	500
Whareorino	2304 - 4678	Feb. 1980	2		450
Whareorino	2304 - 4678	Feb. 1980	3		450
Rangitoto	2916 - 4742	11.12.80	1	tawa cut-over	550
Rangitoto	2926 - 4743	11.12.80	1	tawa cut-over	550
Rangitoto	2926 - 4742	11.12.80	1	tawa cut-over	550
Rangitoto	2933 - 4737	11.12.80	1	tawa cut-over	550
Rangitoto	2935 - 4734	11.12.80	1	tawa cut-over	625
Rangitoto	2945 - 4738	11.12.80	1	tawa cut-over	575
Rangitoto	2939 - 4745	11.12.80	1	tawa cut-over	600
Rangitoto	2942 - 4771	12.12.80	1	tawa cut-over	650
Rangitoto	2895 - 4865(?)	1980	-	u.m. rimu-tawa	-
Rangitoto	29 - 48	1980	-	-	-
Mapara	2748 - 4580	Feb. 1981	2	u.m. rimu-tawa	300
Mapara	2749 - 4573	Feb. 1981	1	u.m. rimu-tawa	300
Mapara	2749 - 4564	Feb. 1981	2	u.m. rimu-tawa	300
Mangakara	2427 - 4287	13. 1.81	1	modified rimu-tawa	500
Mohakatino	c.2385 - 4275	1980, 1981	-	u.m. rimu-tawa	500-700
Waitangi	2425 - 4131	14. 1.81	1	u.m. rimu-tawa	500
Waitaanga	2395 - 4194	14. 1.81	1	u.m. rimu-tawa	500
Waitaanga	2441 - 4180	14. 1.81	1	u.m. rimu-tawa	575
Waitaanga	2411 - 4185	14. 1.81	1	u.m. rimu-tawa	475
Waitaanga	2405 - 4195	14. 1.81	11	u.m. rimu-tawa	550-575
Waitaanga	c.2405 - 4195	21. 1.81	8	u.m. rimu-tawa	550-575
Waitaaga	2447 - 4103	15. 1.81	1	u.m. rimu-tawa	450
Rerekapa Track	2257 - 4074	11. 1.81	2	u.m. rimu-tawa	400
Skinners Hill	c.2290 - 4095	1980, 24.8.81	-	u.m. rimu-tawa	450
Marco Road	c.2280 - 3995	1980	-	mixed hardwood	400
Whangamomana	22 - 38	1976	-	rimu-tawa	-

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COLIN F. J. O'DONNELL, *New Zealand Wildlife Service, Department of Internal Affairs, P.O. Box 1308, Christchurch*

SHORT NOTE

LONG-TAILED CUCKOO FLIGHT SPEED

On 30 December 1983, while driving on State Highway 5 about 12 km south of Rotorua, I had the opportunity to measure the ground speed of a Long-tailed Cuckoo *(Eudynamys taitensis)* in flight. The time was 10.30 a.m. and the weather sunny and calm. The cuckoo was in open country flying at the side of the road 15-20 metres up. The bird flew parallel to the road and beside my car for 5 seconds before the road curved away from its flight path. The speed of my vehicle was exactly 80 km/h, and the cuckoo appeared untroubled in matching my speed for the 5 seconds.

How long the Long-tailed Cuckoo spends in transit to and from its winter or summer quarters may always be a matter for conjecture, but perhaps my brief observation may hint at its capabilities.

S. C. SPARROW, *30 Gosset Street, Christchurch 1*

THE WEKA ON MACQUARIE ISLAND

By N. P. BROTHERS and I. J. SKIRA

ABSTRACT

Wekas have been on Macquarie Island for just over 100 years. They occur in the coastal tussock grassland, mainly in the northern half of Macquarie Island.

Males are larger than females and the sexes can be separated on a combination of culmen and tarsus lengths. The sex ratio in favour of males was considered to be due to behavioural differences. Breeding begins in August and, although four eggs may be laid, only one or two chicks are usually reared. Losses are probably due to predation by feral cats and skuas.

Preferred foods are vegetation, insects and spiders. Mammal and bird remains were present in fewer than half the gizzards examined, but rats and mice are thought to be important food because of their size.

The weka was introduced to Macquarie Island as a source of food for sealers, and all sources agree that it was the Stewart Island subspecies, *Gallirallus australis scotti.* The date of introduction is uncertain. It seems that the first release was in 1874 and another in 1879 (Falla 1937, Cumpston 1968). Buller (*in* Oliver 1955) said that wekas were taken down in 1830, but this date seems unlikely.

Initially wekas were scarce (Scott 1882), but they had become widespread by 1890 (Cumpston 1968). Hamilton (1894) recorded that they had " increased and multiplied in a most extraordinary way " and that they were all around Macquarie Island except at the extreme north. They were used as food by the Australasian Antarctic Expedition of 1911-13 and Falla (1937) found them plentiful during his visit in 1930. Sobey *et al.* (1973) recorded that their distribution largely coincided with the distribution of the tussock grassland on the coastal fringe.

The presence of wekas on Macquarie Island for over a century has had a disastrous effect on the native fauna (Taylor 1979, Brothers 1984). Attempts to eradicate them are now being implemented. The aim of this study was to collect information about the wekas before their extermination.

Wekas were counted monthly in 1976 along the coastline between the Nuggets and Sandy Bay (5 km) and in 1979 between Green Gorge and Brothers Point (5 km) by NPB, who also did night counts between Green Gorge and Brothers Point. See Fig. 1.

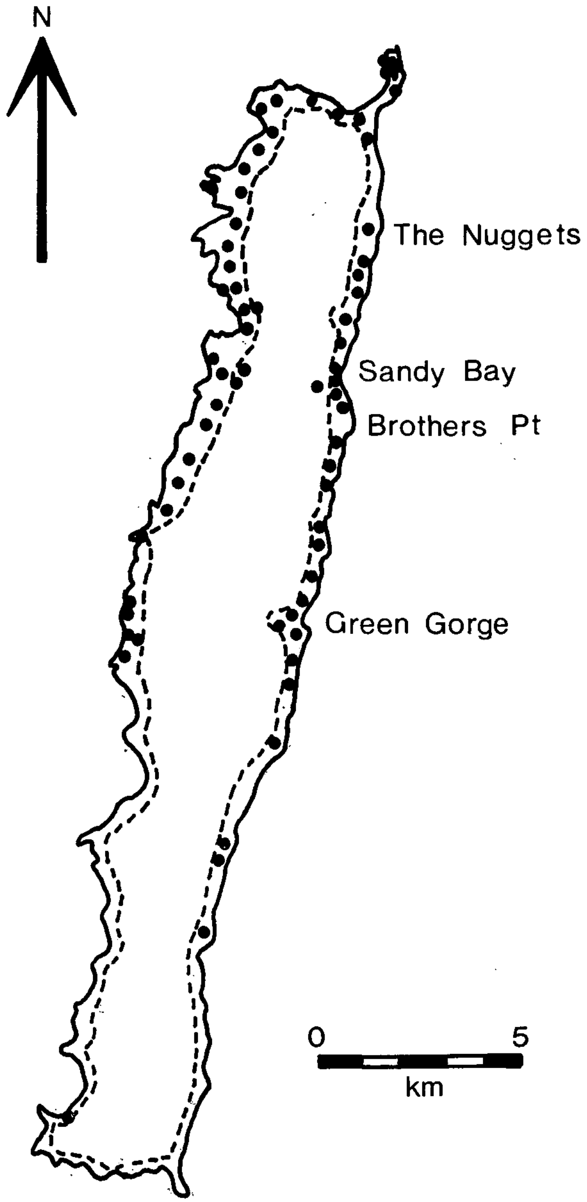

FIGURE 1 — Distribution of weka sightings on Macquarie Island. Each dot represents one weka. The dotted line indicates the edge of the plateau

Between January and October 1979, 98 wekas were shot. Standard measurements of 96 birds were taken, breeding condition was noted, and gizzards were examined microscopically for food items. General observations were made on distribution, habits and nesting.

POPULATION

Characteristics

Males were larger than females in all characters measured, except tail length, which had no significant statistical difference (Table 1). Carroll (1963) reliably sexed wekas using culmen length, tarsus length and body weight, and Coleman *et al.* (1983) by culmen length and bill depth. Discriminant analysis of the eight characters measured gave a discriminant function of $Z = 0.62\ C + 0.25\ T + 0.04\ MTC - 0.01\ MC + 0.03\ W - 0.008\ TAL - 0.002\ TLN + 0.001\ WGT$, where C = culmen length, T = tarsus length, MTC = middle toe and claw length, MC = middle claw length, W = wing length, TAL = tail length, TLN = total length, and WGT = body weight. All values of Z above O were males and below −2 were females, as

TABLE 1 — Measurements of male and female wekas on Macquarie Island. The mean ± one standard error and range in brackets are given. The F-ratio was obtained through U-statistic analysis. ***$p<0.001$.

	Males	Females	F-ratio
Weight (g)	1034 ± 16 (600 - 1425)	753 ± 17 (500 - 884)	85.5 ***
Culmen (mm)	50.2 ± 0.21 (46.2 - 54.2)	45.3 ± 0.42 (41.2 - 48.0)	135.3 ***
Tarsus (mm)	58.4 ± 0.26 (52.3 - 62.1)	51.7 ± 0.42 (45.5 - 54.5)	162.5 ***
Middle Toe & Claw (mm)	71.8 ± 0.32 (65.6 - 78.8)	64.9 ± 0.63 (59.5 - 68.6)	92.2 ***
Middle Claw (mm)	15.2 ± 0.19 (11.4 - 22.0)	13.8 ± 0.19 (11.7 - 15.7)	15.6 ***
Tail (mm)	125 ± 1.6 (74 - 175)	120 ± 1.0 (110 - 130)	3.5 NS
Wing (mm)	184.4 ± 1.2 (165 - 226)	162.5 ± 3.4 (110 - 180)	51.6 ***
Total Length (mm)	511 ± 3.1 (455 - 580)	471 ± 4.2 (425 - 503)	49.3 ***
Sample Size	70	26	

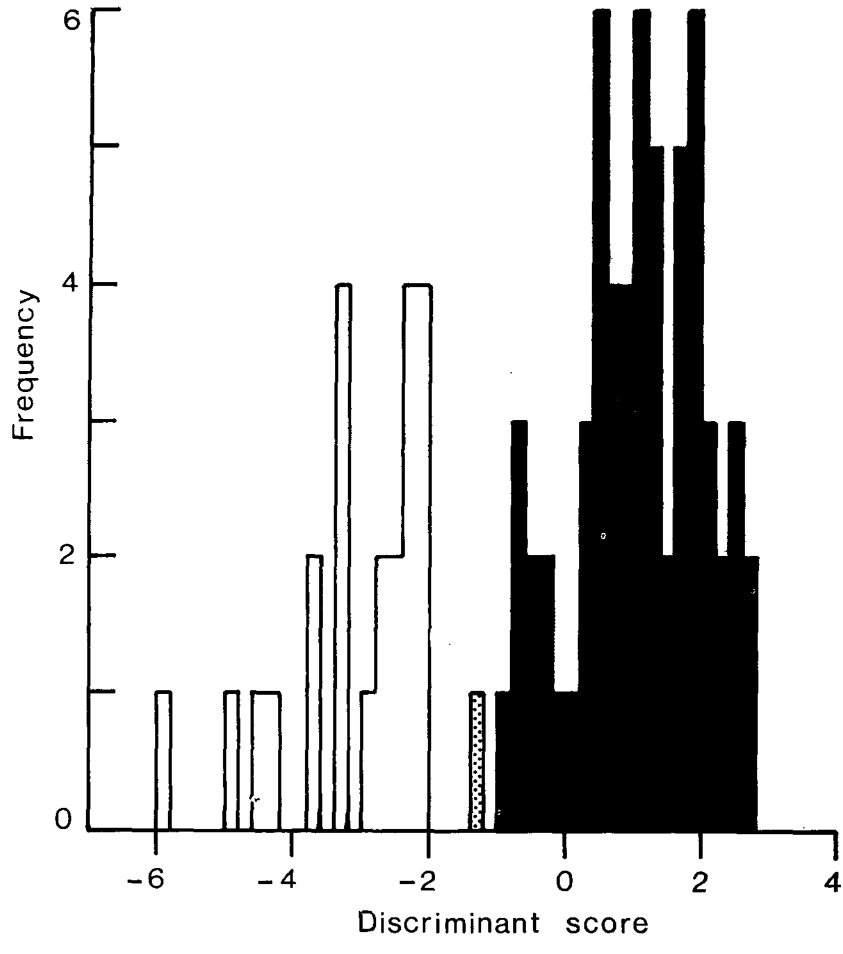

FIGURE 2 — Frequency histogram of the discriminant scores obtained for male (shaded) and female (unshaded) wekas. The light shade represents an overlap of one male and female weka. The class interval is 0.2.

shown in the histogram (Fig. 2). There was one overlap between 0 and −2, but the probability of classifying males correctly was 98.4% and females 100%.

