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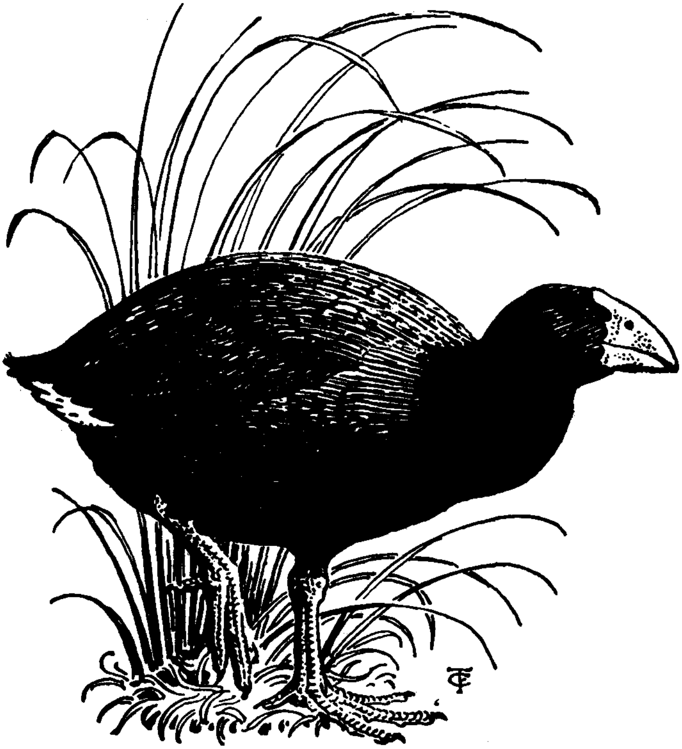

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FEEDING BEHAVIOUR OF THE BLACK-FRONTED DOTTEREL

By MICHAEL K. TARBURTON

ABSTRACT

Since its recent arrival in New Zealand the Black-fronted Dotterel has begun winter flocking, and a newly observed feeding technique has become common. This new feeding behaviour is used mainly on hard substrate. The bird taps the substrate before pecking at prey, and on hard substrate the capture rate is higher than by simple pecking. By imitating the tapping on soft, intermediate and hard surfaces, I found that vibrations from the tapping on hard substrate alone caused flies to jump, making them more visible.

In winter, birds were heard calling an hour before sunrise as they flew from sleeping sites scattered along the Manawatu River to the sludge ponds at the freezing works. The dotterels returned to the river after several hours of feeding but again visited the sludge ponds from mid-afternoon to almost an hour after sunset. At both the river and the sludge ponds most prey consisted of two species of fly.

Daily time budgets showed that birds were feeding for 38% of the day while incubating, 69% while tending chicks and 86% during a winter's day. It was estimated that during a winter's day, one apparently normal bird caught 28 737 insects. To do this it pecked at 31 579 insects and caught one insect every 1.5 seconds.

INTRODUCTION

The Black-fronted Dotterel *(Charadrius melanops)* is a bird of inland Australia and, although it is seldom seen on Australia's coastal beaches (Pringle 1987), it crossed the Tasman Sea and was first recorded in New Zealand near Napier in 1954 (Brathwaite 1955). Since then it has become established as a breeding species in both the North and South Islands.

In Australia the Black-fronted Dotterel is not gregarious (Maclean 1977, Pringle 1987); however, winter flocks of feeding birds were reported in New Zealand soon after its arrival (Mackenzie 1962). Flocks of 10-12 birds were seen in Hawke's Bay (Mackenzie 1963), 9 birds at the Masterton sewage ponds and 10-12 birds at the Greytown sewage ponds (Heather 1973).

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Subsequent visits to the last site recorded a winter maximum of 25 feeding birds. This paper records the behaviour of still larger flocks at Longburn in the Manawatu. Recently, Heather (pers. comm.) has seen wintering flocks of similar size to those found at Longburn (about 100 birds) at Lake Hatuma, Lake Wairarapa and the Feilding sewage sludge ponds.

Heather (1977) noted for the first time that Black-fronted Dotterels would sometimes tremble one foot before pecking at prey, and he proposed that this was a response to some feature of the substrate. Because the foot of birds at Longburn usually touched the ground, the term foot-tapping used by Heather (1977) seems appropriate to separate the behaviour from leg-shaking, where the foot does not touch the ground.

As the numbers of dotterels at the Longburn sludge ponds were large and the substrate varied from hard to soft, the situation looked ideal for finding whether the birds were foot-tapping or leg-shaking. It also looked promising for finding out the purpose and advantages of foot-tapping and winter flocking. As the birds nested nearby on the shingle beds of the Manawatu River, I had the opportunity to look at parental feeding during breeding.

METHODS

Black-fronted Dotterels were studied at the Manawatu River and the Longburn Freezing Works sludge ponds, 1 km from the river (Figure 1). These ponds were ideal for the study because large numbers of Black-fronted Dotterels used them and the birds were more approachable than usual. In addition, the sludge varied in its hardness and so I was able to test the ideas of Heather (1977).

The sludge, built up from the floor washings of the freezing works, was composed largely of wool, with smaller amounts of faeces, blood, fat and other tissues. It was piped to and dumped between earth walls, where it formed a soft sludge. The further from the outlet pipe and the longer after pumping stopped, the harder the sludge became. Heavy or persistent rain would soften the whole surface.

To correlate feeding behaviour with the firmness of the substrate, I divided the sludge into three categories – hard, intermediate and soft. On hard substrate the birds' feet did not depress the surface. On soft substrate, the sludge covered more than the birds' toes. Intermediate was between the two.

The numbers of birds feeding, both normally (including "run and peck" and "walk and peck" methods) and by "tapping and pecking" were tabulated according to the hardness of the substrate they were on. Data were also recorded for the peck rate and success rate of the two feeding methods in relation to the hardness of the stratum they were on.

To record the success or capture rate of the two methods, I noted whether a peck was followed by a bill movement or a swallowing action; with either of these the peck was considered successful.

