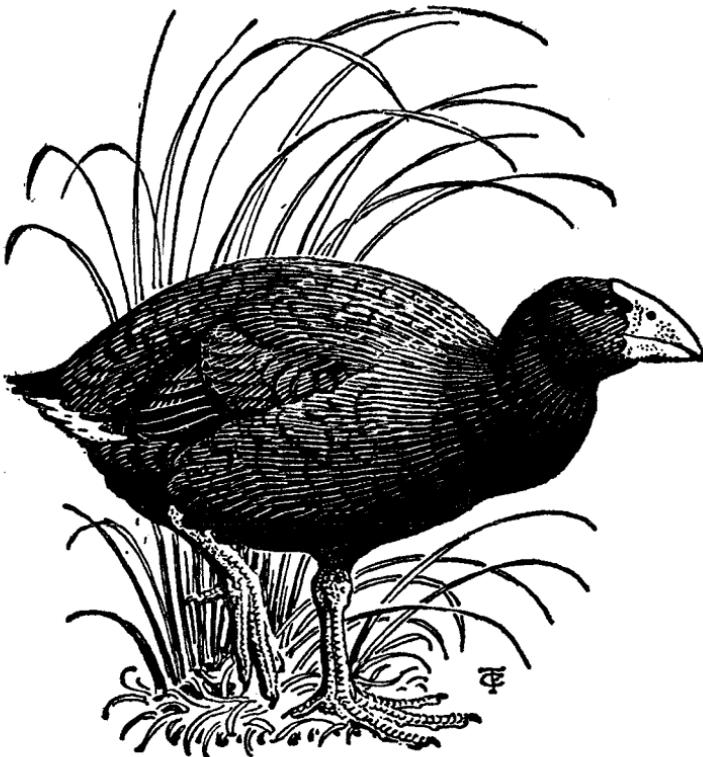


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LAYING SEASONS OF THREE INSECTIVOROUS SONG-BIRDS AT KOWHAI BUSH, KAIKOURA

By B. J. GILL, R. G. POWLESLAND and M. H. POWLESLAND

In this note we compare three native insectivorous songbirds — the Robin (*Petroica australis*), the Grey Warbler (*Gerygone igata*) and the Fantail (*Rhipidura fuliginosa*) — the laying seasons of which we studied at Kowhai Bush, Kaikoura, from July 1977 to January 1978. These three species occupy much the same habitat at Kowhai Bush, which is kanuka forest (*Leptospermum ericoides*) with a mixed hardwood understorey. Hunt & Gill (1979) described the study area in detail.

Figure 1 shows the dates (grouped into weeks beginning 21-27 July) on which all eggs under study were laid. All three species were multi-brooded and showed more than one peak of laying. Robins had the longest egg-laying season (24 weeks), whereas Grey Warblers and Fantails laid for a shorter period (15 weeks each). Robins began laying first, followed five weeks later by Warblers. Fantails started laying three weeks after Warblers. Grey Warblers stopped laying three weeks before the other species.

Robins had four peaks of laying. The mean date of laying of the first eggs of first Robin clutches was 16 August 1977. Thus the first peak represents almost entirely the laying of first clutches for the season. The second peak (in September) represents mainly the laying of replacement clutches for first nestings that failed. Second clutches laid after the fledging of a first brood generally appeared in mid-October, as indicated by the third peak of the histogram. The broad fourth peak of laying in November mainly represents replacement of the large proportion of second clutches and broods destroyed by

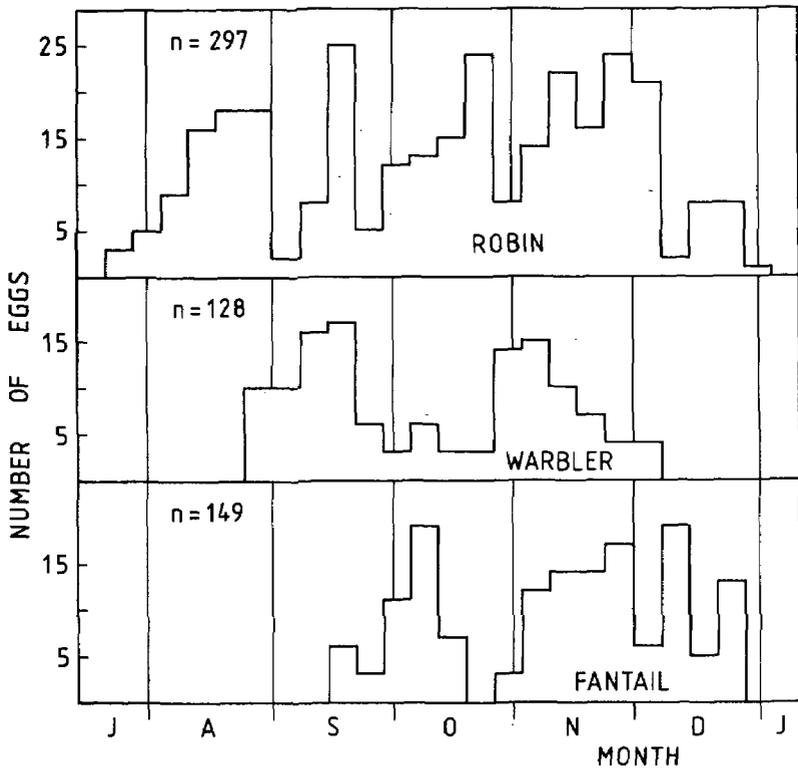


FIGURE 1 — Numbers of eggs laid per week by Robins, Grey Warblers and Fantails at Kowhai Bush, Kaikoura, in the 1977-78 breeding season

predators after September. If the second clutch hatched and the nestlings fledged, a third clutch was laid about mid-December, as shown by a fifth and minor peak.

The two peaks of laying by Grey Warblers simply reflect the laying of first clutches and then second clutches (after the successful raising of a first brood). The average day of initiation of first clutches was 8 September 1977, and the earliest egg of a true second clutch appeared on 23 October 1977. However, some clutches in October and early November were replacements for first nests that failed.

Fantails show two main peaks of laying, one in early October representing mainly first clutches, and a second extended peak in November-December. Fantails can raise to fledging up to three broods in a breeding season, but in 1977-78 the maximum number a pair raised was two. Most pairs had one or more unsuccessful nestings,

and a pair could build and lay up to five times a season. The second laying peak for Fantails thus represents both second and replacement clutches. Re-nesting usually began within a few days of the loss of a nest.

All three species are insectivores, but they tend to feed in different ways on different kinds of invertebrates. Robins at Kowhai Bush (weight 31.45 g; J. A. D. Flack, pers. comm.) feed almost entirely on invertebrates (Powlesland 1981). They spend 90% of foraging time on or within two metres of the ground, even though the forest at Kowhai Bush is 7-12 m tall. In winter and spring when the soil is moist, Robins feed mainly on earthworms, slugs, snails and larvae of the March Fly (*Philia negrostigma*). By late spring and early summer increasing numbers of larval and adult Lepidoptera are eaten. In January, when cicadas (*Amphipsalta zelandica*) are abundant, some Robins seem to feed on them almost exclusively.

Grey Warblers at Kowhai Bush (mean weight 6.4 g) glean invertebrates from twigs and living foliage on 94% of occasions that food is obtained (Gill 1980). They concentrate on intermediate to high levels of the forest, and glean by perching upright (55% of occasions) or by hovering (41%). Warblers almost never alight on the ground or flycatch. The food, to judge from that fed to nestlings (Gill 1983), is mainly caterpillars and spiders.

Fantails (mean weight 7.6 g; Powlesland 1982) catch most of their food on the wing and aerial insects presumably predominate in the diet. Gravatt (1971) noted that Fantails on Little Barrier Island feed mainly at middle to low levels of the forest. Ude Shankar (1977) found that Fantails at Riccarton Bush, Christchurch, forage in all levels of the forest. In winter, the birds seek out insects that their movements (or those of other birds) disturb on the ground or on vegetation. Once breeding begins (August) and aerial insects proliferate, Fantails change to feeding by fast direct flights from a perch or by aerobic manoeuvres.

We have no evidence, but it seems likely that soil-dwelling invertebrates become abundant (and/or available) at Kowhai Bush before foliage-dwellers (especially caterpillars) reach their peak, and also that caterpillars are plentiful before the peak in flying insects. If this is so it may explain the staggered start to laying by the three birds concerned, assuming that their laying is timed to coincide with the maximum availability of food for their nestlings. Clearly, data on the abundance and activity of invertebrates in New Zealand forests are needed to test these ideas.

In this interpretation we follow Lack (1950), who postulated that the diet of two garden songbirds of similar size near Halifax, England, accounted for the difference in their laying seasons. He found that the Robin (*Erithacus rubecula*), which feeds its young on caterpillars, had its peak of laying seven weeks before the Spotted Flycatcher (*Muscicapa striata*), which feeds its young on adult insects.

Caterpillars were abundant in the habitat before winged insects, and so the observations suggest that this induced the Robin to lay before the Flycatcher.

Another factor that may contribute to early and prolonged laying by South Island Robins is their ability to cache food (Powlesland 1980). Robins frequently store invertebrates, especially earthworms, during autumn and winter, mostly for retrieval within three days. By storing food, Robins can better exploit a temporarily abundant supply and help overcome the bad effects of short periods of adverse weather. Grey Warblers and Fantails are not known to cache food.

Many areas of New Zealand commonly experience serious droughts in summer (Hurnard 1978) and the Kaikoura Plain is no exception. At Kowhai Bush in mid to late summer, the dominant tree (kanuka) undergoes its greatest loss of leaves, and broad-leaved species often show signs of serious wilting. Grey Warblers at Kowhai Bush feed mainly from kanuka (Gill 1980) and a reduction in foliage-dwelling invertebrates caused by drought may be why Warblers stop laying relatively early. One would expect dry conditions to reduce the Robin's supply of soil-dwelling prey but Robins are able to exploit cicadas and stick-insects (phasmids) in late summer (Powlesland 1981). Fantails should be least affected by the influence of drought on soil and vegetation.

The Robin is subgenerically endemic to New Zealand and one might expect this relatively archaic form to have a lower breeding potential than the Warbler and Fantail, which are only specifically and subspecifically endemic (respectively) and which are much better at exploiting man-modified habitats. The long laying season of the Robin seems to contradict this expectation, but consideration of potential productivity gives a trend closer to expectation. The maximum number of broods raised per season multiplied by the average clutch-size is 8.1 for Robins (3×2.7), 7.8 for Warblers (2×3.9) and 10.5 for Fantails (3×3.5).

ACKNOWLEDGEMENTS

The field-work for this study was done while BJB and RGP were students at the University of Canterbury. We thank the Zoology Department for its support, the Marlborough Catchment Board for permission to work at Kowhai Bush, and Dr M. C. Crawley for improving a draft of this note.

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SHORT NOTE

FIRST SIGHTING OF CHESTNUT-BREADED SHELDUCK IN NEW ZEALAND

On 11 December 1982 Canterbury region members of OSNZ visited the western shore of Lake Ellesmere. While watching a group of predominantly male Paradise Shelduck (*Tadorna variegata*), Kathleen Harrison drew our attention to one bird that had a chestnut breast instead of a black breast.

It was suggested that the bird might be a Chestnut-breasted Shelduck (*Tadorna tadornoides*) and so we made detailed observations before the bird flew off with the Paradise Shelducks. None of us was already familiar with the species.

At first sighting the bird was viewed from about 300 m using telescopes and gave frontal views only. The bird seemed slightly smaller than most of the Paradise Shelducks in the flock and seemed slightly finer in the neck. Description: Head, neck, back and underparts black; breast and mantle chestnut brown and well demarcated from the black neck and underparts; legs and bill black, and a prominent white ring around the base of the bill and a narrow white ring around the eye. In flight, the bird showed a similar wing pattern to that of the Paradise Shelduck with large white shoulder patches and white underwing.

Some of us saw it again later in the day, a rear-end view showing that the chestnut tertials formed a coloured patch on the lower back when the wings were folded.

The following day PS, KH, B. R. Armstrong and C. F. J. O'Donnell returned to the area and soon saw the bird on a shallow brackish pond, again accompanying Paradise Shelducks. Both species fed alike, by swimming slowly with head in the water.

Frith (1967) reported that in a sample of 200 Chestnut-breasted Shelducks all females, both adult and juvenile, had white at the base of the bill but so had 21% of males. Nearly all females, of all ages, had white eye rings but no males did and so he concluded that this

character was a reliable guide for sexing. The amount of white around the eye was not considered to be adequate for ageing purposes.

Both sexes may have a white neck ring but it is always wider and more noticeable in males. The breast colour in males is described as cinnamon brown (Frith 1967) and buff (Pizzey 1980) and in females as chestnut (Frith 1967, Pizzey 1980).

On the basis of breast colour, lack of white neck ring, presence of white eye ring and white ring at the base of the bill we conclude that the bird was a female Chestnut-breasted Shelduck (alternative name, Australian Mountain Duck).

This is the first confirmed sighting of this species in New Zealand. However, Oliver (1955) recorded a specimen in the Canterbury Museum collection which had been shot at Lake Ellesmere. Neither the annotated checklist of New Zealand birds (Kinsky 1970) nor the amendments (Kinsky 1980) accepted this species to the New Zealand list.

This specimen came from the O'Connor collection and a check of his catalogues shows that he purchased the specimen in Christchurch. The locality is recorded at Lake Ellesmere but no date is given. However, in his systematic catalogue, which was presumably compiled later, O'Connor himself questioned the locality and this presumably led to its non-acceptance by the checklist committee.

In Australia the Chestnut-breasted Shelduck occurs mainly in south-west and south-east Australia, being particularly numerous in Tasmania (Pizzey 1980). Tasmania annually receives an influx from the mainland during the summer and in drought years. It is possible that the Lake Ellesmere bird was a migrant caught up in the persistent strong westerly winds that prevailed during spring and early summer 1982.

We thank G. A. Tunncliffe for his help with the Canterbury Museum collection.

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INTRASPECIFIC NEST PARASITISM IN THE WHITE-THROATED MUNIA

By MANJIT S. DHINDSA

ABSTRACT

Evidence is described indicating intraspecific nest parasitism in the White-throated Munia (*Lonchura malabarica*). The munias seem to prefer breeding in abandoned nests of weaverbirds (*Ploceus* spp.) and have little tendency to make their nests in the open. The scarcity of deserted weaverbird nests suitable for occupation by munias seems to be the main reason for the development of this intraspecific nest parasitism. The possibility of the White-throated Munia becoming a nest parasite of weaverbirds is also discussed.

INTRODUCTION

Yom-Tov (1980) defined intraspecific nest parasitism as "the laying of eggs in a conspecific nest without taking part in the process of incubation and/or caring for the hatchlings." He listed 53 species of birds in which the phenomenon has been reported. I have added two more species to this list (Dhindsa 1983), and this paper gives evidence to add a third, the White-throated Munia (*Lonchura malabarica*, subfamily Estrilinae, family Ploceidae).

The White-throated Munia (Fig. 1) is a common resident species throughout India and is also found in Bangladesh, Nepal, Pakistan and Sri Lanka. It extends westwards to southern Arabia and to Africa, where it is present south to Tanzania. These munias generally inhabit cultivated lands, grass lands, *babul* (*Acacia* spp.) jungles, sparsely scrubbed country as well as light secondary jungles (Ali & Ripley 1974). They are usually seen in flocks of a few to more than 50 birds feeding on the ground, on standing crops of pearl millet (*Pennisetum typhoideum*), *Sorghum* sp., cultivated fodder grasses, etc., and also at grain stores. Their breeding continues almost throughout the year. The nest they make is an untidy ball of grass (lined with feathers, cotton, etc.) with a lateral entrance hole and is placed in thorny bushes. Empty nests of weaverbirds (*Ploceus* spp., subfamily Ploceinae, family Ploceidae) are also habitually used by these munias for breeding (Fig. 2 & 3) and roosting (Ali 1931, Ali & Ambedkar 1956, Ambedkar 1964, Ali & Ripley 1974, Dhindsa 1980). Incubation and brooding are probably shared by both sexes and both members of the pair occupy the nest at night. After the breeding is over, the same nests are generally used as dormitories where family parties of five or six birds sleep huddled together.



FIGURE 1 — White-throated Munia with grass inflorescence in its beak to be carried to its nest

I made the following observations from April 1979 to April 1980 while surveying the old and abandoned nests of weaverbirds to determine their use by other animals in Jullundur district (30°58' to 31°37' N, 75°03' to 76°15' E and c. 237 m above sea level) of the Punjab, India. The disused weaverbird nests are available to the White-throated Munias for breeding during the non-breeding season of weaverbirds (late October to early April). During the weaverbird breeding season (April to October) also some isolated, fully formed and deserted nests of weaverbirds are occupied by munias, which build their own nests inside. Thus the White-throated Munias were recorded breeding throughout the year in the old nests of three weaverbird species, Baya Weaverbird (*Ploceus philippinus*), Black-throated Weaverbird (*P. benghalensis*) and Streaked Weaverbird (*P. manyar*).

EVIDENCE OF INTRASPECIFIC NEST PARASITISM

I monitored 14 clutches of the White-throated Munia in weaverbird nests. Of these, 11 were without parasitic eggs as the egg-laying sequence or clutch size was normal. These clutches had 3 to 6 eggs laid at 1-day intervals, and the average clutch size was 4.27 ± 1.10 (mean \pm s.d.). I have the following circumstantial evidence of intraspecific nest parasitism in the other three clutches.

Clutch 1, new eggs laid after hatching of the young: When discovered on 22 April, this clutch had 7 nestlings (about 1-6 days old) and 5 eggs. The eggs were dirty white and had been joined together by the dried droppings of the nestlings, which suggested that they had been laid a few days earlier. Another fresh egg appeared in the

nest on 23 April. In most passerine birds the eggs are laid at 1-day intervals until the clutch is completed and incubation begins with the laying of the last egg. Therefore, the eggs that are laid later in a clutch do not belong to the incubating female because the ovary and related reproductive organs regress soon after the clutch is completed (Bullough 1942, Yom-Tov 1980). Furthermore, the total number of nestlings plus eggs ($7 + 6 = 13$) was almost triple the average clutch size. Therefore, it is reasonable to assume that this clutch was the product of more than one female munia.



FIGURE 2 — White-throated Munia clinging to a weaverbird nest just before entering it



FIGURE 3 — A weaverbird nest cut open to show a nest of White-throated Munia in the brood pouch. Feathers, cotton, etc. were stuffed by munias into the nest.

Clutch 2, irregular laying: In this clutch the first five eggs were laid on 25, 26, 27, 28 and 29 June. The sixth, seventh and eighth eggs appeared in the clutch on 3, 4, and 5 July, that is, 5, 6 and 7 days after the laying of the fifth egg. These extra eggs, therefore, were laid by some female other than the nest owner. The total number of eggs was almost double the average clutch size.

Clutch 3, two eggs laid on the same day: The first four eggs of this clutch were laid at normal 1-day intervals on 29, 30, 31 October and 1 November. However, two more eggs appeared simultaneously on 2 November. As a female normally lays one egg per day, more than one female was probably involved.

These three cases indicate that intraspecific nest parasitism occurs in the White-throated Munia. Earlier workers also recorded abnormally large clutches of this bird. Baker (1926) mentioned that normally there are 4-8 eggs per clutch but that one clutch of 15 eggs had been found. According to Ali & Ripley (1974), as many as 25 eggs have been found in a single nest and such abnormally large clutches are the products of several females.

REASONS FOR INTRASPECIFIC NEST PARASITISM

In my study area the White-throated Munias bred almost exclusively in abandoned weaverbird nests and seldom seemed to make their nests in the open. The eggs and nestlings of munias can be recorded in the disused weaverbird nests throughout the year. The weaverbirds desert all of their nests after completion of their breeding season and these fully formed nests remain intact for long periods, sometimes through to the beginning of next breeding season. The munias occupy these nests for roosting and breeding. All the deserted nests, however, are not available to the munias because other birds, rodents and insects also occupy them (Dhindsa 1980). The number of old weaverbird nests is highest at the end of the weaverbirds' breeding season. The number goes on decreasing, however, because of climatic wear and tear, and by the start of the next breeding season only a few nests remain intact. While founding their new colonies the weaverbirds cut down these old nests of the previous season.

During their breeding season, some weaverbirds desert their nests after having raised their first brood or when the nest contents are lost to some natural calamity. Such freshly deserted nests are usually cut down by the male weaverbirds to clear the sites for new nests, but some of the new nests are built elsewhere and so the abandoned nests are not cut down. Nevertheless, the empty nests available for the munias are much fewer than in the non-breeding season of the weaverbirds. The munias seem to prefer making their nests in the deserted weaverbird nests rather than in the open, even during the breeding season of weaverbirds, perhaps because weaverbird nests are usually sited in inaccessible sites that provide protection from predators. In addition, the nests are oriented in such a way that few contents are lost because of strong winds (Davis 1971, Dhindsa 1980).

I collected five complete nests of the Baya Weaverbird from below a colony and secured them with thread to the branches of a tree. To my surprise, I found an egg of the White-throated Munia in one of these nests on the second day. The munias that occupied this

nest were stuffing nesting material into the brood pouch of the nest, and so the female may have already mated and as soon as it found the empty weaverbird nest could start egg laying. Two more of these five nests were occupied by munias within one week.

From these observations I assume that the number of mated female munias may be more than the available deserted weaverbird nests suitable for them and that this scarcity of preferred nesting sites may be responsible for intraspecific nest parasitism. When mated females are unable to find an empty weaverbird nest, they may prefer to lay in a nest that already has a conspecific clutch.

POSSIBILITY OF WHITE-THROATED MUNIA BECOMING A NEST PARASITE OF WEAVERBIRDS

One or more pairs of the White-throated Munias are often seen in the active breeding colonies of weaverbirds apparently trying to enter and examine their nests. The eggs of these munias are pure white like those of weaverbirds but are smaller and weigh less. So far, no one has found munia eggs in the clutches of weaverbirds, but the general resemblance of their eggs and the habits of munias may well lead to White-throated Munias becoming nest parasites of weaverbirds. Ali (1931) was the first to observe White-throated Munias trying to enter occupied nests of the Baya Weaverbirds and to point out the possibility of parasitism. A White-throated Munia egg has been recorded in a clutch of the House Sparrow (*Passer domesticus*) (Ali & Ripley 1974).

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SOME POPULATION STATISTICS AND MOVEMENTS OF THE WESTERN WEKA

By J. D. COLEMAN, B. WARBURTON and W. Q. GREEN

ABSTRACT

In central Westland, 110 Western Wekas (*Gallirallus australis australis*) were marked between August 1975 and May 1978, and 38 corpses were examined. Wekas occurred throughout the study site but preferred ecotonal scrublands while avoiding dense forest. Captures fell by 50% over the study period and the number of sightings also decreased significantly. Adults were sexed by a discriminant function based on the bill measurements of dead birds, with a probability of misclassification of live adults of about 4.6%. A sex ratio biased towards males was revealed. Breeding began in late June/July when both sexes had attained maximum annual body weights and fat reserves. Home ranges were generally less than 4.5 ha. The main foods identified from birds collected during June-August and in November were fruits of indigenous forest plants, especially *Coprosma* spp., and plant foliage, insects and earthworms.

INTRODUCTION

Although the weka (*Gallirallus australis*) is often locally abundant, it is absent from large tracts of seemingly suitable habitat throughout its range. Its disjunct distribution may be only recent because it vanished from most of the North Island between 1918 and 1940 and from the eastern side of the South Island by 1924 (Falla *et al.* 1979). Conversely, populations in central Westland and in north-west Nelson are recolonising old range (JDC, pers. obs.) and wekas introduced on to Chatham, Macquarie and numerous small offshore islands have prospered. Wekas continue to flourish about Gisborne and have provided the nucleus of liberations elsewhere in the North Island (Falla *et al.* 1979).

The reasons for local fluctuations are not known. Anecdotal reports abound in early New Zealand literature (summarised by Oliver 1968) and in general ornithological texts, but only Carroll (1963 a, b, c) has given a substantial description of the species' diet, breeding cycle and sexual characteristics. Little is published on its movements, densities, diseases or favoured habitat — data crucial to the understanding of fluctuating weka populations.