In addition the variates measured were included in a stepwise discriminant analysis which used Wilks' criterion for selection of variables (Klecka 1975). The programmes used were those available on the SPSS package (Nie *et al.* 1975). The stepwise discriminant analysis between males and females required only 4 of the 8 variables to achieve maximum discrimination. The standardised and unstandardised loading obtained were respectively as follows

Culmen	Tarsus	Wing	Weight	Constant
0.470	0.571	0.311	0.182	
0.273	0.261	0.026	0.002	— 34.191

We did not find any eggs but Gavin Johnstone (pers. comm.) measured six eggs from three nests in 1970. The means and ranges were 58.3 x 38.5 (55.4-61.0 x 38.1-39.0) mm.

The sex ratio was in favour of males, 70 : 26 (X^2 = 20.16, d.f. = 1, p> 0.001). Coleman *et al.* (1983) also found an imbalance in favour of males and thought that disease was responsible. In this study, however, all dissected females were disease free, and so the sex imbalance is probably a result of behavioural differences not necessarily related to the sampling technique.

Two colour phases of wekas occur on Stewart Island. The first introduction to Macquarie Island in 1874 is said to have been of the " ordinary chestnut form " (Falla 1937) and the second introduction in 1879 of a darker form (Oliver 1955). The lighter form dominates on Macquarie Island, and in 1976 and 1979 we saw only two very dark birds. The light form had red-brown feathers and chestnut legs, and the dark form had brown-black feathers and legs.

Distribution and numbers

Macquarie Island consists of a plateau averaging 250 m above sea level, bounded by steep tussock-covered slopes that are fringed by shingle beaches and raised coastal terraces. Almost all wekas were on the coastal terrace in a total area of about 50 km² (Fig. 1). Their habitat was the tussock grassland alliance of *Poa foliosa* and Macquarie Island cabbage *(Stilbocarpa polaris)*. Large areas of tussock grassland on the extensive coastal terrace in the northern half of the west coast are where most of the population occurred. Some wekas did venture up to 1 km inland in low coastal valleys, as at Green Gorge, up to an altitude of 100 m but very few ventured on to the plateau. All birds seen on the plateau were foraging near or in tussocks and not on the open herbfield.

Counts of wekas fluctuated throughout the year and more birds were counted at night than by day. Birds could only be seen when on or near the beach feeding out of the dense vegetation and numbers were higher when foraging conditions were most suitable such as when large numbers of kelp flies were present amongst rotting kelp *(Durvillea antarctica)*. On the Nuggets to Sandy Bay transect, 36 counts were made between 28 November 1975 and 11 February 1977. The most wekas seen were 17 on 15 April 1976 and 15 on 20 February 1976. The counts ranged between 0 and 17 at an average of 5.3 wekas. On the Green Gorge to Brothers Point transect, 13 counts were made and the most seen were 12 on the night of 23 April 1979. The seven night counts ranged between 3 and 12 at an average of 7.6 wekas and the six day counts between 0 and 7 at an average of 4 wekas.

The population estimate for Macquarie Island derived from the maximum count of 17 over 5 km was only 170 wekas but the actual total is likely to be much higher. Some birds probably remained hidden among tussocks during counts and counting was impractical on the extensive habitat of the west coast, where the majority of wekas occur. We estimate that there may have been up to 500 wekas on the island.

Breeding

The weka hides its nest well in the middle of the base of tussocks, for we have found only four nests in October and November. The first indication of breeding was on 6 August, when the behaviour of two separate birds suggested that their mates were on a nest. On 9 August a female with a well-formed egg was shot near Green Gorge. Up to four eggs may be laid, for on 4 October a weka was shot that had four eggs in its oviduct.

The first chicks were seen on 27 August and the last chick, which was about three-quarters grown, on 22 May. There were 30 sightings of chicks in 1976 and 1979, of which 19 were of one chick and 11 of two chicks. Chicks accompanied by one or two adults were seen on 27 occasions and were all less than half grown. The three chicks unaccompanied by adults were all at least two-thirds grown. The prolonged breeding season suggests that more than one brood can be raised. One weka was known to have two broods (G. Copson, pers. comm.). It was accompanied by a very small chick on 28 November 1975, and on 19 January 1976 it was feeding another chick in down.

The discrepancy between the number of eggs that may be laid and the number of chicks seen indicates that chick mortality may be high. The period when losses occurred is not known. Chicks are predated upon by feral cats and skuas *(Stercorarius skua lonnbergi)* and we saw feral cats and skuas trying to catch adult wekas. Rats *(Rattus rattus)* may take eggs.

The mean monthly body weight of male wekas increased in the winter, but from July to when observations ceased in October, it was similar at 1028 g. From examination of gonads and sightings of chicks we concluded that the peak of breeding probably occurred between August and November. Seasonal differences in body weight of female wekas were not apparent, perhaps because the sample was small.

Diet

Gizzards of 25 female and 73 male wekas were examined. The occurrence of food items each month is shown in Table 2. Vegetable

TABLE 2 — Occurrence of food items in stomachs of 98 adult wekas on Macquarie Island. The figures are the number of stomachs in which food occurred.

	J	F	M	A	M	J	J	A	S	O	TOTAL
Grit/stones	3	12	8	10	7	5	9	14	9	20	97
Vegetation	3	8	7	9	5	5	5	11	7	18	78
Kelp			2	1	1		1	1			6
Earthworms		1			1			3		1	6
Molluscs	1	10	5	10	6	3	4	10	6	19	74
Crustaceans			2						1		3
Insects	2	11	9	9	7	3	8	12	7	13	81
Arachnids		7	8	10	3	4	4	8	5	14	63
Birds	1	4	4	5	1	1	2	3	4	3	28
Mammals	2	6	3	5	2	2	4	8	4	4	40
	3	12	9	10	7	5	9	14	9	20	98

material and invertebrates were most frequent, and mammal and bird remains less frequent. Grit and pebbles up to 5 mm in diameter were usually present.

Vegetation was in 78 of the 98 wekas examined and was in equal proportion throughout the year. It consisted mainly of fibrous material together with some seed. Carroll (1963) postulated that much vegetable matter may be accidentally eaten while wekas probe for invertebrates or other ground-dwelling animals. This possibility cannot be discounted on Macquarie Island.

Kelp occurred irregularly throughout the year but was found in only six wekas. Earthworms and crustaceans were rare, even though worms are widespread and abundant on the island. The intertidal copepod *Tigriopus angulatus* occurred only twice, each time over 50 of them, and a claw of a crab was found in a weka in September.

Marine shells were in 71 birds and land snails in 8. Marine shells were usually in fine pieces and may have been scavenged after storms, taken from intertidal pools, or picked up as grit while birds searched for invertebrates. One species of land snail, *Phrixgnathus hamiltoni,* occurs on Macquarie Island. Although it is very common under leaves of *Stilbocarpa polaris* and at the base of tussocks, only one was in each weka that had it, and so it may have been picked up accidentally.

Larvae of the kelp flies *Coleopa curvipes* and *C. nigrifrons* and adult *Apetaenus watsoni* were in 32 gizzards and occurred throughout the year. All three flies are widespread around the coast within decaying kelp, and *A. watsoni* is also found under stones. Over 100 and up to 358 larvae were present, but fewer than five adult *A. watsoni* were in any one of the gizzards. Other species of Diptera found were an *Erioptera macquariensis* pupa (one weka), *Drosophila melanogaster* adults (two wekas) and Dolichopodidae larvae (seven wekas).

Caterpillars of the endemic moth *Eudoria mawsoni* were in 36 wekas and occurred throughout the year. No adult moths were found. The caterpillars are widespread but are particularly abundant in the herbfield terrace of the island's north coast (Watson 1967).

Collembola (*Arthropleona* sp.) occurred in only five wekas and Coleoptera (Staphylinidae, Omalinae larvae and *Halmaeusa* sp.) in ten wekas.

Arachnids, mainly spiders, were often in the diet. No identification to species level was attempted and usually fewer than five spiders were in each weka. Acarina (Oribatei and *Ixodes* sp.), which were present in 11 wekas, may have been picked up accidentally among vegetation and in penguin colonies.

Bird remains consisted of penguin and weka feathers and eggshell fragments in two birds. Penguin feathers were probably picked up accidentally by wekas searching for invertebrates in penguin colonies. Weka feathers may have been ingested during preening, fighting or courtship. No petrel feathers were identified, probably because sampling finished in October before burrow-nesting petrels bred, most predation by wekas being early in the chick-rearing stage (Brothers 1984). About 20 colonies of Sooty Shearwater *(Puffinus griseus)* and White-headed Petrel *(Pterodroma lessonii)* occurred within weka habitat and contained generally less than 100 burrows each. Predation on individual colonies may be limited to only a few wekas, but more intensive sampling is necessary than we did to gauge the extent of damage by wekas. Other species of burrow-nesting petrels do not coincide with weka distribution or are present on inaccessible stacks.

Mammals were in 40 gizzards. Mice *(Mus musculus)* were in 23, rats in 19 and rabbits *(Oryctolagus cuniculus)* in 2. Rats are restricted to tussock, and mice occur in both tussock and herbfield (G. Copson, pers. comm.). Although less than half of the gizzards contained mammal remains, mice and rats may be important foods because of their bulk and because they occur abundantly. Although wekas were seen to catch rabbit kittens and remove them from burrows, the low frequency of their occurrence in stomachs reflects their minor importance, which is in part due to low rabbit numbers in weka habitat.

Incidental food items were unidentified flesh in two wekas and a squid beak in one.

Wekas were often observed feeding along the rocky beaches and coastline, where they overturned stones and rotting kelp in search of food. Areas of vegetation on the coastal terrace were systematically turned over, as if ploughed, as wekas searched for invertebrates and perhaps seeds.

DISCUSSION

The weka is omnivorous and finds much of its food on the rocky beaches and among vegetation. Rabbits form a small proportion of its diet but rats and mice are probably important. They do not eat earthworms, which form a major part of their food in New Zealand, whether they are in farmland or forests (Carroll 1963, Coleman *et al.* 1983). However, no comparable study in New Zealand has been done of weka diet in lowland or alpine tussock grasslands. It may be that birds feeding in tussocks in New Zealand do not take many worms. Perhaps on Macquarie Island other invertebrates such as kelp flies, caterpillars and spiders are so abundant that wekas do not need to eat earthworms. This conclusion is supported by the absence from the stomachs of adult moths, which are very common, whereas caterpillars, which are even more abundant, were in many gizzards.

The great increase in weka numbers by 1890 was probably brought about by the introduction of rabbits in 1878. Between 1874 and the early 1880s, predation on wekas by feral cats and their slow natural increase made them scarce. However, the quick dispersal and increase in rabbits from 1878 alleviated predation on wekas and we postulate that they increased dramatically because of the abundance of burrow-nesting petrels as a source of food.

The Blue Petrel *(Halobaena caerulea)* and Common Diving Petrel *(Pelecanoides urinatrix)* were formerly abundant on the lower coastal slopes where wekas occur (Campbell 1901). Nowadays they are confined to offshore stacks but are resident throughout the year (Brothers 1984). Falla (1937) found many damaged burrows of Antarctic Prion *(Pachyptila desolata)* and remains of chicks in tussocks, which he attributed to wekas. Prions now breed only in the herbfield on the plateau, and their absence from tussock is largely due to predation by wekas.