To determine the daily time budget for a winter's day, I spent two separate half-days at the river in a continuous watch and then added the two together. I did the same again for incubating birds and for a pair with

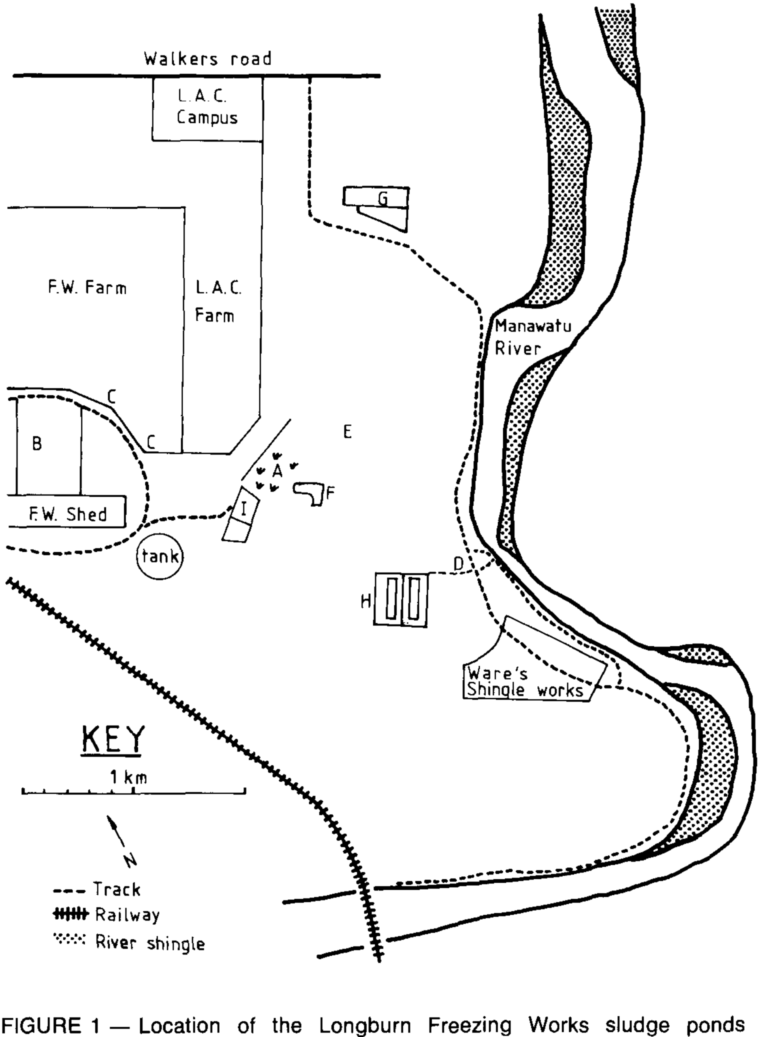

FIGURE 1 — Location of the Longburn Freezing Works sludge ponds and surrounding farm areas. F.W. = Freezing Works, L.A.C. = Longburn Adventist College. River census site 1 was north of point D and site 2 was south of that point

chicks about 8 days old. During these watches I timed all activities other than feeding, and then presumed that the birds had spent the rest of the time feeding. From a sample of the peck rates of birds feeding I calculated the average peck rates and the total number of pecks per day. The success rate was then used to estimate the number of prey taken in a day.

RESULTS

Feeding methods

Table 1 shows the numbers of birds found using each of the two feeding methods in relation to the hardness of the substrate at the Longburn Freezing Works sludge ponds.

TABLE 1 — Numbers of dotterels using each feeding method on sludge ponds at Longburn Freezing Works

Surface Hardness	Tap and Peck	Simple Pecking
Hard	193	9
Intermediate	59	72
Soft	5	175

The feeding method used depended on the hardness of the substrate (X_{22} = 394.1, n = 513, P <0.001). This does not mean that some individuals specialised in the "tap and peck" but rather that individuals varied their feeding method according to the substrate. There were times when all birds were using the tap and peck method on hard substrate and other times when all the same birds were using the simple peck method on soft substrate. In addition, birds moving from hard to soft substrate normally switched to simple pecking, although sometimes they gave an ineffective tap sequence or two before settling into simple pecking. It is clear that they chose the feeding method according to the firmness of the substrate.

TABLE 2 — Peck and capture rates

Location	Mean Number Simple Pecks/ Minute	SD	Minutes	Mean Number Tap & Pecks/ minute	SD	Minutes
Sludge Pond						
Peck rate (all surfaces)	51.0	14.9	197	29.6	6.1	116
Capture rate (all surfaces)	45.3	10.9	59	25.1	4.0	72
River						
Peck rate (hard surface)	18.3	8.8	31	26.8	7.3	22
Peck rate (all surfaces)	36.0	17.4	1046	32.4	7.6	8
Capture rate (all surfaces)	40.7	13.5	24	27.3	9.7	8

The average capture rate of the simple peck method (on all surfaces combined at both the sludge ponds and the river) was higher than that of the tap and peck method (Table 2). On hard surfaces at the river, the peck rate for tap and peck was significantly higher (t_{52} = 3.82, P <0.001) than that for the simple pecks.

At the freezing works, simple pecking was significantly more successful (n = 2934 pecks, success = 91%) than tap and peck (n = 1873, 86%, X_2 = 29.3, $P < 0.001$). A similar analysis of 259 tap and pecks and 1182 simple pecks on the mud and shingle by the river showed that the success rate for tap and peck (85%) was not significantly greater (X_2 = 0.09, $P > 0.5$) than for simple pecking (83%).

The advantage of tapping on these hard surfaces became clear when I took a twig with two forks and similar dimensions to those of a dotterel's leg and foot and vibrated it on the hard substrate. This action caused flies of both the major prey species that were closer than about 300 mm to jump a short distance. As a result I could see more of them than before I imitated the tapping of the dotterels. I repeated this test on different parts of the hard substrate with the same results, but when I tapped soft substrate or water the flies made little or no response. Flies on soft substrate were easy to see.

Seasonal movements

Although Black-fronted Dotterels are on the shingle beds of the Manawatu River in any month of the year, their numbers vary seasonally on the river at Longburn. Monthly mean counts (Table 3) for two river sample areas (Figure 1) increased from January to July and then declined to a December low (Figure 2).