A chance to investigate one subspecies, the Western Weka (*Gallirallus a. australis*), arose during a study of brush-tailed possums (*Trichosurus vulpecula*) in central Westland. As the box traps used for possums also caught wekas, we undertook a limited study of the

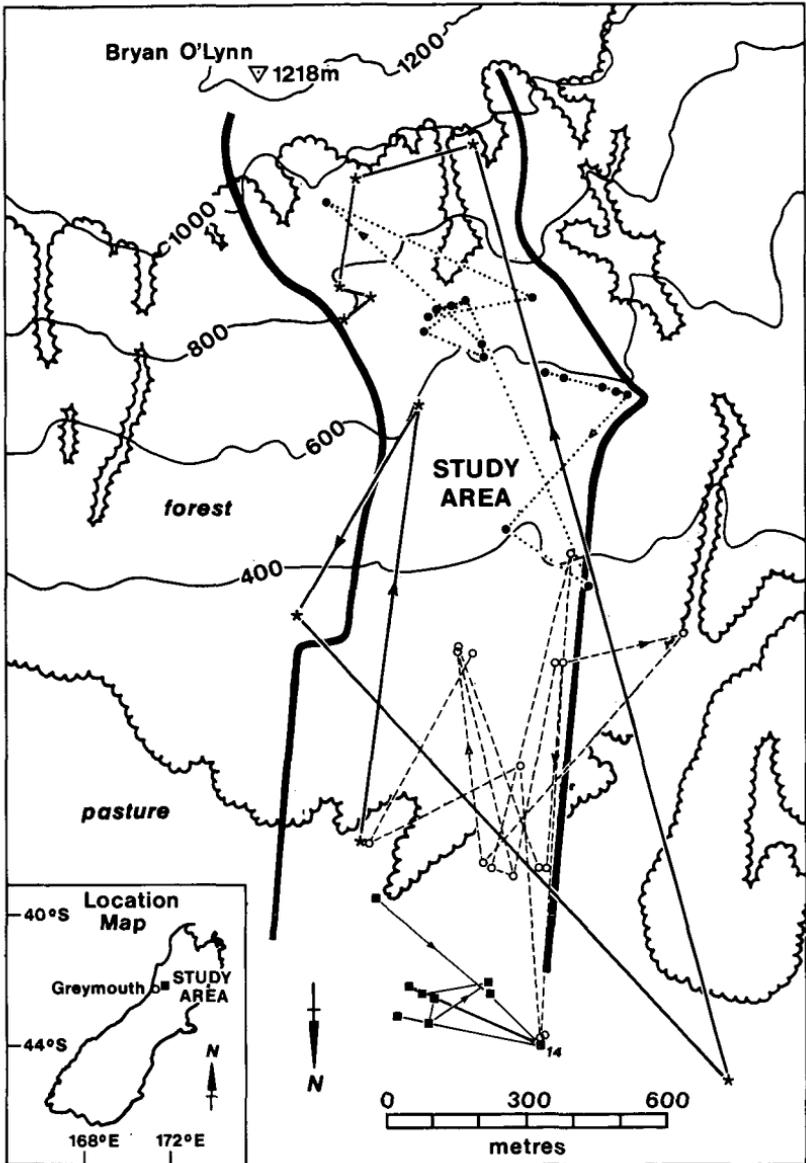


FIGURE 1 — The Mt Bryan O'Lynn study site, with the movement patterns of four frequently observed wekas superimposed on it. The birds include numbers 29363 (solid squares), 29364 (open circles), 37130 (closed circles) and 37138 (asterisks).

bird's population density, movements, habitat use, diet, and breeding biology in an area of farm edge and native forest.

The study area, which was described in detail by Coleman *et al.* (1980), comprises a belt of forest and adjacent pasture 1.5 km wide extending from farmland at 220 m a.s.l. to alpine grassland at 1200 m a.s.l. on the north-facing slopes of Mt Bryan O'Lynn (see NZMS 1, S52, 190690; also Fig. 1). At low altitudes morainic terraces support either rough pasture dotted with clumps of scrub or cutover podocarp forest dominated by hardwood canopy species and tree ferns. On the steep schistose hillside, the forest shows a regular altitudinal progression of dominant trees, viz. *Weinmannia racemosa*, *Quintinia acutifolia*, *Metrosideros umbellata* and *Libocedrus bidwillii*, with alpine scrub at the upper forest limit. Ground cover varies from a cryptogamic and vascular vegetation at low altitudes to litter or bare soil on ridge and many high-altitude sites.

Wekas have been present on Mt Bryan O'Lynn only since the mid-1960s, according to M. Wallace, a local farmer. The birds seem to be colonising adjacent habitat and the study population may not be stable.

METHODS

Wekas were captured in 240 permanently sited drop-door box traps set in lines at 300-m intervals from the forest/pasture margin to the lower limits of the alpine scrub. Each line consisted of 30-40 traps aligned along a contour. From August 1975, all traps were set for three fine nights each month.

In all, 110 wekas were captured, banded and colour marked. For each, the length and depth of the exposed culmen, tarsus length and body weight were measured (Gurr 1947) with vernier calipers accurate to 0.1 mm and a spring balance accurate to 50 g, and the colour of the irides was recorded. On subsequent captures, adult birds were reweighed, but all measurements were taken again for immature birds. Lastly, blood samples were collected from the radial artery of 30 adult wekas and checked for haematozoan parasites.

Free-ranging marked birds were noted incidentally during the possum studies, which kept six observers in the study area for 8-10 days each month. Whenever possible, birds were identified by their colour-band combinations and located precisely on a grid system (Coleman *et al.* 1980). Home ranges were calculated for each marked bird from capture and sighting records with a minimum area polygon technique (MAP) based on the minimum area circumscribed by all sightings (King 1975). Isolated but extensive forays away from their normal centre of activity extended the home ranges of some birds dramatically. A modified MAP technique (MMAP) was developed which excluded any record further away than one half of the range diameter of all other sightings.

From possum trappers working about Mt Bryan O'Lynn, 38

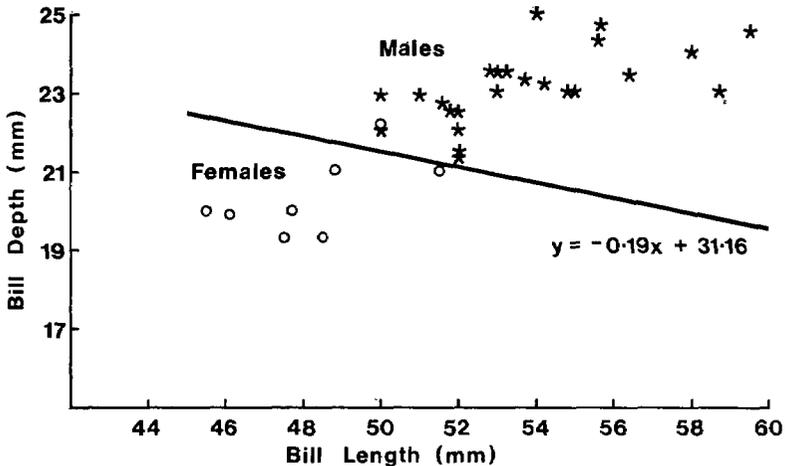


TABLE 1 — Bill measurements of autopsied adult wekas

	MALE			FEMALE			Fs	P
	N	Mean	95% C.L.	N	Mean	95% C.L.		
Total length (mm)	24	53.76	1.026	8	48.20	1.358	31.2	<0.001
Total depth (mm)	24	23.13	0.375	8	20.35	0.679	51.8	<0.001

The age of wekas was indicated by progressively darkening irides as birds grew and matured. Small to very small birds, which by their behaviour towards siblings or parent birds were clearly chicks of the year, always had olive-green irides. Larger birds not accompanied by offspring or by defensive adults, which were larger each time they were measured, were classified as juveniles and usually had liver irides. Birds with chicks clearly were adult and always had red irides. Birds with intermediate liver-red irides, which appeared to be approaching sexual maturity, were harder to age. Some could be aged from their previous measurements and trap history.

Life history

Nests and incubating birds were not seen on Mt Bryan O'Lynn, but 22 adult corpses recovered in June, July and August all had enlarged gonads and one female recovered on 7 June 1979 had a fully developed egg in its oviduct. Five adults taken in November showed no heightened gonadal activity.

The laying period was further indicated by the presence of small but rapidly growing chicks with body weights of 0.2-0.3 kg, seen between early October and late January. As the incubation period for wekas is approximately 27 days (Oliver 1955), we conservatively estimate that females in our study area laid between late June and early December.

Parent/chick combinations were seen from October to April, though mostly before February. We found no chicks weighing less than 0.2 kg, presumably because they did not move about much. Parent birds accompanied and defended broods for several months and were agitated onlookers while young chicks were being measured.

Young birds apparently lose their chick features of body size and iris colour when they become independent of their parents, as all those trapped after April had full juvenile plumage. Adult body weights were attained by mid-winter (AM = 1.33 kg, JM = 1.28 kg, Fs = 0.70, P > 0.50), 6-9 months after hatching, and some young birds bred soon afterwards.

Fifteen broods with attendant parents were seen: six of one chick, three of two chicks, five of three chicks, and one of four chicks —

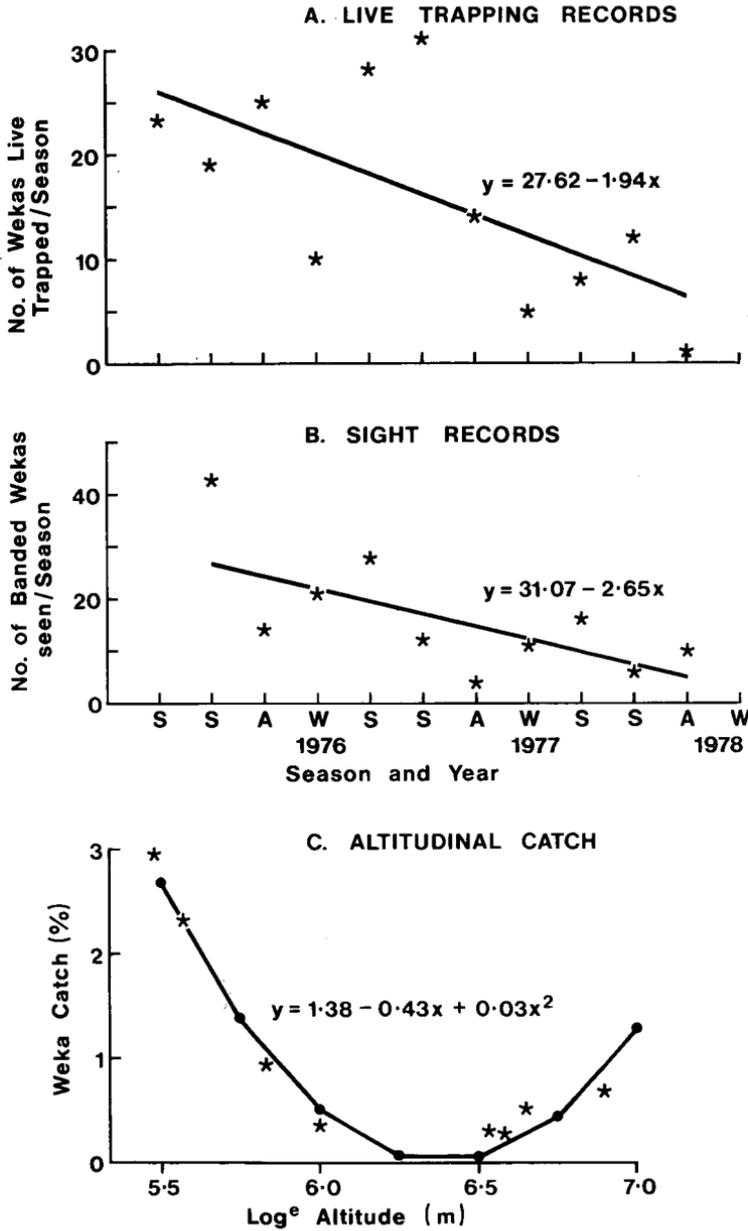


FIGURE 3 — Changes in weka numbers within the study area over time (A & B) and over an altitudinal gradient (C)

a mean of 2.1 chicks per brood. Most of these chicks were in the 0.5-0.8 kg range of body weight and so probably survived to independence. Sequential brooding was recorded for two mated pairs. One pair was seen with three broods over a 10 month period, and the other pair had four broods over 15 months.

Population trends

Numbers and habitat preferences: The combined number of adult and immature wekas trapped each season fell significantly over the 1975-78 study period (Fig. 3A, slope significance : $F_{s, 1,9} = 6.61$, $F_{1,9} (0.05) = 5.12$). Likewise, the number of marked wekas (adults, juveniles and chicks) seen in the study area also fell significantly as the study progressed (Fig. 3B, slope significance: $F_{s, 1,9} = 7.21$). Overall, the number of birds captured and seen in 1978 was about half that captured and seen in 1976.

Wekas on Mt Bryan O'Lynn showed distinct habitat preferences. From trapping records, as shown in Fig. 3C, most were in the low-altitude rough pasture and forest/pasture margins (<300 m a.s.l.), fewest in the mid-altitudinal forest (400-800 m), and intermediate numbers in the high-altitude scrub forest (800-1000 m). Unfortunately, no trapping was attempted in the high-altitude grasslands, although weka 'sign' (probe holes, litter disturbance and feathers) was seen there. Overall, the altitudinal 'catch' was best described by a curvilinear regression of quadratic form which accounted for 96.5% of the sample variation ($F_{s, 2,5} = 68.72$, $P < 0.001$). In addition, 60% of the wekas seen were on the rough pasture or pasture-forest interface, which comprised only 26% by area of the study site. Although wekas are easier to see in rough pasture than in forest, this result supports the trend shown by trapping.

Losses: The disappearance of marked wekas from the study area was substantial. Statistics of dispersion and death are always hard to get and in this study few dispersing birds were recorded or corpses recovered. For example, at the beginning of the final 12 months of the study (June 1977), 100 marked wekas were presumed to be in the study area and yet only 23 were seen again. As resighting intervals for all marked birds averaged 3.1 ± 0.60 months and only 7 out of 110 birds marked were seen after a 12-month 'absence,' most birds marked before June 1977 apparently left the study area. Some infrequently trapped birds may have lived outside the study area and have been captured during isolated forays into it, and others may have been immature transients, but many of the birds that disappeared had long trap histories and must have been residents.

The reasons for most weka "losses" were unknown (Table 2). A few corpses were recovered from commercial possum trappers, and local trapping may have been a significant cause of death. Two long-distance dispersers were found dead (see below) but had no obvious injury. Survival of adults appeared lower than that of juveniles or of chicks.

TABLE 2 — Weka losses

Status at Banding	Number Banded	Corpses Recovered	CAUSE OF DEATH			Survival (%)
			Gin Trap	Unknown	Vanished	
Adult	39	5	3	2	30	10.3
Juvenile	41	3	2	1	23	36.6
Chick	30	-	-	-	24	20.0
TOTAL	110	8	5	3	77	22.7

Information gleaned during this study on weka diseases was inconclusive. The bloods of 30 adult birds showed no pathogenic haematozoa. However, during the autopsy of trap-killed birds, distinct lesions were recorded on the livers of 8 of 32 adults and in none of six juveniles. The lesions were small white spots up to 3 mm in diameter, generally subcapsular but sometimes extending into the liver parenchyma (J. Hutton, Animal Health Division, MAF), and were typical of parasitic granulomas.

Sex ratios: The sex ratio of 38 autopsied birds collected over 3 years significantly favoured males (Table 3A). Similar imbalances were shown by captured birds sexed by the discriminant function based on bill measurements (Table 3B). Here, however, juvenile wekas were hard to assign. Young birds with positive discriminant values were clearly male, but those with negative discriminant values may have been of either sex. At the end of the study the banded population included eight unsexed birds with small bills, but even when all of these were lumped together in the analysis as "young females," males remained more numerous (M:F = 50:24, $X^2 = 8.45$, $0.01 > P > 0.001$).

Sex ratios amongst trapped and seen adults also varied seasonally. Males were most predominant in mid-winter (June/July, Table 3C). As this period coincided with the beginning of breeding, the scarcity of females was probably related to egg laying and incubation.

Body weights: As Fig. 4 shows, adult males were heavier than adult females at all times of the year, with seasonal means showing significant differences ($P < 0.05$). Within the sexes, males were significantly heavier in autumn and winter than in spring and summer ($P < 0.01$). Females showed a similar pattern, but with winter weights not differing significantly from autumn or spring and summer weights ($P > 0.05$). Overall, males and females showed late-winter weight losses of 18.4 and 23.2% respectively, coincident with the onset of breeding.

Perivisceral fat measurements both reflected and influenced the trends recorded for adult body weights. Scale measurements from 10 adults collected in June, 9 in July, 7 in August and 5 in November

TABLE 3 — Sex ratios of wekas trapped or seen

Note: Seasonal data include all capture and sight records collected over the three years of study.

	AM	JM	AF	JF	χ^2	P
A. Autopsy sample	24	3	8	3	5.92	0.05 > p > 0.01
B. Banded sample - Adult	44	.	16	-	12.15	< 0.001
- Adult + juvenile	44	6	16	0	16.50	< 0.001
C. Seasonal Variation	AM	AF	%F	χ^2	P	
Dec/Jan	48	13	27.1	18.95	< 0.001	
Feb/Mar	25	7	28.0	9.03	0.05 > p > 0.01	
Apr/May	36	5	13.9	21.95	< 0.001	
Jun/Jul	24	1	4.2	19.36	< 0.001	
Aug/Sep	34	7	20.6	16.49	< 0.001	
Oct/Nov	45	11	24.4	19.45	< 0.001	

averaged 8.3, 5.8, 5.8 and 2.1 respectively. Skeletal elements such as bill size were also greater in males and Western Wekas clearly follow the usual ralline pattern of males being larger.

Movements and home ranges

To study the movement and home range of any long-lived bird, a large number of marked birds must be seen repeatedly for several years. On Mt Bryan O'Lynn 110 wekas were marked, comprising 39 adults, 41 juveniles and 30 chicks, with 20 young birds seen subsequently as adults. Of 410 resightings only 22 birds were seen on six or more occasions and of these, only 13 were seen as adults. The rest were seldom seen and provided only incidental information on movements. Altogether, our home range information is limited and should be considered indicative rather than absolute.

Birds often moved long distances between sightings on successive days. Adults, on average, moved a minimum of 189.0 ± 80 m ($n = 20$) and juvenile birds 170.0 ± 94 m ($n = 13$), with one young adult moving overnight from the bottom to the top of the study area, a distance of 2050 m (No. 37138, Fig. 1).

The areas of the home ranges occupied by adult wekas seen on six or more occasions varied greatly and appeared to be independent of the period of residency (Table 4, MMAP values). Nine adults were

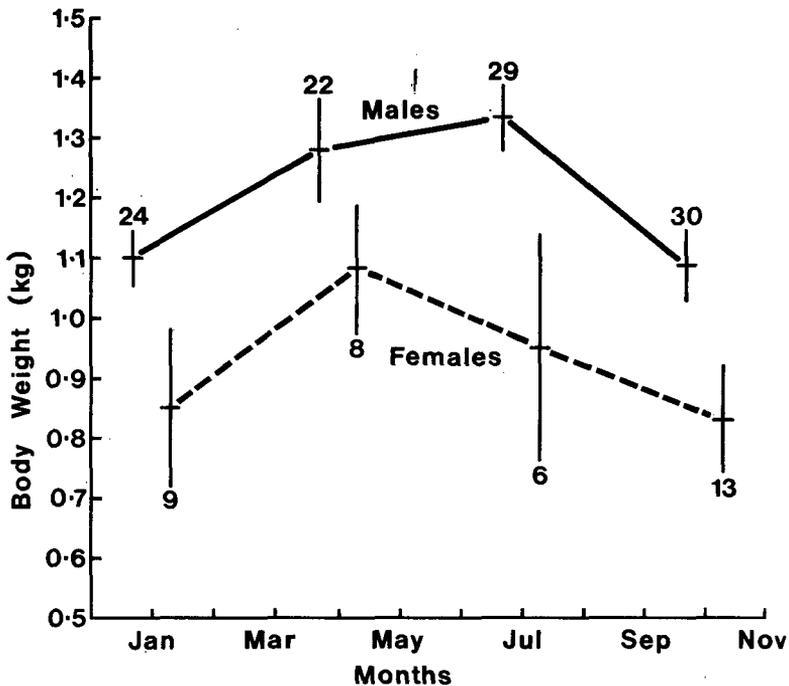


FIGURE 4 — Seasonal variations in the body weights of adult males and adult females. Each seasonal entry is represented by a mean, 95% confidence limits, and the sample size.

confined to areas of 4.5 ha or less. For example, weka 29363 was seen on 22 occasions over 33 months and had a home range of only 1.75 ha (Fig. 1). Even smaller home ranges were recorded for some adults, but these birds were rarely seen. Conversely, four adults had much larger home ranges (e.g. 29364, see Fig. 1) and appeared to move freely throughout them. The data were not robust enough for a detailed study of sex-related home ranges. Only two adult females were seen repeatedly, and their limited ranges may not have been typical.

Home range diameters of adult wekas averaged 710 ± 268 m and, like range areas, were quite variable (Table 4).

Two juveniles were seen on 11 occasions each. Both birds occupied ranges between 5.5 and 6.0 ha, a little greater than that of most adults.

Only five birds were seen often enough as both juveniles and adults to show any change in range location with age. Four moved to new ranges at maturity, while one retained its juvenile range.

TABLE 4 — Home range sizes and range diameters of adult wekas

Band Number	Sex	No. of Sightings	Period of Residency (months)	Home Range Diameter (m)	Home Range Area MAP	Area (ha) MMAP*
29363	M	22	33	300	1.75	1.75
29364	M	16	25	1000	28.25	28.25
29381	M	6	5	290	0.50	0.50
29382	M	6	33	900	11.00	1.75
37101	F	7	20	425	3.75	0.50
37104	M	10	18	600	7.75	4.50
37113	M	8	7	800	9.25	9.25
37119	M	9	17	850	2.25	1.65
37124	M	11	15	700	14.75	14.75
37130	M	10	9	350	3.00	2.00
37135	F	8	5	400	2.50	2.50
37138	M	8	9	2100	69.00	12.75
37159	M	6	3	500	1.10	0.75

Note: MAP and MMAP expanded in methods section.

Some data on the long-range dispersal of wekas was obtained. The most dramatic were an adult male found dead 35 km from the study site 7 weeks after banding and an unsexed juvenile found dead 9 km away 6 weeks after banding. Lesser movements were shown by two other unsexed juveniles seen 2.0 and 4.5 km from the study site about 12 months after banding. All four recoveries were made beyond major rivers or lakes, and two from beyond major mountain ranges.

Foods

The foods identified from 35 Western Wekas taken mostly in winter consisted of a very wide range of plant and animal tissues (Table 5). Dominant vegetative items included both plant foliage and fruits, mostly from forest species. Animal foods included invertebrates and vertebrates. In addition, all birds contained enough gravel to suggest deliberate ingestion.

The commonest food was fruit scavenged from the forest floor. Large numbers of seeds of *Coprosma* spp. (particularly *C. pseudocuneata*, *C. parviflora*, *C. rigida* and *C. rhamnoides*) occurred in 86% of all stomachs examined. Other hardwood fruits included those of *Carpodetus serratus*, *Myrsine divaricata* and *Pennantia corymbosa*.

TABLE 5 — The foods identified from the stomachs of 35 wekas

CLASSIFICATION	N	%F	%F ^C
<u>Plant Foods</u>			
Foliage - Dicotyledoneae	-	65.7	16.7
Monocotyledoneae	-	17.1	61.1
Pteridophyta	-	28.6	11.1
Seeds - Forest spp. - <u>Coprosma</u> spp.	1875	85.7	5.6
<u>Nertera</u> sp.	250	25.7	-
<u>Podocarpus</u> spp.	34	20.0	-
<u>Dacrydium</u> sp.	125	2.9	-
<u>Carex</u> sp.	32	14.3	-
Other	62	20.0	/
- Pasture spp. - Gramineae	9	8.6	50.0
Other	5	8.6	/
<u>Animal Foods</u>			
Insecta - unident. remains	-	51.4	/
Diptera	14	11.4	5.6
Coleoptera	20	8.6	>44.4
Other	4	11.4	>50.0
Arachnida	8	22.9	5.6
Crustacea	1	2.9	22.2
Myriapoda	1	2.9	38.9
Mollusca	5	5.7	5.6
Annelida	-	80.0	66.7
Vertebrata - Reptilia	1	2.9	-
Amphibia - <u>Litoria</u> sp.	1	2.9	-
Marsupialia - <u>Trichosurus</u> sp.	-	14.3	-
Rodentia	2	5.7	-
Unident. flesh	-	22.9	-

Note: N - Total number of items ingested, %F - Percentage of stomachs containing each food item. Items which defied numerical estimation have been scored only as %F.

%F^C gives percentage frequency of food items of 18 North Island Wekas (Gallirallus a. greyi) taken during June-August (Carroll 1963a) when data are comparable. Items identified from both studies but not in a comparable form (/) and Western Weka food items not identified by Carroll (-) are also listed.

Fruits of *Podocarpus ferrugineus* and *P. totara* were also taken. Fruits of pasture species were insignificant in the diet. Foliage occurred in many stomachs, mostly as unidentified dicotyledonary tissue, but grasses, fern and moss leaves were also common.

Wekas ate a wide range of invertebrates, mostly insects, spiders and worms. Few birds ate vertebrates but the size of the vertebrates made them more important in the diet than their numbers suggest. Thus, remains from a lizard, a frog, two rodents and several possums were identified as well as several unidentified portions of flesh. The wekas had probably captured the smaller vertebrates but scavenged the possum tissue from carcasses. Other mammals were also eaten because on one occasion, we saw a weka kill a young (1 kg) hare.

DISCUSSION

The population statistics of *Gallirallus a. australis* outlined above show close agreement with those presented in the limited literature available. The most striking observation made during the present study was the apparent reduction in population size between 1975 and 1978, indicated through trap catches and live sightings, despite seemingly unlimited food and vigorous breeding, i.e. clutches of up to four eggs, multibrooding (also recorded elsewhere, see Trail 1951, Martin 1954), attentive and defensive parents, and rapid maturation of chicks. Trap catch alone is unconvincing evidence of population change as wekas clearly differ individually in how readily they can be trapped. Live sightings of marked birds is a more reliable indicator of population change, as free birds seemed uninterested in nearby human observers throughout the study period. Certainly, there is no evidence of an increasing avoidance of observers as the study progressed. Taken together, we believe trap catch and live sightings reliably reflect trends in the total population.

Fluctuations in weka populations are almost legendary. Not only have there been dramatic reductions in the overall range occupied by the species since European colonisation, but in the last half century many local colonisations and population collapses have been recorded, e.g. Davenport (1950), Gee (1956), Carroll (1963a). Suggested reasons have included local migrations (Oliver 1955), burning of tussock lands (Smith 1888, Buller 1898), death in possum traps (Moncrieff 1941), avian epidemics (Carroll 1963a) and predation by small mammals (Kirk 1895, Deeming 1948). However, Williams (1973) argued that wekas appeared to maintain themselves quite successfully in the presence of mammalian predators. The presence of stoats (*Mustela erminea*), rats (*Rattus* spp.) and feral cats (*Felis catus*) has not prevented the weka from recently colonising our study area or other South Island areas known to us, and so predators are unlikely to cause the weka's demise elsewhere.