Present-days changes in distribution of wekas can be accounted for by changes in numbers and distribution of rabbits. Sobey *et al.* (1973) recorded wekas even at the southern end of Macquarie Island. In this study, few wekas were seen south of Green Gorge. The habitat in the southern half is not as extensive as that in the northern half and rabbits have further reduced it by removing tussocks. The rabbits are localised and mostly at low density. Numbers of wekas are highest in areas where rabbit density is high, providing an abundant food supply for cats, and in habitat unsuitable for both cats and rabbits. That is, when rabbit numbers are low, cat predation upon wekas intensifies. The rabbit population on Macquarie Island was estimated at 150 000 in 1965 (Sobey *et al.* 1973), 50 000 in 1974 and 150 000 in 1978 (Copson *et al.* 1981). In a study of the diet of cats during 1974, weka remains were found in 12% of cat guts examined (Jones 1977). Predation may have been alleviated when rabbits increased between 1974 and 1978 because Brothers (unpubl.) found weka remains in only 1% of cat guts examined in 1976 and 1979. These years, however, were too few for wekas to increase and disperse. The first introduction of myxomatosis in November 1978 reduced rabbits considerably (Brothers *et al.* 1982). This would have intensified cat predation on wekas, and at last observations in October 1983, wekas were rare in all areas.

The presence of feral cats, rabbits and wekas has had a severe effect on the native flora and fauna. Elimination of cats and wekas, and reduction of rabbits to an acceptable level where their damage is minimal, are the aims of the Tasmanian National Parks and Wildlife Service's management programme. Eliminating the cats and wekas should have little effect on rabbit numbers. The populations of all three are currently low and control of rabbits is proceeding successfully despite the low numbers of cats and wekas.

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N. P. BROTHERS and I. J. SKIRA, *National Parks and Wildlife Service, P.O. Box 210, Sandy Bay, Tasmania 7005*

SEABIRDS FOUND DEAD ON NEW ZEALAND BEACHES IN 1982 AND A REVIEW OF PENGUIN RECOVERIES SINCE 1960

By R. G. POWLESLAND

ABSTRACT

In 1982, 3705 kilometres of coast were patrolled and 6957 dead seabirds were found. Large numbers of Sooty Shearwaters *(Puffinus griseus)* were found on Stewart Island beaches (mainly in July) and Auckland West beaches (November-December). Large numbers of Blue Penguins *(Eudyptula minor)* were found on Auckland West and Auckland East beaches in January-February and August-September. Unusual finds were single specimens of Long-tailed Skua *(Stercorarius longicaudus)*, Black-fronted Tern *(Sterna albostriata)*, Arctic Tern *(S. paradisaea)* and Little Tern *(S. albifrons)*. A summary is given of the coastal and monthly distribution for each species of penguin found over the 1960-1982 period.

INTRODUCTION

This paper records the results of the Ornithological Society of New Zealand's Beach Patrol Scheme for 1982. Patrols were carried out on all sections of coast except Fiordland. Some beaches on the Chatham Islands were patrolled and the results are given under the heading Outlying Islands. In all, 577 Beach Patrol Cards and 34 Specimen Record Cards were submitted. Conventions used are the same as in previous reports (see Powlesland 1983).

RESULTS AND DISCUSSION

In 1982 the total distance of coast travelled was 3705 km and 6957 seabirds were found dead by 215 members of the Ornithological Society of New Zealand and their friends. The average number of birds found per kilometre of coast covered monthly was 2.11 (Table 1). The total distance travelled in 1982 was similar to the average of 3732 km for the previous ten years (1972-1981). However, the averages of 9948 birds per year and 3.15 birds per kilometre covered for the previous 10 years are much greater than the values for 1982. Table 1 also gives the kilometres covered and the number of seabirds found per month and in total for the various coasts, plus the number of birds picked up per kilometre covered for each coast. Table 2 gives the coastal and monthly distributions of the less commonly found seabirds (1-13 birds in 1982) and Tables 3 and 4 give these of the more commonly found seabirds.

TABLE 1 — Numbers of dead seabirds recovered and kilometres covered on each coast in 1982.

COAST	CODE		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL KM	TOTAL BIRDS	BIRDS/KM /COAST
AUCKLAND WEST	AW	KM	152	100	67	83	154	97	54	177	126	100	96	118	1324		
		BIRDS	473	209	63	95	149	67	38	889	219	100	435	755		3492	2.64
TARANAKI	TA	KM	14	5	4	9	17	2	18	17	12	13	-	8	119		
		BIRDS	36	7	12	20	28	5	22	33	34	16	-	71		284	2.39
WELLINGTON WEST	WW	KM	17	12	10	32	57	14	25	15	29	7	8	15	241		
		BIRDS	46	74	10	16	54	7	29	47	54	15	21	120		493	2.05
AUCKLAND EAST	AE	KM	88	58	57	61	69	66	65	75	52	51	42	36	720		
		BIRDS	362	37	40	72	257	74	49	217	73	53	12	14		1460	2.03
BAY OF PLENTY	BP	KM	14	11	-	-	34	29	7	34	102	39	16	16	302		
		BIRDS	27	20	-	-	40	18	5	23	107	14	19	5		278	0.92
EAST COAST NI	EC	KM	5	1	3	8	8	2	2	6	5	5	4	5	54		
		BIRDS	11	3	5	0	2	0	0	0	2	1	6	0		30	0.56
WAIRARAPA	WA	KM	4	-	-	12	-	-	-	-	-	-	-	-	16		
		BIRDS	1	-	-	6	-	-	-	-	-	-	-	-		7	0.44
WELLINGTON SOUTH	WS	KM	3	1	-	7	3	12	-	1	1	1	-	-	29		
		BIRDS	2	1	-	5	6	7	-	2	1	2	-	-		26	0.90
NORTH COAST SI	NC	KM	-	-	-	-	-	3	-	-	-	2	-	-	5		
		BIRDS	-	-	-	-	-	6	-	-	-	0	-	-		6	1.20
WESTLAND	WD	KM	8	4	-	-	5	5	3	2	-	-	4	2	33		
		BIRDS	6	3	-	-	3	5	4	0	-	-	2	0		23	0.70
CANTERBURY NORTH	CN	KM	11	5	11	30	29	14	8	4	-	5	-	-	117		
		BIRDS	31	7	9	41	18	4	10	1	-	3	-	-		124	1.06
CANTERBURY SOUTH	CS	KM	9	6	6	33	14	7	33	12	7	6	7	29	169		
		BIRDS	18	5	18	51	67	41	9	11	16	4	5	19		264	1.56
OTAGO	OT	KM	8	9	6	9	6	5	1	-	-	-	-	-	44		
		BIRDS	6	9	2	1	0	1	0	-	-	-	-	-		19	0.43
SOUTHLAND	SD	KM	12	25	8	-	10	-	22	-	8	-	-	-	85		
		BIRDS	23	106	5	-	16	-	262	-	1	-	-	-		413	4.86
OUTLYING ISLANDS	OI	KM	28	-	12	-	-	-	-	-	-	-	-	-	40		
		BIRDS	38	-	0	-	-	-	-	-	-	-	-	-		38	0.95
TOTAL KILOMETRES TRAVELLED			437	266	194	297	479	271	327	380	370	246	198	240	3705		
TOTAL KILOMETRES COVERED			373	237	184	284	406	256	238	343	342	229	177	229	3298		
TOTAL SEABIRDS RECOVERED			1080	581	264	307	640	235	428	1223	507	208	500	984		6957	
BIRDS/KM COVERED/MONTH			2.90	2.45	1.43	1.08	1.58	0.92	1.80	3.57	1.48	0.91	2.83	4.30			2.11

No patrols were reported from Fiordland

Unusual finds

A Long-tailed Skua, picked up on Muriwai Beach (AW) in January, is only the second record in the 44 year history of the Beach Patrol Scheme (Table 2). The first specimen was found on the Auckland East coast on 23 September 1981, not October as previously stated (Powlesland 1983).

The other unusual finds for the year were the fourth specimens for each of three species of terns: Black-fronted Tern, Arctic Tern and Little Tern (Table 2). The Black-fronted Tern was found on Makatere Beach (CS) in July. The previous records are 1976, WS, June; 1978, BP, July; and 1981, OT, April. All four specimens have been picked up by patrollers in autumn and winter. During spring and summer the birds breed along the braided rivers of the eastern South Island, migrating to coastal regions afterwards (Lalas 1979).

In November a recently dead Arctic Tern was recovered from Waikanae Beach on the Wellington West coast. The records for the three previous specimens are 1963, WW, November; 1969, SD, January; and 1975, Chatham Islands, January. This tern breeds in arctic and temperate regions of Asia, northern Europe and North America, migrating as far south as the Antarctic pack ice for the northern winter. It may regularly frequent the subantarctic islands of New Zealand, having been reported from the Auckland and Campbell Islands, and Macquarie Island. There are two major migration routes, one down the eastern side of the Atlantic, the other down the eastern side of the Pacific (Falla *et al.* 1979). Although mainland New Zealand is not on the migration route, at least eight reports of this tern (other than those of the Beach Patrol Scheme) having strayed or been blown on to the mainland of New Zealand have been documented (Kinsky 1970). The four specimens found by patrollers in November (2) and January (2) were probably birds on their southern migration.

A Little Tern was recovered from the Firth of Thames (AE) in April. The records for the other specimens are 1975, CS, October; 1978, AW, November; and 1980, AW, December. This tern is a regular summer migrant to New Zealand. Although single birds have been seen as far south as Stewart Island, most remain in the northern North Island, particularly about the Kaipara and Manukau Harbours and the Firth of Thames. The Little Tern's breeding distribution is from southern and eastern Asia to the Philippines, Moluccas, Papua New Guinea, eastern Australia and Tasmania (Falla *et al.* 1979). Each year the first individuals arrive during October-November and peak numbers occur from January to March. Most flocks consist of fewer than 20 birds, but a large flock of 88 was seen at Rangiputa Bank, Northland, in January 1976 (Edgar 1976). Some of these terns overwinter in New Zealand, but usually only occasional sightings are made from June to September. The condition of their plumage on arrival in spring, the times of moult and the seasonal behaviour of most of the Little Terns suggest that they are Eastern Little Terns

TABLE 2 — Seabirds of which 1 to 13 specimens were found in 1982.

SPECIES OR SUBSPECIES	NUMBER FOUND	COAST(S)	MONTH(S)
Megadytes antipodes	2	WS,CS	MAY,JUN
Eudyptes pachryhynchus	2	SD(2)	JAN(2)
Diomedea exulans	4	AW(2),EC,WS	MAR,MAY,JUN,DEC
epomophora	2	AW,WA	APR,NOV
melanophrys	6	AW(4),WW,AE	JAN,MAY,JUN,AUG(2),DEC
cauta subspp*	11	AW(6),AE,WD,CS,SD(2)	JAN(2),FEB,APR,JUL,AUG(3),NOV,DEC(2)
salvini	5	AW(2)WS,CN,SD	JAN,FEB,APR,AUG(2)
Fulmarus glacialoides	11	AW(8),TA(2),WS	JAN(2),MAY(3),JUN,JUL,AUG,OCT(2),NOV
Pterodroma spp*	6	AW(3),TA,WW,AE	APR,MAY,JUL,AUG,DEC(2)
pycrofti	2	AW(2)	APR,AUG
cookii	13	AW,TA,AE(10),SD	JAN(3),FEB(2),MAR(4),APR(2),MAY(2)
nigripennis	10	AW(10)	JAN(8),MAR(2)
Pachyptila salvini	8	AW(6),WW(2)	MAY,JUN,AUG(5),NOV
crassirostris	1	OI	JAN
Procellaria spp*	5	AW(3),WW,SD	FEB,APR,OCT,DEC(2)
cinerea	2	AW(2)	JAN,AUG
parkinsoni	9	AE(9)	FEB,MAY(7)JUN
westlandica	10	AW(10)	AUG,SEPT,OCT(2),NOV(2),DEC(4)
aequinoctialis	9	AW(6),WW(2),CN	JAN(5),FEB,OCT,DEC(2)
Puffinus spp*	10	AW(2),TA,WW(6),CS	JAN(2),MAY(3),JUN,JUL,OCT(2),DEC
Oceanites oceanicus	1	BP	JUN
Garrodia nereis	1	WW	DEC
Phalacrocorax spp*	1	WD	JUN
carbo	9	AW,AE(2), EN(4),CS,OT	JAN,FEB,MAR,MAY,JUL,SEP(2),NOV(2)
melanoleucos	7	AW(2),TA,AE,CN,OT(2)	JAN(3),JUL,AUG,SEP,NOV
Leucocarbo carunculatus chalconotus	4	OT,SD(3)	JAN,JUL(3)
Strictocarbo punctatus featherstoni	1	OI	JAN
Stercorarius skua lonnbergi	1	OI	JAN
parasiticus	1	AW	FEB
longicaudus	1	AW	JAN
Larus bulleri	10	WW,AE(3),EN(2),CN,CS(3)	JAN,FEB,MAR(3),MAY,AUG,DEC(3)
Hydroprogne caspia	4	AW,AE(2),BP	JAN,APR,SEP,NOV
Sterna albostriata	1	CS	JUL
paradisaea	1	WW	NOV
albifrons	1	AE	APR
fuscata	1	WW	DEC
TOTAL	173		

*Species or subspecies could not be identified by the patroller

(S. a. sinensis) from the Northern Hemisphere rather than from Australia (Falla *et al.* 1979).