TABLE 3 — Summary of Black-fronted Dotterel counts on the Manawatu River at Longburn

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Site A												
$\bar{x}$	1.3	1.0	1.8	2.2	3.2	3.7	5.1	4.3	2.8	1.9	2.1	1.0
s.d.	1.4	1.3	1.5	1.9	2.6	6.1	5.0	3.5	1.5	1.5	0.6	0.0
max.	4	6	7	9	9	26	17	15	5	7	3	1
n	90	27	34	47	24	18	18	26	28	38	25	2
Site B												
$\bar{x}$	5.0	3.6	5.6	9.1	10.2	6.6	13.3	6.1	3.6	3.7	2.2	2.0
s.d.	-	3.9	3.6	7.3	7.3	3.6	5.1	5.9	2.4	1.7	1.5	-
max.	5	10	12	26	21	12	20	20	10	7	5	2
n	1	7	16	17	13	10	12	17	23	19	11	1

Numbers of Black-fronted Dotterels were highest at both the freezing works ponds and the silt areas of the river (Figure 2) during the winter months. Flocks were larger at the freezing works sludge ponds (I on Figure 1) than at the river but this did not stop them using very local and even very temporary sites where waterlogged soil had encouraged the congregation of those flies used as prey. At Longburn these sites included: the swampy paddock at A (Figure 1), the paddock at B after its grass was disturbed by building activity, small ponds at C after pipes had been laid, the clay patch at D after the freezing works drain had been deepened, bare areas in the Manawatu Co-operative Dairy Company paddocks at E, the pond in the

FIGURE 2 — Monthly averages (1981-1988) of Black-fronted Dotterels for both census sites on the Manawatu River at Longburn

disused shingle pit at F, and the sewage ponds (G) when their level fell enough to expose the earth below the concrete part of the wall. Towards the end of the study, the dotterels used the new freezing works effluent ponds at H. When the works closed down, the water and effluent levels of these ponds dropped below the concrete rim and were used daily by feeding dotterels.

By far the most popular feeding site away from the river was that of the freezing works sludge ponds. The first birds to use this site after breeding generally arrived between April and June. The largest feeding flocks assembled during July but there was a rapid decline in late August. In only one year were any birds seen at the sludge ponds after August (Table 4). The largest number of feeding birds I saw at one time was 91 on 18 May 1979. However, a week or two earlier Michael Dennison and Hugh Robertson (pers. comm.) had counted 104 birds on the same ponds.

TABLE 4 — Black-fronted Dotterel numbers at Longburn Freezing Works sludge ponds

Year	1977	1978	1979	1981	1982	1983	1984	1985	1986
Earliest	Jun 3	Jul 20	May 18	Feb 8	Jun 1	Apr 22	Feb 7	Apr 24	Jun 30
Latest	Aug 28	Oct 20	Aug 15	Aug 25	Aug 28	Aug 2	Aug 13	Aug 12	Aug 12
Maximum	54	65	91	26	52	27	62	43	11
Mean	18	38	76	9	10	6	26	16	6
s.d.	24	38	14	8	11	8	29	17	5
n	4	2	6	17	49	15	34	13	4

The most popular feeding site away from the river, apart from the sludge ponds, was the sewage ponds when they had completely emptied into the river (about 2 June 1983 & 16 July 1985). The first time up to 25 birds were seen feeding slowly and taking much longer rests than normal because the midge (chironomid) larva prey were abundant and large. The swampy paddock (A) provided food for up to 19 birds at one time during a particularly wet spell.

In one year only were any of the feeding sites away from the river seen to be visited between September and late March by more than four birds. As this is the time when the birds are defending territories and breeding on the river bed, I assumed that birds breeding on the adjacent river moved to these feeding sites during the breeding season. The only exception was March 1984 when six adult birds were seen at the sewage pond a few days before seven were seen at the sludge ponds. I assume these to be failed or early breeders.

Daily movements

Between 0630 and 0700 h (about 50 min before sunrise) on winter mornings, birds could be heard calling as they left the river and flew to the sludge ponds. The commonest calls given in flight were a short metallic *plink plink* and a drawn-out mechanical *ch-u-u-r-r-r*. Other calls such as *chink-oo-chink*, *churr-choo-ch* and *cler-it* had similar tones to the common calls and may have only been variations of them. How long the birds stayed at the ponds was not determined accurately but there were rarely any left when I checked the ponds between 1000 and 1400 h.

The dotterels arrived back at the ponds between 1400 and 1600 h. There was a trend to delay arrival times as August progressed. Departure times were more constant, most birds leaving for the river in one or two flocks about 50 minutes after sunset. The feeding behaviour of the birds could be watched for only 30-40 minutes after sunset, but the birds probably fed until they left.

Even when the river was in flood and the shingle was under water, the daily feeding routine did not change. During the middle of the day birds fed along the silt that had been deposited on the banks or nearby land. Even when large numbers were feeding at the sludge ponds during early morning or late afternoon one or two birds could still be found feeding along the river, and so winter censuses based at popular feeding sites such as the Longburn ponds will not give complete counts.

Daily time budgets

In winter and while tending chicks, the Black-fronted Dotterels on the Manawatu River spent most time feeding (Table 5). Observations at the nest showed that, like those breeding in Otago (Child & Child 1984), the birds were very nervous when incubating. This resulted in the eggs being unattended for 2.5 hours out of the 7 hours of observation on 7 November 1986. Two days later the eggs were left unattended for 5 hours 10 minutes out of 9 hours 38 minutes of observation. I do not know whether these eggs hatched or whether this is normal behaviour, though eggs left unattended for 1 hour 45 minutes at a time have hatched (Child & Child 1984). In Table 5, the time spent incubating (and on the other activities) is divided equally between the two birds because they could rarely be identified. During another 4.5 hours, when I could tell the two brooding birds apart, one incubated 44% and the other 56% of the time.

TABLE 5 — Daily time budgets for dotterels on the Manawatu River at Longburn

Activity	Non-breeding May		Incubation November		Tending chicks December	
	min.	%	min.	%	min.	%
Feeding	612	86	360	38	667	69
Preen/scratch	21	3	61	6	63	6
Flying	2	<1	16	2	17	2
Rest/watching	71	10	32	3	85	9
Running	6	1	8	1	19	2
Bathing	1	<1	<1	<1	<1	<1
Drinking	0	0	<1	<1	0	0
Copulation	0	0	<1	<1	0	0
Incubation	0	0	478	50	0	0
Brooding	0	0	0	0	121	12
Total	713	100	956	100	972	100

Concurrent with the activities shown in Table 5, incubating birds spent time escaping human disturbance (8 min), watching Australasian Harriers *Circus approximans* and Black-backed Gulls *Larus dominicanus* (0.2 min), performing displays and otherwise showing aggression to conspecifics (6.5 min) and to Banded Dotterels *Charadrius bicinctus* (0.1 min), as well as calling (6.5 min).