Food is a factor which limits some bird populations, particularly of species with specialised diets (Lack 1954). Western Wekas appear

quite catholic in diet, and the same seems true of the North Island Weka (Carroll 1963a, see Table 5). Birds in both areas rely heavily on foliage, on insects and on earthworms. Dietary differences result mainly from the differences in the habitat occupied by wekas in each area. Thus, birds taken from a forest-dominated environment in Westland depend heavily on the fruits of forest species. By comparison birds collected from rough pasture/scrubland situations about Gisborne depend largely on the fruits of Gramineae and pasture weeds. Vertebrates were commonly taken by Western Wekas but only rarely by Gisborne birds. Altogether, the availability of food seems unlikely to be limiting the weka population of this study.

Likely reasons for local weka losses are avian diseases, endoparasites, or both. Laird (1950) argued that avian diseases are "perhaps the only theory which can even partially explain the wholesale disappearance of certain species . . ." No avian diseases were detected in our study. However, a heavy infestation of an endoparasite was recorded and although its identity is unknown, its incidence and the amount of non-functioning liver tissue indicate a local epidemic leading at the very least to birds in suboptimal health. Similar parasitic granulomas have been seen in other wekas and in Pukeko (*Porphyrio porphyrio melanotus*) (J. Hutton, AHD, MAF), but their effect on the host is not known.

Weka samples trapped or sighted in the study area contained a preponderance of males amongst both juveniles and adults. Sex ratios in nature are not always at 1:1 equilibrium ratio — indeed extraordinary sex ratios are frequently described (Hamilton 1967). Some form of sampling bias can often be responsible, although in the present study we found no evidence that female wekas are less mobile or observable than males. Trapping may well have been male selective, and if so, would in turn have led to male-dominated sight records. The strongly biased kill-trap sample was less easily dismissed, as there wekas were taken in unlured gin traps set on possum 'runs' which rely on animals unwittingly entering them. We therefore argue that such consistent and overwhelming bias must reflect the sex ratio of the total population. Such an imbalance in the sex ratio of a monogamous species like the weka is unlikely to be a permanent population feature. We suggest that the reduction in population size recorded in this study could be due to a recent differential loss of females, resulting from a seasonal increase in the pathogenicity to females of the liver parasite described. For all birds, the liver stores considerable food reserves which in females are in part mobilised for egg production (Bellairs 1964). Thus a decrease in liver function for whatever reason can result in critical physiological stresses during egg laying.

The recolonisation by wekas of lands formerly occupied by them occurs freely and frequently and is attributable directly to the species' remarkable mobility and dispersal capabilities — especially when its flightlessness is borne in mind. Seemingly severe geographic barriers

are overcome regularly and with ease. Blackburn (1964) and Trail (1951) recorded wekas regularly swimming substantial rivers and estuaries, Penniket (1955) found abundant weka sign on the crests of mountain ranges, and Robertson (1976) recorded a weka 'transplant' moving about 300 km in 6 weeks, including a traverse of the Auckland Isthmus. Not to be outdone, Wright (1981) reported three transplanted birds returning to old home ranges in several days via 900 m of strong tidal current. By comparison, dispersal movements witnessed in the present study almost pale into insignificance, except that the outflow of young birds into adjacent weka-free areas may also help account for the real losses of birds recorded from the study area.

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SHORT NOTES

GREY-BACKED STORM PETREL ON ROUTEBURN TRACK

On 5 November 1982 at about 10 p.m., Dean Sander found an unusual bird on the verandah of Lake Howden Hut (708 m) in Fiordland. The bird was in good condition. At the time there was a strong NW wind, heavily overcast sky and complete darkness. The only light in the hut was from a Tilley lantern.

On 6 November I collected the bird and noted these features: size the same as a South Island Robin (with which I am very familiar); charcoal-grey head, upper back, throat and upper breast; silver-grey lower back and rump; white from the lower breast to the undertail coverts; white underwing with a dark border on the leading edge; black long legs; black webbed feet; short dark bill with prominent nostril tubes. I identified the bird as a Grey-backed Storm Petrel (*Garrodia nereis*) from Harper & Kinsky's 'Southern Albatrosses and Petrels' (1978).

In the afternoon I released the petrel at Milford Sound in calm conditions. The bird repeatedly dipped its head in the sea before swimming and fluttering across the sound.

KIM MORRISON, *Box 29, Te Anau*



WHY IS THE KIWI SO CALLED ?

In *Notornis* 28: 216-217 Rogan Colbourne speculated on the origin of the name *kiwi* as applied to the New Zealand birds, and made the point, surely noticed by others, that the name is not particularly onomatopoeic in its New Zealand context. While in Hawaii I had occasion to consult a Hawaiian dictionary and noticed that *kiwi* in that dialect means "bent" (the example given being "as in a horn of an animal").

Therefore, it seems logical that the dialectal variation *kiwi* is used by the Cook Islanders as their name for the Bristle-thighed Curlew (*Numenius tahitiensis*). Presumably the same word was applied by the original human inhabitants of New Zealand as a name for *Apteryx* for the same reason. However, the Hawaiian name for the Bristle-thighed Curlew is *kioea*, and *kiwi* is not used as a bird name in Hawaii, the nearest being *'iwi* or just *iwi*, which means reddish; and in fact, the *'iwi* (*Vestiaria coccinea*) is the reddest of all the honeycreepers and also has a curved bill. "Bent" or "curved" in Maori is *piko* or *tiwhana*.

I, like Rogan Colbourne, look forward to further comments on this matter.

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A BANDING STUDY OF NORTH ISLAND BROWN KIWIS IN AN EXOTIC FOREST

By ROGAN COLBOURNE and RUUD KLEINPASTE

ABSTRACT

Territory, distribution and dispersal of the North Island Brown Kiwi (*Apteryx australis mantelli*) were studied at Waitangi State Forest, Northland, from February 1981 to July 1982.

In all, 84 kiwis were banded and individually coded and 220 resightings were recorded. Weights and bill measurements are given, together with some growth rate data. Territories of 23 birds are shown and these approximate 5 ha per adult pair, but territory size may decrease with greater abundance of food and with immigration from logged areas. Kiwis frequent many burrows within fixed territories, and males defend these territories from other pairs, primarily by calling. Juveniles under 1 year old are accepted in these ranges, whereas larger juveniles and some females do not have regular haunts.

Kiwis try to retain their territories in the face of logging and other forest management practices and this behaviour demonstrates the importance of site attachment. Swamp margins and swamp arms are important to kiwis as a temporary refuge after clearfelling and as feeding areas during dry periods of the year. Despite the forestry practices the Waitangi kiwi population is thought to be viable.

INTRODUCTION

Ever since its discovery the kiwi has generated scientific curiosity. However, owing to the species' nocturnal habits and wariness, which makes it difficult to study in the field, most research has centred around anatomy, evolution and taxonomic affinity, and physiology. No detailed studies have been published of the ecology of kiwis in the wild.

Corbett surveyed the North Island Brown Kiwi population in Waitangi State Forest by means of a systematic vocalisation count from July until November 1978. His unpublished report (Corbett *et al.* 1979) includes a map giving the location of kiwi pairs and single birds within the forest. This map shows areas of high kiwi densities and areas with almost no kiwis.

The New Zealand Forest Service decided to fund a further ecological study of the Brown Kiwi population in Waitangi State Forest, covering topics such as feeding ecology, movements and dispersal, and the influence of exotic forest management. The field work for this study was done from February 1981 to July 1982 in liaison with the

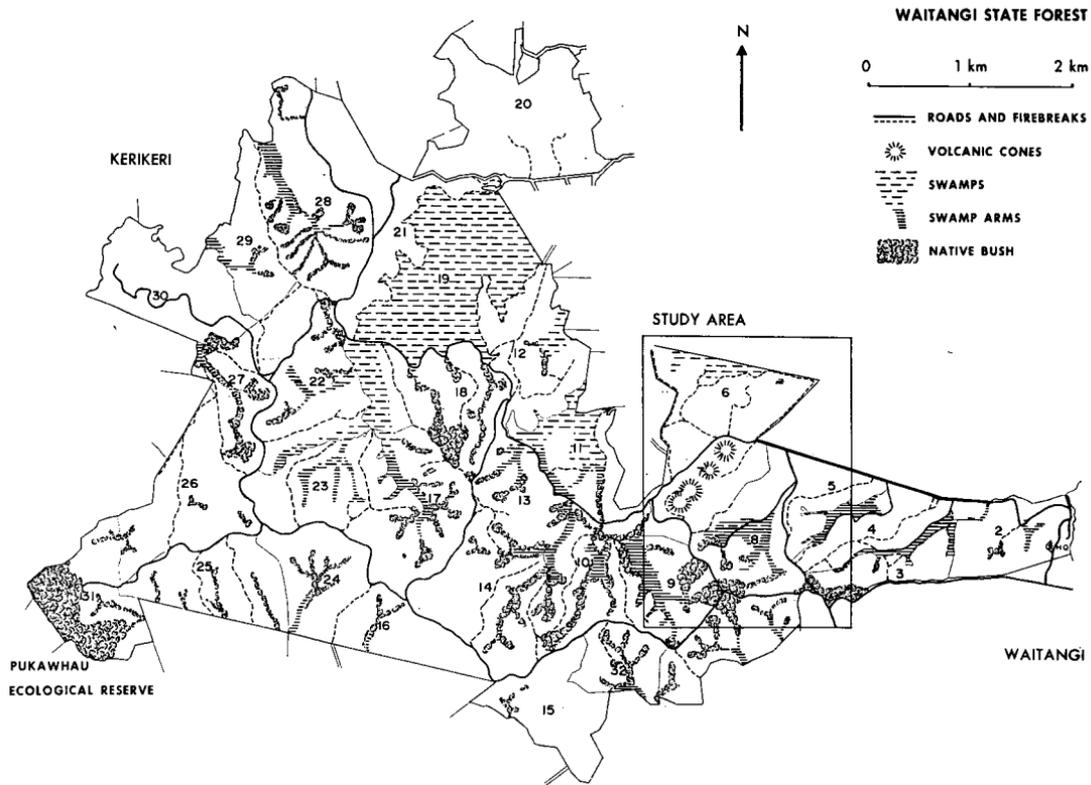


FIGURE 1 — Map of Waitangi State Forest, showing the location of the study area

Wildlife Service (Department of Internal Affairs) and the Entomology Division of DSIR.

STUDY AREA

Waitangi State Forest (Fig. 1) is a small exotic plantation situated between Waitangi and Kerikeri in the Bay of Islands (35°15'S 174°02'E). Of its 2888 ha, 2000 ha are planted in exotic trees, mostly pines, and the rest is remnant native bush, particularly in the steep gullies, and extensive swamp fingers in the valleys. The chosen study area, encompassing compartments 5, 6, 7, 8 and 9, lies within the eastern half of the forest, measures approximately 350 ha, and contains a medium to high density of kiwis in a diverse range of habitat types. Until recently *Pinus elliottii* was the most common crop but a policy of replanting with *P. radiata* has changed that rapidly. The topography consists of a system of ridges and gullies with steep slopes (compartments 5, 8 and 9) with moderately leached podsolized clays that are very muddy in winter and rockhard in summer. Flat areas broken by volcanic cones around compartments 6 and 7 consist of rich black soils of volcanic origin.

In an exotic production forest the plant cover constantly changes. Compartments are logged, the ground is bulldozed or burnt, trees are planted, sprayed, thinned, pruned, and logged again, to complete the cycle. In this situation successional stages of undergrowth proceed from bracken (*Pteridium aquilinum*) and inkweed (*Phytolacca octandra*), to gorse (*Ulex europaeus*) and manuka (*Leptospermum scoparium*), and later, as the pine stand matures, to mingimingi (*Cyathodes fasciculata*), treeferns (*Alsophila tricolor* and *Sphaeropteris medullaris*), tobacco weed (*Solanum mauritianum*), hangehange (*Geniostoma ligustrifolia*) and a variety of native shrubs. Logging of mature pines and subsequent burning of the slash were proceeding in compartment 8 during our study.

METHODS

The Brown Kiwi population in the study area was surveyed in the first three months of the study to get an impression of numbers and distribution of the birds. This survey was carried out by monitoring kiwi vocalisations from permanent listening stations which were regularly spaced along roads and ridgetops.

In places with dense obstructing undergrowth, tracks were cut for easier access at night. Kiwis were caught by hand after chasing on foot and banded with a metal serial band (R-size; butt-ended). Self-adhesive reflective tape (Scotchlite; available in seven colours) was fixed to the bands in various combinations enabling each bird to be individually colour coded. To increase the number of possible colour combinations, a plastic leg band with reflective tape was sometimes used on the other leg. Reflective tape not only made a kiwi more conspicuous during a pursuit in torchlight but made recognition of individuals possible without resorting to recapture.

Each captured kiwi was weighed with a Pesola spring balance, accurate to ± 0.03 kg and the bill length (from the tip of the upper mandible to the concave of the cere) was measured with vernier calipers accurate to ± 0.03 cm. The sex of the bird was determined by the call it made before it was pursued or if it did not call, by the length of the bill. Kiwis with bills longer than 11.7 cm were considered to be females (Reid & Williams 1975) while those with bills shorter than 11.7 cm could be males or juveniles. Males may also show conspicuous brood patches during the incubation period.

Sites of capture, resighting or recapture of each bird were carefully plotted on transparent sheets over a map of the study area so that territory, movements, and the spatial relationships of neighbouring kiwis could be determined.

RESULTS AND DISCUSSION

Weight and bill length

Females at Waitangi were, on average, 16.5% heavier than males and their bills were 24.4% longer. The range of weights of 31 adult females was 2.06-3.85 kg (mean 2.54) and of 15 adult males was 1.72-2.73 kg (mean 2.12). The mean bill length for 40 adult females was 13.02 cm (range 11.70-14.20) and for 22 adult males was 9.84 cm (range 8.98-10.56).

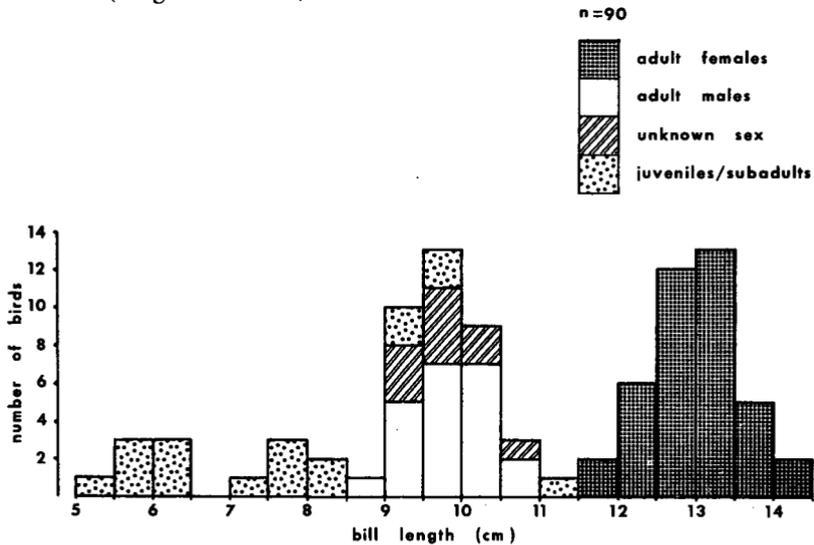


FIGURE 2 — Histogram of North Island Brown Kiwi bill lengths from Waitangi State Forest

Bill measurements gave a bimodal distribution separating the adult sexes without overlap (Fig. 2). No adult male in the sample had a bill longer than 10.60 cm. The weights of kiwis (Fig. 3) showed much overlap between the sexes. On average, females were larger, but only 16% of the females were consistently heavier than the heaviest recorded male.

Most measured adults lost weight (up to 16%) from late November 1981 to mid-February 1982 (Fig. 4). The most important cause was considered to be the sharp decline in soil penetrability due to the "drought" conditions of summer because a female occupying a territory in an irrigated part of the forest was the only bird, other than chicks, that gained weight during this period. However, other factors could contribute to weight loss. In summer most of the permanent soil-dwelling invertebrates (e.g. earthworms) migrate to the moister, lower, soil levels and other important soil-dwelling invertebrates (e.g. cicada nymphs and scarabaeid larvae) emerge in summer, temporarily decreasing the amount of food in the soil. Moreover, in Northland, nights in midsummer are about 5 hours shorter than in midwinter and so time available for feeding is less.

This summer weight loss was not related to breeding because the peak egg-laying period was from July to September (Colbourne & Kleinpaste, in prep.) and only one male captured in summer had a brood patch.

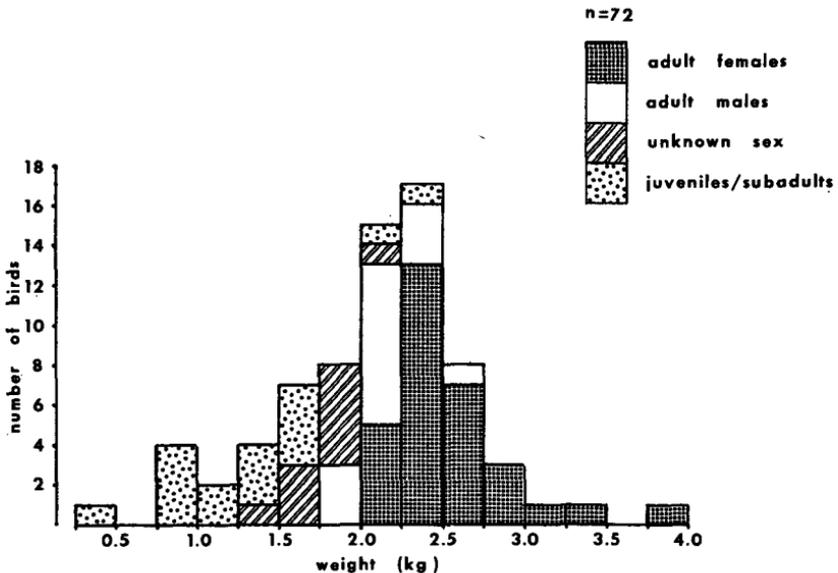


FIGURE 3 — Histogram of North Island Brown Kiwi weights (weights at first capture) from Waitangi State Forest

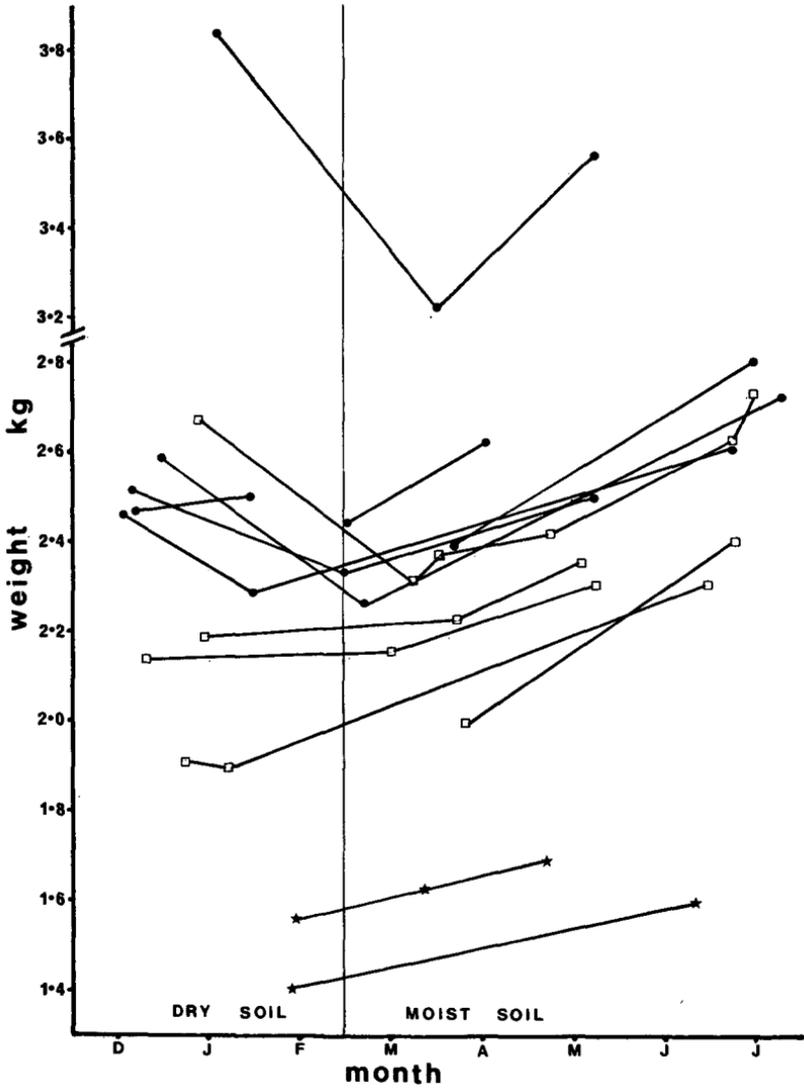


FIGURE 4 — Weight changes of Brown Kiwis from December 1981 to July 1982 (females, black dot; males, box; and juveniles, star)

Kiwis carry an exceptional amount of subcutaneous fat, which can represent 30% of the body weight, and so they can survive for three weeks without food (Reid & Rowe 1978). The importance of fat can be attributed to the males' reduced foraging while incubating, to the females' higher energy requirements before egg laying, and to the need to survive the regular dry periods in summer, when food is in short supply.

If, indeed, bill growth is fastest shortly after hatching and progressively decelerates with increasing age until a limit is reached, then by measuring changes in bill length, over time, we should be able to provide information to separate juvenile females from unconfirmed males, male juveniles from female juveniles, and subadults from adults.

A chick estimated to be 1 month old when first caught (bill 5.09 cm, weight 0.36 kg) showed a bill-length increase of 13.2 mm in 70 days (a growth rate of 5.7 mm per month). Juveniles estimated at 1-1.5 years old had an average bill growth rate of 1.5-3.0 mm per month. Kiwis 1.5-2 years old had reached the body size of adult males but, because some bills were still growing, we could distinguish juvenile and subadult females from adult males. As shown in Figure 5, the bill growth rate of one juvenile tapered off at approximately 9.5 cm, indicating that it was a male, whereas the bills of other birds continued growing steadily at 2.0 mm per month past this limit, perhaps showing that the birds were females. From only one measurement, bill length gives no indication of an adult's age. Although some females' bills had stopped growing at about 12.2 cm, one female's bill was slowly increasing at 14.0 cm.

The measured bill length of one male actually regressed by -0.7 mm. This bird was at its maximum weight in June and due to 'obesity' the cere had pushed forward over the bill making the bill seem shorter. There was no correlation between bill length and weight within each sex (Pearson's correlation test; females: $r = 0.09$; males: $r = -0.12$).

Eggs

Two empty egg shells were found measuring 13.51 x 8.02 cm (compartment 31 : indigenous forest) and 13.47 x 8.00 cm (compartment 9 : *Pinus radiata*). Compared with measurements of 107 wild North Island Brown Kiwi eggs (Reid 1981), these are among the largest found to date. Two eggs from a nest measured 12.10 x 8.23 and 11.97 x 7.64 cm (compartment 5 : *Pinus elliottii*, 19 August 1982).

Moult

No detailed data were collected on kiwi moult. However, we found new feathers emerging from the skin in most months, and so moulting may be continuous. In midwinter, feathers were noticeably larger than in summer (pers. obs.), which may indicate better nutrition in winter rather than a specific moulting season.

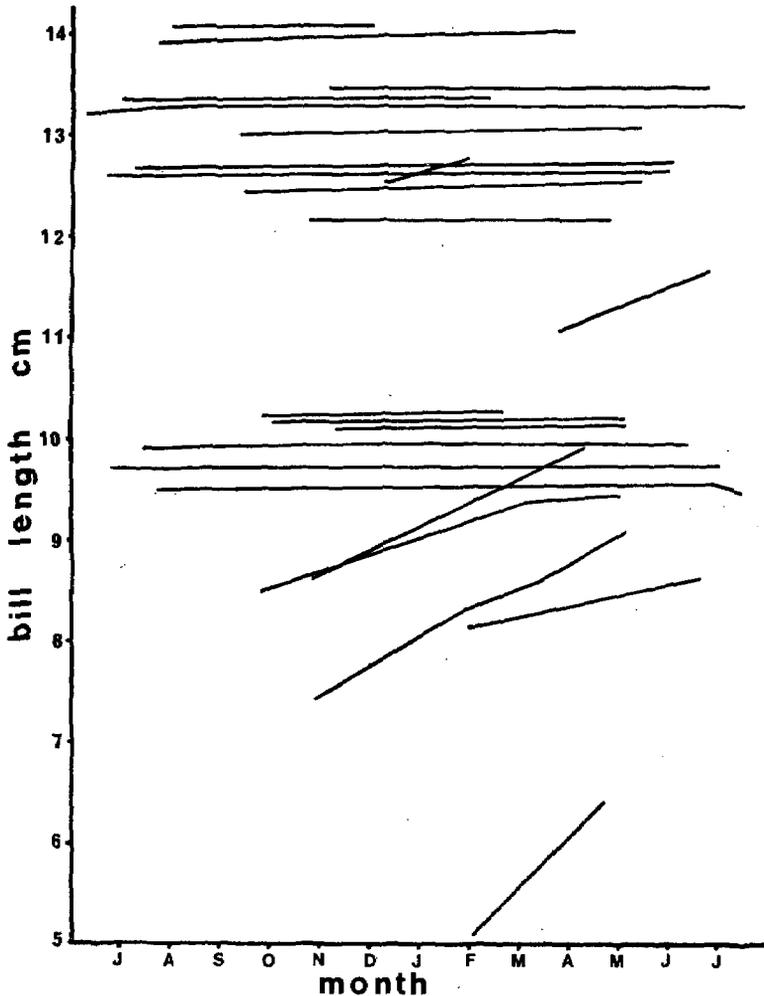


FIGURE 5 — Kiwi bill lengths and growth rates, July 1981 to July 1982

Distribution and territory size

The estimated positions of calling birds were combined with later sightings of banded and non-banded individuals to give the distribution of kiwis within the study area as shown in Figure 6.