Three species were found in greater numbers in 1982 than in previous years. Sixteen Buller's Mollymawks *(Diomedea bulleri)* were picked up in 1982, mainly from Auckland West (6) and Southland (7) beaches (Table 3). The previous highest annual total was 13 in 1975. Sixty-eight Mottled Petrels *(Pterodroma inexpectata)* were found in 1982, also mostly from Auckland West (27) and Southland (32) beaches (Table 3) in January and February (49) (Table 4). The previous highest total was 58 in 1978. The third species is the White-fronted Tern *(Sterna striata)*, of which 112 were found in 1982, compared with the previous highest annual total of 84 in 1975. Many (59%) were picked up on Auckland West beaches during autumn.

Wrecks

Although not the highest annual totals on record, enough of two other species were found for them to be considered wrecks. The 1839 Little Blue Penguins found in 1982 is exceeded only by the totals of 1973 (2115) and 1974 (4741). Most (88.5%) of the penguins in 1982 were found on Auckland West and Auckland East beaches. The two main periods of mortality were January-February (30.5%) and August-September (54.1%).

A large number of Sooty Shearwaters was also picked up in 1982, the total of 1557 having been exceeded only in 1971 (1627), 1975 (3668) and 1978 (6913). However, the totals are an insignificant proportion of the New Zealand population: Warham & Wilson (1982) estimated 5.5 million breeding birds on the two largest of the Snares Islands alone. This figure would probably be increased by several more millions if it included non-breeding birds and the birds nesting on other islands about New Zealand. Therefore, a wreck of 7000 birds represents less than 0.002% of the Snares Islands' breeding population.

In 1982 most of the shearwaters were found in July and November-December (Figure 1). The combined 1960-1981 data reveal two periods of high mortality, in October-January and in May, with greatest mortality in summer. The regular peak of Sooty Shearwater mortality during the October-January period (Veitch 1977, 1980) coincides with the period between the arrival of the birds at the breeding grounds and the end of incubation (Warham *et al.* 1982). Perhaps many of the shearwaters that die during this period are first- or second-year birds and hence are inexperienced at foraging in New Zealand waters. The May peak in mortality of the 1960-1981 data coincides with the departure of the chicks from burrows from mid-April to May (Warham *et al.* 1982) and the start of their migration north. Although the 1982 results show a July peak in mortality (Figure 1), 98% of these were picked up on Mason's Bay and Little Hellfire Beach, Stewart Island (SD), and were judged to have been dead for over a month. Therefore, they too were probably recently fledged chicks.

TABLE 3 — Coastal distribution of the seabirds more commonly found dead in 1982.

SPECIES OR SUBSPECIES	MONTH JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL BIRDS
Eudyptula minor subspp.*	402	165	76	60	94	41	26	645	236	45	21	28	1839
albosignata	5	1	-	5	4	-	1	1	3	-	-	-	20
Diomedea spp.*	2	11	-	3	3	2	3	-	4	1	4	1	34
chrysostoma	-	3	-	2	1	2	1	6	8	1	1	4	29
bulleri	2	7	-	1	1	2	2	1	-	-	-	-	16
cauta cauta	-	2	2	1	3	4	-	4	3	1	2	8	30
Phoebetria palpebrata	3	-	-	-	-	-	1	2	4	-	2	2	14
Macronectes spp.*	4	-	2	6	5	1	4	4	6	2	2	-	36
Daption capense	1	1	1	1	-	1	1	12	9	9	6	6	48
Pterodroma macroptera	12	1	-	1	20	5	-	5	2	-	4	3	53
lessonii	6	7	4	2	5	6	7	6	6	9	9	20	87
inexpectata	14	35	2	3	2	1	-	-	-	1	1	9	68
brevirostris	3	1	-	-	-	-	2	8	3	1	-	-	18
Halobaena caerulea	7	1	-	1	-	-	4	12	12	6	5	1	49
Pachyptila spp.*	18	48	5	4	7	7	8	29	33	8	5	30	202
vittata	9	2	-	1	5	6	3	4	2	-	1	4	37
desolata	1	1	-	1	10	6	-	-	-	-	-	1	20
belcheri	1	1	-	-	1	-	3	7	4	5	1	6	29
turtur	30	32	3	6	21	13	26	52	27	23	14	45	292
Puffinus carneipes	31	8	17	7	47	-	-	-	-	1	1	8	120
bulleri	33	14	21	6	23	-	2	1	4	10	35	42	191
griseus	106	55	9	25	123	26	243	3	3	16	315	633	1557
tenuirostris	54	9	5	-	16	16	8	1	4	1	2	17	133
gavia	133	52	22	19	49	21	15	129	38	14	11	20	523
huttoni	5	-	1	4	1	-	-	5	2	1	-	6	25
assimilis	2	-	1	2	3	5	2	5	1	-	3	3	27
Pelagodroma marina	8	-	1	-	3	4	-	-	5	-	-	2	23
Pelecanoides urinatrix	55	15	2	1	25	10	10	197	38	7	1	10	371
Sula bassana	20	27	13	5	16	6	4	23	18	17	17	27	193
Phalacrocorax varius	3	1	1	1	4	3	1	2	1	-	4	2	23
Strictocarbo punctatus	7	9	14	25	39	11	5	6	6	4	3	5	134
Larus dominicanus	40	37	32	56	51	18	31	17	13	11	14	14	334
novaehollandiae	16	10	11	11	14	9	3	10	3	2	5	3	97
Sterna striata	9	15	8	37	22	-	2	7	4	4	1	4	112
TOTALS	1042	571	253	297	618	226	418	1204	502	200	489	964	6784

* Species or subspecies could not be identified.

The coasts having the highest rates of Sooty Shearwater mortality (birds per 100 km of coast covered) were Auckland West and Southland (Table 5). Presumably, most of the birds that were washed ashore on the Auckland West beaches were birds that died during the migration back to the nesting sites, whereas the Southland birds were recently fledged chicks that had left the nest in weak condition. Young birds that had recently left their nests are likely to be more vulnerable to storms than older birds returning to New Zealand and are therefore more likely to be wrecked. Of the ten wrecks of more than 400 birds in the past 23 years, eight occurred on Auckland West beaches and only one each on Wellington West and Southland beaches. Although not fully documented as part of the Beach Patrol Scheme, in May 1961 hundreds of juvenile Sooty Shearwaters were washed ashore on to South Canterbury beaches (Stonehouse 1964). Indications were that the birds had fledged in an undernourished state and became exhausted and drowned during persistent easterly and southeasterly winds.

The distribution of beach-wrecked seabirds may not fully reflect the distribution pattern of the live birds. Such factors as wind direction, coastal currents and whether a beach is patrolled regularly influence the distribution of dead seabirds (Veitch 1976). For example, although the distribution of dead Sooty Shearwaters suggests that most birds migrate to and from the nesting islands off the west coast of New Zealand, both M. J. Imber and J. Warham (pers. comm.) consider, from observations at sea, that the shearwaters' main route of migration is along the east coast.

Miscellaneous birds

Miscellaneous birds recovered in 1982 but not considered to be seabirds totalled 193. There were 31 magpies, 26 Mallards, 17 Black Swans, 15 Blackbirds, 11 Starlings, 10 Rock Pigeons, nine Grey Ducks, seven each of Canada Geese and unidentified ducks, six each of Australasian Harriers and Indian Mynas, five each of Paradise Shelducks, Pukekos and House Sparrows, four Variable Oystercatchers, two each of domestic geese, California Quail, South Island Pied Oystercatchers, Eastern Bar-tailed Godwits, New Zealand Pigeons and Song Thrushes, and one each of White-faced Heron, Reef Heron, Brown Teal, New Zealand Falcon, Pheasant, domestic turkey, Australian Coot, Spur-winged Plover, Knot, Pied Stilt, North Island Kaka, Rainbow Lorikeet, Long-tailed Cuckoo, New Zealand Kingfisher and Tui.

PENGUIN RECOVERIES 1960-1982

One of the objectives of the Beach Patrol Scheme is to provide information about the seabirds around New Zealand — their seasonal distribution, dispersal or migration routes, and variations in their annual mortality (Imber 1969). Now that we have annual records of beach-patrolling for more than 20 years it seems appropriate to begin summarising this information. The summaries will be given for

TABLE 4 — Monthly distribution of the seabirds more commonly found dead in 1982.

SPECIES OF SUBSPECIES	COASTS AW	TA	WW	AE	BP	EN	WA	WS	NC	WD	CN	CS	OT	SD	OI	TOTAL BIRDS
Eudyptula minor subspp.*	904	27	25	724	123	-	-	2	1	-	1	9	2	15	6	1839
albosignata	-	-	-	-	-	-	-	-	-	-	11	9	-	-	-	20
Diomedea spp.*	10	4	2	-	-	-	-	-	1	-	3	-	-	14	-	34
chrysostoma	26	-	1	1	-	-	-	-	-	-	-	-	-	1	-	29
bulleri	6	-	1	-	-	-	-	-	-	1	1	-	-	7	-	16
cauta cauta	16	3	6	-	-	-	-	1	-	2	-	1	-	1	-	30
Phoebetria palpebrata	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14
Macronectes spp.*	18	2	1	-	-	1	1	-	-	2	5	4	-	2	-	36
Daption capense	27	3	4	3	4	-	-	-	-	1	-	5	-	1	-	48
Pterodroma macroptera	21	4	-	24	4	-	-	-	-	-	-	-	-	-	-	53
lessonii	70	11	2	-	1	-	-	-	-	1	-	-	-	2	-	87
inexpectata	27	3	2	1	1	-	-	-	-	-	-	1	-	32	1	68
brevirostris	13	-	5	-	-	-	-	-	-	-	-	-	-	-	-	18
Halobaena caerulea	33	11	1	3	-	-	-	-	-	-	-	-	-	1	-	49
Pachyptila spp.*	42	12	133	1	2	-	-	1	1	2	-	1	-	4	3	202
vittata	9	-	4	3	-	-	-	1	-	-	1	10	-	4	5	37
desolata	17	-	1	-	-	-	-	-	-	-	1	1	-	-	-	20
belcheri	22	4	1	-	-	-	-	-	-	1	-	-	-	1	-	29
turtur	127	16	100	33	2	1	-	2	-	3	2	2	-	1	3	292
Puffinus carneipes	15	1	-	104	-	-	-	-	-	-	-	-	-	-	-	120
bulleri	105	7	9	54	7	-	1	3	-	1	1	3	-	-	-	191
griseus	948	59	74	72	32	12	-	5	-	2	10	35	-	299	9	1557
tenuirostris	49	11	20	34	6	-	-	-	-	-	1	7	-	5	-	133
gavia	252	26	21	187	25	1	-	-	1	-	3	7	-	-	-	523
huttoni	17	-	3	-	-	-	-	-	-	-	3	2	-	-	-	25
assimilis	5	1	-	18	1	-	-	-	-	2	-	-	-	-	-	27
Pelagodroma marina	3	-	-	1	1	-	-	-	-	-	1	12	-	-	5	23
Pelecanoides urinatrix	258	21	12	63	11	1	1	-	1	-	-	-	-	3	-	371
Sula bassana	143	7	3	31	4	2	-	-	1	-	1	1	-	-	-	193
Phalacrocorax varius	9	-	-	5	8	-	-	-	-	-	1	-	-	-	-	23
Strictocarbo punctatus	1	-	2	2	-	-	-	-	-	-	32	88	9	-	-	134
Larus dominicanus	107	36	37	31	22	4	3	6	-	3	33	40	4	7	1	334
novaehollandiae	38	4	3	16	14	1	-	1	-	-	6	11	-	3	-	97
Sterna striata	66	5	3	18	8	-	-	-	-	-	3	7	-	-	2	112
TOTALS	3418	278	476	1429	276	23	6	22	6	21	120	256	15	403	35	6784

* Species or subspecies could not be identified by the patroller

species that have had wrecks during the year being reviewed; as was given, for example, for the 1981 wrecks of Kerguelen Petrels *(Pterodroma brevirostris)* and Blue Petrels *(Halobaena caerulea)* (Powlesland 1983). In addition, I intend to summarise the information for related species, as given below for penguins. Although a summary of the seabirds found during 1939-1959 has been published (Bull & Boeson 1961), the records for penguins were not detailed as to year, month or coastal region and so are not included in the results given below.