Prey species

I could not find any visible organisms in samples of the upper 80 mm of substrate at the sludge ponds, taken from where birds had been seen feeding. I could see on the surface of the sludge only three invertebrate species, which I later found to be common on most days. Adult moth flies (Psychodidae) were the largest (5 mm), another fly (Ephydridae) was next in size (3-4 mm), and the smallest but most numerous were springtails (*Collembola* spp.) (2.5 mm). Small black beetles, midge larvae (*Chironomus* spp.), mites and wood slaters present were too few to be major prey. As the birds ignored the springtails, even those common enough to form broad grey patches up to 2 metres long, adults and larvae of the two fly species formed the bulk of the prey.

On only four occasions was the captured prey large enough to be seen through the telescope. Two seemed to be bloodworms, the larvae of the midge, one was a freshwater snail at the river and the other was possibly a crustacean. On several occasions the surface was covered with earthworms (dead and alive) but the birds ignored them. Once a bird picked up an earthworm, worked it in the bill three or four times, and rejected it.

The same two flies were not common on the river feeding sites during some winter days but they were the only surface invertebrates present. Their numbers increased noticeably through September, the time when the number of birds visiting the sludge ponds had declined. Also at this time a small kind of crane fly (Tipulidae) appeared at the river's edge and was occasionally taken for prey, though the other two flies were still the major food.

Through the telescope, I could on occasions see the bird's bill penetrate several millimetres into soft substrate. This became more frequent as the soft areas contracted into small pools, the birds making many pecks without taking a step, presumably at abundant immobile prey. On inspection, I found a high density of fly larvae about 4 mm long.

The prey that attracted the dotterels to the mud floor of the Longburn sewage pond when it emptied into the river was bloodworms. Their average length was 16.4 mm (*s.d.* = 3.0, n = 31) and their average weight was 0.020 g (*s.d.* = 0.008, n = 36). The mass of these worms was far greater than the average 0.001 g (n = 301) for the flies commonly taken.

DISCUSSION

Foot tapping

Foot-trembling has been recorded in at least ten plovers and one godwit species. The Lapwing *Vanellus vanellus*, Little Ringed Plover *Charadrius dubius*, Ringed Plover *Charadrius hiaticula*, Kentish Plover *Charadrius alexandrinus*, Golden Plover *C. apicarius*, Dotterel *C. morinellus*, Three-banded Plover *C. tricollaris* and Black-tailed Godwit *Limosa limosa* were reported by Simmons (1961a,b). Heather (1977) recorded it in the Black-fronted Dotterel and published Alan Jones's record of it in the New Zealand Dotterel *C. obscurus* (footnote to Searle 1984). Both Simmons (1961b) and Heather (1977) suggested that foot-trembling may cause camouflaged invertebrates to move.

My observations confirm these suggestions about foot-tapping. On Ninety Mile Beach, in December 1981, I saw a New Zealand Dotterel *C. obscurus* foot-tapping on the solid sand of a small driftline where sandhoppers congregate. It was clear that the foot movements were intended to flush prey, which were then taken in the bill just as the Black-fronted Dotterels did at Longburn.

Waders whose chicks have to run and peck for their food have been shown (Nol 1986) to have longer incubation periods than those species whose chicks beg. Nol (1986) predicted that a "run and peck" wader with an egg weight equal to that produced by the Black-fronted Dotterels (6.67 g) would have an incubation period of 23 days. This is close to the 23-26 days found by Child & Child (1984) and Pringle (1987). The extra time in the egg presumably allows for a greater development before hatching and so equips the young with abilities to catch their own prey. Young Black-fronted Dotterels certainly have high feeding activity, as demonstrated by the high peck rate of the 8-day-old chicks observed in this study. These chicks had a significantly higher ($t_{77} = 3.3$, $P<0.002$,) peck rate ($\bar{x} = 47.6$) than their parents on the same day ($\bar{x} = 35.0$). The chicks probably need more energy than their parents (for growth and building reserves) and their capture success rate might not be as high.

TABLE 6 — Peck rates and estimated daily catches

	Non-breeding (May)	Incubating (November)	Tending chicks (December)
$\bar{x}$ pecks/min	51.6	31.3	33.0
n (peck rate)	237	248	179
s.d.	18.8	10.4	16.4
n (feeding)	612	360	667
Est. total pecks	31,579	11,275	22,011
Est. daily catch	28,737	10,260	20,030

We might ask why these dotterels use the tap and peck method at all as it expends more energy and is performed at a slower rate than simple pecking. However, as this study has shown a higher success rate for tap and peck over simple pecking on hard substrate, it is clear that the birds benefit by resting the soft substrate while using the method most effective on the hard substrate, even though the average success rate for this method is less than that for simple pecking on soft substrate.

One exception to this situation was noted when both the sludge surface and the fly larvae were frozen in a severe frost. Under these conditions the prey were obvious and simple pecking alone was used on the hard icy surface.

Seasonal movements

The lower density of prey at the river (indicated by the lower peck rate) would explain why the dotterels leave the river bed to feed from the denser supply at the sludge ponds. But, why do the dotterels not stay at the sludge pond all day? Optimal foraging theory suggests that they should stay at the best site. My suggestion is that the dotterels are drawn to the river for part of each day to defend a nesting territory. In winter they tend to do this by wing displays rather than physically chasing other birds from their nesting area, which they do during breeding. This is more appropriate as not all birds are on their home territories and more tolerance would allow greater use of locally dense food supplies.

It is interesting to speculate on the origin of the birds that join the winter flocks at Longburn, for at least some of the South Island rivers used by this species are deserted during winter (Child & Child 1984). However, as 117 Black-fronted Dotterels were recorded (11/12 November 1978) by members of the Manawatu branch of the OSNZ on the Manawatu River between Hopelands Bridge and Opiki it is not essential to look to birds arriving from other river basins to make up the numbers found at Longburn. Alternatively, this does not rule out the possibility of a few birds travelling large distances as these birds are opportunistic and that they ever reached New Zealand is proof of this.

Time budgets

Parents of precocial self-feeding waders have been divided into those that constantly move with their young at the expense of their feeding time and those that watch their young from a distance and so lose little feeding time

(Winkler & Walters 1983). Plovers in the first group lost an average 42% of their foraging time, and Winkler & Walters (1983) suggested that this loss was the major factor limiting clutch size in those species.