From May 1981 to July 1982 we banded 84 kiwis: 38 adult females, 22 confirmed adult males, 10 juvenile females/unconfirmed males and 14 juveniles. In addition, four chicks were captured but

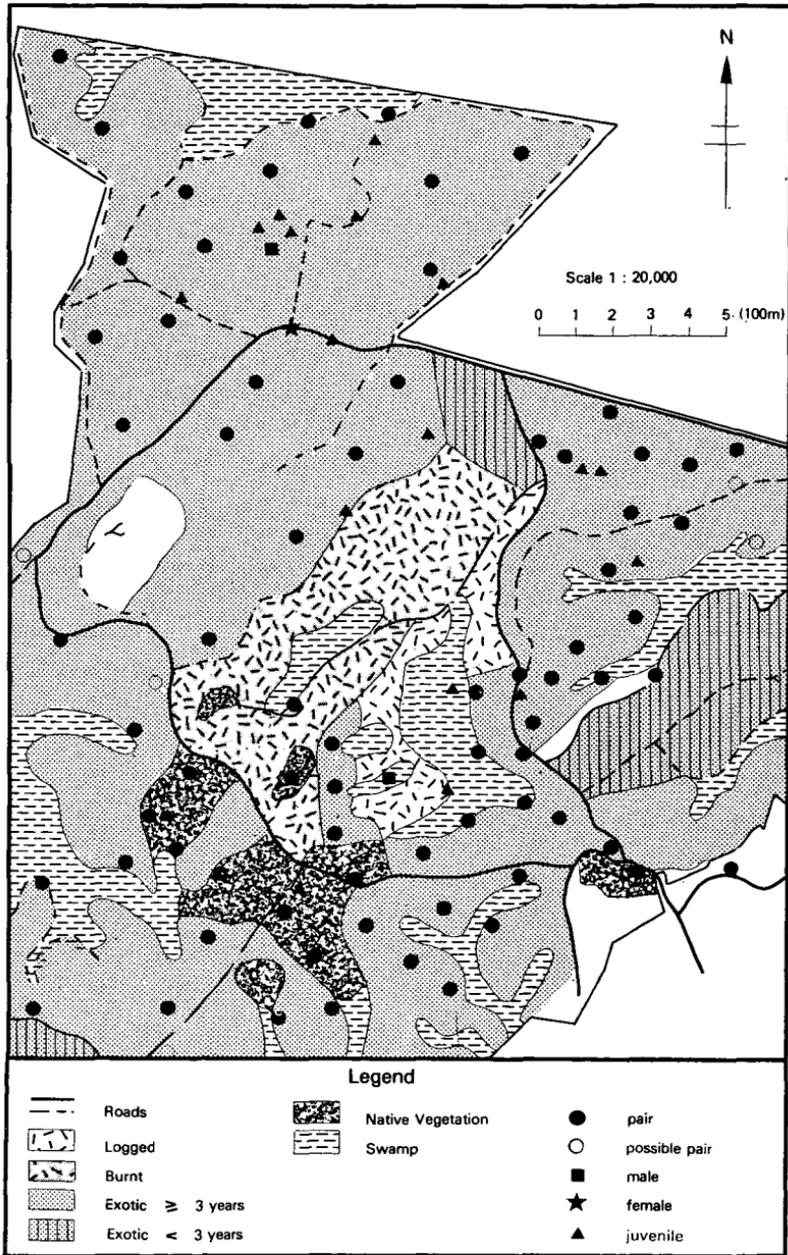


FIGURE 6 — Distribution of Brown Kiwi in the habitat types of the study area, Waitangi SF, 1981-1982

were too small to band. Females, although less vocal, were caught more often than males, which can be explained as follows. A number of males are incubating eggs for at least 2½ months of the year and leave their nests only infrequently or for short periods to feed (Buller 1888; Robson 1947; Reid & Williams 1975; Reid & Rowe 1978). Moreover we found that males are more wary of human noises, run faster than females, often in a zig-zagging fashion, and are more likely to "freeze" suddenly or hide under ferns or behind logs when pursued. They are therefore very hard to catch.

A total of 220 sightings and recaptures of 59 banded birds gave a series of sites which were plotted on maps. Figure 7 shows the results of repeated recaptures or resightings of 23 banded birds within the northern part of the study area. The accuracy with which a territory can be plotted on the map depends on the number of recaptures of a bird. In the generally flat and undisturbed compartments 6 and 7, the territorial areas of kiwis recaptured 15 times or more all approximated 5 ha.

The peripheries of territories often followed physical boundaries such as differences in vegetation and age of plantings, ridges, valleys, volcanic cones, roads and firebreaks. Areas of overlap occurred between neighbouring pairs, but the epicentres of the plotted territories were rather evenly spaced. Mean distance between epicentres was 250 metres. Territories which included swamp valleys and native bush gullies tended to be somewhat smaller, and we thought this to be partly food related. Significantly more invertebrate food is available to kiwis in the soil and litter at the bottom of the slopes and at swamp margins than higher up on the ridegetops ($t_s = 3.13$; $x = 0.05$; 22DF; Kleinpaste & Colbourne, in prep.). The soil in the valleys and native bush gullies is also moister and so easier for kiwis to probe. In terms of biomass, the native bush gullies contain 35-95% more invertebrates in the soil and litter than do the drier pine stands (Kleinpaste & Colbourne, in prep.). As a result kiwis inhabiting these valleys and gullies could subsist in a somewhat smaller territory than those inhabiting higher or drier areas.

In the southern and eastern edge of compartment 8 and in compartment 5, the density of kiwis was much higher than average, territory size being approximately 3 ha. We believe that past logging operations elsewhere in compartment 8 and in compartment 4 had forced kiwis out of their initial territories into the adjacent intact pine stands. No territories were found smaller than 3 ha.

Multiple burrows — movements within territories

We use the term "burrow" for a kiwi daytime shelter site. Over 95% of the burrows found in Waitangi State Forest were at ground level in vegetation such as large clumps of toetoe (*Cortaderia toetoe*) or under dense bracken cover, hanging dead treefern fronds, or pine slash covered with a thick layer of fallen pine needles. In

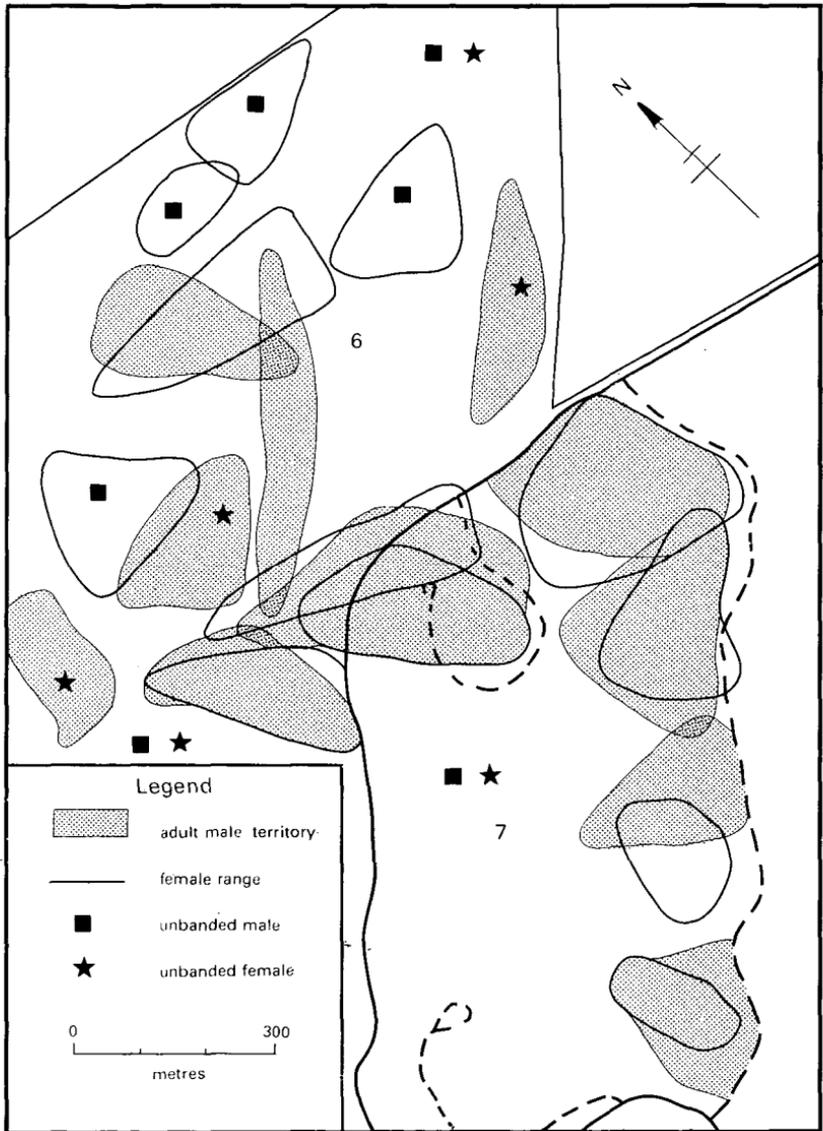


FIGURE 7 — Kiwi territories, determined from banding recoveries in compartments 6 and 7, Waitangi SF, 1981-1982

addition, hollow logs and piles of volcanic boulders provided convenient natural burrows, requiring little excavation. We found only four elaborate burrows dug into banks, each with an entrance (diameter c. 13 cm) which led gently downwards to a chamber of about 27 cm wide by 27 cm high at a depth of 30-75 cm. Eggshell fragments showed that these burrows had been used for breeding. Other nests resembled the daytime shelter sites and one nest with two eggs was merely a simple cavity in the pine litter on the forest floor.

Each territory had many burrows, some of which were in use from time to time. We often saw banded kiwis emerging from their burrows shortly after sunset but, on our return to these locations the next evening, would see no birds. Some of these same birds were seen emerging from other burrows elsewhere. The "waking-up" calls of a bird shortly after sunset also indicated the position of its sleeping site; often these calls came from quite different directions on successive nights.

Similarly, feeding places changed within territories, judged by the distribution of fresh probing sign. A kiwi would work over a certain area of its territory for a variable number of nights and then shift to another area within its territory. Changes of feeding area were unpredictable. These and the foregoing observations suggest that the territory of a pair is an accumulation of smaller ranges, centred around various burrows.

Seasonal movements within territories

During the driest months of the year, December to February, the soil on the mid and upper slopes of the hills in the forest became rock hard and almost impenetrable for kiwis. As the kiwi at Waitangi extracts approximately 78% of its food from the soil (Kleinpaste & Colbourne, in prep.), these dry conditions are unfavourable for the birds. In spite of this, kiwis were seen feeding on ridgetops, particularly on the grassy road verges where black field crickets (*Teleogryllus commodus*) occurred in high numbers. However, field observations and the results of faecal analysis showed that, during drought, kiwis spent more time feeding along lower slopes and moist swamp margins than on the mid and upper slopes. Birds occupying territories that did not include swamp areas were not seen moving out of them in a desperate search for food, but they did lose much weight.

Juveniles and straying adults

Younger juveniles and chicks regularly frequented areas which were often congruent with the territory of an adult pair. Most of the juveniles and all of the young chicks found were wandering by themselves with no indication of the nearby presence of adults. Several family groups of three kiwis, including juveniles, were seen feeding close together, suggesting that juveniles are tolerated within their parents' territory for at least 1 year. Robson (1947) found that juveniles do not make the adult call until they are 1 year old.

When these birds had left or had been evicted from their parents' territory, they were found roaming randomly (Fig. 8). The youngest ages reported for sexual maturity of captive North Island Brown Kiwis are 2 years for a female and 14 months for a male (Calder & Rowe 1977). Presumably, a pair bond takes longer to establish in the wild, as young males first have to find and secure a territory before starting to solicit for a mate. If space is not available for young to establish territories, it could be expected that, in a stable environment, a kiwi population would disperse by means of its juveniles.

A few banded adult kiwis in Waitangi State Forest did not seem to hold a territory (Fig. 8). Three females were recaptured 600, 1000 and 1200 metres away from their respective initial capture sites. One female seemed to commute between two areas about 1000 metres apart and separated by a volcanic cone. This bird was once seen with a possible mate in compartment 7, but the other straying birds were thought to be unpaired.

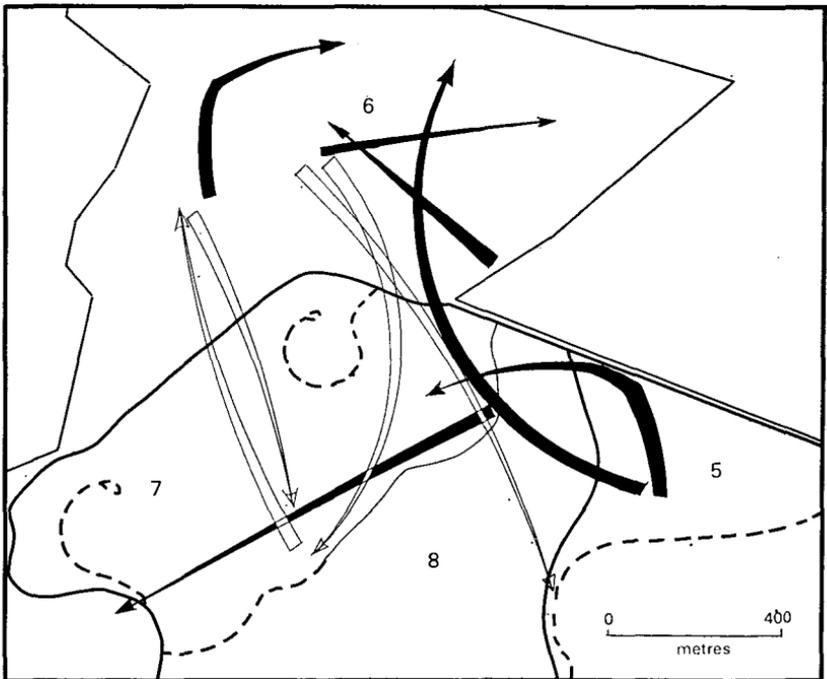


FIGURE 8 — Movements of six juveniles (dark arrows) and two females (light arrows) in the northern half of the study area

Repercussions of forest management

Clearfelling of exotic stands in winter, spring and summer and the subsequent burning of the slash and litter in autumn are management practices that modify the kiwis' physical environment to the extreme. The New Zealand Forest Service management policy for Waitangi State Forest deliberately excludes the modification by logging or burning of remnant swamp areas and native bush gullies. We followed the movements of eight banded birds occupying territories in a logging area in compartment 8, and all kiwis were accounted for during those operations.

When a territory was logged, the occupants were seen to be feeding in the open for periods up to 7 weeks, thus showing a considerable reluctance to vacate their heavily modified environment. We did not discover whether they slept in the logged areas under the extensive piles of slash or commuted from nearby swamps or native bush gullies.

Gradually the "logged-out" kiwis established themselves around the swamp margins, from where they later dispersed to adjacent pine stands. By the time of the burn-off, 2-6 months after clearfelling, these kiwis had vacated their logged territories, thus surviving the danger carried by this aspect of forest management.

One factor inducing the birds to leave is the gradual but eventually drastic decline of invertebrate populations in litter and soil due to drying out by wind and direct sunlight. In a burnt area the litter invertebrates are absent altogether and soil-inhabiting invertebrates have moved to deeper moister levels (Kleinpaste & Colbourne, in prep.). Occasionally, probing sign was found in burnt compartments and one female, banded two weeks before her territory was logged, was recaptured 6 months later at the same site a week after the burn-off. Her initial range included part of a small native bush gully and she may have stayed there after clearfelling and during the fire.

Although kiwi habitat is destroyed by logging in an exotic forest, replanting creates new habitat. A survey in Puhipuhi State Forest (Colbourne 1982) revealed a high density of Brown Kiwis when all of that exotic forest was into its second production cycle. Therefore, current forest management practices and a large viable kiwi population may be compatible. However, we stress that the length of time between clearfelling and burning should not be less than 2 months, thereby allowing the soil to dry out and the birds to leave their clearfelled territories. This would greatly enhance the birds' chances of survival at that stage.

Aspects of behaviour and social structure

A nocturnal ground-dwelling bird with limited eyesight such as the kiwi faces a different set of problems than its diurnal free-flying counterparts. It cannot overlook its territory at a glance and has to rely on its well-developed senses of smell and hearing for its feeding,

territorial spacing and survival. It could be advantageous for a kiwi to be intimately familiar with all parts of its territory. This seems to be so because birds chased for banding know exactly where to go at a fast pace without crashing too much into tree trunks or other obstacles. They usually run straight to the nearest thick cover in the form of a dense bracken patch or impenetrable slash or swamp. With fixed territory, birds can acquire detailed knowledge of the best feeding sites, sleeping sites, and in the breeding season, of the best nesting sites (Tinbergen 1964).

In the undisturbed compartments 6 and 7, kiwi pairs frequented the same territories for more than a year, which, with the observed territory familiarity, could indicate that the pair bond is long lasting and that the territories remain the same from year to year. Further study of the banded kiwis could clarify these points. The territorial borders of kiwi pairs are probably maintained by the relative calling positions of neighbouring birds, topographical familiarity and occasional border fights. Tinbergen (1957) considered site attachment and intra-specific hostility (which includes attack and avoidance) to be the key factors in the concept of territory.

The visual aspect of territorial behaviour has not been recorded in kiwis and is thought to be non-existent (Robson 1947; Rowe 1974; Reid & Williams 1975), but aggressive threat behaviour in the form of vocal duels between males seems to be important. In most bird species singing is widely used by the male to assert the occupancy of its territory (Thorpe 1964). Of 1032 callings noted, 75.3% were made by male kiwis and the calling frequency peaked conspicuously in the first months of the breeding season (Colbourne & Kleinpaste, in prep.). Excited vocal display of male kiwis was heard or observed often when a neighbouring male ventured too close to a bird feeding on the perimeter of its territory, and trespassing, responsible for the overlaps of territory shown in Figure 7, occurred only at times when the resident bird was feeding at the opposite side of its territory. Females showed a slightly greater overlap than males, probably because they posed less of a threat to the stability of the male's territory. Males may also be rather reluctant to attack females, which are physically the stronger of the two. We saw attacking and especially avoidance behaviour much less in females than in males, which may explain why females were easier to catch.

We twice watched at close quarters actual fighting between rival males. In one case, growlings and vigorous movements in the undergrowth culminated in chase, during which the resident male stopped three times to call excitedly. The ejected male called four minutes later from its own territory. Reischek (1930) and Robson (1947) also noted that males fight aggressively, especially in the breeding season, and Buller (1888), Robson (1947), Reid & Rowe (1978) and H. Corbett (pers. comm.) recorded vigorous attacks on humans venturing too close to a nest site. These observations and the presence of a

few straying adult females suggest that, in the North Island Brown Kiwi, the male is territorial and the female is faithful to her mate. Thus, when the male of a pair dies, the female may mate with a subadult male or leave the territory entirely in search of a new mate.

Falla (1979) suggested that kiwi behaviour seen during the breeding season indicates the possibility of polyandry, and Buller (1888) recorded this phenomenon to be a Maori belief. However, in most polyandrous bird species, males are believed to outnumber the females (Armstrong 1964). This appears not to be the case with the kiwis in our study area as the sex ratio was found to be about equal. If kiwis were polyandrous we could reasonably expect that the range of a female would be at least twice that of a male. Apart from three straying females, the range of females closely coincided with that of their mates. However, as polyandry, which is rare amongst birds, occurs within the group of ratite orders (e.g. *Rhea americana*) and the closely related Tinamous (*Nothocercus bonapartei* and *Crypturellus variegatus*), we hesitate to label the rather puzzling movements of one of the females (Fig. 8) simply as "straying."

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SEABIRDS FOUND DEAD ON NEW ZEALAND BEACHES IN 1981

By R. G. POWLESLAND

ABSTRACT

In 1981, 3654 kilometres of coast were patrolled by 182 members of the Ornithological Society of New Zealand and their friends, and 5627 dead seabirds were found. New records for the Beach Patrol Scheme were a Kermadec Petrel (*Pterodroma neglecta*) and a Long-tailed Skua (*Stercorarius longicaudus*). Unusual finds were Yellow-nosed Mollymawk (*Diomedea chlororhynchus*), Wedge-tailed Shearwater (*Puffinus pacificus*), Wilson's Storm Petrel (*Oceanites oceanicus*), Black-bellied Storm Petrel (*Fregetta tropica*) and Black-fronted Tern (*Sterna albobriata*). A major wreck of Kerguelen Petrels (*Pterodroma brevirostris*) and Blue Petrels (*Halobaena caerulea*) occurred in spring along the western coast of the North Island.

INTRODUCTION

This paper records the results of the Ornithological Society of New Zealand's Beach Patrol Scheme for 1981. Patrols were carried out on all sections of coast except Fiordland. 569 Beach Patrol Cards and 42 Specimen Record Cards were submitted.

METHODS

The coastline of New Zealand is divided into 15 sections (Imber & Boeson 1969), with an additional grouping, "OI," for Outlying Islands that are 50 km or more from the mainland. Kilometres "travelled" are the total lengths of coast patrolled; kilometres "covered" are the lengths of coast patrolled monthly. Hence, if a kilometre of beach is patrolled twice in one month, two kilometres have been travelled but only one kilometre covered per month.

RESULTS AND DISCUSSION

In 1981 the total distance travelled was 3564 km, 5627 seabirds were found and the mean number of birds found per kilometre of coast covered monthly was 1.77 (Table 1). These values are below the averages for the previous ten years (1971-80). For this period the averages are 3705 km of coast travelled per year, 10 010 birds picked up per year and 3.25 birds per kilometre per month.

The monthly and coastal distributions of the less commonly found seabirds (1-14 birds in 1981) are given in Table 2 and of the more commonly found seabirds in Tables 3 and 4. Two species are

TABLE 1 — Numbers of dead seabirds recovered and kilometres covered on each coast in 1981

COAST	CODE		MONTH												TOTAL		BIRDS/KM /COAST
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	KM	BIRDS	
AUCKLAND WEST	AW	KM	92	104	110	131	129	98	111	187	120	105	128	100	1415	2298	1.62
		BIRDS	130	96	96	106	158	52	110	265	561	292	275	157			
TARANAKI	TA	KM	22	3	3	11	11	4	16	15	27	43	6	10	171	166	0.97
		BIRDS	9	7	8	16	12	2	15	8	34	42	4	9			
WELLINGTON WEST	WW	KM	10	1	1	21	5	1	7	3	81	29	16	19	194	474	2.44
		BIRDS	9	5	1	17	8	2	4	0	268	69	39	52			
AUCKLAND EAST	AE	KM	115	41	68	48	89	40	58	65	41	91	69	85	810	1558	1.92
		BIRDS	549	119	243	31	65	25	56	15	13	40	204	198			
BAY OF PLENTY	BP	KM	6	-	-	17	-	-	4	6	-	-	1	7	41	48	1.17
		BIRDS	20	-	-	4	-	-	2	3	-	-	2	17			
EAST COAST NI	EC	KM	-	-	-	-	14	7	4	-	3	-	8	2	38	53	1.39
		BIRDS	-	-	-	-	4	5	0	-	1	-	35	8			
WAIRARAPA	WA	KM	5	-	-	10	-	-	-	5	2	2	-	-	24	4	0.17
		BIRDS	0	-	-	3	-	-	-	0	1	0	-	-			
WELLINGTON SOUTH	WS	KM	11	16	12	33	18	3	17	-	30	-	10	-	150	134	0.89
		BIRDS	2	20	1	21	43	1	27	-	19	-	0	-			
NORTH COAST SI	NC	KM	-	-	-	-	-	-	-	1	-	3	25	-	29	24	0.83
		BIRDS	-	-	-	-	-	-	-	4	-	5	15	-			
WESTLAND	WD	KM	1	-	5	2	2	-	3	3	2	3	3	2	26	13	0.50
		BIRDS	0	-	0	0	1	-	0	0	0	2	3	7			
CANTERBURY NORTH	CN	KM	24	10	13	13	8	15	22	7	20	10	10	22	181	410	2.27
		BIRDS	68	30	29	13	7	36	12	8	14	37	39	117			
CANTERBURY SOUTH	CS	KM	5	6	8	7	6	9	7	7	6	6	7	6	80	213	2.66
		BIRDS	14	3	22	23	64	39	19	4	5	5	10	5			
OTAGO	OT	KM	1	1	-	16	6	-	-	-	1	3	1	3	32	103	3.22
		BIRDS	9	0	-	23	65	-	-	-	0	1	5	0			
SOUTHLAND	SD	KM	19	4	4	7	7	4	4	20	10	5	4	-	88	129	1.47
		BIRDS	36	10	8	2	7	3	2	29	11	6	15	-			
TOTAL KILOMETRES TRAVELLED			341	208	240	344	306	197	267	333	399	338	309	282	3564		
TOTAL KILOMETRES COVERED			311	186	224	316	295	181	253	319	343	306	288	257	3279		
TOTAL SEABIRDS RECOVERED			846	290	408	259	434	165	247	336	927	499	646	570	5627		
BIRDS/KM COVERED/MONTH			2.72	1.56	1.82	0.82	1.47	0.91	0.98	1.05	2.70	1.63	2.24	2.22		1.77	

new records for the Beach Patrol Scheme. One Kermadec Petrel was picked up in April on Muriwai Beach (AW) (Table 2). Only two other beach-wrecked specimens of this petrel have been recorded in New Zealand, both also from Muriwai Beach (Oliver 1955). The Kermadec Petrel has a widespread breeding range in the subtropical Pacific from Lord Howe Island east to Juan Fernandez Island (Falla *et al.* 1979). In the New Zealand region it breeds on Macauley Island (B. D. Bell, pers. comm.) and the Herald Islets of the Kermadec Group, the latter having up to 5000 pairs (M. J. Imber, pers. comm.). This petrel formerly bred on Raoul Island but has been exterminated by feral cats (*Felis catus*) and Norway rats (*Rattus norvegicus*) (Merton 1970). Although Kermadec Petrels migrate into the northern Pacific, they are present about the Kermadecs year round (Oliver 1955) and are rarely reported at sea far from the breeding sites (Jenkins 1967). Presumably it takes exceptionally strong north-easterly winds to blow a bird as far as New Zealand.