In total, 142 Yellow-eyed Penguins *(Megadyptes antipodes)* have been found during the past 23 years. The highest annual total was 50 in 1972, the second highest 14 in 1977. They have been found beach-wrecked predominantly on Wellington and eastern South Island beaches (Table 5). A specimen was found on Campbell Island (OI), where the species breeds. It also nests on Stewart Island and its outlying islands, Auckland Island and along the Canterbury South, Otago and Southland coasts. A banding study of Yellow-eyed Penguins on Otago Peninsula (Richdale 1949) showed that most fledglings moved north, dispersing much further than adults. By their third year of life these penguins are fairly sedentary, particularly those that have acquired a nest site. The adults are resident at the colony all year (Richdale 1941, 1949). The high rate of recovery on the Otago coast (Table 5) presumably results from deaths of adults as well as of independent young (fledglings).

In determining the monthly rate of recovery of the Yellow-eyed Penguin, I have analysed only data from the Wellington West and South, Canterbury North and South, Otago and Southland coasts. Most penguins (79%), in total and per 100 km covered (Figure 2), were found from March to July inclusive. Richdale (1949) found that the fledglings entered the sea between 29 January and 25 March, and that half died in their first 5 weeks at sea. Therefore, the annual peak in recoveries of this penguin was probably due to undernourished young that had recently gone to sea or to young that could not forage proficiently.

One Adelie Penguin *(Pygoscelis adeliae)* has been found during the 1960-1982 period. The dried corpse was found on the Canterbury North coast in December 1962 (Kennington 1963). This is a circumpolar species that breeds on the coasts and islands around the shores of the antarctic continent and rarely straggles north beyond 60°S (Kinsky 1970).

Five subspecies of Blue Penguin are recognised in the New Zealand checklist (Kinsky 1980), but because four of them could not be readily distinguished from one another by patrollers, the records for the Northern Blue Penguin *(Eudyptula minor iredalei)*, Cook Strait Blue Penguin *(E. m. variabilis)*, Southern Blue Penguin *(E. m. minor)* and Chatham Island Blue Penguin *(E. m. chathamensis)* have been combined.

Overall, 15 808 penguins of the four subspecies (henceforth called the Blue Penguin) have been found from 1960 to 1982. Most (85.6%) were beach-wrecked along the Auckland West and East coastlines (Table 5). The 67 penguins found on beaches of Outlying Islands were all on the Chatham Islands and so were presumably the local subspecies.

The North Island west coast regions (AW, TA, WW), North Coast South Island, Auckland East, Bay of Plenty and Southland are the coastlines from which more than 10 Blue Penguins have been found per 100 km of beach covered (Table 5). Even if the 1974 wreck of 3729 birds is deleted from the Auckland East total, the rate of 42.3 penguins per 100 km of coast covered remains the highest recovery rate for the various coasts. In addition, if the totals for Blue Penguins and White-flippered Penguins *(E. m. albosignata)* are

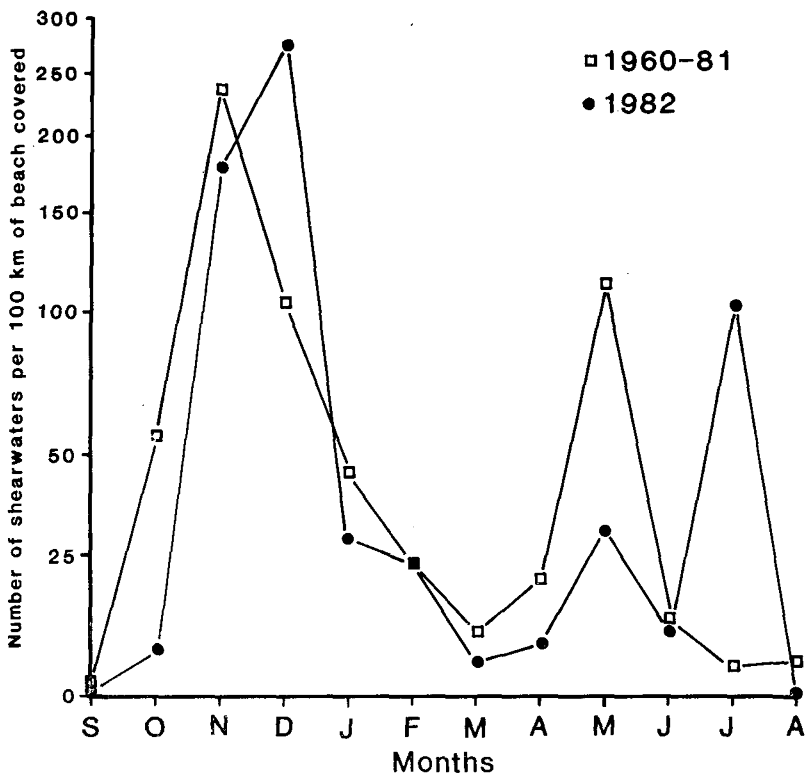

FIGURE 1 — Monthly rate of recovery (number of birds found dead per 100 km of beach covered) of the Sooty Shearwater during the period 1960-1981 and in 1982.

combined, the rates of recoverey for Canterbury North and Canterbury South are 12.8 and 14.6 penguins per 100 km of coast covered. Do these rates of recovery reflect differences in the density of Blue Penguins inhabiting the various coasts? Apparently so, because banding studies by Jones (1978) on Tiritiri Matangi Island (AE) and Kinsky (1960) on Somes Island (WS) have shown that most adult Blue Penguins are resident on a particular section of coastline throughout the year. The coasts with the higher penguin recoveries may have more penguins because they have islands and/or sections of coast that can not be reached by mammalian predators and are free of human disturbance. It would be interesting to compare the breeding success of a predator-free population with that of a nearby population to which predators have access.

The monthly recovery rate of Blue Penguins varies considerably because of the large influence that wrecks of penguins have on the results (Figure 2). For example, in April 1974, 2437 penguins were found compared with 100 or less for April in most other years. Therefore, to obtain a more realistic indication of monthly penguin mortality, I have replaced the figures for wrecks with the number usually found dead per month to give the " amended " line in Figure 2. The period of highest mortality is from January to March. During this time, both fledglings and adults could be struggling to feed themselves adequately; the fledglings when they first enter the sea, and the adults when they attempt to accumulate fat reserves to sustain them during their 2-3 week fast while moulting and again when they try to regain condition after the moult (Kinsky 1960, Jones 1978). Therefore, the increased mortality of Blue Penguins over summer occurs presumably because increased requirements for food coincide with poor foraging conditions. Crockett & Kearns (1975) concluded similarly that the high mortality of Northern Blue Penguins in 1973 and 1974 resulted from starvation, accentuated by heavy parasite loads and rough weather.

Of the five subspecies of Blue Penguin in the New Zealand region, only the White-flippered Penguin, with its fairly distinctive flipper markings, was readily distinguished by patrollers. In total, 320 White-flippered Penguins were picked up. Of these, 91% were found on the Canterbury North and Canterbury South coasts (Table 5), as is to be expected because they breed on Motunau Island (CN) and Banks Peninsula (CN & CS) (Falla *et al.* 1979). The few birds found on other coastlines were probably juveniles, which go through a dispersive phase before returning to the vicinity of their natal colony to breed. The numbers found along the North Coast South Island and Otago coastlines (Table 5) indicate that the young disperse to the north and south of the nest sites. This pattern could, however, be caused by the mortality of penguins of the Cook Strait and Southern Blue Penguin subspecies, some of which have markings like those of the White-flippered subspecies (Kinsky & Falla 1976). To calculate

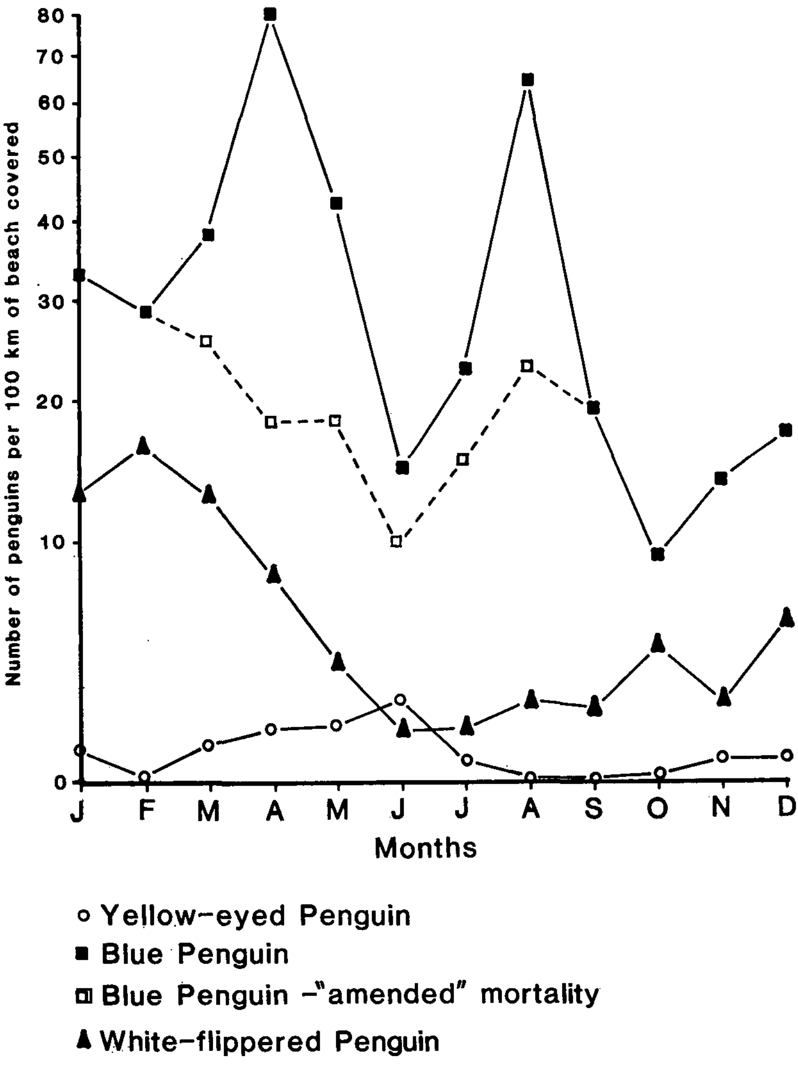

FIGURE 2 — Monthly rate of recovery (number of birds found dead per 100 km of beach covered) of the Yellow-eyed, Blue and White-flippered Penguins during 1960-1982.

TABLE 5 — Number and rate of recovery (number of specimens found per 100 km of coast covered) of the Sooty Shearwater and Yellow-eyed, Blue and White-flippered Penguin found along each coast.