Black-fronted Dotterel parents lost only 18% of their foraging day while tending their chicks, and so they should be classed in the second group where the reduction in the foraging time caused by chick tending duties is too small to reduce clutch size by restricting the number of chicks they can look after. Because one Black-fronted Dotterel parent stays within 2-3 metres of the chicks, the chicks have much less risk of predation than those of waders where the parents watch the chicks from a distance of 14-28 metres (Winkler & Walters 1983). While one Black-fronted Dotterel parent is tending the chicks the other is away feeding. Because the parents tend the chicks in turn fairly equally both parents lose little foraging time. This small loss is perhaps important and is possibly one factor that allows them to maintain a normal clutch size for plovers even though their prey is very small.

CONCLUSIONS

Black-fronted Dotterels may gather into large winter flocks in New Zealand. These flocks sometimes formed on the Manawatu River but more frequently at richer sludge ponds up to 1 km from the river at the freezing works and sewage plant. At all three sites a new feeding technique was observed.

The success of the "tap and peck" method was significantly greater than that of simple pecking only on hard substrates. This applied to both the river and the sludge ponds. The advantage of this technique derives from transfer of vibrations from the foot through the substrate to prey, which move and are seen by the feeding bird. These vibrations do not disturb prey on soft substrate. As prey are more visible on soft (wet) surfaces, they need not be disturbed, and the extra time and energy taken by this behaviour is unnecessary.

ACKNOWLEDGEMENTS

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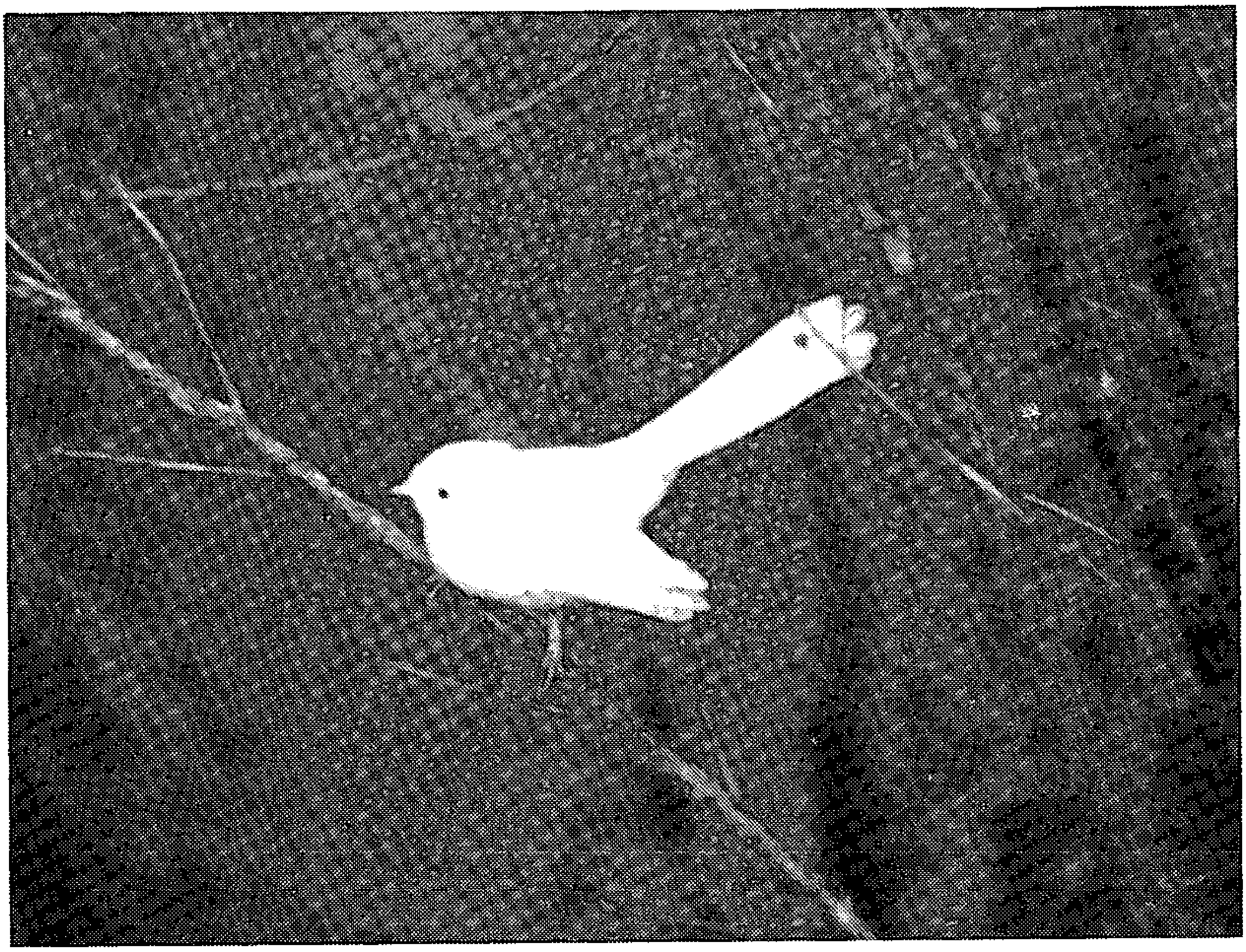
An albinistic Fantail



An albinistic North Island Fantail (*Rhipidura fuliginosa placabilis*) was seen in May 1989. The habitat was pasture and gully scrub (manuka) in the headwaters of the Orautaha Stream, north of Raetihi. I took the photograph on 21 May. The bird had a yellow beak, black eyes, and entirely white plumage. [In the colour photo, the visible leg is pink and the feet are pinkish white - Ed.] It travelled and fed with up to 12 normally pied fantails, spending much of its time following cattle as they disturbed insects. It was visible for long distances and spent a lot of time on the ground. It was not seen after a heavy snowfall on 30 May.