The other species new to the Beach Patrol Scheme is the Long-tailed Skua, a specimen of which was found in October on East Beach (AE) (Table 2). This skua is a northern circumpolar breeder, which makes a transequatorial migration to winter in the southern hemisphere (Serventy *et al.* 1971). While most overwinter off the coasts of South America, very occasionally the species is sighted in the south-west Pacific. One specimen has been found on a New Zealand beach before; at Muriwai in January 1964 (Sibson 1967).

Three Yellow-nosed Mollymawks were found along the Auckland West coast, one each in April, June and November (Table 2). Only two other specimens of this species have been picked up by beach patrollers previously, both along the Auckland West coast, one each in May and August 1980 (Veitch 1982). For the previous records of this mollymawk in the New Zealand area, see Robertson (1975), Wilson (1976), and Sibson (1979, 1981).

Three Wedge-tailed Shearwaters were recovered at Waipu Cove (AE), one in January and two in February (Table 2). Previously, only one specimen of this shearwater had been found, in June 1972 from the Wellington West region.

A Wilson's Storm Petrel picked up on Oreti Beach (SD) in January (Table 2) is the seventh specimen of this species to be recorded for the Beach Patrol Scheme. Previous records are 1939-59, AE-BP, ?; 1963, WW, Nov; 1968, WW, Jan; 1969, SD, Apr; 1971, AE, Dec; and 1973, EC, Apr. A Black-bellied Storm Petrel, also found on Oreti Beach in January (Table 2), was the fifth for the scheme. The previous records are 1963, Campbell Island, Feb; 1968, WS, May; 1975, WW, Jun; and 1977, SD, Nov.

One Black-fronted Tern was found on Brighton Beach (OT) in April (Table 2). This is only the third Black-fronted Tern for the Beach Patrol Scheme, the others being in June 1976 (WS) and July 1978 (BP). It is interesting that so few of these terns have been

TABLE 2 — Seabirds of which 1 to 14 specimens were found dead in 1981

SPECIES OR SUBSPECIES	NUMBER FOUND	COAST(S)	MONTH(S)
<i>Megadyptes antipodes</i>	6	OT(5),SD.	APR,MAY,NOV(4).
<i>Eudyptes</i> spp*	2	WD(2).	OCT,NOV.
<i>pachyrhynchus</i> subspp*	2	NC,SD.	SEP,NOV.
<i>Diomedea exulans</i>	5	AW(3),AE,CN.	MAR,MAY,JUL,SEP,OCT.
<i>epomophora</i>	1	AE.	JAN.
<i>melanophrys</i>	6	AW(5),AE.	JAN,APR,MAY(3),AUG.
<i>chlororhynchus</i>	3	AW(3).	APR,JUN,NOV.
<i>bulleri</i>	7	AW(2),AE,OT(2),SD(2).	JAN,FEB,APR(2),JUL,SEP(2).
<i>cauta</i> subspp*	3	AW(2),CN.	JUN,JUL,NOV.
<i>salvini</i>	3	AW,CN(2)	JAN,MAR,OCT.
<i>Phoebastria palpebrata</i>	14	AW(13),WW.	FEB,MAY(2),JUL(2),AUG(4),SEP(4),NOV.
<i>Thalassoica antarctica</i>	1	WW.	SEP.
<i>Pterodroma</i> spp*	13	AW(11),AE(2).	MAY,JUL,AUG(3),SEP,OCT(2),DEC(5).
<i>inexpectata</i>	13	AW(9),AE(2),WS,SD.	JAN(4),FEB(2),APR,MAY(2);NOV(2),DEC(2).
<i>neglecta</i>	1	AW.	APR.
<i>pycrofti</i>	1	AW.	DEC.
<i>nigripennis</i>	13	AW(13).	APR,MAY,DEC(11).
<i>Pachyptila salvini</i>	10	AW(10).	JAN,MAY(5),JUL,AUG(2),SEP.
<i>desolata</i>	13	AW(12),TA.	JAN,APR,MAY(2),JUN,JUL(5),AUG(2),SEP.
<i>Procellaria</i> spp*	1	AW.	JAN.
<i>cinerea</i>	3	AW(3).	JAN,JUL,DEC.
<i>westlandica</i>	4	AW(3),WW.	MAY,AUG(3).
<i>Puffinus</i> spp*	5	AW(2),WW(2),AE.	FEB,MAR,OCT,NOV,DEC.
<i>pacificus</i>	3	AE(3).	JAN,FEB(2).
<i>gavia/huttoni</i> *	6	WW(2),CN(4).	SEP(2),OCT(4).
<i>Oceanites oceanicus</i>	1	SD.	JAN.
<i>Fregetta tropica</i>	1	SD.	JAN.
<i>Phalacrocorax</i> spp*	4	AW(2),WW,AE.	AUG(3),OCT.
<i>carbo</i>	12	AW(4),TA,AE(3),EC(3),WS.	JAN(4),MAY,JUN(2),AUG(2).
<i>sulcirostris</i>	4	AW(3),AE.	JAN,JUN,JUL,OCT.
<i>Leucocarbo carunculatus chalconotus</i>	2	OT,SD.	JAN,APR.
<i>Stercorarius skua lomnbergi</i>	1	AW.	JUN.
<i>parasiticus</i>	1	AE.	JAN.
<i>longicaudus</i>	1	AE.	OCT.
<i>Larus</i> spp*	2	AE,CN	FEB,SEP.
<i>Sterna albobristata</i>	1	OT.	APR.
<i>Hydroprogne caspia</i>	5	AW,WS,NC(2),CS.	FEB,SEP,NOV(2),DEC.

TOTAL 174

*Species or subspecies could not be identified by the patroller.

picked up because the species, presumably numbering several thousands, frequents coastal regions of the North and South Islands from about January to August (Lalas 1979, Latham 1981).

An important feature of the 1981 Beach Patrol results is the wreck of Kerguelen Petrels and Blue Petrels. This occurred from late July until December, most being found in September (Tables 3 & 4; see Reed 1981). Strong to gale force southerly to south-westerly winds prevailed from late August to early September in the Tasman Sea and several depressions of 960-990 mb passed south of Campbell and Macquarie Islands.

Altogether 280 Kerguelen Petrels were found during 1981, compared with 490 for all previous years of the scheme (1939-1980). Before 1981, the highest annual total was in 1975, when 162 birds were picked up. Of the 468 birds of known date of recovery during 1939-1980 and the 280 in 1981, 93% were picked up from August to October inclusive (Figure 1). Of those found in 1981, 97.5% were picked up from North Island west coast beaches (AW, TA, WW). Likewise, of those found from 1939 to 1980, 96.1% were picked up from beaches in the same three regions. This is not the result of a bias in patroller effort between the western North Island beaches and elsewhere. In 1981 an average of 6.5 km of North Island west coast beaches was covered per Kerguelen Petrel found, compared with 214.1 km per bird for the rest of the country.

The Kerguelen Petrel breeds on Prince Edward (M. J. Imber, pers. comm.), Marion, Possession and East Islands in the Crozets, Gough Island, Inaccessible Island in the South Orkneys and perhaps also on some of the islands of Tristan da Cunha in the subantarctic waters of the Atlantic and Indian Oceans (Mougin 1975). This species ranges eastwards in autumn and may be quite numerous in the Tasman Sea during some winters (Falla *et al.* 1979). On Possession Island the laying period of the species is very restricted, lasting for only five days around 10 October (Mougin 1969), and so the petrels found on our beaches from August to October are probably non-breeders.

Almost as many Blue Petrels were found in 1981 (343) as were found from 1939 to 1980 (360). As for the Kerguelen Petrel, the highest annual total of Blue Petrels before 1981 was in 1975, when 89 birds were found. Most Blue Petrels were picked up during August, September and October (Figure 2); 72.2% of the 360 birds found during the period 1939-1980 and 93.6% of the 1981 specimens. The coastal regions in which most Blue Petrels were found are similar to those detailed for the Kerguelen Petrels. Of the Blue Petrels found in 1981, 98.5% were picked up along western North Island beaches (AW, TA, WW), compared with 89.3% of the 354 of known region of recovery found from 1939-1980. On average, one Blue Petrel was found for every 5.3 km covered of AW, TA and WW regions in 1981, but only one was found for every 300.0 km for the rest of the New Zealand coastline.

TABLE 3 — Coastal distribution of the seabirds more commonly found dead in 1981

SPECIES OR SUBSPECIES	COAST														TOTAL BIRDS
	AW	TA	WW	AE	BP	EC	WA	WS	NC	WD	CN	CS	OT	SD	
<i>Eudypstula minor</i> subsp* [*]	272	21	19	357	6	1	-	14	-	-	8	3	-	9	710
<i>Eudypstula minor</i> albosignata	-	-	-	-	-	-	-	-	1	-	18	7	-	-	26
<i>Diomedea</i> spp*	5	2	2	1	-	-	-	1	-	-	1	-	-	9	21
<i>chrysostoma</i>	19	-	2	-	-	-	-	-	-	-	-	-	-	21	
<i>cauta cauta</i>	12	1	2	2	-	-	-	-	-	-	1	-	-	18	
<i>Macronectes</i> spp*	25	-	-	7	-	1	-	1	-	-	1	-	-	3	38
<i>Fulmarus glacialisoides</i>	18	-	9	-	-	-	-	-	1	-	-	-	-	1	29
<i>Daption capense</i>	25	8	5	5	-	-	-	3	-	-	3	7	1	57	
<i>Pterodroma macroptera</i>	20	-	-	95	1	-	-	1	-	-	2	-	-	119	
<i>lessonii</i>	139	4	18	2	1	-	-	-	-	-	1	-	-	165	
<i>brevirostris</i>	202	24	47	4	1	-	-	-	-	1	1	-	-	280	
<i>cookii</i>	17	-	-	74	1	-	-	-	-	-	-	-	-	92	
<i>Halobaena caerulea</i>	243	13	82	-	-	-	-	1	1	-	-	-	-	3	343
<i>Pachyptila</i> spp*	63	11	75	2	-	-	-	9	1	-	5	-	-	4	170
<i>vittata</i>	9	-	1	-	-	-	-	-	-	1	4	6	-	8	29
<i>belcheri</i>	28	1	1	-	-	-	-	-	-	-	-	-	-	9	39
<i>turtur</i>	204	8	95	79	3	-	-	11	5	1	18	1	-	4	429
<i>Procellaria parkinsoni</i>	-	-	-	17	5	-	-	-	-	-	-	-	-	-	22
<i>Puffinus carneipes</i>	6	-	-	151	-	1	-	-	-	-	2	-	-	-	160
<i>bulleri</i>	84	5	7	73	2	-	1	3	-	-	3	-	-	1	178
<i>griseus</i>	202	5	22	122	9	40	-	44	2	2	66	17	57	38	626
<i>tenuirostris</i>	45	4	7	40	1	-	-	-	1	5	-	10	-	5	118
<i>gavia</i>	139	10	16	178	8	2	1	5	2	-	3	6	-	-	370
<i>huttoni</i>	18	1	2	7	-	-	-	-	1	-	20	-	-	-	49
<i>assimilis</i>	2	-	-	23	2	-	-	1	-	-	1	-	-	-	29
<i>Pelagodroma marina</i>	5	-	-	5	2	-	-	-	-	-	-	6	-	-	18
<i>Pelecanoides urinatrix</i>	59	2	20	94	5	1	1	7	-	-	3	-	-	5	197
<i>Sula bassana</i>	119	6	1	79	1	2	-	-	-	-	1	-	-	1	210
<i>Phalacrocorax varius</i>	9	-	-	20	-	-	-	-	-	-	8	-	-	-	37
<i>melanoleucos</i>	10	2	-	5	-	-	-	-	-	-	1	-	1	-	19
<i>Stictocarbo punctatus</i>	-	-	-	2	-	-	-	1	1	-	64	104	3	1	176
<i>Larus dominicanus</i>	121	24	20	55	-	2	1	18	4	-	52	32	24	11	364
<i>novaeollandiae</i>	36	11	11	33	-	-	-	8	1	-	83	1	8	-	192
<i>bulleri</i>	-	-	1	-	-	-	-	3	-	-	12	6	-	7	29
<i>Sterna striata</i>	36	1	1	7	-	-	-	1	-	-	19	6	-	2	73
TOTALS	2192	164	466	1539	48	50	4	131	21	11	401	212	94	120	5453

* Species or subspecies could not be identified by the patroller.

TABLE 4 — Monthly distribution of the seabirds more commonly found dead in 1981

SPECIES OR SUBSPECIES	MONTH												TOTAL BIRDS
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
<i>Eudyptula minor</i> subspp*	137	32	141	51	78	16	50	67	26	17	49	46	710
<i>Eudyptula minor</i> albosignata	2	1	3	3	1	3	1	2	2	3	4	2	26
<i>Diomedea</i> spp*	3	2	-	-	1	1	1	9	3	-	-	1	21
<i>chrysostoma</i>	-	-	-	-	1	-	-	7	10	1	2	-	21
<i>cauta cauta</i>	1	-	1	-	3	2	1	3	1	4	1	1	18
<i>Macronectes</i> spp*	5	-	-	1	1	3	8	14	-	2	2	2	38
<i>Fulmarus glacialis</i>	-	-	-	-	-	-	-	-	15	9	3	2	29
<i>Daption capense</i>	2	1	2	1	-	5	7	6	14	10	6	3	57
<i>Pterodroma macroptera</i>	86	4	1	2	2	3	-	2	12	5	2	-	119
<i>lessonii</i>	2	1	-	5	6	5	3	5	63	63	5	7	165
<i>brevirostris</i>	-	-	-	1	-	-	2	20	191	49	13	4	280
<i>cookii</i>	16	4	17	3	-	-	-	1	-	7	34	10	92
<i>Halobaena caerulea</i>	-	-	-	-	-	1	-	9	252	60	14	7	343
<i>Pachyptila</i> spp*	9	11	3	4	11	3	7	14	43	31	21	13	170
<i>vittata</i>	6	1	-	-	5	-	3	7	1	1	2	3	29
<i>belcheri</i>	-	1	-	1	4	1	4	9	4	2	13	-	39
<i>turtur</i>	75	14	1	4	9	6	24	50	130	57	30	29	429
<i>Procellaria parkinsoni</i>	5	1	5	-	-	-	-	-	-	-	8	3	22
<i>Puffinus carneipes</i>	40	12	52	2	4	1	1	-	-	2	27	19	160
<i>bulleri</i>	62	27	13	7	7	3	3	-	3	16	21	16	178
<i>griseus</i>	59	18	24	15	136	8	6	18	3	22	180	137	626
<i>tenuirostris</i>	25	-	4	5	8	1	3	-	2	4	24	42	118
<i>gavia</i>	93	37	27	30	5	8	31	24	36	18	18	43	370
<i>huttoni</i>	5	4	2	1	-	1	-	-	3	2	14	17	49
<i>assimilis</i>	3	1	2	3	-	1	2	-	-	1	10	6	29
<i>Pelagodroma marina</i>	3	-	-	1	1	-	-	1	2	1	3	6	18
<i>Pelecanoides urinatrix</i>	35	2	4	3	13	17	24	15	23	13	31	17	197
<i>Sula bassana</i>	29	27	25	10	6	4	7	13	18	22	31	18	210
<i>Phalacrocorax varius</i>	7	5	7	2	2	1	1	1	1	1	5	4	37
<i>melanoleucos</i>	-	3	3	-	1	2	-	1	1	6	2	-	19
<i>Stictocarbo punctatus</i>	19	4	10	15	48	23	10	3	3	2	21	18	176
<i>Larus dominicanus</i>	46	46	36	43	35	27	23	13	31	16	24	24	364
<i>novaeollandiae</i>	28	13	14	23	14	8	6	1	11	22	10	42	192
<i>bulleri</i>	10	3	2	1	1	2	3	1	4	1	1	-	29
<i>Sterna striata</i>	11	6	6	11	11	2	2	1	1	6	2	4	73
TOTALS	824	281	405	248	414	158	233	316	909	485	632	548	5453

* Species or subspecies could not be identified by the patroller.

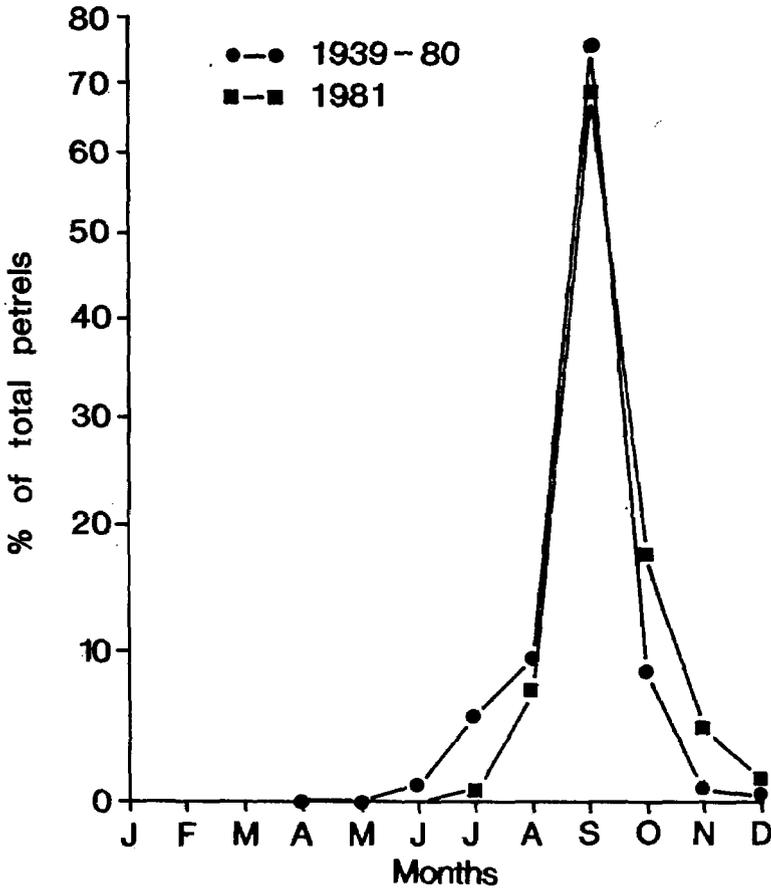


FIGURE 1 — Monthly distribution (% of total) of beach-wrecked Kerguelen Petrels during the period 1939-80 ($n = 468$) and in 1981 ($n = 280$)

The Blue Petrel is a bird of the subantarctic zone, probably with a circumpolar flight range (Dell 1952). It nests on Prince Edward, Marion and East Islands of the Crozets, Macquarie Island, Kerguelen Island, and Bird Island of the South Georgia group (M. J. Imber, pers. comm.). Most of the New Zealand and Australian specimens have been taken during September (Dell 1952; Figure 2), which suggests that during this month a considerable number of Blue Petrels are somewhere to the west of the two countries and within the influence of the prevailing south-westerly winds. Like the Kerguelen Petrels, the Blue Petrels found on our beaches in September are probably non-breeders.

Miscellaneous birds recovered, but not considered to be seabirds, totalled 185. There were 38 Magpies, 23 Mallards, 17 Black Swans, 16 Rock Pigeons, 15 Blackbirds, 10 Grey Ducks, eight Mynas, six each of Australasian Harriers and Starlings, five House Sparrows, four each of South Island Pied Oystercatchers and Tuis, three each of Pukekos and unidentified passerines, two each of Californian Quail, Pheasants, Pied Stilts, New Zealand Pigeons, Long-tailed Cuckoos, Skylarks and Greenfinches, and one each of White-faced Heron, Canada Goose, domestic goose, domestic fowl, Paradise Shelduck, Brown Teal, New Zealand Shoveler, Stewart Island Weka, Variable Oystercatcher, New Zealand Dotterel, Banded Dotterel, Eastern Bar-tailed Godwit, Turn-

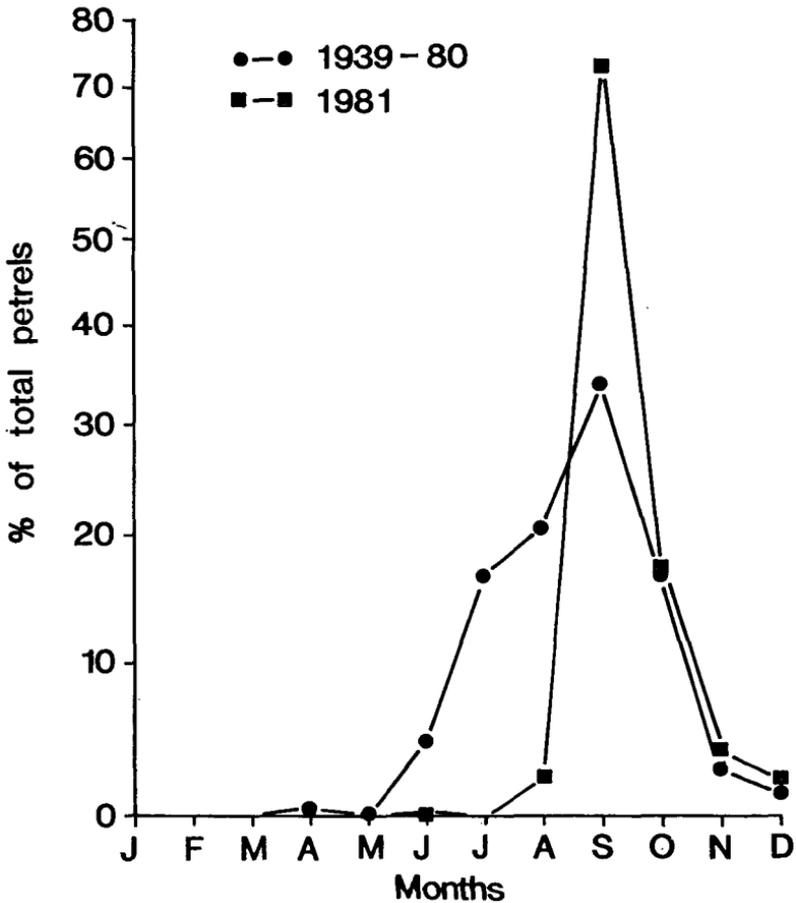


FIGURE 2 — Monthly distribution (% of total) of beach-wrecked Blue Petrels during the period 1939-80 ($n = 360$) and in 1981 ($n = 343$)

stone, North Island Kaka, Song Thrush, Yellowhammer, Goldfinch and Redpoll.

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E & O E

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SHORT NOTE

THE NESTING BEHAVIOUR OF A KIWI

A number of studies have focused on the nesting behaviour of birds, particularly gulls. Experiments by Tinbergen (1953) on egg recognition have shown that birds will brood surrogate objects and that some of these objects, especially larger ones, will act as hyper-natural releasers of incubating behaviour.

A recent field trip to a coastal property in Northland yielded some unexpected results in that a party observed a North Island Brown Kiwi (*Apteryx australis mantelli*) apparently happily incubating a beer bottle.

The party consisted of staff from the Department of Lands and Survey and the Commission for the Environment and a private consultant. The purpose of the trip was to investigate a proposal for a marine park at Mimiwhangata, situated on the east coast about halfway between Whangarei and Cape Brett. The property at Mimiwhangata, which consists of an attractive assemblage of forested hills, farmlands, marsh areas, coastal margins and offshore islands, has been transformed into a farm park by the owners. The owners are Lion Breweries Ltd.

A previous ecological study of the farm park by Darby & Darby (1973) had given an indication that up to five pairs of kiwis are resident in the area. One of the highlights of the field trip was a hike to a hill-top viewing platform, perched high in a puriri tree. While marvelling at the view, a member of the party happened to glance down at an object in a relatively open area of the bush near the base of the tree. After a discussion about the identity of the object, someone clambered down the bank to identify it. Initially it was identified as a dead "kiwi," recognisable as a rather spread-out mound of feathers. Further careful examination revealed, however, that the kiwi was in fact very much alive but sleeping soundly. What also

became evident was that the bird was straddling a partially buried 750 ml beer bottle.

Concern for the condition of the kiwi prompted the party to examine the bird more closely. The bird was encouraged to remain relatively calm during this process by someone holding a covering over its eyes. The kiwi was a male, its beak being 8-12 cm long, and hence could be expected to be nesting in October (breeding season, July-February in Northland — R. Kleinpaste, pers. comm.). The area in the vicinity of the bottle was littered with about two dozen feathers, indicating that the bird may have nested there for some time. Kiwis have been observed nesting at the Waitangi State Forest (Kleinpaste, pers. comm.) in a variety of situations, ranging from highly camouflaged nests to open casual sites. Interestingly, the bird was also facing north while sitting on the bottle, which conforms to observations made by Robson (1947).

The bottle itself was partly buried along its length and was about two-thirds full of liquid. The rounded contours of the bottle that were exposed did not appear to be unlike the familiar shape of an egg. The kiwi was straddling the bottle lengthwise with the tip of the bottle just visible in front of the bird. Studies by Tinbergen (1953) have identified that size, and to some extent shape, rather than colouring or marking, stimulate incubating behaviour. His experiments with larger than normal eggs demonstrated that the bird's incubation drive was highly stimulated by the extra size.

It is impossible to determine how the kiwi was originally attracted to the bottle. It may have lost its own egg, or it may have found the bottle more attractive. One imponderable question remains; the label on the bottle was missing and hence we may never learn which brand of beer kiwis really prefer.

The original sighting of the kiwi occurred in October and since that time there have been a number of subsequent sightings of the bird, always in the same position straddling the beer bottle. The bird appears to sleep quite soundly and is undisturbed by visitors using the viewing platform directly above it.