	AW	TA	WW	AE	BP	EN	WA	WS	NC	WD	CN	CS	OT	SD	OI	TOTAL
Sooty Shearwater																
1960-81 Number	15,762	387	1753	1078	349	116	17	901	83	21	432	343	349	2266	69	23,926
Rate of recovery	85.0	15.4	21.5	16.8	22.1	31.4	7.0	32.7	15.3	4.9	29.6	31.6	27.4	213.4	20.0	51.1
1982 Number	948	59	74	72	32	12	-	5	-	2	10	35	-	299	9	1,557
Rate of recovery	71.6	49.6	30.7	10.0	10.6	22.2		17.2		6.1	8.5	20.7		351.8	22.5	47.2
Yellow-eyed Penguin																
1960-82 Number	-	-	24	-	1	-	-	37	-	-	5	14	51	9	1	142
Rate of recovery			0.3		0.1			1.3			0.3	1.1	3.9	0.8	0.3	0.3
Blue Penguin																
1960-82 Number	6,778	345	872	6755	428	20	3	146	87	4	55	39	71	138	67	15,808
Rate of recovery	34.1	13.1	10.4	94.5	22.8	4.7	1.2	5.3	15.9	0.9	3.5	3.1	5.4	12.0	17.4	31.6
White-flippered Penguin																
1960-82 Number	-	-	2	1	-	-	-	6	6	-	147	144	13	-	-	320
Rate of recovery			0.0	0.0				0.2	1.1		9.3	11.5	1.0			0.6

the seasonal variation in the mortality of White-flippered Penguins, I have used only data for the North Coast South Island, Canterbury North, Canterbury South and Otago coasts. Figure 2 shows that, as for the Blue Penguin, the White-flippered Penguin has a peak of mortality from January to March.

The coastal and monthly distributions of *Eudyptes* penguins beach-wrecked from 1960 to 1982 are given in Table 6. The identity of 13 specimens could not be determined by patrollers and so have been grouped under the heading *Eudyptes* spp. Two Rockhopper Penguins *(E. chrysocome)* have been found: one on Campbell Island, where the species breeds (February), and the other on the Canterbury North coast (March). Stragglers have very infrequently been seen on the Canterbury and Otago coasts (Oliver 1955). However, Warham (1967) reported that a few reach the Snares Islands each summer, and often moult there. The Rockhopper Penguin is very abundant and breeds on many islands in the subantarctic and antarctic zones, Macquarie, Campbell, Antipodes and Auckland Islands being the closest breeding sites to New Zealand. Although the species is highly pelagic, spending the winter at sea, the scarcity of dead birds on our mainland beaches suggests that most remain in the subantarctic zones (Warham 1963).

In total, 19 Fiordland Crested Penguins *(E. pachyrhynchus)* have been found. Breeding colonies of this species are south of Bruce

TABLE 6 — Coastal and monthly distribution of **Eudyptes** penguins found dead on beaches from 1960 to 1982.

Species	Number found	
Eudyptes spp.* (= pachyrhynchus spp.)	13	Coasts: AW,WW(2),NC,WD(4),CS(2),OT. Months: Jan,Feb,Mar(3),Apr(2),Sep,Oct.
Eudyptes chrysocome (= crestatus)	2	Coasts: CN,Campbell Is. Months: Feb,Mar.
Eudyptes pachyrhynchus	19	Coasts: AW,WW(2),WD(7),CS,OT(2),SD(6). Months: Jan(2),Feb(2),Apr,May,Jul,Aug, Sep,Oct(2),Nov(5),Dec(3).
Eudyptes robustus (= pachyrhynchus atratus)	2	Coast : SD(2) Months: Jan,Feb.
Eudyptes sclateri	13	Coasts: WW,WS,SC(4),OT(3),SD(2), OI(2; Campbell Is.,Chatham Is.) Months: Jan,Feb,Mar(4),Apr(3),May, Jun,Aug,Sep.

* Species could not be identified by the patroller.

Bay in Westland, along the Fiordland coast and on the Southland coast as far east as the Green Islets (J. Warham, pers. comm.). In addition, some birds nest on and around Stewart Island, with a major colony on Codfish Island. Although many breed along the Fiordland coast none has been found on its beaches, almost certainly because the beaches have been rarely patrolled. Most specimens were found on Westland (7) and Southland (6) beaches, but one was found as far north as the Auckland West coast. Fiordland Crested Penguins straggle to the Campbell, Macquarie and Auckland Islands, and yearlings are commonly found on the Snares Islands in summer (Warham 1967). Single birds have been picked up on the coasts of southern Australia and Tasmania (Serventy *et al.* 1971). Many of the beach-wrecked birds were found during the period October to February (Table 6). This period coincides with when fledglings first enter the sea and when many breeding adults begin accumulating fat reserves in preparation for the moult, and following their moult (Warham 1974a).

Two Snares Crested Penguins *(E. robustus)* have been picked up by patrollers, both from Southland beaches in summer (Table 6). Sightings of live birds have been reported from Stewart Island, Akaroa and Hokitika (J. Warham, pers. comm.). This species breeds only on the Snares Islands, about 300 km south of Bluff. The colonies are deserted from mid-February until late March, after which the breeders, followed later by yearlings and prebreeders, return to moult (Warham 1974b). The two beach-wrecked birds on Southland beaches in January and February may therefore have been fledglings.

Thirteen Erect-crested Penguins *(E. sclateri)* have been recovered. This species breeds on the Bounty, Antipodes, Campbell and Auckland Islands (Falla *et al.* 1979). Stragglers have occurred as far south as Macquarie Island, and immatures and moulting birds as far north as North Cape (Falla *et al.* 1979). Most beach-wrecked specimens have been found along the south-eastern coast of the South Island (Table 6) during March and April. As breeders moult in March at their nest sites (Warham 1972), presumably many of the birds we find are young. However, Falla (1935) noted that the Otago, Canterbury and National Museums all had specimens from beaches nearby that were obtained in May, June and July. The regular finding of specimens along the Wellington and South Island east coasts in winter, together with the fact that this species has attempted to breed on the Otago Peninsula (Falla *et al.* 1979), suggests that at least some adults spend winter in the coastal waters of New Zealand, well to the north of their breeding grounds.

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RALPH G. POWLESLAND, *Wildlife Service, Department of Internal Affairs, Private Bag, Wellington*

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SHORT NOTES

KINGFISHER TAKING A SILVEREYE

Andrew Grant's note about predation of a Goldfinch by a Kingfisher (*Notornis* 30: 318) reminded me of a similar experience we had on 8 June 1982 near the Matukituki River mouth, West Wanaka. A richly coloured New Zealand Kingfisher *(Halcyon sancta)*, after resting in a kowhai tree, flew to the top of a dead manuka, from whence it darted into a live manuka and emerged with a small bird; later in good sunlight we identified this prey as a Silvereye *(Zosterops lateralis)*. It then moved in a series of flights of 20-30 metres towards a swampy pond, at each stop bashing its prey against its perch and gradually swallowing it, feathers and all. Progress was easy to follow because at each stop it was mobbed by two or three Fantails *(Rhipidura fuliginosa)*. A few minutes later, with a very distended stomach, it stayed about the pond — where we recorded one a few years ago. (The Kingfisher is a rare bird in Central Otago.) Other potential prey species in this vicinity probably include insects, tadpoles and frogs of *Litoria aurea*, skinks, and trout fry.

PETER CHILD, *10 Royal Terrace, Alexandra*

THE FAIRY MARTIN *(Petrochelidon ariel)* IN NEW ZEALAND

In December 1978, D. Sim found two unusual nests, one in each of the two compartments of a pumping station at Te Hopai, southern Wairarapa. As the construction of the station was begun in 1977 and finished in mid-November 1978, the nests had presumably been built during a slack period in construction work. No birds were present but the nests had been used by House Sparrows *(Passer domesticus)* and so were badly damaged. The station was commissioned in March 1979 and since then, the noise of the pumps and the turbulence of the water have made the station unsuitable as a nesting site.

At first, D. Sim assumed the nests to be unusual nests of Welcome Swallow *(Hirundo tahitica neoxena)*, but he took some slides, which he showed to B. D. Heather in mid-1980. BDH visited the site and measured the less damaged of the nests in August 1980. It was made of mud pellets with a wall thickness of c. 1 cm. The entrance tunnel was c. 3 cm deep, and the distance from the entrance to the back of the nest chamber was 16 cm. The external dimensions of the nest chamber were 7 cm deep by 14 cm from side to side and 10 cm from front to back. The general shape of both nests had been that of a bottle on its side glued to the roof from mouth to base and with the base glued to the wall, quite unlike the open cup of a swallow. The photographs were submitted to several people familiar with the nests of Australian martins and swallows, and they agreed that the nests were almost certainly those of Fairy Martin. However, as the Fairy Martin had not been recorded in New Zealand and none has yet been seen in the Wairarapa, the record was held in suspense.

On 18 November 1982, at 1900 h summertime, J. M. Hawkins, B. D. Bell, and I. Flux saw a martin over the fields of the Puponga Farm Park at the base of Farewell Spit. BDB had seen many martins in Australia some years previously. Although expecting the bird to be a Tree Martin *(P. nigricans)*, which often occurs in New Zealand as a vagrant, the party took a description.

The martin was flying near some Welcome Swallows. It tended to glide more, had a very noticeable white rump, was slightly smaller, and had a much more shallow fork in the tail. The white underside was a positive white rather than the greyish white of the swallows, and the black upper surface lacked the bluish sheen of the swallows. The head and nape were orange. The colour extended down the side of the head but not underneath. When this description was compared with that in an Australian field guide, the bird was clearly a Fairy Martin, and this identfication has been accepted by the OSNZ Rare Birds Committee. The bird could not be found on the following two days. The wind at the time, as it had been beforehand, was strong westerly.

In late February 1983, at Totaranui, Abel Tasman National Park, Linley Robertson saw three small young 'swallows' sitting quietly on a fence near the shore. When two older birds appeared, the three became very excited and fidgety, and so she thought that the two may have been the parents. She noted a broad white band across the base of the tail, which was very short compared with a swallow's. Doubting that they were swallows, she asked an Australian visitor, who without hesitation said that they were a family group of Fairy Martins. As the young were flying, they could have been some hundreds of metres away from a nest site; and several likely sites are in the rocky banks at the mouth of the nearby estuary. These birds were seen only once.

Although much of the above observations is uncertain, the positive sighting of one bird makes the others more credible, especially now that two more have been positively identified in Otago in February-March 1983 (Neville, this issue). The possibility of both Fairy and Tree Martins having bred in New Zealand cannot be completely discounted.

According to Australian authorities, the Fairy Martin is widely distributed in Australia except in Tasmania (and Papua New Guinea), where it is a vagrant. In south-eastern Australia, it is present only during the summer months. Around Canberra, for example (Frith 1969, *Birds in the Australian high country*), normally it first appears in September and most leave by February with some remaining to April. According to Pizzey (1980, *A field guide to the birds of Australia*), the nest is " bottle-shaped; of mud-pellets; swollen nest-chamber c. 150 mm in diameter; neck or spout from 50 to 300 mm long. . . . It is the only Australian bird that builds a bottle-shaped mud nest." It nests in colonies and constructs its nest " against the wall or ceiling of a cave, building or culvert, the side of a hollow tree, a cliff-face or creek bank " (Frith 1969). The nests are often used by House Sparrows.

B. D. BELL, *Wildlife Service, Department of Internal Affairs, Private Bag, Wellington*

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FAIRY AND TREE MARTINS IN OTAGO

Lake Holm Farm lies at the southern end of the Taieri Plain and slopes from exotic forest down to wetland near Lakes Waihola and Waipori. Near the buildings are a line of old macrocarpa trees and a small orchard and woodlot area. The woolshed roof has been a favourite sunning place for Welcome Swallows *(Hirundo tahitica neoxena)*, which have also congregated on the various power lines in increasing numbers over the last 10 years. A favourite spot for families of young swallows is our rotary clothesline, which is in a fairly sheltered position close to the old house.

On 3 December 1981 we first glimpsed a white-rump flash in a group of swallows. For two days we watched this bird in flight and at rest, and when Dr R. F. Smith saw it, he confirmed that it was a Tree Martin *(Hylochelidon nigricans)*, as we had suspected. We did not see it again until 12 January 1982, after which it stayed about until early March. It was usually the last to leave the clothesline if anyone went too close. On 21 February, two Tree Martins were seen together on a power line, and until 5 March both were often seen together.

We next saw martins on 19 and 20 December 1982, when two were about sometimes on their own and sometimes with swallows. There were no more sightings until 20 January 1983, when three Tree Martins were on the woolshed roof. Although obviously Tree Martins, only one was in the usual sleek glossy plumage. The plumage of the other two was scruffy and fluffy with grey down-like feathers showing through the black. They were greyer on the breast than the third, lacked its iridescence on the back, and had pinkish cream rather than dull white rumps, and one had a whitish rather than russet forehead. These two tended to keep together, apart from the third. We could never decide whether they were young birds or in moult, perhaps the latter because we did not see them being fed. These three remained individually identifiable whenever seen at close range until at least mid-February, when they were much less scruffy, although one still had a pale forehead.