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SEXING GREY-FACED PETRELS BY DISCRIMINANT ANALYSIS OF MEASUREMENTS

By ROBIN M. JOHNSTONE and BRIAN E. NIVEN

ABSTRACT

Discriminant function analysis was used to calculate classification formulae for predicting the sex of 98 adult Grey-faced Petrels *(Pterodroma macroptera gouldi)* at the start of incubation. Body weight, bill length, bill width, and bill depth all showed statistically significant sexual dimorphism. A classification formula based solely on bill measurements is impractical for sexing Grey-faced Petrels because of 37% error. The combination of body weight and bill depth in the formula proved useful, correctly classifying 92% of birds. This method provides a simple and reliable way of sexing Grey-faced Petrels in the field just after laying. Cloacal examination also allows definitive sexing at this time.

INTRODUCTION

Identification of sex is often necessary for ecological and behavioural studies of seabirds but can be difficult because many species lack obvious sexual dimorphism.

Morphometric characteristics are frequently used for sexing seabirds (Warham 1975, Scolaro *et al.* 1983, Schnell *et al.* 1985, Gales 1988, Schreiber & Schreiber 1988). Body weight and bill size differ enough between the sexes of many procellariiform birds to allow reasonably accurate sexing (Croxall 1982). Imber (1971) demonstrated sexual dimorphism in the Grey-faced Petrel *(Pterodroma macroptera gouldi)*. He sexed pairs by comparing partners' weights, filoplume count, and culmen length. The partner with the higher score in at least two of the three measurements was assumed to be the male.

Petrels lay a large egg for their size (Rahn *et al.* 1975), for which the female cloaca dilates to allow its passage. From the obvious dilation, one can tell the female from the male by eye after egg laying (Serventy 1956). Thus, this method is applicable only to females that have recently laid eggs and to their known mates (Serventy 1956, Boersma & Davies 1987).

The aim of this study was to calculate formulae which could be used to predict the sex of Grey-faced Petrels in the field without having to compare mates.

METHODS

We analysed measurements taken by RMJ from 98 adult Grey-faced Petrels on Whale Island (Motuhora) (37°52'S, 176° 58'E) in the Bay of Plenty between 12 June and 14 September 1987.

Petrels found in a nesting burrow during the day were removed through an observation hole that had been dug into the nest before the birds had reoccupied it at the start of egg laying. We sealed this opening with a plastic bag filled with soil.

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The birds were weighed with a 1 kg Pesola scale accurate to ± 5 g. Bills were measured with vernier callipers accurate to ± 0.1 mm. Bill length measures the length of exposed culmen (Baldwin *et al.* 1931, Imber 1971).

Bill depth was measured from the anterior-most feather on the dorsal surface of the culmen to the fusion of the mandibular rami; bill width was measured below the gape at the anterior-most feather on the border between the dorsal and ventral rhamphotheca plates of the mandible (Baumel 1979).

The birds were sexed by a superficial examination of the cloaca within two days after the egg had been laid (Serventy 1956), females being identified by swelling and transverse distension of the cloaca. At least one partner of each pair was colour banded (green for males, black for females).

The data was analysed by discriminant function analysis (DFA) on the BMDP computer software package (Dixon 1981). The discriminant function calculated by DFA weights morphometric characters according to their discriminatory power. It is used to predict the sex of petrels. The assumption of DFA that the variance covariance matrices of the two sexes are equal was confirmed for this data using Box's M test ($F = 0.64$; $d.f = 1, 38212$; $P = 0.59$).

RESULTS

Table 1 shows the means, standard deviations, and ranges in measurements of birds sexed by cloacal examination. Although there is much overlap, all characters are significantly different between sexes, the males being larger.

The sex of a Grey-faced Petrel is predicted from the following classification formula when weight is excluded and only bill measurements are used in the analysis:

$$D = -18.11 + (0.88BD)$$

where D is the discriminant score and BD is the bill depth. If the score is postive, the petrel is a male; if it is negative, a female. This is equivalent to saying that the sex is a male if the bill depth is greater than 20.58 mm.

To test the accuracy of this classification function we calculated the discriminant score for the 98 known-sex birds and compared the predicted sex with the actual sex. The formula provided little discrimination for classifying the known sex sample (Fig 1.). It classified only 35 of of the 56 males (63%) correctly and 27 out of the 42 females (65%) correctly.

When weight was included with bill measurements the analysis produced this classification formula:

$$D = -41.4 + (0.03\ W) + (1.11\ BD)$$

where D is the discriminant score, W is the bird's weight, and BD is the bill depth.

This formula provided greater accuracy, correctly classifying 52 out of the 56 males (93%) and 38 out of the 42 females (91%) (Fig. 2).

Note that this classification formula was derived from weights taken straight after laying and at the start of incubation. It may not be appropriate at other stages of the breeding cycle because of the significant loss of weight by incubating birds.

TABLE 1 — Weights (g) and bill measurements (mm) of Grey-faced Petrels

Character	Sex	*n*	Mean	Range	s.d.	*t*-statistic
Weight	F	45	505	385-650	61	10.36*
	M	56	641	460-820	69	
Bill depth	F	42	20.2	18.4-22.5	1.04	4.14*
	M	56	21.0	19.4-23.5	0.90	
Bill length	F	42	36.7	34.3-39.5	1.25	2.00*
	M	56	37.2	34.0-39.3	1.25	
Bill width	F	42	12.4	10.7-14.5	0.85	2.26*
	M	56	12.8	10.7-14.7	0.84	

*indicates $P < 0.05$

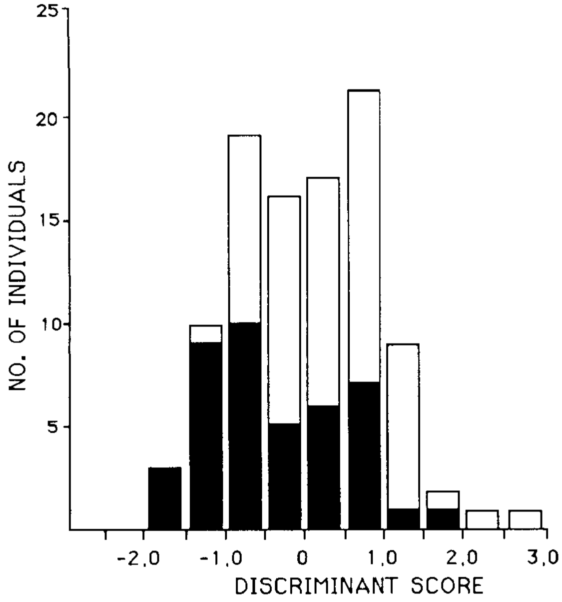

FIGURE 1 — Discriminant scores of known-sex male (light) and female (dark) Grey-faced Petrels, calculated from bill measurements only