It seems that the kiwi is now reaching the end of the normal incubation period and it will be interesting to see how long it perseveres. Perhaps the bird will experience some difficulty in giving up the bottle.

I am grateful to E. G. Turbott, Convenor of the Scientific Committee, Hauraki Gulf Maritime Park Board, for making available several relevant articles. Specific comments and advice were also provided by R. Kleinpaste of the Ministry of Agriculture and Fisheries.

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BREEDING HABITS OF THE GREY WARBLER (*Gerygone igata*)

By B. J. GILL

ABSTRACT

Grey Warblers at Kowhai Bush, Kaikoura, apparently moulted once annually — between January and March. They nested in 19 kinds of trees and shrubs — mostly small-leaved species, especially kanuka, the dominant plant in the study area. Behaviour associated with selection of the nest site is described. A list of materials used in building is given. On average, nests were 14 cm long and just over 7 cm wide. Nearly half the nests hung freely from their upper attachment; others also had attachments laterally and below. The entrances of nests were non-randomly orientated in 1976 but not so as to face away from prevailing winds. Copulation is described. Three eggs in September were laid close to sunrise. Late eggs were wider on average than early ones but no different in length. The constant that related fresh weight of eggs, length, and the square of width was 0.598. Eggs lost about a quarter of their weight during incubation. Grey Warblers hatched with natal down distributed in eight main and two minor patches. The physical and behavioural development of nestlings is described. A sample of 19 nestlings had been fed invertebrates of six orders. Caterpillars occurred in 90% of stomachs and made up 42% of ingested items. Spiders were next most important of total items. Nestlings were parasitised by the blood-sucking mite *Ornithonyssus bursa*. Fledglings had distinctive dark brown irides and yellowish facial plumage until February-March, when they moulted to adult form. Males played the greater role in caring for early fledglings while the female built the late nest. Young males seemed rarely to be successful in holding territory the summer after that in which they were reared. Brood parasitism by Shining Cuckoos was the main cause of failure of late eggs (though a relatively minor factor overall); mammalian predation was the greatest single cause of nestling mortality.

INTRODUCTION

For three seasons beginning 1976-77 I studied the breeding of Grey Warblers (*Gerygone igata*, Muscicapidae: Acanthizinae) in a 30-ha study area at Kowhai Bush, Kaikoura. Elsewhere, I have described the study area (Gill 1980), the brood parasitism of warblers by the Shining Cuckoo (*Chrysococcyx lucidus*) (Gill 1982c and in press) and many aspects of the warbler's breeding (Gill 1982a). In this paper I report some of the more descriptive parts of the study — in particular the morphology of nests and the natal pterylography and development

of nestlings — and I compare the two intensively studied seasons (1976-77 and 1977-78).

By "early" nests, eggs and nestlings, I mean those associated with a clutch started before 23 October. By "late" eggs, I mean those laid on or after 23 October, when the first second clutch in my sample (after the fledging of earlier nestlings) was started. I use the word "fledge" to mean "leave the nest."

METHODS

Identifying the sexes

Male and female Grey Warblers look alike but are distinguishable by behaviour. Only adult males give the full song, whereas females and independent juveniles at most give occasional tuneful subsongs. Males sing all year, although the intensity varies (Cunningham 1955). Males also have a distinctive wing-fluttering display in which they vigorously flap their half-outstretched wings while advancing along a perch. The display occurs at all stages of breeding, mainly in the female's presence. Very rarely females wing-flutter, and so wing-fluttering is not completely diagnostic of males.

Only females collect material and build nests, but males often accompany their mate to and from the nest. Only females incubate eggs and brood nestlings, but both sexes feed the young. Thus, any bird entering the nest, as opposed to merely perching at its entrance, is a female.

Catching adults

I caught adult warblers in small mist-nets (5.5 m long, 2.1 m high) hung between two wooden poles (2 cm in diameter). The poles were held upright in short sections of square iron pipe driven part-way into the ground, and a single guy-rope from the top of one pole was enough to keep the net taut. Nets of about 32-mm mesh (measured knot-to-knot with the netting stretched diagonally) are needed. Warblers can pass through 38-mm mesh.

I lured warblers into nets with recordings of their song. It was advantageous to use twin extension speakers set one on either side of a net and connected by a two-way switch so that the sound could be changed from one speaker to the other. Warblers in an area quickly became accustomed to a tape-recording, and so I changed tapes regularly.

During the breeding season I caught 15 incubating females on their nests by means of a fine hair-net mounted on a wire loop at the end of a stick. The nest had to be approachable from below or behind, and such that the net could be gradually advanced towards it and suddenly pushed over the entrance without catching on twigs. I caught birds only after they had been incubating at least 5 days and released them immediately after banding. None deserted.

Finding nests

The surest way to find a nest was to follow a building female. At intervals, she would break off from foraging to collect material, and once she had a load, would fly directly to the nest, usually with the male close behind. Early nests were easiest to find because they were built slowly, and for a long period early in the season most females were building, accompanied by the vocal and thus easily located male. However, the female does not regularly visit the nest for up to 8 days after she has completed building and during the 7 days needed to lay the clutch of four.

To find nests during incubation, I located the male by his song and followed him until he was joined by his mate after her spell on the nest. However, at this stage she would return to the nest cautiously and indirectly. For the same reason, parents were hard to follow back to the nest when they were collecting food for nestlings.

Late nests were hard to find because breeding was then out of phase, with not all pairs building at a given time, and nests were built quickly with little delay before laying. Also, females were hard to locate late in the season if there were fledglings of a previous brood. The male usually attended these, and so the female built unaccompanied by the vocal male.

Handling eggs and nestlings

I counted eggs by inserting one or two fingers through the nest's entrance, slight enlargement of which did not cause desertion. It was generally too risky to remove eggs for examination, as they are so fragile, but safe removal was possible at low nests with wide entrances. I marked eggs (for later recognition) with an alcohol-based felt-tipped pen. Occasionally I accidentally broke or cracked an egg but only once was this the likely cause of a deserted clutch.

To examine nestlings I removed them by inserting two fingers through the entrance. For broods of four I removed the nestlings in pairs and stood well away so that the parents could feed those left in the nest. I kept one nestling warm in a breast pocket while handling the other.

At the first visit after they hatched I marked nestlings with bright red nail varnish on the toes of one or both feet, leaving the last hatchling unmarked. This identified individuals in a brood until banding at 13-15 days old. The varnish had to be re-applied every 3-4 days, but it lasted well on the claws of older nestlings. Warblers did not fledge prematurely if carefully handled.

No nests at which I handled young were deserted on my account so far as I was aware. One female at a low nest was so tame that I could remove small nestlings from beneath her and replace them, while she continued to brood. Once, when a nest with feathered

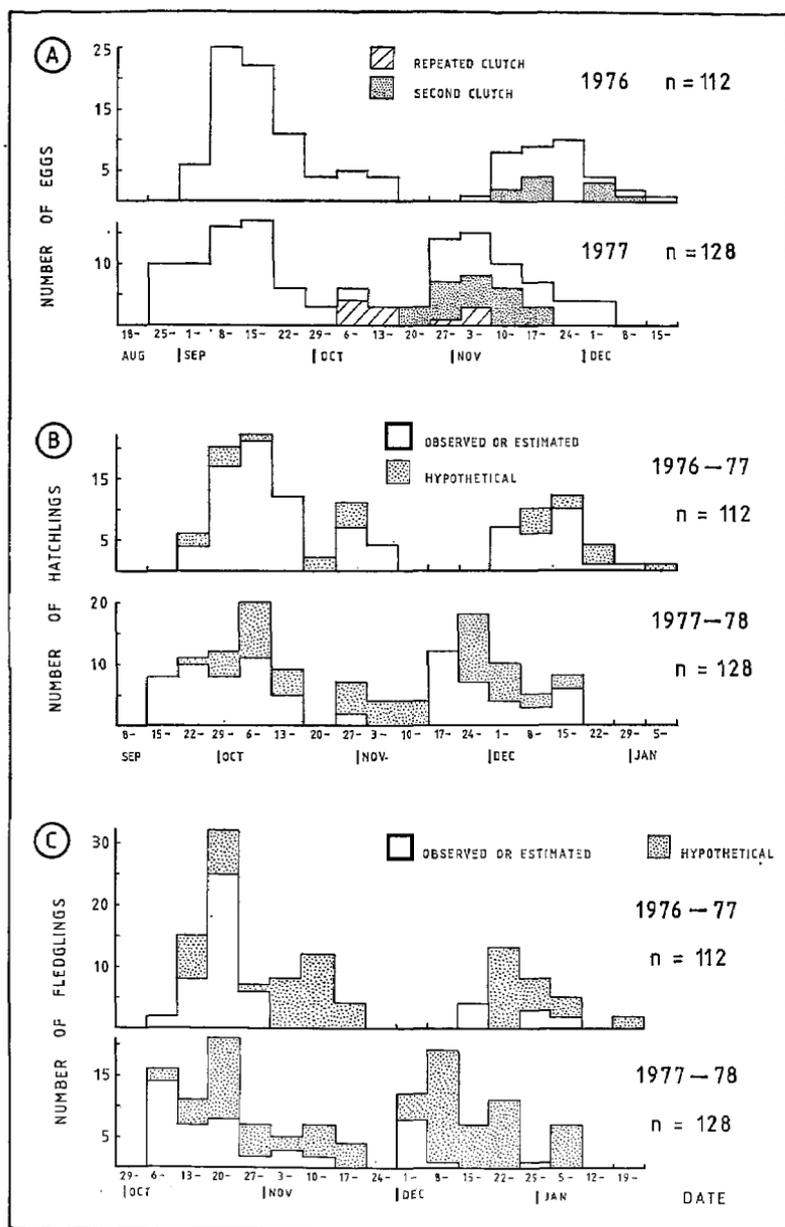


FIGURE 1 — Dates (grouped by week) of (A) laying, (B) hatching and (C) fledging of Grey Warblers at Kowhai Bush

young came away from its attachment, I wired it to a new position 30-40 cm away and the parents continued to feed the nestlings.

BREEDING SEASON AND MOULT

Figure 1 shows for 1976-77 and 1977-78 the distribution of dates of laying (Fig. 1A), hatching (Fig. 1B) and fledging (Fig. 1C) of individual eggs, hatchlings and fledglings at Kowhai Bush. The data are grouped by weeks beginning 18-24 August. Some dates of laying, hatching and fledging were not determined accurately in the field and so were estimated from other known dates. To counteract the effect of mortality in reducing sample sizes, "hypothetical" dates of hatching and fledging were calculated for eggs which did not hatch and young which did not fledge.

All first nests, and most second attempts at building after an unsuccessful first nest, were completed by mid-October. New nests for true second clutches (following the fledging of at least one nestling from the earlier brood) were started from mid-October to November. The earliest and latest eggs in my sample were laid on 25 August 1977 and c. 17 December 1976, the earliest and latest nestlings hatched on 20 September 1977 and c. 6 January 1977 and the earliest and latest nestlings fledged on 8 October 1977 and c. 22 January 1977. Repeated clutches after loss of a first, and true second clutches, are shown in Fig. 1A when known. The earliest egg of a true second clutch was laid on 23 October 1977.

Figure 1 suggests that warblers bred earlier in 1977 than in 1976. My greater experience in finding nests in the second year may have biased results, but information from banded birds supports the trend. Table 1 gives dates of completion of clutches in the two years by pairs with at least one partner banded. In all five cases laying was earlier in 1977, by 7-20 days. Snow, which is rare on the Kaikoura Plain, fell at Kowhai Bush during a four-day southerly storm in late

TABLE 1 — Dates of clutch-completion at Kowhai Bush for banded Grey Warblers (H, B, 9, 13 and 2) in two years. U = unbanded bird; * = late clutches — all others early

Male	Female	Date		Difference (days)
		1976	1977	
U	9	19 Sep	12 Sep	7
H	U	27 Sep	14 Sep	13
U	13	16 Sep	5 Sep	11
B	2	17 Sep	31 Aug	17
B	2	9 Dec*	19 Nov*	20

June 1976. The cold winter and cool wet spring of 1976 may have delayed breeding that year.

Grey Warblers at Kowhai Bush apparently moulted only once annually, after breeding. Both rectrices and body plumage were moulted from January, and by March most birds had complete unworn tails. In early January a male was moulting 30 days after his brood had fledged, and in late January a female was moulting while her mate was still feeding their single young, which had fledged 18 days before. In mid-January I saw three separate non-moulting adults attending fledgling Shining Cuckoos, while elsewhere a male was moulting whose cuckoo had fledged 24 days before.

NESTS

Selection of the site

Occasionally I saw behaviour at Kowhai Bush which I assumed to be associated with selection of the Grey Warbler's nest site. The female, constantly twittering, flew excitedly in wide circles with the male close by. Then she collected nesting material and flew to a twig, closely followed by the male who perched 10-20 cm away. The female leaned backwards and held an almost hanging position for 4-5 seconds with head and body vertically aligned, tail spread and wings outstretched. The male did likewise while the female, still hanging, wound material around the twig with her bill and resumed a normal perching position. After the male perched normally again he sang and both departed, often repeating the sequence after a few minutes.

Sometimes I later found a nest in the shrub at which this behaviour took place, but indecision in siting nests also occurred. In three instances a pair began building at one site but began again a few days later 30, 36 and 52 m away.

Spreading of the wings and tail, as here described, was a common display at all stages of the nesting cycle, perhaps to reinforce the pair bond and synchronise the pair's activities.

Plants used

At Kowhai Bush Grey Warblers nested in 19 kinds of trees and shrubs (Table 2), all but five of them natives. Most nests (69%, $n = 129$) were in plants with leaves < 2 cm long, especially kanuka (33%), the physiognomic and numerical dominant at Kowhai Bush. Three small-leaved exotic legumes (Montpellier broom, broom and gorse) accounted for another 26% of nests. Small-leaved species were favoured for nesting probably because attachment was easier and camouflage better where branching was dense, and because spines (gorse) and needle-leaves (*Leptospermum* and mingimingi) deterred predators.

Grey Warbler nests reported to the OSNZ Nest Record Scheme from throughout New Zealand were in plants of at least 40 species (16 exotic). Of 130 nests recorded, 35% were in manuka, 11% in

TABLE 2 — Trees and shrubs that Grey Warblers nested in at Kowhai Bush; n = 129; * = exotic species

	Frequency (%)
Leaves >4 cm long	17.8
Karamu <u>Coprosma robusta</u>	5.4
Tutu <u>Coriaria arborea</u>	0.8
Akeake <u>Dodonaea viscosa</u>	6.2
Mahoe <u>Meliccytus ramiflorus</u>	2.3
Akiraho <u>Olearia paniculata</u>	2.3
Tarata <u>Pittosporum eugenoides</u>	0.8
Leaves 2-4cm long	13.2
Putaputaweta <u>Carpodetus serratus</u>	1.6
* Traveller's Joy <u>Clematis vitalba</u>	1.6
<u>Coprosma propinqua</u> x <u>robusta</u>	1.6
Kohuhu <u>Pittosporum tenuifolium</u>	7.6
* Sweet Brier <u>Rosa rubiginosa</u>	0.8
Leaves <2 cm long	69.0
<u>Coprosma propinqua</u>	3.9
Mingimingi <u>Cyathodes fasciculata</u>	1.6
* Montpellier Broom <u>Cytisus monspessulanus</u>	10.1
* Broom <u>C. scoparius</u>	4.7
<u>Helichrysum aggregatum</u>	2.3
Kanuka <u>Leptospermum ericoides</u>	32.5
Manuka <u>L. scoparium</u>	2.3
* Gorse <u>Ulex europaeus</u>	11.6

gorse, 5% in matagouri (*Discaria toumatou*) and 7% in species of *Coprosma*. The average height above ground of these nests was 2.7 m ($n = 135$, s.d. 2.80, range 0.3-21.3 m), compared with 3.2 m ($n = 103$, s.d. 1.93, range 0.7-9.0 m) for all nests found at Kowhai Bush (Gill 1982a).

Dimensions, form and attachment

I measured the dimensions (Fig. 2) of a sample of nests at Kowhai Bush to the nearest 0.5 cm. The results (Table 3) show that entrances were just under 3 cm in diameter. The deepest entrance (6.0 cm) was also one of the widest (3.5 cm), and the smallest was 2.0 x 2.0 cm. The outside depth of an exceptionally low-slung nest

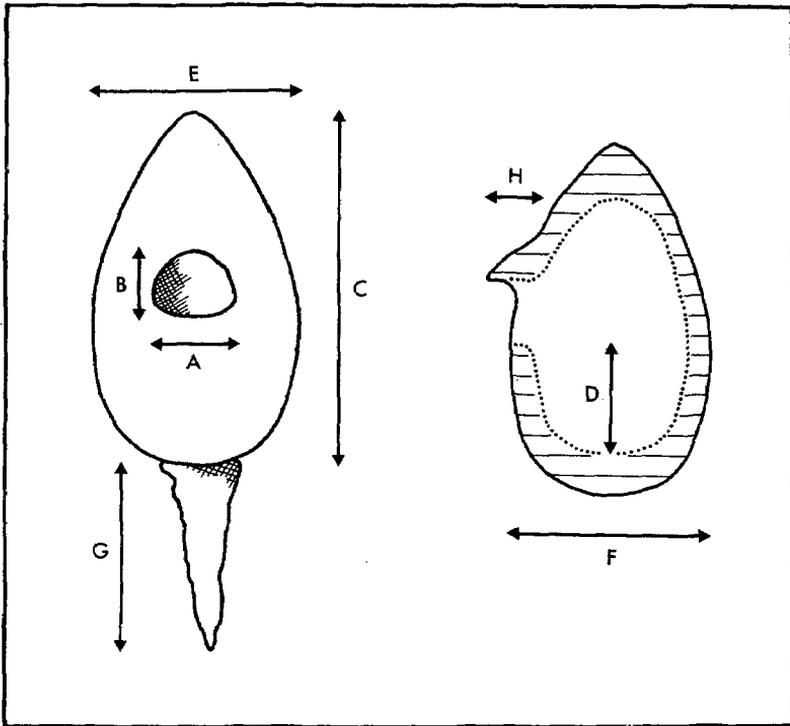


FIGURE 2 — Dimensions of Grey Warbler nests: (A) width of entrance, (B) depth of entrance, (C) outside depth, (D) inside depth below entrance, (E) outside frontal diameter, (F) outside lateral diameter, (G) length of "beard," (H) length of hood

was 21.0 cm. Lengths of "beard" (or "tail") and of hood varied greatly and usually had to be measured approximately because the base of the hood often merged imperceptibly with the body and the beard was sometimes extended by one twig or straw to a misleading length.

Nearly every nest at Kowhai Bush (94% of 92 nests) was attached to living vegetation, and the exceptions, although attached to dead twigs, were often surrounded by live foliage from adjacent branches. All nests ($n = 88$) had an upper attachment beneath which they were slung, and 46% were truly pensive in having no, or negligible, other connections. However, 41% of nests had significant lateral attachments and 28% were secured below. Considered another way, of the 88 nests, 25% had lateral attachments but none below, 13% were attached below but not laterally, and 16% had both attachments.

TABLE 3 — Measurements (cm) of Grey Warbler nests at Kowhai Bush; see Fig 2

	Mean	n	s. d.	Range
(A) Width of entrance	2.9	61	0.33	2.0-3.5
(B) Depth of entrance	2.8	61	0.68	2.0-6.0
(C) Outside depth	14.0	58	1.65	10.0-16.5 (21.0)
(D) Inside depth below entrance	4.0	27	1.08	2.0-6.0
(E) Outside frontal diameter	7.2	56	0.72	5.5-8.5
(F) Outside lateral diameter	7.5	55	0.81	6.0-9.0
(G) Length of beard	6.6	35	3.85	2.0-19.0
(H) Length of hood	2.9	49	0.87	1.5-4.5

In general, nests either hung more or less freely, or were secured in a matrix of surrounding twigs.

"Beards" were present on 63% of nests ($n = 89$). They either hung freely, perhaps helping to make the nests cryptic, or were involved in attachment. A hood was a feature of 94% of nests ($n = 88$), and in 14% ($n = 81$) a sort of threshold (Andersen 1926: 49) or ledge extended from the lower rim of the entrance.

Figures 3 and 4 illustrate a range of nests from Kowhai Bush. In Fig. 3, nests a, b, g and h were truly pensile, whereas c, from the crown of a kanuka, was securely stayed by the beard. Nests d, e and f had many lateral attachments and were built in thickets of leaves and twigs.

Direction of entrance

According to Maori folklore, Grey Warblers direct the entrances of their nests opposite to the direction of prevailing winds (Andersen 1926). At Kowhai Bush I noted the orientation of entrances and compared this with wind roses for the Kaikoura Peninsula (Figure 5). I used the frequency of winds of force 4 (Beaufort Scale) or stronger recorded at 0900 h for the four months during which warblers built (August-November; data from Kaikoura Meteorological Office, Ministry of Transport).

Directions of entrances were significantly different from random in 1976-77 (chi-squared = 28.35 for 7 d.f.; $P < 0.001$) and for the two seasons combined (chi-squared = 31.80 for 2 d.f.; $P < 0.001$). However, direction did not differ significantly from random in 1977-78 (chi-squared test; $P > 0.1$). To see if the frequencies of orientation of entrances varied in proportion to the frequencies of winds from the opposite direction, I had to group E-SE-S in 1976-77 and 1977-78, SE-S in both seasons combined and SW-W-NW in every case. Results for 1976-77 (chi-squared = 16.01 for 3 d.f.; $P < 0.005$), 1977-78 (chi-squared = 13.85 for 3 d.f.; $P < 0.005$) and seasons combined

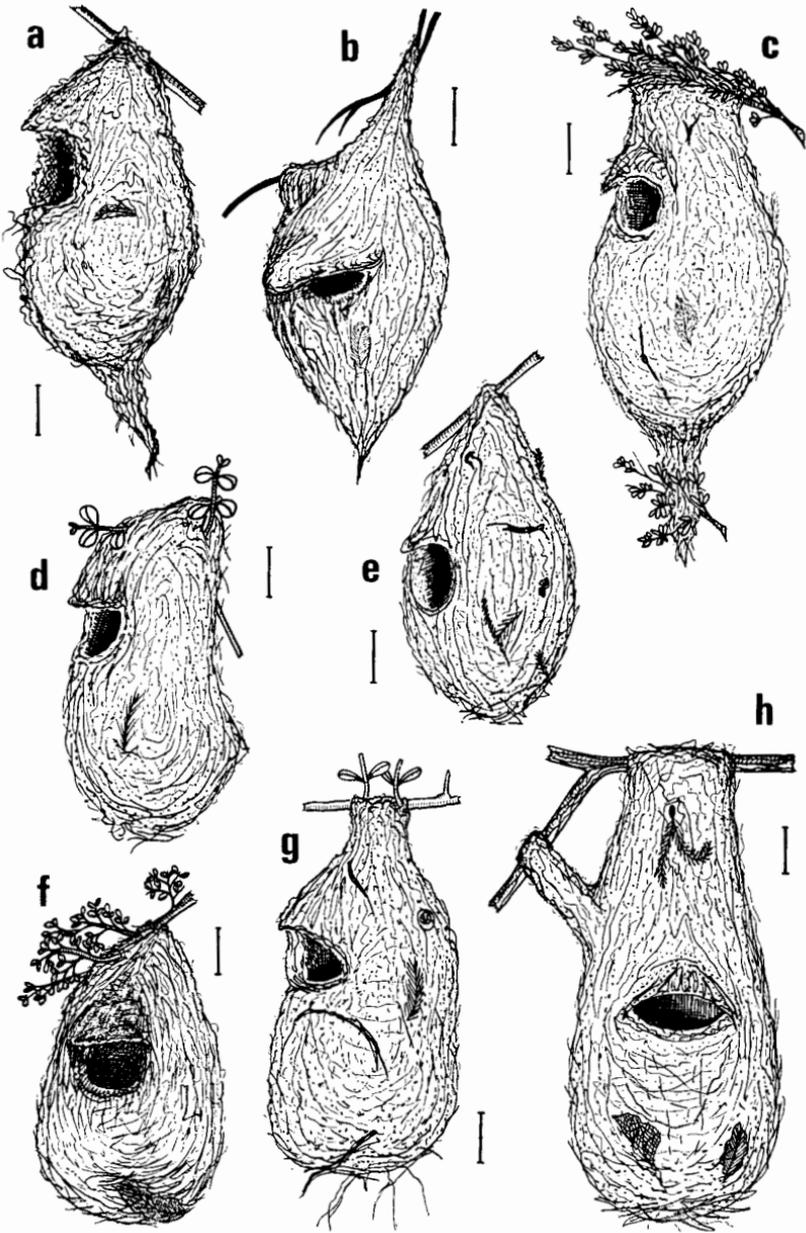


FIGURE 3 — Nests from Kowhai Bush; scale line = 2 cm

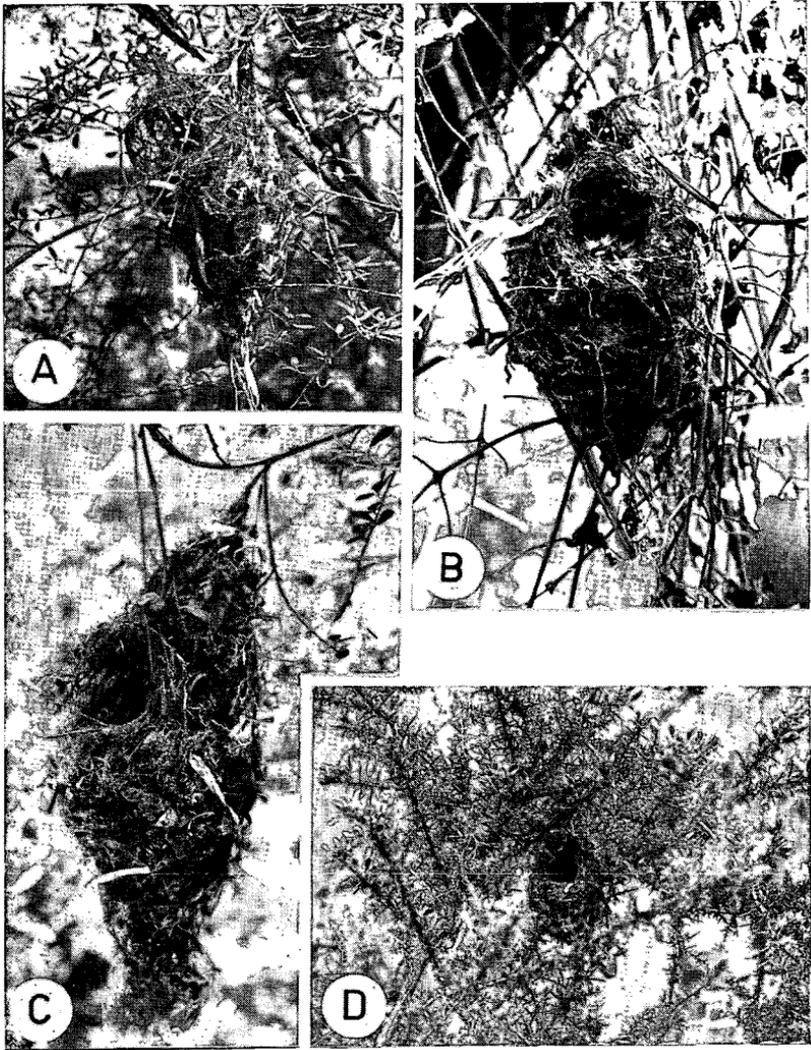


FIGURE 4 — Nests from Kowhai Bush. (A) Pensile nest with prominent hood (in *Coprosma propinqua*; 2 m above ground). (B) Semi-pensile nest (*Clematis vitalba*; 3.5 m) containing four nestlings (8-9 days old; two visible at entrance). (C) Precariously attached pensile nest (*Cytisus monspessulanus*; 1.5 m). (D) Pensile nest without "beard" (*Ulex europaeus*; 1 m)

(chi-squared = 124.58 for 4 d.f.; $P < 0.001$) show that there was always a significant difference between observed orientations of nests and orientations expected from the occurrence of winds.