On 17 February, we suspected that four martins were present but did not see the fourth at rest. On the 20th, my husband, Stuart, saw a martin on the clothesline, face on, which had a more vivid white front than usual and seemed thinner. Next morning, of two martins together on a power line, one was conspicuously smaller with more vivid white parts. Through binoculars, its gingery orange head was in distinct contrast to the Tree Martin's black head. A glance at the illustrations in Pizzey's *Field guide to the birds of Australia* (1980) left us in no doubt that it was a Fairy Martin *(H. ariel)*.

After this, all four martins were seen on the clothesline almost daily for a week and a full description was taken. The Fairy Martin was smaller and more slender than the Tree Martin, and the underparts were a more vivid white than the Tree Martin's grey. The head, instead of looking smooth, glossy and black like the head of the Tree Martins and Welcome Swallows, looked as if it had been crew-cut, the feathers standing up rather than sleek, and in some lights the bright carroty orange on the head seemed to glow. Above the bill was a paler V-mark, and the eye stood out black in a dark streak that separated the orange head from the grey cheeks. The throat was slightly greyer than the bright white underparts. The orange of the head extended to the nape, where it did not end as a sharp line against the black back. The mantle was broken by white zig-zag lines, perhaps four or five, running down it. When both birds were seen at rest together, the white rump of the Fairy Martin seemed to start further down the back, and it was bright white, unlike the pinkish grey of the Tree Martin's pale rump, and had a tinge of yellow across the top. During preening, the underwing of the Fairy Martin was seen to be paler grey.

On 26 February, a second Fairy Martin appeared on the clothes-line with the first. It was slightly different in that its head was less bright and looked rather as if it had been powdered with soot, and it had a noticeable yellow tinge on the flank below the line of the folded wing and across the top of the white rump.

On 5 March, Peter Schweigman saw the first Fairy Martin on the woolshed roof with two Tree Martins and some 40 swallows. On 28 March, George Grant from Outram told me by phone that, about an hour earlier, he had seen a martin, possibly Fairy, at the Berwick tip about a mile away across the wetland. As I was talking to him, a flock of swallows arrived beside the house, including a Fairy and a Tree Martin. We did not see Fairy Martins again. On 10 May, I saw closely a Tree Martin flying with a flock of swallows, and on 14 May, when many swallows had been about all afternoon, especially among the flax by the lagoons (perhaps a flock passing through), I saw a Tree Martin several times among swallows on a power line. This is the only time we have seen a martin so late in the season.

ALISON NEVILL, *Lake Holm Farm, Berwick, Outram RD, Otago*

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ESTABLISHMENT OF THE STITCHBIRD ON HEN ISLAND

The Stitchbird *(Notiomystis cincta)*, after a period of rapid decline, became extinct on the mainland of New Zealand in the 1880s or soon afterwards. For almost a century it has been restricted to Little Barrier Island in the Hauraki Gulf. Species with such restricted ranges can be very vulnerable, as was demonstrated when black rats *(Rattus rattus)* invaded Big South Cape Island in 1964 (D. V. Merton, *Wildlife — A review,* 1969) and eliminated several species and subspecies. To reduce the chances of such disasters in the future, the New Zealand Wildlife Service has followed a policy of establishing additional populations of species that are at present limited to one or a few localities. The dramatic success of this policy in increasing the range of the Saddleback suggested that such a course might also benefit the Stitchbird.

Hen Island (Taranga) in the Hen and Chickens group off Whangarei was chosen as the first transfer site for Stitchbirds. The island is fairly large (484 ha) and similar to Little Barrier in its rugged topography (455 m at its highest point). Two major vegetation types occur: coastal forest (300 ha) on the steeper parts of the island and regenerating kanuka forest (125 ha) on the central plateau in areas the original Maori inhabitants had cleared for cultivation. These vegetation types are very similar in composition and physiognomy to some parts of Little Barrier.

In March 1980, a Wildlife Service party led by C. R. Veitch captured 30 Stitchbirds on Little Barrier and released them at Pukanui Bay near the western end of Hen Island. In April 1981 16 birds were released at Dragon's Mouth Cove immediately west of the previous release point. All birds transferred had a single metal band (C. R. Veitch, pers. comm.).

Several observations of Stitchbirds were made in the course of capturing Saddlebacks on Hen Island for transfer to Kapiti Island in 1981 and 1982. In January 1981 a member of the Saddleback transfer team saw a female Stitchbird feeding a juvenile near Dragon's Mouth Cove, showing that breeding took place in the first year after transfer. In February 1982, a banded female Stitchbird was captured near the centre of the island (east of the pinnacles), showing that some of the introduced birds had dispersed well away from the release areas (R. A. Anderson, pers. comm.).

To find out more about the progress of the introductions, two expeditions (organised by GRA and R. A. Anderson, Wildlife Service, Whangarei) have visited Hen Island. The first party, which visited the island on 7-9 July 1982, consisted of G. R. Angehr, R. A. Anderson, M. Bellingham, A. Davis, G. Taylor, S. Courteney, and L. Brett. Despite poor weather at least 12 Stitchbirds were found. This number is conservative because, whenever a bird was seen or heard in roughly the same area at different times, it was assumed to be a single individual, unless the places of encounter were more than 100 m apart. Of the seven birds seen well enough to determine whether they were banded, six were unbanded, a ratio which suggested that Stitchbirds had bred very well on the island. The only banded bird was a male.

The second party, which visited the island on 1-4 June 1983, consisted of G. R. Angehr, R. A. Anderson, M. Bellingham, A. Davis, T. G. Lovegrove, and C. West. At least 21 birds were found, and they were almost from one end of the island to the other (from behind Lighthouse Bay on the west to past Astelia Knoll on the east). Of the seven birds seen well enough to determine whether they were banded, only one was banded, a female seen over 1.2 km from the original release site.

Although only a few birds (12 and 21) were found on the two visits, these totals were accumulated by small parties searching a large and very rugged island for only 3-4 days. In addition, Stitchbirds are very hard to detect in midwinter, when calling is at a minimum (Angehr, pers. obs.). Therefore many more birds were probably present.

To estimate the density of Stitchbirds, we set up a transect route from near the camp site at Dragon's Mouth Cove to Baldy Peak near the centre of the island. This transect traverses c. 1 km of coastal forest and 1 km of kanuka forest. On the mornings of 2 and 3 June we surveyed the transect route 10 times, recording all birds seen or heard within 10 m of the transect. We recorded

Stitchbirds 19 times on these transects; at least eight different birds were present. They were seen about twice as often in coastal forest as in kanuka (13 to 6). This pattern is similar to that on Little Barrier, where Stitchbirds are usually much more common in mature than in regenerating forest (Angehr, pers. obs.).

The transect data give only a very rough estimate of the density of Stitchbirds in different habitats because of small samples. With a transect width of 20 m, 2 ha are surveyed per kilometre walked. The 10 transects yielded estimates of 0.65 Stitchbirds/ha in coastal forest and 0.30 Stitchbirds/ha in kanuka forest. If Stitchbirds are evenly distributed at these densities throughout the island, more than 200 birds may be present. This assumption may be unrealistic. Although Stitchbirds have been found in all parts of the island, they may still be more numerous in the western half of the island, which is closest to their release point. However, even if the density estimates apply only to the western half of the island, a population of well over 100 stitchbirds is indicated. Based on my experience on Little Barrier, the rate at which party members encountered birds (calculated per hour or per kilometre) during non-transect surveys tends to support the higher figure. The fact that 85% of the birds seen well had been bred on the island also suggests that numbers may be high.

In summary, Stitchbirds appear to be breeding very well on Hen Island and are well distributed in both major forest types. The population is probably at least 100 and may well exceed 200 birds. Projections based on the population densities in similar habitats on Little Barrier suggest that Hen Island could eventually support more than 500 birds.

Stitchbirds have also been transferred to Cuvier Island (29 birds in June 1982) and to Kapiti Island (30 birds in August 1983). Although it is too early to know whether these introductions will succeed, the status of the Stitchbird on Hen Island gives strong grounds for optimism.

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GEORGE R. ANGEHR, *Wildlife Service, Department of Internal Affairs, Wellington*

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FOURTH RECORD OF A BARN OWL IN NEW ZEALAND, WITH COMMENTS ON LONG-DISTANCE AIRCRAFT AS A POSSIBLE MEANS OF DISPERSAL

On 27 March 1983 at 3.30 p.m., a schoolgirl, Sharon Richardson, found an owl in the grounds of the Flat Bush School, near Papatoetoe, Auckland. The bird was weak and died within about 18 hours. It was brought to the Auckland Museum and identified as a Barn Owl

(Tyto alba): it is now preserved as a study skin (B1962.1) and bones (B1962.2) in the museum collection.

Measurements, taken from the fresh bird, are: total length (bill to tail) 300 mm, wing (flattened but unstraightened chord) 275 mm, tail 109 mm, tarsus 74 mm, bill (base of skull to tip) 33 mm. Wing and tail feathers are strongly barred and the distal half of the tarsus is very sparsely feathered.

The Australian race of Barn Owl *(T. a. delicatula)* is so similar to the southwest Pacific race *(T. a. lulu)* that they cannot be separated by colour (Amadon 1942). Race *delicatula* tends to have a longer wing and tail but the two races overlap in these measurements (Amadon 1942) and our specimen lies in the region of overlap. Therefore we cannot identify the Flat Bush owl to subspecies.

Upon dissection the owl proved to be a male. There were large fatty deposits beneath the abdominal wall, along the large intestine and about the stomach. The intestine contained a small amount of dark digested residue along its length, and the gizzard contained the fur and bones of a mouse *(Mus musculus)*. In the gizzard was also an ant's head, identified as *Notoncus ectatommoides* (Forel) a species widespread in parts of Queensland, New South Wales, Victoria and South Australia (Dr R. W. Taylor, pers. comm.). This establishes that the owl originated in one of these Australian states. The owl must have reached New Zealand relatively quickly because, even at death (18 hours after discovery), the gizzard and intestine had not had time to empty.

Scarlett (1967) reported *Tyto alba* as a subfossil in New Zealand, but Millener (1983) discounted this record. There are three recent records of Barn Owls (said to be the Australian race) in New Zealand, all from Westland. An adult female (Canterbury Museum AV 2346) was shot at Barrytown in August 1947 (Falla 1948). The second specimen (not preserved) was struck by a car near the Haast River mouth in October or November 1955 (Falla & Riney 1958). A male (Canterbury Museum AV 19,597) was found dead at Runanga in August 1960 (Grant 1960).

There seem to be three possible explanations of the arrival of the Flat Bush Barn Owl in New Zealand.

1. *The owl was smuggled in and escaped:* Proximity to an international airport strengthens this possibility, but the owl is not a species likely to be sought by aviculturists.

2. *The owl arrived unaided:* J. W. D. Hessell and N. Gordon (NZ Meteorological Service) report that between 24 and 27 March 1983 New Zealand experienced strong westerly winds associated with the passage of two cold fronts across the country. Pressures were such that a passive object travelling at low altitude on an isentropic surface would have taken 2½ days to pass from south-east Australia to Papatoetoe if it reached its destination at noon on 26 or 27 March. For

arrival at noon or midnight on 25 March transit time would have been longer ($3\frac{1}{2}$-4 days). Presumably a bird would reduce these transit times by its own power of flight and it seems likely that a Barn Owl could have reached Flat Bush at the time concerned in under 2 days. This explanation of the owl's arrival gains considerable support because, in the first half of 1983, there was a spate of sightings of vagrants in New Zealand (see *OSNZ News* 28 and 29). However, the owl's fat condition and the presence of some food in the gut seem to argue against even a rapid unaided passage.

3. *The owl was dispersed by a long-distance aeroplane:* Flat Bush School (and the Richardson's house in the same area) is almost directly in the line of approach of overseas jet aircraft landing at Auckland International Airport at times when the wind is westerly or southwesterly, and it is also at about the point where the undercarriage is lowered. It thus seems likely that a bird which had become trapped in the undercarriage bay would fall out at about this point. Mr K. J. Fisher, of the Airport engineering staff, confirms that adequate space would be available in the undercarriage bay. Further, he informs us that international jet aircraft may remain on the ground, often well away from the terminal buildings, for some time both by day and by night between flights at the different Australian airports, thus affording the opportunity for an owl to enter the undercarriage bay.