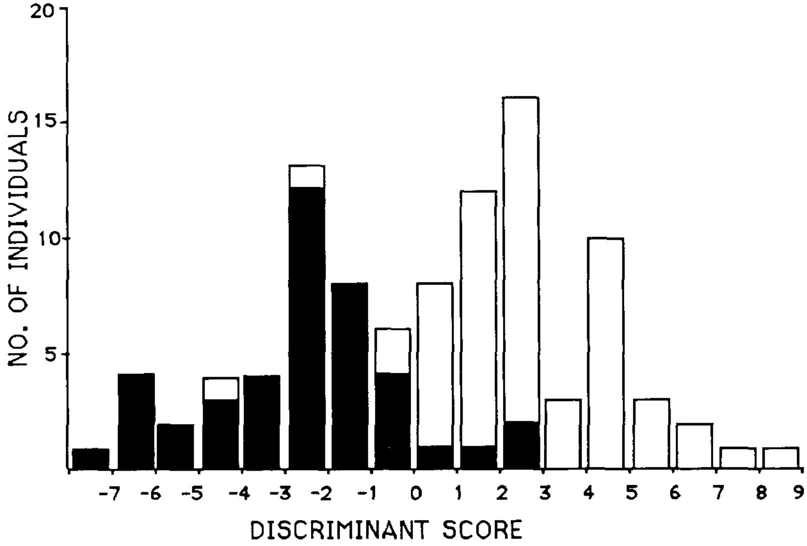

FIGURE 2 — Discriminant scores of 98 known-sex male (light) and female (dark) Grey-faced Petrels, calculated from bill measurements and body weight

DISCUSSION

Imber (1971) found separation in the same direction as this study between sexes in body weight, bill length, and bill width. Discrimination between sexes of the Grey-faced Petrel is possible on the basis of this separation.

A Grey-faced Petrel's weight varies greatly, especially during the incubation period when it fasts and loses a great deal of weight (Imber 1976). A classification formula without weight as a parameter would thus give accurate sexing in the field throughout the breeding cycle. Despite significant differences between sexes, the combined bill measurements had too little discriminatory power, giving 37% error, and so the formula based solely on bill measurements was impractical for sexing Grey-faced Petrels.

Adding other characters, for example, wing, tarsus, and middle-toe length (Scolaro 1987, Schreiber & Schreiber 1988) may increase the accuracy of a classification formula based solely on morphometric measurements. The use of filoplume counts for discriminating between sexes is limited because an accurate count takes too long (Imber 1971).

Including post-laying body weight in the formula greatly increases the the accuracy of sexing. Body weight has a high discriminating power, and when combined with bill depth it gives a formula by which Grey-faced Petrels can be sexed with 92% certainty. This method does not rely on the presence of both partners for sexing, as in Imber (1971), who did. Highly reliable sexing at the start of incubation is possible in the field by measuring these two characters and applying them to the classification formula.

Although this method does allow accurate sexing, the inclusion of body weight restricts the application of this formula to the start of incubation, a period when cloacal examination already allows definitive sexing (Boersma & Davies 1987).

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SHORT NOTE

Petrels at sea off South Westland in June-July

From 27 June to 2 July 1988, I made observations of seabirds while on a trawler over orange roughy spawning grounds, centred on 43° 05′ and 169° 00′, adjacent to the Cook Canyon, about 98 km west of Okarito. My observations were made from 900-1100 metres. The sea was constantly rough, and winds were occasionally at gale force. Offal discharge consisted of less than 5% of the catch but this provided a rich food supply for offal-feeding birds. Deep sea trawlers nearby were also discharging offal.

In total I recorded 15 species of Procellariiformes. The offal-feeding species which congregated each time the net was lifted were as follows, together with the range in numbers:
Cape Pigeon (*Daption capense*) 600-1000, Wandering Albatross (*Diomedea exulans*) 50-100, Northern Giant Petrel (*Macronectes halli*) up to 20, Shy Mollymawk (*Diomedea cauta cauta*) 10-15 , Buller's Mollymawk (*D. bulleri*) c.10, Black-browed Mollymawk (*D. melanophrys*) up to 10, Westland Black Petrel (*Procellaria westlandica*) c.5, Grey-faced Petrel (*Pterodroma macroptera*) c.5. I saw also singles of Grey-headed Mollymawk (*Diomedea chrysostoma*), Salvin's Mollymawk (*D. cauta salvini*), Light-mantled Sooty Albatross (*Phoebetria palpebrata*) and Southern Giant Petrel (*Macronectes giganteus*).

A stream of tens of Grey-backed Storm Petrels (*Garrodia nereis*) was also over the fishing grounds. Prions (*Pachyptila* spp.) congregated when the trawl was retrieved, and I saw one White-headed Petrel (*Pterodroma lessonii*) just north of the grounds.

Of the 15 species, the Cape Pigeon and Wandering Albatross were the most numerous. Cape Pigeons are highly seasonal in New Zealand waters, and Cheshire *et al.* (1979) noted an increase in South Island coastal waters during April and May, their numbers reaching a peak in August and September. According to Warham (1985), the Wandering Albatross migrates northwards during winter.

Seeing only 5 Westland Black Petrels was surprising, considering their tendency to follow trawlers (Bartle 1974). In late June many Westland Black Petrels are on the breeding grounds incubating (Bartle 1985), but non-breeding birds could be expected on these trawling grounds. The Royal Albatross (*D. epomophora*) was notably absent. It is rare in the Tasman Sea, only occasionally reaching Australia (Blakers *et al.* 1984).

I thank P. C. Harper, P. M. Sagar and G. A. Tunnicliffe for criticism on this note.

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THE STRATIFICATION OF PASSERINES IN FIJIAN FORESTS

By N.P. LANGHAM

ABSTRACT

The vertical and horizontal zonation and foraging habits of 17 Fijian forest passerines are described. Mist-netting showed that five species, Island Thrush, Fiji Shrikebill, Blue-crested Broadbill, Spotted Fantail and Orange-breasted Honeyeater, contributed to 60% of the captures. These were the five main lower-zone species on Viti Levu, but only two and three on Vanua Levu and Taveuni, respectively, where other species occupied this zone. The species foraging in the middle and upper zones were more similar between the islands with two species of White-eye, two or three species of honeyeater, Polynesian Starling and Vanikoro Broadbill predominating. Horizontal zonation showed that most species occupied the middle and outer zones, except for the Fiji Shrikebill. Foraging strategies revealed that the Spotted Fantail and the Vanikoro Broadbill were the main flycatchers, followed by the Golden Whistler and Slaty Flycatcher. The main gleaning species were the Fiji Shrikebill and the Silktail, most other species being foliage-searchers.