Thus, although warbler nests were often non-randomly orientated, there was no correlation with winds from the opposite direction. Responses to direction of sunlight may have been involved, but there was no obvious trend (Fig. 5). Alternatively, orientation may have been to aspects of the nest site, rather than to any gross environmental factor.

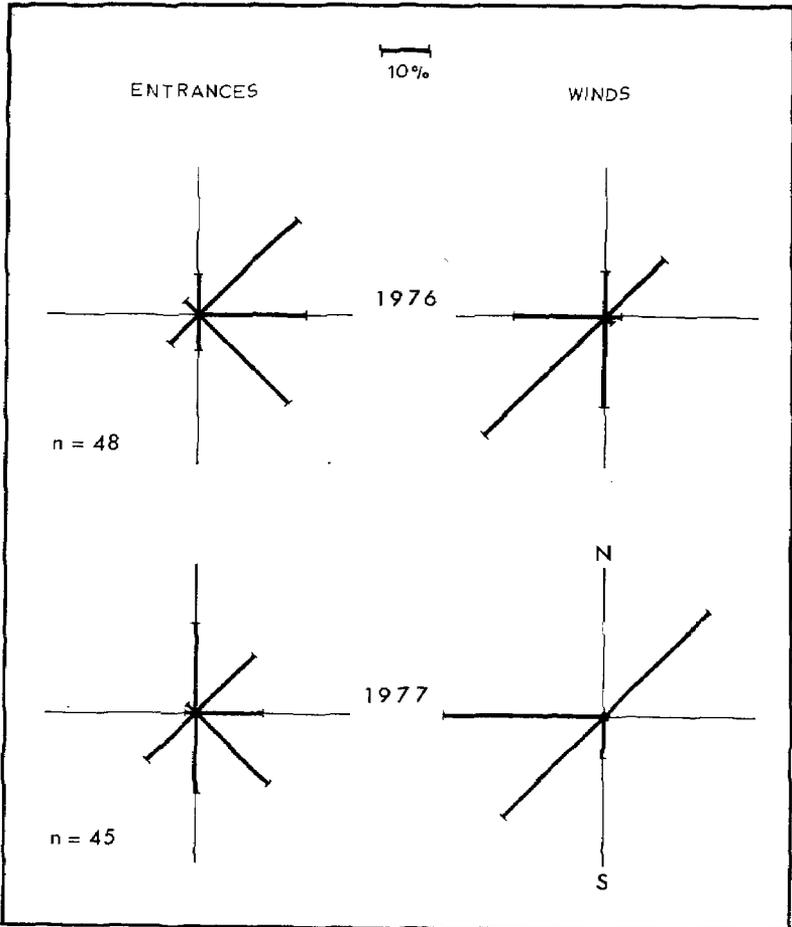


FIGURE 5 — Directions which nest entrances faced at Kowhai Bush, and from which winds blew on the Kaikoura Peninsula

Composition

The nest's exterior, including points of attachment, was a dark brown-grey-green fabric comprising a framework of stout material (rootlets and grass stems) filled out with fine matter (e.g. moss and sheep's wool) intimately bound together with cobwebs. Many nests at Kowhai Bush simply had an outer shell of this material and a lining, whereas others had an intermediate layer of wool or *Clematis* seeds. I dissected two nests (after removing the lining) but was left with residues (10% and 36% by weight) of intimately bound cobwebs, moss and other fine matter that I could not separate further. Otherwise the nests comprised roughly equal amounts by weight of moss, rootlets or grass stems, and spiders' webbing or egg cases.

The composition of nests depends partly on what materials are available. Nests at the edge of Kowhai Bush near farmland, for example, contained large amounts of sheep's wool. Moss and *Leptospermum* bark were found everywhere at Kowhai Bush, and both adorned the exterior of most nests. The following list of the nesting materials of Grey Warblers was compiled from the present study and from about 50 cards of the Nest Record Scheme:

Moss; cobwebs and spiders' egg cases; lichen; sheep's wool; hair of horses, cows, deer and humans; feathers; leaves, pine needles and leaf skeletons; scales and fibres from ferns; twigs; bark; rootlets; thistledown and willow catkins; decayed wood; scraps of paper; fine creepers.

Nests are lined with feathers (one at Kowhai Bush had 255), downy seeds and tree-fern scales.

Similarity of nests of a pair

At Kowhai Bush, a late nest was often strikingly similar in form to the same pair's earlier nest, and I considered this for up to 22 pairs of nests. The degree to which nests were pensile was the same in 9 of 14 pairs; presence of a hood was consistent in all of 13 pairs and of a ledge in 8 of 10 pairs; direction of entrance was the same in 13 of 15 pairs (adjacent eighths of the compass considered equal); and outside depth was identical to within 1 cm in 6 of 7 pairs. However, as many pairs of nests were consistent in the presence of a "beard" as were inconsistent ($n = 12$), and the nests of only 8 of 22 pairs were in the same species of tree. Sixteen of 22 late nests were lower than their earlier counterpart; 13 of 17 were in shorter trees; 10 of 17 were lower in relation to tree height; and 14 of 17 were lower relative to canopy height. This trend towards late nests being low was general for Grey Warblers at Kowhai Bush (Gill 1982a).

EGGS

Copulation

Six times (between late October and mid-December) I saw Grey Warblers copulate. I saw one pair copulate 14 days before

the first egg was laid. Another pair copulated on about the same day that they produced the first egg (nest undiscovered at the time) and another on about the day that they laid the third egg of four. One instance of copulation (apparently fruitless) preceded moulting in the male by only a month.

Mounting lasted less than 10 seconds but was usually repeated, the male alternately balancing on the female's back by constantly fluttering his wings, and perching beside her. The female displaced her tail to the left (two instances) for cloacal contact, and sometimes held nesting material or food in her bill. A harsh chattering was given, at least on one occasion by the female. Birds copulated on the ground or on perches, some nearly vertical.

Time of laying

In September 1977 I determined for three eggs in two early clutches the times at which they were laid. All were laid within an hour of first light (c. 0600 h), probably, in two cases, a few minutes after sunrise (0640 h). In the best-documented example (12 September), the unbanded female entered the nest (containing two eggs) 36 minutes after first light, followed to the entrance by ♂-H, which had been singing repeatedly nearby. After 9 minutes (at 0645 h) the female reared up and held this position for 1.5 minutes, except for a brief lowering at 0646 h. This period was presumably the actual moment of laying, at which time birds typically raise the body (Welty 1975). The male sang but also gave short down-slurred calls. The female stayed in the nest for 7.5 minutes more, fidgiting occasionally, and then flew off at 0654 h after ♂-H sang. She had spent 18 minutes in the nest, which then contained three eggs.

Two mornings later the female was on the same nest when I inspected it only 14 minutes after first light. I flushed her to be sure there were only three eggs. She re-entered after 15 minutes (at 0629 h), and 25.5 minutes later, she reared up in the nest, peering from side to side with her head extended through the entrance. This lasted a minute and was followed by 9 minutes more in the nest. The male sang as close as 1 m from the nest, but for much of the time he was elsewhere driving an intruding warbler from the territory. When the female departed at 0704.5 h (after 35.5 minutes in the nest) there were four eggs.

In the third case (12 September), at a neighbouring nest, I flushed ♀-9 from three eggs at 0618 h. When I inspected the nest 48 minutes later the female was off but the clutch was complete (four eggs). Grey Warblers may not always lay at sunrise. Card 6435 of the Nest Record Scheme reports the laying of a fourth and final egg between 0800 h and 1600 h on 30 November 1967.

Morphology

The Grey Warbler's egg is white with reddish-brown speckles. The speckling varied, both within and between clutches, from almost

none to intensive, and the blotches ranged from minute to about 1.5 mm wide. Figure 6 shows large-speckled and finely speckled eggs from two different clutches. Speckles were usually concentrated into a dense band at the egg's larger end, but a few eggs were nearly uniformly speckled. Early writers reported pure white eggs, attributed to young birds (Potts 1869) or to a possibly separate species (Buller 1870), but they are not mentioned in recent literature and I found none.

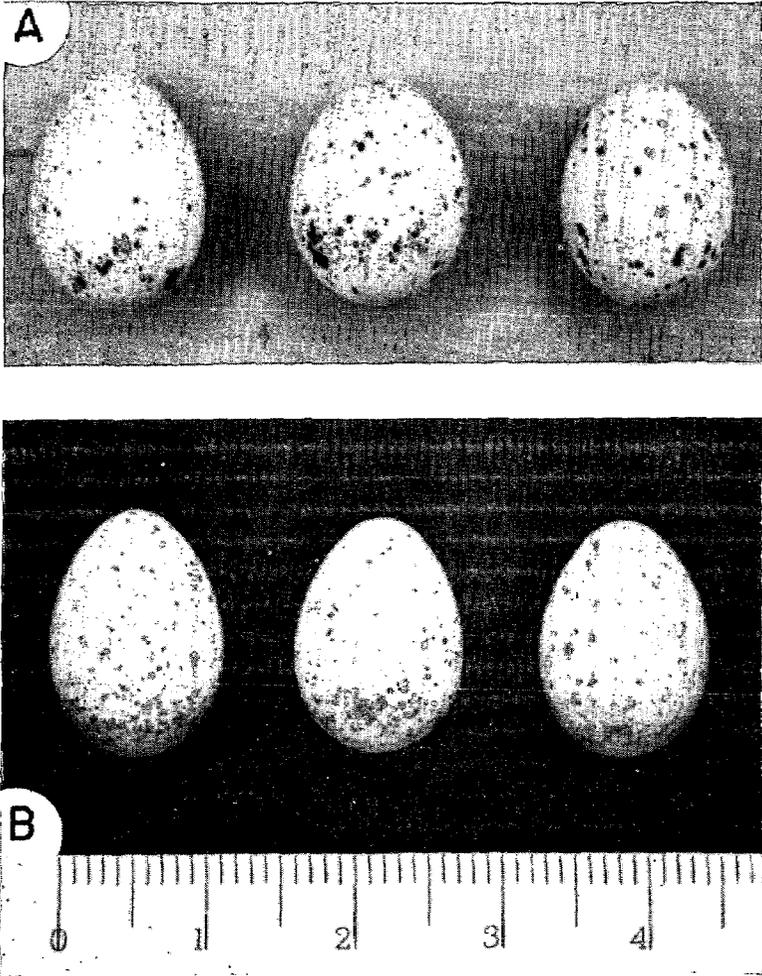


FIGURE 6 — Eggs from two Grey Warbler clutches showing variation in pattern; scale in mm. In (A) the angle of view is slightly oblique, favouring the larger end.

The shell was translucent and slightly pink in the fresh egg but became chalky-white and opaque with incubation.

The longest egg I measured at Kowhai Bush was nearly the narrowest (18.8 x 11.4 mm), and the shortest was nearly the widest (15.8 x 12.8 mm), but there was no statistical correlation between length and width ($r^2 = 0.01$, $n = 35$). On average, eggs of early clutches were 16.95 mm long ($n = 16$, s.d. 0.638), compared with 17.21 mm ($n = 15$, s.d. 0.895) for late eggs, the difference being not significant (t-test). However, the difference in width between early eggs (mean = 11.96 mm, $n = 17$, s.d. 0.381) and late eggs (mean = 12.23 mm, $n = 15$, s.d. 0.362) was highly significant ($t = 5.50$ for 30 d.f.; $P < 0.001$). By contrast, early eggs of the Robin (*Petroica australis*) at Kowhai Bush were longer than later ones, but widths were similar (R. Powlesland, pers. comm.).

The weight (W), length (L) and width (B) of avian eggs are related by the expression $W = kLB^2$. Average values for Grey Warblers at Kowhai Bush were: fresh weight 1.49 g, length 1.708 cm and width 1.208 cm. Therefore $k = 0.598$. This is close to the value ($k = 0.546$) that Romanoff & Romanoff (1949) gave for 14 altricial species. The mean weight of seven warbler eggs on the day before hatching was 1.13 g (s.d. 0.04, range 1.10-1.20 g), showing an average loss during incubation of 0.36 g or 24% of fresh weight.

NESTLINGS

Natal pterylography

The young of some passerines are naked at hatching, but many sport a natal down, especially on dorsal surfaces. The down feathers (neossoptiles) are pushed from their follicles by the ensheathed teleoptiles ("pin feathers") that develop later, and to which the down remains attached until the juvenile feathers unfold (Pettingill 1970). Not all teleoptiles are preceded by neossoptiles. Therefore, the tufts and rows of down feathers only roughly match the arrangement of pterylae, and separate naming is required. I followed the nomenclature of down-patches used by Saunders (1956) for North American passerines.

The natal down of Grey Warblers occurred in eight main patches: ocular, coronal and occipital patches on the head; dorsal, humeral, femoral and abdominal patches on the body; and secondary patches on the wings (Figure 7). Occipital and dorsal patches were median; all others were bilaterally paired. In addition to the above patches, 10% of nestlings had a minute tuft (on one or both thighs) of crural down, and nearly 80% ($n = 45$) had single or multiple tufts of down to one or both sides of the throat. This throat patch was not noted by Saunders and I called it the jugular patch. It occurs also in Willie Wagtails (*Rhipidura leucophrys*) in Australia (Gill 1982b). Crural and jugular down was insignificant and variable in Grey Warblers, and I overlooked it during the first breeding season.

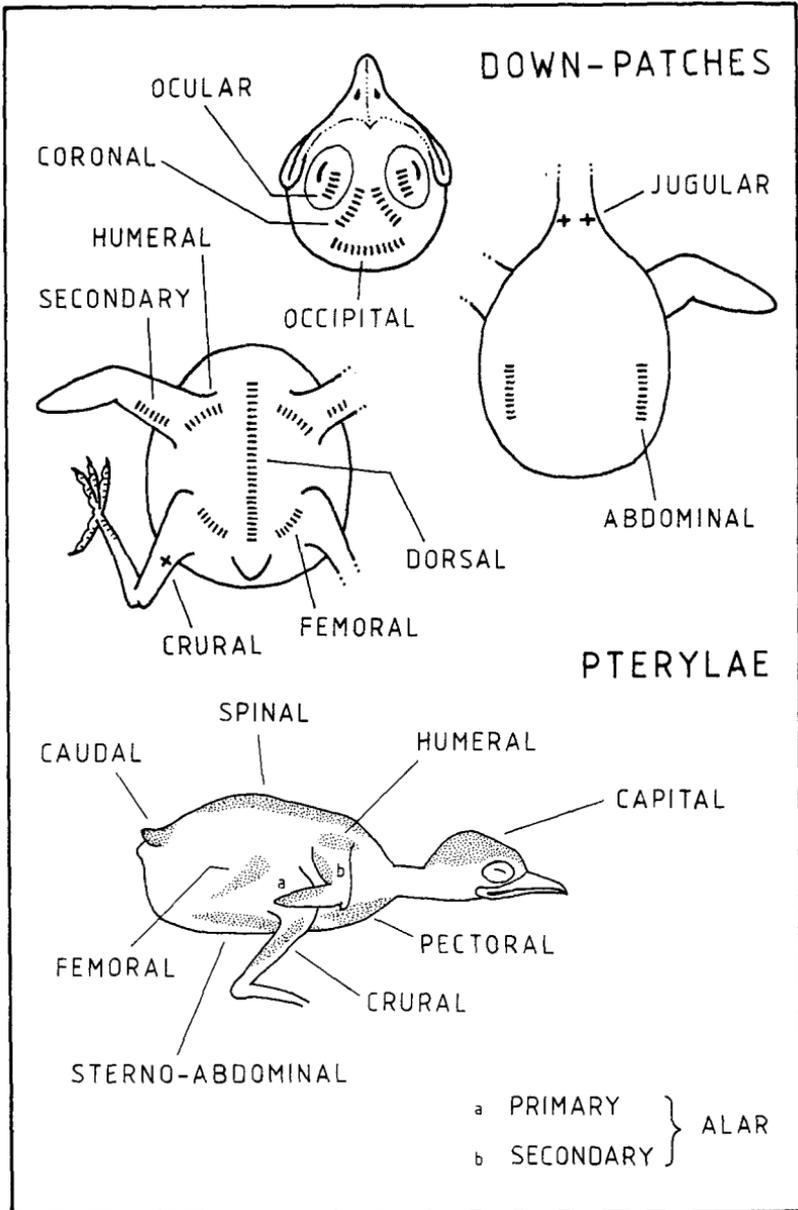


FIGURE 7 — Names and positions of the down-patches and pterylae of nestling Grey Warblers

Of the 12 down patches described by Saunders, three (the primary, caudal and lateral patches) were absent in Grey Warblers. The ocular patch (just above the eye; see Figure 8A), was seen only in a tyrannid flycatcher by Saunders, who predicted wrongly that it would not be found in song birds.

The neossoptiles of Grey Warblers (as seen in full-term embryos from unhatched eggs; Fig. 8A) were in rows rather than patches, many at the ends of rows being shorter than the rest. Ocular, coronal and abdominal neossoptiles were in a single row, whereas those of the occipital, secondary, humeral and femoral patches were in a double row, though not always paired off. Neossoptiles were paired in the anterior part of the dorsal patch but formed one row posteriorly. Three-quarters of nestlings had a dorsal patch in two sections separated by a gap, but in some it was continuous and in others nearly absent.

Physical development

I described the superficial development of Grey Warblers from repeated examination in the field of 40-60 nestlings. The developmental sequence was uniform, but the rate varied greatly among individuals — the nestling in Fig. 8D, for example, developed much more slowly than those in Fig. 8C & E. The description that follows is composite and generalised. Day 0 was the day of hatching. The nomenclature of major pterylae (Fig. 7) follows Lucas & Stettenheim (1972: 74-75).

Day 0 (Fig. 8B): Two warblers at hatching weighed 0.80 g and 1.15 g, and of 83 nestlings weighed within 24 hours of hatching, 14 were 1.00 g and a further seven were 0.85-0.95 g, these presumably having recently hatched. Thus newly hatched warblers weighed about 1 g, often a little less. The skin colour of nestlings at hatching was either distinctly grey (32% of the 87 examined) or pink. Most nestlings were clearly assignable to one or other category but others suggested continuous variation. Sometimes both forms were in the same brood. The significance of the two skin colours is obscure, and both forms developed the same plumage. Natal down and rictal flanges were white. The grey bill had a black tip and claws were dark grey. Bristles less than 1 mm long were on the caudal tract and primary and secondary alar tracts.

Day 1-2: The skin darkened on all dorsal surfaces and on the legs. Skin covering the eyes slit in many cases. Some rictal flanges turned pale yellow.

Day 3-4: Emerging pin feathers were visible along the pectoral and sternoabdominal tracts, and on the alar tracts they were up to 2 mm long (including terminal bristle). Skin over the eyes slightly parted (i.e. widened beyond a slit) in some cases. Rictal flanges were mostly yellow or bright yellow (with buccal skin and tongue to match); only a few remained white.

Day 5-6: Capital, caudal, femoral, humeral and crural pin

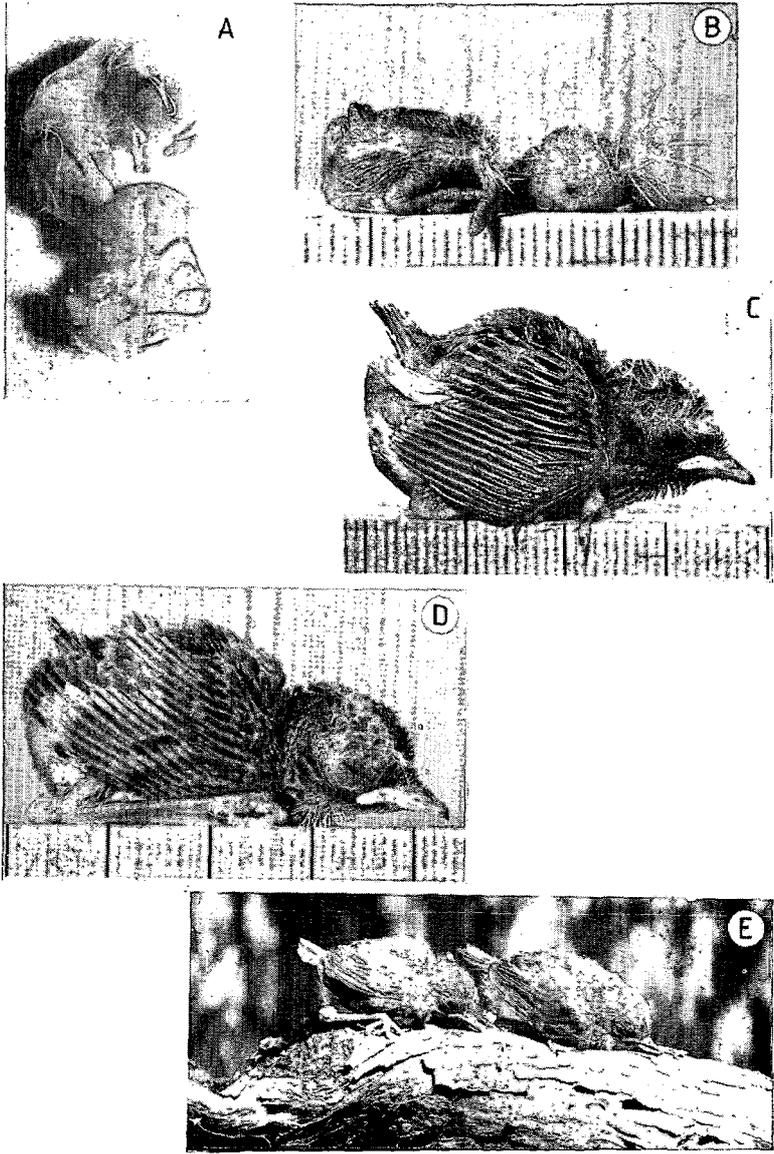


FIGURE 8 — Developmental stages of nestling Grey Warblers; scales in mm. (A) Full-term embryo (under water) showing yolk-sac and natal down. (B) Day of hatching. (C) c. 8 days old. (D) 12 days old. (E) 15 days old

feathers were less than 1 mm long; others reached 1 mm (spinal, pectoral and sternoabdominal tracts), 4 mm (secondary tract) or up to 5 mm (primary tract). The opaque sheaths showed the grey of the underlying feathers except in the sternoabdominal and femoral pterygiae, where they showed pale. All rictal flanges were cream to bright yellow.

Day 7-8 (Fig. 8C): Spinal, pectoral, sternoabdominal and femoral feathers were first to erupt from their sheaths. Sometimes, primary and secondary remiges and capital, humeral and crural feathers also emerged. Sternoabdominal and femoral feathers were white, and the others grey. Rectrices remained ensheathed. The longest primary pin feather was 10-12 mm before the sheath started to disintegrate, and the longest secondary was a little shorter. Spinal, pectoral, sternoabdominal, femoral and humeral pin feathers did not exceed about 3 mm, and capital and crural pin feathers reached up to 1.5 mm. Some nestlings lost the egg tooth; most had half-open eyes. Legs were dark grey-pink but for conspicuously pale ankles.

Day 9-10: Caudal feathers erupted before the intact sheaths exceeded about 4 mm. Most feathers in all pterygiae were at least partly unsheathed, but much natal down persisted, presumably at the tips of intact pin feathers.

Day 11-12 (Fig. 8D): White keratinous flakes were shed profusely as the sheaths disintegrated. Remiges extended to 20 mm from base to tip, whereas the longest rectrix was barely 10 mm. The bill (progressively from tip to base) and legs darkened. Many nestlings had yellowish ankles and a pale stripe along the hind edge of the tarsometatarsus. Some nestlings retained the egg tooth.