We have confirmed that there were flights from Brisbane, Sydney and Melbourne between 25 March and 3.30 p.m. on the 27th. Mr N. A. Rapson (Meteorological Office, Auckland Airport) reports that throughout this period overseas aircraft were using the eastern approach above Flat Bush, winds being fresh to strong W. to S.W.

We have no physiological evidence that an owl could survive the changes in altitude and temperatures involved in transport in an undercarriage bay. Such a mode of dispersal might, however, account for the presence on an airport approach path of a weak Barn Owl that had recently eaten and was in fat condition.

We are grateful to the Richardson family for reporting the owl and to Mr R. A. Richardson for suggesting the aeroplane hypothesis. We thank the various authorities who advised and commented.

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B. J. GILL *and* E. G. TURBOTT, *Auckland Institute and Museum, Private Bag, Auckland*

LITTLE SHEARWATERS VISITING BURROWS AFTER BREEDING

Little Shearwaters *(Puffinus assimilis)* are winter breeders in New Zealand " occupying the nesting burrows from about April, with eggs in May and June and most of the young on the wing by the end of October " (Falla *et al.* 1981). In October/November 1982, while studying the prebreeding activities of Pycroft's Petrel *(Pterodroma pycrofti)* on Lady Alice Island in the Hen and Chickens Group, I encountered pairs of Little Shearwaters occupying burrows by day on four separate occasions. I inspected about 40 burrows each day for 12 consecutive days between 25 October and 5 November. I suspected that these were all breeding burrows of Pycroft's Petrel, which breeds in the summer, and it is not known how many of them may have been occupied by Little Shearwaters earlier in the year. As little information may be available about Little Shearwaters at this stage of the breeding season, I have given details of all eight birds in Table 1. I saw only one Little Shearwater at night on the surface in the study area during this visit and none in burrows or on the surface during an 11-day visit from 23 November to 3 December or a 5-day visit from 11 to 15 January 1983.

On 28 September we had banded a large downy Little Shearwater chick weighing 216 g with tarsus length 40 mm at Burrow 129. On 29 October the skeleton of this chick, together with its band, was found on the surface above the burrow. One of the birds in Burrow 102 had been banded (X8402) as a breeding adult on Lady Alice Island on 25 August 1981. The others were unbanded when caught and so may or may not have been established breeders. None of the shearwaters in the burrows had an egg or chick.

One of the birds had very worn flight feathers, some primaries with broken tips, and certainly had not moulted recently. Another had primaries that were fresher but not obviously newly grown.

TABLE 1 — Measurements of eight Little Shearwaters

			Wing Length	Bill Length	Bill Depth	Tarsus	Mid-toe & Claw	Weight (g)
29 Oct	Burrow 129	Bird 1	196	26.5	6.8	41.1	-	220
		Bird 2	190	23.4	6.5	40.8	45.9	220
30 Oct	Burrow 133	Bird 1	192	24.4	6.9	39.9	-	230
		Bird 2	196	23.6	6.9	40.0	50.0	227
31 Oct	Burrow 102	Bird 1 (X8402)	199	26.7	6.4	-	-	242
		Bird 2	191	24.9	6.9	-	-	219
2 Nov	Burrow 127	Bird 1 (X8415)	193	26.2	6.9	41.4	49.2	204
		Bird 2 (X8416)	191	25.6	6.3	40.1	48.2	185

No flight feathers were missing, and all were fully grown in the birds handled.

"The Little Shearwater is a non-migratory species throughout its wide range and may be found on its island haunts ten months of the year" (Serventy *et al.* 1971). Other non-migratory shearwaters may also be on the breeding islands outside the breeding season, and Falla (1934: 255) said of the Grey-faced Petrel *(Pterodroma macroptera)* in New Zealand: "within a month of departure of the last of the young from the burrows in January, some few old birds will be found in occupation again, at first only single birds, and usually males. This is so in February and March. From April till June pairs are often found in burrows during the day, but not in all burrows in any one day. Laying takes place at the end of July and early in August . . . ."

When Jouanin (1964) visited Grande Salvage Island in the Atlantic on 13-23 July 1963, about 1-2 months after the young Little Shearwaters had fledged there, he found no sign of adults on land by day, although they were very active at night, when several, all showing primary moult, were captured. In an interesting review, Jouanin went on to consider similar patterns of attendance outside the breeding season in other petrels and in particular referred to the work of Paulian (1953), who found on Kerguelen Island that in the Blue Petrel *(Halobaena caerulea)*, which lays from late October to mid-November and fledges in March, large numbers of adults return from mid-April onwards and are present by day, often in pairs, in the burrows in which they remain, calling, during the night. This activity declines during June, and at the end of June adults disappear from their breeding places until they return to prepare for nesting early in September. For such behaviour, Jouanin proposed the term *protogamique* and considered that its function is to enable prebreeders to become paired and to strengthen the bonds between established pairs of adults.

My observations of Little Shearwaters on Lady Alice Island seem consistent with these ideas of protogamic behaviour, and it is interesting that no burrows contained single shearwaters, that only one adult was seen on the ground at night (on 4 November), and that none was seen during the later visits in November/December and in January.

I wish to record my thanks to M. C. Crawley and M. J. Imber of the New Zealand Wildlife Service for their support.

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G. M. DUNNET, *Zoology Department, University of Aberdeen, Scotland*

SOLANDER ISLAND BIRDS

We flew to the Solander Islands by helicopter from Te Anau on 8 February 1984, arriving over Little Solander Island at 0710. After a brief aerial reconnaissance of Little Solander, we flew around Solander Island and landed in South-west Bay at 0725. On 9 February we were picked up at 1825 and returned to Te Anau. The weather was fine and sunny on 8 February but overcast and showery on 9 February.

Fiordland Crested Penguin *(Eudyptes pachyrhynchus pachyrhynchus)*

Twelve adults and one immature were ashore on boulder beaches along South-east Peninsula and two adults were ashore in Western Bay. All birds were in moult, one towards completion.

Buller's Mollymawk *(Diomedea bulleri)*

These were nesting on both islands. Nests were well scattered up to the summit of Little Solander (180 m) and on Solander Island from 18 m to 210 m above sea level on open slopes, ridge tops and under dense canopy on the edge of the summit plateau. Most birds were incubating clean pinkish-white eggs. Some lone birds were occupying empty nests. Courting behaviour was seen at some nests and one pair copulated behind our camp at 0845 on 9 February. Sitting and non-incubating birds rarely moved from nests if disturbed, and then only to about a metre away.

White-capped (Shy) Mollymawk *(Diomedea cauta cauta)*

One was flying off South-west Bay on 8 February.

Northern Giant Petrel *(Macronectes halli)*

One was sitting on the sea in South-west Bay on 8 February.

Prions (*Pachyptila* spp.)

On 9 February at 0410-0426 prions were heard over the camp and seen in torchlight. As it was raining at the time, we were unable to identify the species.

Sooty Shearwater *(Puffinus griseus)*

Throughout the day several hundred Sooty Shearwaters were flying offshore and moderate numbers were calling overhead from 2245 to 0610. Burrows were scattered sparsely over the higher slopes behind South-west Bay but mainly in areas of scrub. Three dead chicks were found outside burrows. Two of these had been extensively pecked about the head and breast, and weka tail feathers were close by.

Southern Diving Petrel *(Pelecanoides urinatrix chathamensis)*

Skeletons were found on the beaches at South-west Bay and along South-east Peninsula. Extensive areas of small burrows, apparently of this species, were seen from the air on Little Solander.

Australasian Gannet *(Sula bassana serrator)*

Two groups were seen from the air on Little Solander. One group of 28 birds was in a clearing on the northern slope about 60-80 m above sea level, and the other group of six birds was on steep rock at the north-eastern end about 20 m above sea level. The birds were obviously nesting but it was not possible to count the nests.

Small numbers were flying off South-west Bay during both days.

Stewart Island Weka *(Gallirallus australis scotti)*
Common and well distributed. Up to 12 at a time were on the beach at South-west Bay, feeding among weedy rocks at low tide. A pair with two juveniles were seen on the summit (340 m), and a pair with one juvenile were seen on South-west Bay beach.

Variable Oystercatcher *(Haematopus unicolor)*
Three were in South-west Bay on both days and a further five were on the boulder beach around South-east Peninsula on 9 February.

Southern Great Skua *(Stercorarius skua lonnbergi)*
A skua midden was seen from the air on Little Solander and one bird was seen flying between there and Solander Island a few minutes later. One unidentified skua was flying in South-west Bay on 8 February.

Southern Black-backed Gull *(Larus dominicanus)*
Moderate numbers were around all the beaches visited and more were flying close inshore, especially in the morning and early evening. Two unfledged chicks were at South-west Bay and one was on the boulder beach along South-east Peninsula.

Red-billed Gull *(Larus novaehollandiae)*
Small numbers were around all the beaches visited and several adults with juveniles were ashore between South-east Peninsula and Western Bay.

New Zealand Pigeon *(Hemiphaga novaeseelandiae)*
On 8 February three New Zealand Pigeons flew into *Olearia lyallii* at 325 m and later a group of eight circled the edge of the summit plateau near the razorback ridge.

Red-crowned Parakeet *(Cyanoramphus novaezelandiae)*
Single parakeets or groups of up to three were regularly seen flying over scrub. We positively identified five Red-crowned Parakeets in *Olearia-Senecio* scrub on the summit.

Hedgesparrow *(Prunella modularis)*
Three single sightings on the summit plateau, at Western Bay and South-west Bay.

Grey Warbler *(Gerygone igata)*
In moderate numbers but not conspicuous by song.

South Island Fantail *(Rhipidura fuliginosa)*
Seven adults and one juvenile were seen on the summit plateau.

Yellow-breasted Tit *(Petroica macrocephala macrocephala)*
Widespread in areas of scrub.

Silvereye *(Zosterops lateralis)*
Seen and heard in low numbers on scrub faces.

Bellbird *(Anthornis melanura)*
Well distributed in moderate numbers.

WYNSTON COOPER, *Box 1044, Invercargill;* KIM MORRISON, *Box 29, Te Anau*

OBITUARY

JOHN HERIOT SEDDON 1927-1984

John Seddon was killed at Tauranga on 19 February, when the microlight aircraft which he was piloting crashed suddenly. Flying had long been one of his great loves. He had held a Private Pilot's licence for the last ten years.

Graduating from the Otago Medical School in 1952, he became an esteemed and much loved General Practitioner, first at Te Puke and Mangakino, and then in 1962 at Cambridge. He was a distinguished member of the NZ College of General Practitioners, being made a Fellow of the College in 1982 and earning their gold medal for his research work and services to general practice. He also served a term as president of the Waikato Division of the NZ Medical Association.

John lived with zest and devoted such leisure as the demands of a busy practice allowed to outdoor pursuits, especially watching birds, if possible in remote places. He also loved boating, scuba-diving and mountain walking with a special interest in native trees and alpine plants. His notebooks were illustrated with charming sketches and skilful photographs. In all things he was a perfectionist.

John and Betty were a wonderful team who inspired others. Over some years in early summer they used to escape for a few precious days to the wide open spaces of the Far North. Locally they organised regular censuses of Kawhia and Aotea harbours. John had scoured from the air every swamp and waterway in the Waikato and Bay of Plenty in search of Cattle Egrets and in the hope of pin-pointing a breeding colony. John and Betty accompanied several expeditions to Farewell Spit, where they became very much at home as, telescope and tripod on shoulder, their long raking stride carried them over the miles of dunes and salicornia. Among the great flocks of resting waders, few rarities escaped their discerning eyes. On the Chathams the Wildlife Service was happy to have John as MO; and both, as first-class naturalists. They are among the privileged few who have bedded down in the ghostly woolshed on South East Island.

The Ornithological Society remembers John with affection and gratitude. New Zealand can ill afford the untimely loss of a man so wise, so gifted and so kindly, at the peak of his powers. The many who have enjoyed the privilege of the stimulating companionship and lively hospitality of an outstanding couple mourn with Betty and her family in their sudden bereavement.

— R. B. Sibson