Day 13-17+ (Fig. 8E): No sheaths or apteria were externally visible on nestlings resting with folded wings. The ventral apterium and much of the nakedness under the wing were occluded before fledging. The longest remex approached 30 mm and the longest rectrix 15 mm. The tail was conspicuously short at fledging, at which time natal down sometimes persisted on the head. Small yellow feathers developed in the orbital region. At fledging, claws were black, legs distinctly grey with paler soles, and the bill dark grey with a black tip. Eyes opened fully revealing dark brown irides. Warblers could fly when they left the nest.

Behavioural development

The following simplified composite description of behavioural development refers mainly to nestlings in the hand, their behaviour in the enclosed nest being hard to see. Although influenced by disturbance these details show the main events.

Newly hatched nestlings rested on their abdomen in the foetal or "egg" position characteristic of most altricial birds (Banks 1959). They did little other than raise their head to gape, often when their bill was touched. After 2-3 days, they struggled during handling by

stroking with their legs, and as dexterity developed, by clenching and unclenching their toes. Day 4 was the earliest that a nestling showed signs of grasping the nest's lining, and from that time I noted faint cheeping (begging calls) in the hand. From day 5, nestlings squealed (protest calls) when taken from the nest. On day 7, nestlings were just able to right themselves when inverted, and at rest they gripped with the toes, held the wings folded against the body and hunched the head without raising it. From day 8, I saw nestlings shuffling in the nest and could hear them cheeping when I was within 5 m. Between days 8 and 12, nestlings began to raise their head and look from side to side, obviously responsive to visual stimuli.

At 12 days, many nestlings could grasp twigs but could not raise their own weight, and so, if made to perch, they rested on their belly. From about 13 days, the crown feathers were erectile and nestlings raised them (as did adults) when I measured their bill. Older nestlings gave single cheeps almost continuously in the nest but broke into rapid cheeping whenever a parent arrived with food. Sometimes nestlings so crowded the entrance and begged so vigorously that a parent could not perch there and had to deliver food from an adjacent twig. When removed from the nest older nestlings sought cover in dark cavities, but nearer fledging they remained in the light and gaped at objects thrust close to their bill. When I approached them, nestlings never left the nest suddenly, unless about to fledge anyway. Thus, this species does not have the explosive response to disturbance noted for many north-temperate passerines (Pettingill 1970).

Young nestlings rose up in the nest only when an adult brought food; otherwise they lay prostrate, pressed against one another. The natal down of nestlings at rest formed a dense layer which blended with the lining in the nest. Thus, the young nestlings' first defence against predation was camouflage. If molested, nestlings clung to the floor of the nest, and if dislodged, they squealed loudly. The parents usually responded at once, and both presented the human intruder with a repertoire of beak-clicking, growling and agitated trilling while they hovered, perched and swooped to within centimetres of the squealing nestlings. When a nestling fledged the watchful parents followed it immediately and, as occasion demanded, fed it or attempted its defence by the above displays.

Stomach contents

I investigated the diet of nestling Grey Warblers at Kowhai Bush by removing the stomachs from 19 nestlings that had died. All were 10 days or older, collected from October to January. I examined the contents of the gizzard and proventriculus (though the latter was usually empty) under a dissecting microscope, and identified items of food to order (Table 4). I measured or estimated the length of the longest axis of items to the nearest whole millimetre.

TABLE 4 — Classification by order of 173 invertebrates collected from the stomachs of 19 nestling Grey Warblers at Kowhai Bush

	Stomachs		Total items		Items/stomach	
	No.	%	No.	%	Mean	Maximum
Hemiptera	3	16	6	3.5	0.3	4
Coleoptera	9	47	9	5.2	0.5	1
(caterpillars)	(17)	(90)	(72)	(41.6)	(3.8)	(16)
(moths)	(2)	(11)	(5)	(2.9)	(0.3)	(4)
Lepidoptera	18	95	77	44.5	4.1	16
Diptera	12	63	21	12.1	1.1	3
INSECTA	19	100	113	65.3	6.0	21
Araneae	12	63	38	22.0	2.0	8
ARACHNIDA						
Unidentified arthropods	8	42	16	9.2	0.8	5
ARTHROPODA	19	100	167	96.5	8.8	31
Stylommatophora	3	16	6	3.5	0.3	3
MOLLUSCA						
INVERTEBRATES	19	100	173	100	9.1	31

Grey Warblers fed their nestlings solely on invertebrates; *Leptospermum* leaves and small pieces of grass in some stomachs were probably ingested accidentally. The maximum number of items in a single stomach was 31. On average there were 9.1 invertebrates per stomach, but several held only finely comminuted remains.

The proportion of stomachs in which a category of food appears indicates selectivity and/or the availability of food. All stomachs contained insects and most held caterpillars. Dipteran flies and spiders were well represented. In general, however, the diet was rather narrow, comprising members of only six invertebrate orders. By comparison, nestling parid tits in Britain were fed invertebrates of 14 orders (Betts 1955).

Of all items ingested, 45% were lepidopterans, 20% other insects and 20% spiders. On average there were six insects (including four lepidopterans) per stomach and two spiders. Three stomachs contained small discoid snails 1-2 mm in diameter, showing that warblers may

collect prey that is neither large nor fast-moving. Silvereyes (*Zosterops lateralis*) in New Zealand also eat small snails (Kikkawa 1966). Nearly half the ingested items were 5 mm long or less (Figure 9), even though the data refer to nestlings at least half-grown. In my sample, nearly all items longer than 10 mm were caterpillars.

Sanitation and mites

After delivering food at the nest, parents removed faecal sacs if the nestlings produced any. The enclosed nest made observation difficult, but often adults seemed to prod to stimulate defecation, and nestlings revolved in the nest and presented their rump at the entrance. The gelatinous faecal sac was carried to a perch 6-15 m from the nest and some, perhaps all, were dropped. Adults at the nest sometimes made repeated swallowing motions, but whether they ate faecal matter or were clearing their bill of the food just brought was not clear.

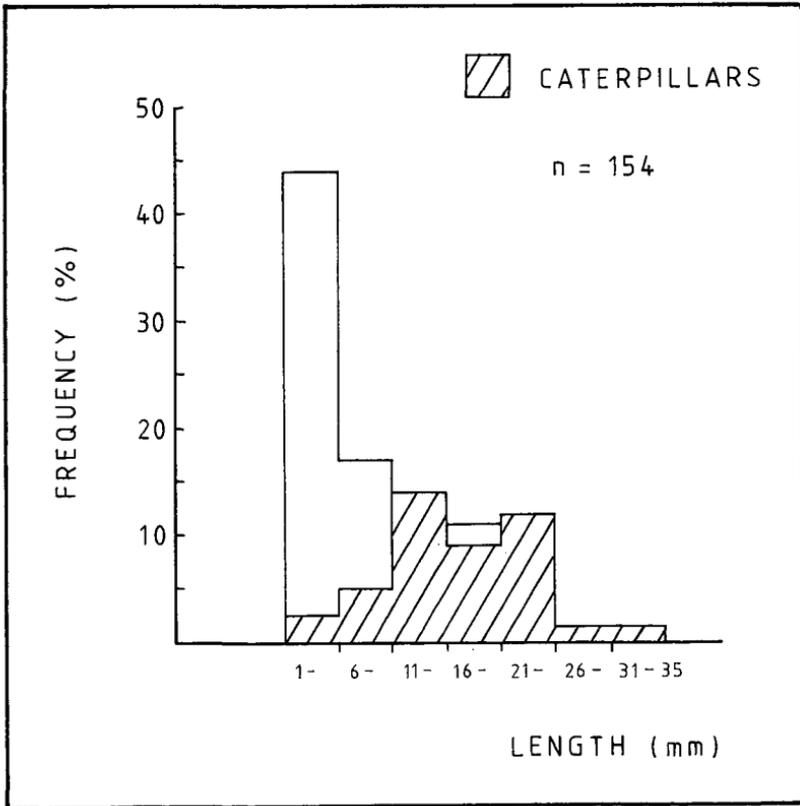


FIGURE 9 — Distribution of items from the stomachs of nestling Grey Warblers according to length of the longest axis

Nests were clean initially, but as the nestlings grew, dried faecal sacs accumulated in the lining along with flakes of keratin from the pin feathers. Nearly 40% of 37 nests at Kowhai Bush developed infestations of red or brown mites (Acarina), which I usually noticed after the young were half-grown. I may have transmitted mites from nest to nest by the polythene bags in which I weighed young, and so the incidence quoted here may be inflated. Sometimes, mites were so numerous that they swarmed over the nest's exterior and over adjacent vegetation, after the nestlings fledged.

Samples of mites from several nests were examined by Dr R. Domrow (Queensland Institute of Medical Research, Brisbane) and found to be *Ornithonyssus bursa* (Berlese 1888), which is known also from Starlings (*Sturnus vulgaris*), House Sparrows (*Passer domesticus*) and Domestic Fowls (*Gallus gallus*) in New Zealand (Powlesland 1977).

FLEDGLINGS AND JUVENILES

Fledgling Grey Warblers were recognisable in the field at Kowhai Bush until about mid-March, two months after the last fledged. The irides were dark brown (red in adults), the legs dull grey (black in adults) and the buccal lining yellowish (black in adults). The facial plumage was suffused with yellow, and a pale yellow circum-orbital ring was often apparent, even at a distance. The tail was paler than in adults. Two banded young developed adult appearance in early February, 12 and 15 weeks after fledging. At this time other banded juveniles had moulting tails and red irides. Young apparently became indistinguishable from adults at their first moult, which seemed to coincide with the post-nuptial moult of adults (January to March). Juveniles dispersing from their natal areas could often be distinguished by their quietness and secretiveness. Sometimes they were chased from territories by resident adults; often they were tolerated.

For 1-3 weeks after fledging, warblers of early broods usually stayed together and were fed by both parents, but the male often did most feeding when only two young fledged. Then, during the next 1-3 weeks, the male often attended the juveniles alone, while the female left the group intermittently to build a second nest. When with the group at this time the female often ate the food she collected and ignored or drove off fledglings that begged to her.

In two of nine families that I watched regularly, the male cared for two of four, and two of three, juveniles, and the female attended to the rest. Both parties within the family were always nearby, but each juvenile begged to, and received food from, only one parent. Twice at Kowhai Bush I saw an adult warbler feeding an unrelated juvenile in addition to its own.

At Kowhai Bush less than 10% of fledglings (six birds) were recruited to the breeding population during my study (Gill 1982a). One was probably a female — I saw it in November 1978 near the

TABLE 5 — Fates of Grey Warbler eggs at Kowhai Bush that did not hatch

Cause of mortality	1976-77		1977-78		Early		Late		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Infertility	4	12	4	9	6	17	2	5	8	10
Death of embryo	6	20	7	15	6	17	7	16	13	17
Cuckoo-parasitism: removal	5	16	6	13	0		11	26	11	14
Cuckoo-parasitism: eviction	3	9	3	6	0		6	14	6	8
? : disappearance	9	28	16	34	11	30	14	32	25	31
? : eviction	4	12	10	21	12	33	2	5	14	18
? : broken in nest	1	3	1	2	1	3	1	2	2	2
	n 32		47		36		43		79	

TABLE 6 — Fates of Grey Warbler nestlings at Kowhai Bush that did not fledge

Cause of mortality	1976-77		1977-78		Early		Late		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
? : death in nest	10	25	7	22	14	43	3	8	17	23
? : disappearance	14	34	3	10	9	27	8	20	17	23
Cuckoo-parasitism: eviction	3	7	9	29	0		12	31	12	17
? : eviction	0	-	4	13	0		4	10	4	6
Predation	12	29	8	26	8	24	12	31	20	28
Competition?: "runts"	2	5	0		2	6	0	-	2	3
	n 41		31		33		39		72	

natal territory from which it had fledged in October 1976. The others were males that I saw proclaiming territory. Two males were singing on territories (0.8 km and 2.3 km from their natal sites) in the season after that in which they had been raised. Another held a territory (0.6 km from the natal site) in the second summer after it had been raised, although it may also have done so in the first summer. I did not determine whether any of these three males had mates and bred.

The fourth, ♂-K, was netted, probably as a juvenile, in July 1977 and seen repeatedly on a territory 0.4 km away from August to October 1977. It sang regularly and fought neighbouring males but probably did not breed because I did not see a mate. It apparently lost its territory for the second half of the 1977-78 breeding season, but in 1978-79 ♂-K held a territory throughout the summer and bred at least twice with an unbanded mate. The fifth male held a territory 9 months after fledging. The unbanded mate built a nest 0.7 km from that in which the male had been raised. I did not determine whether eggs were laid, and later in the season an unbanded pair were occupying the area.

Nearly all territorial birds begin reproduction in the first season after that in which they are raised (Lack 1968). The evidence is meagre but it seems that male Grey Warblers at Kowhai Bush were rarely successful in holding territory and breeding in this first year.

MORTALITY OF EGGS AND NESTLINGS

Tables 5 and 6 give the known or inferred causes of death at Kowhai Bush of 79 eggs and 72 nestlings. Infertility of eggs was more common in early clutches than late ones, suggesting poor behavioural or physiological synchronisation during some initial copulations. Parasitism by Shining Cuckoos destroyed eggs in two ways: a warbler's egg was apparently removed in substitution for the cuckoo's and nestling cuckoos evicted warbler eggs (Gill, in press). Parasitism affected only late clutches but it was the main cause of loss of late eggs (40%). Eggs that disappeared without trace vanished all at once or sporadically, and sometimes only part of a clutch was lost. Eviction of eggs (other than by cuckoos), as indicated by their presence on the ground beneath nests, was particularly common for early clutches in 1977 when strong winds seemed responsible for the loss of 9 eggs. Most eggs that disappeared, that were broken in the nest, or that were evicted (other than by cuckoos) were probably destroyed by ship rats (*Rattus rattus*) or stoats (*Mustela erminea*).

The greatest single cause of mortality of nestlings was predation (presumably mammalian), indicated by a destroyed nest and/or mutilated nestlings. Unrecognised predation may have contributed to the disappearance of nestlings, which for reasons unknown was more common in 1976-77 than in 1977-78. More nestlings died in the nest without obvious cause in early broods than in late ones. Food supply early in the season may have been involved, but some of the dead nestlings

I dissected had full stomachs and so they had not starved. The last nestlings hatched in two broods of four in 1976 did not gain weight and died, whereas their siblings were healthy. These "runts" that apparently starved were from early broods. The eviction of nestling warblers by young cuckoos was a major cause of mortality for late broods but a relatively minor one overall. In Table 6, eviction (other than by cuckoos) refers to four nestlings in two late broods of 1977-78 found unharmed on the ground beneath their nests, perhaps after disturbance by a predator.

The average number of young to fledge per nest was similar in 1976-77 (1.74) and in 1977-78 (1.71), but whereas 3.3 nestlings on average hatched per nest in 1976-77, only 2.4 did in 1977-78. This suggests high mortality of eggs in 1977-78 but of nestlings in 1976-77.

Of 65 early eggs (in 18 nests) in 1976-77, 92% hatched, whereas of 70 early eggs (in 18 nests) in 1977-78 only 64% hatched. Of 60 early young hatched in 1976-77, only 63% fledged, whereas of 45 early young in 1977-78, 80% fledged. The success of late eggs and nestlings was similar in the two seasons, as was the overall proportion of eggs (early and late) that yielded fledglings (43% of 109 eggs in 1976-77; 34% of 123 eggs in 1977-78).

DISCUSSION

Several factors combine to make Grey Warblers very suitable for study in the field. They are common and widespread; breeding adults are sedentary and long-lived (Gill 1982a); adults are relatively easily caught in mist-nets for banding; females may be caught on the nest; and observations and manipulations at the nest bring little risk of desertion. The biology of this species deserves to be fully explored.

The arrangement of natal down in neonate passerines warrants more attention than it has received because it is a potential taxonomic character that may help resolve generic and familial relationships. A start has been made here for New Zealand species. Further records of natal pterylography may lead to a better understanding of the relationships between, for example, the Acanthisittidae and New Zealand song-birds, and between *Mohoua/finschia* and the malurid and acanthizid warblers of Australia.

The developmental sequence (physical and behavioural) that nestling Grey Warblers follow is very similar to that of other song-birds. However, I suspect that the rate of development in warblers varies more among individuals than is so for most north-temperate species. Also, warblers are physically very advanced at fledging compared with Northern Hemisphere species with shorter nestling periods. In North America, White-crowned Sparrows (*Zonotrichia leucophrys* Emberizidae) fledge at 9-10 days old, often with partly ensheathed feathers and a partly exposed ventral apterium (Banks 1959), and newly-fledged Rufous-winged Sparrows (*Aimophila carpalis* Fringillidae), which are 8-9 days old, hide in grass because they cannot fly

(Austin & Ricklefs 1977). It is interesting that Grey Warblers shun the light for part of the nestling period. This presumably befits life in an enclosed nest, but the opposite tendency must be developed for fledging to occur.

Some of the eggs and nestlings that failed to survive at Kowhai Bush may have been taken by avian (rather than mammalian) predators, though none is known to rob warbler nests. Fulton (1910) was convinced of Shining Cuckoos being predatory, which is realistic because European Cuckoos (*Cuculus canorus*) avidly prey on eggs and nestlings (Wyllie 1975). Michie (1948) apparently saw a Shining Cuckoo eating the contents of a warbler egg but this may have been removed during parasitism rather than by deliberate predation. In Australia, Fien (1970) saw a Horsfield's Bronze-cuckoo (*Chrysococcyx basalis*) remove a host nestling. Magpies (*Gymnorhina*) may prey on the contents of Grey Warbler nests (Moon 1960). Another possible predator is the New Zealand Kingfisher (*Halcyon sancta*), which may attack warblers (Hay, pers. comm.), and which I saw at Kowhai Bush provoking alarm in adult warblers.

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Note added in press

Female-14, caught and banded as an adult in September 1977 (see territory plotted in Gill 1982a) was seen in the same part of Kowhai Bush by G. Sherley in August 1981, giving a minimum life span of about 4 years.

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SHORT NOTES

DAY-SLEEPING BIRDS

I have a horizontal stick outside my kitchen window on which I hang tins of syrup in winter time.

On 23 July 1982, I noticed a Silvereye (*Zosterops lateralis*) apparently asleep on the stick with its claws over the hook of the feeding tin. I stroked the Silvereye gently but it made no move. I was able to put a finger under its claw and roll my finger until the bird was perching on it. The empty tin was removed and a full one put on the hook, and I replaced the Silvereye by hooking its claws over the stick and removing my finger. It remained on the stick for another hour and ten minutes, even though other birds came to feed. Eventually it opened its eyes, flew down to feed a little, and then flew off. I did not know how long it had been asleep on the stick before I saw it.

While I was working in the garden on 15 October 1982, a Starling (*Sturnus vulgaris*) landed on the lawn about 2 metres away and laid an egg immediately. The Starling then moved as if to cover the egg, but instead folded its wings and sat on the grass beside it and went to sleep.

Half an hour later the Starling had not moved. I stroked it, with no response from the bird. I covered bird and egg with a large box and inspected it at about half-hourly intervals. On the fourth inspection I noted that the bird had changed its position a little, and so I stroked it gently. Presently the Starling opened its eyes and a moment later took a little run and flew off.

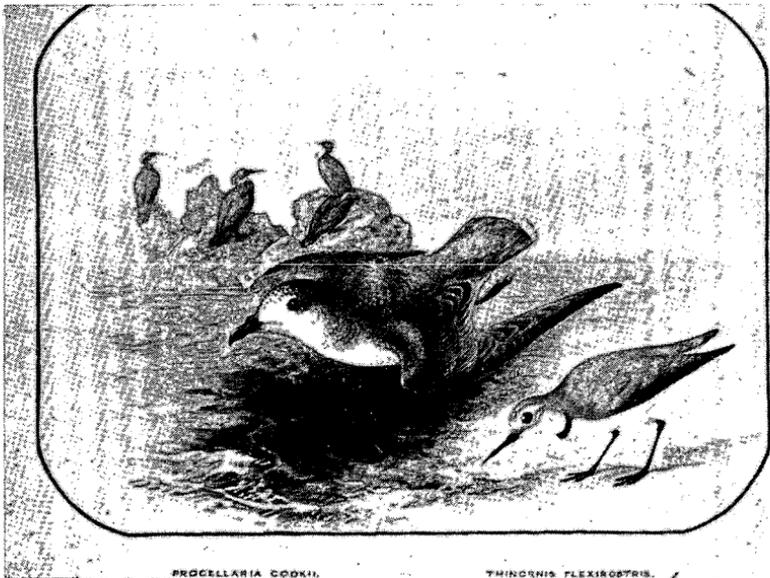
M. LANE, *Ashburton*

A PETREL PUZZLE

The puzzle begins on page 366 of Buller's *History of the birds of New Zealand*, first edition 1873, where the author stated that the only known specimen of Blue Petrel (*Halobaena caerulea*) in the country was in the Auckland Museum. The specimen cannot be traced; nor was Sylvia Reed able to find any record of its accession, which is not surprising in view of the Museum's early vicissitudes, including three or four shifts. The earliest specimen now in the Auckland Museum is labelled "Tamaki River 8/8/1924."

On the next page, 307, Buller, confessing a lamentable lack of information about Cook's Petrel (*Pterodroma cookii*), which at that time he had never encountered, wrote "Captain Hutton informs me that there is a specimen in the collection of the Rev. R. Laishley at Auckland."

The plate numbered 45 in the Laishley folder, BMNH, is a graceful composition. The top left-hand corner is occupied by a quartet of large shags, not named but almost certainly *P. carbo*, resting on rocks. Diametrically opposite, a Wrybill examines the beach, leaning forward with extended neck. Laishley must surely have sketched Wrybills on the tidal flats near Onehunga. The name given by the artist in the subtitle is most intriguing. Where did he find *Thinornis flexirostris*, which means literally 'beach bird with bent bill'?



By courtesy of British Museum of Natural History. Painted probably c. 1867 at Onehunga

and is very apt? No such name appears in Ellman's egregious 1861 list nor in Buller's 1873 synonymy. Did he invent it himself?

The centre of the plate is dominated by an exquisite painting of a Blue Petrel, although the bird is actually named as *Procellaria cookii*. In his 'Gleanings,' Laishley noted that "the tail terminates with a band of white about half an inch in breadth." He was too sharp-eyed a naturalist to miss such a diagnostic feature. He also remarked that, although Buller spoke of Cook's Petrel as rare, "we think this bird has been taken more than once in the Manukau Harbour;" and indeed it still crashes on the Auckland isthmus in autumn when young Cook's Petrels are leaving Little Barrier in misty weather and become dazzled by city lights. If Laishley had been able to examine the two species side by side, he would have noted the differences at once.

Being so impressed both by the delicacy of Laishley's painting and by its historic significance, I asked if I might order a colour transparency. My request was courteously received. When later back in New Zealand I showed the slide to several competent judges, all agreed that the central subject of Laishley's skilful watercolour was indeed a Blue Petrel and not, as it was labelled, a Cook's Petrel. In the 1860s most of the smaller truly oceanic tubenoses were still a closed book. We should be grateful for the picture and readily forgive the mistaken identification. We can be certain that Laishley handled and possibly possessed a good specimen of a storm-wrecked Blue Petrel.

Two earlier paintings of *Halobaena caerulea* have come to my notice. The first, showing a bird in flight over a grey-green sea, was done by George Forster towards the end of 1773 on Cook's second voyage. A faithful reproduction appeared in *Vogel der Sudsee. Segelfahrt mit Georg Forster*. His *Blauer Sturmvogel* preceded Laishley's painting by nearly a century.

The second appeared as plate 52, J. Gould and H. C. Richter, *del et lith*, in Vol. 7 1848 of *Birds of Australia*. Two Blue Petrels are shown squatting on what may be an ice-floe or greenish-topped rocks.

As far as I know the only published drawing of a Wrybill which precedes that of Laishley is reproduced in the *Zoology of the voyage of the Astrolabe*, Quoy & Gaimard 1830. It is a hand-coloured engraving by I. G. Pretre.

During his Onehunga period, 1860-68, Laishley was not short of original material to satisfy both the artist and the naturalist in him.

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OBITUARY

JOHN HERMAN (JACK) SORENSEN

New Zealand lost a noted ornithologist with the passing of John Herman Sorensen at Riverton on 27 October 1982. He was aged 77.

Born in Christchurch in 1905, Jack Sorensen moved with his family soon afterwards to Orepuki, Southland, where his Danish father worked as a gold miner, and where Jack first became interested in geology and natural history. He attended Orepuki School and later Southland Technical College, where he qualified as an engineer in both the gold and coalmining industries, a career which took him to many parts of Southland.

Jack was also a keen historian and took a great interest in the Southland Museum, located for a time at his old school, Southland Technical College, in its assembly hall. It was Jack Sorensen who prepared the plans for the new museum, which was eventually built in 1940 as a centennial memorial for the province, and it was he who became its first paid director.

The second world war found him selected as a member of the Cape Expedition — code name for the small highly secret force of New Zealanders occupying the Auckland and Campbell Islands to watch for enemy ships which could have found the islands' harbours invaluable staging-posts. Jack, part of the Campbell Island force, decided as always to make the most of his surroundings and devoted himself during his off-duty periods to the study of the island's natural history. In all, he spent more time there than anybody has, apart from shepherds during the island's sheep-farming days earlier in the century. Much of what we now know of the life histories of the island's birds, in particular of the Royal Albatross, is due to his studies. He meticulously recorded measurements and banded albatross over the years, working in surroundings that were always bleak and desolate and in a climate that was often inhospitable, gaining as a result the respect of his fellows for his total dedication to his work.

Jack Sorensen's research gave rise to two books, *Wildlife in the Sub-Antarctic* (1951) and, with Dr Bailey of Denver, Colorado, *Sub-Antarctic Campbell Island* (1962), plus numerous articles and papers.

After the war Jack completed his MSc degree at Victoria University while working in Wellington as a scientist with the then Marine Department. He retired to Winton in 1970, continuing his life-long studies in natural history. He is survived by his wife, a son and a daughter, and three grandchildren.

— R. W. Balham