INTRODUCTION

The objectives of this study were to describe the species composition of rainforest passerines on three islands of the Fiji group, and to investigate the zonation of these species. The habitats of most Fijian native birds have been described briefly in recent field guides (Watling 1982, Clunie 1984), in short papers (Brown & Child 1975, Gorman 1975, Holyoak 1979) and for single species (Clunie 1973, 1976, Heather 1977). Most native species are restricted to forested areas, but little has been done to describe their use of these forest habitats, apart from the studies of Brown & Child (1975) and Heather (1977). Compared with continental tropical areas and islands to the west, Fiji's forest avifauna is impoverished, probably because of its isolation. It has only 27 native passerines, of which four are restricted to islands not covered in the present study and five others are either rare or patchily distributed in forest. This account describes the results from 1978 to 1982 of intermittent observations on the three main islands, Viti Levu, Vanua Levu and Taveuni and of mist-netting on these islands and also Rabe.

STUDY AREAS

I mist-netted birds and noted foraging in five study areas on four islands:

1. Wailoku catchment area (18°09'S, 178°27'E) near Suva, Viti Levu.
2. Nadarivatu nature reserve (17°35'S, 178°00'E). Viti Levu.
3. Kubulau estate (16°29'S, 179°55'E), northeastern part of the Natewa Peninsula, Vanua Levu.

4. Tutu (16°50'S, 179°59'W), Taveuni.
5. Rabe (16°30'S, 179°57'W), a small island off the northeastern coast of the Natewa Peninsula.

Observations of foraging from Nadarivatu and Rabe were too few to be included. All areas were in rainforest, either high up, as at Nadarivatu (1000 m) and above Tutu (400 m), or on the eastern side of islands subject to rain-laden trade winds, as at Wailoku and Kubulau (100-200 m). Rabe, a small island, has a drier climate than the other sites.

The vegetation structure was similar in all the study areas except Rabe. The structure was characterised by a heavy litter layer, an undergrowth of shade plants such as ferns, orchids, mosses and various shrubs such as *Psychotria* spp. and *Cyrtandra* spp. The lower storey was dominated by tree ferns (*Cyathea* spp.) and saplings. In Wailoku, the canopy layer was dominated by male or Fijian nutmeg (*Myristica castaneifolia* and *M. grandifolia*). Other tree species present were *Barringtonia edulis*, *Podocarpus neriifolius*, *Canarium* sp., *Pittosporum* sp., *Astronidium* sp., *Crossostylis* sp., *Garcinia* sp., *Alstonia vitiensis*, *Xylopia pacifica*, *Atuna racemosa*, *Amaroria soulamlioides* and climber (*Freycineta caudata*). Important timber trees such as Fijian kauri or dakua (*Agathis vitensis*) and yaka (*Dacrydium nidulum*) were less common due to logging in the past. The study area included a stand of *Pandanus odoratissimus*. The canopy of the high-altitude forest at Nadarivatu was dominated by conifers such as *Dacrydium nausoriensis*, *D. midulum*, *Decussocarpus vitiensis*, *Agathis vitensis* and *Podocarpus* spp. The forest above Tutu had similar undergrowth with *Cyathea* spp. common. The canopy consisted both of conifers such as *Dacrydium nidulum* and *Podocarpus* spp., as well as *Canarium vitiense*, *Callophyllum* spp., and *Myristica castaneifolia*. Kubulau had a similar understorey, but had lost many large timber trees such as *Agathis vitensis* through logging. It contained more coastal species such as *Cerbera manghas, Instia bijuga* and *Barringtonia asiatica*. The drier forest on Rabe Island was also dominated by coastal species in the lowland areas. In all forests, epiphytic orchids, ferns and mosses were abundant.

The Fijian flora has been described by Parham (1972) and Smith (1979, 1981). In continental tropical and subtropical forests many layers can be discerned (Whitmore 1975), but Fijian forests are simpler, with about three or four vegetation zones. Most forests have a broken canopy as a result of logging and removal of the major timber species such as the dakua or Fijian kauri and yaka and of frequent cyclones.

METHODS

The native insectivorous/nectarivorous passerines were investigated in the study areas by direct observation and by mist-netting. Observations were made with 10 × 40 binoculars between 0800 h and 1630 h. Birds were allocated to one of five vertical zones: (1) ground, (2) undergrowth, (3) lower storey, comprising saplings and tree ferns, (4) middle layer and (5) canopy. In addition, three horizontal zones were recognised: (a) an inner zone, on or close to the trunks of trees or the stems of tree ferns and saplings, (b) a middle zone, of branches, and (c) an outer zone, of twigs and leaves. No such division was possible for ground and undergrowth vertical zones. Finally, each bird was classified according to its foraging method: (1) flycatching, where birds caught insects and other invertebrates by hovering or swooping, (2) gleaning, where they sought invertebrates by moving up and down stems, probing and stripping bark, dead leaves and other vegetation, and (3) foliage searching, where they took invertebrates by flying and picking insects off foliage. A fourth category could be included for nectarivorous birds, but as I usually could not differentiate them from foliage-searching insectivorous birds, I grouped these two categories. I did not see birds eating fruit.

All observations were made by spotting a bird and recording, if possible, its vertical and horizontal foraging zones and its foraging method. To avoid biasing the results by following one particular bird, observations were instantaneous and I did not watch the same bird again for at least 5 minutes. As most of the birds in the study area were unmarked, I could not tell whether every bird I recorded was a different one. For less common speices, such as the Vanua Levu Silktail (*Lamprolia victoriae kleinschmidti*), I made many of the observations on the same few birds, but the records were always made at least 5 minutes apart.

Mist-netting gave an indication of only the species which foraged within 2.5 m of the ground because I did not use multiple-net rigs in this study. It also provided information on the more secretive undergrowth species (Karr 1979). The nets used were 2.5 m high with four shelves 12 m wide and a mesh size of 36 mm.

At Wailoku, the main study area, I used eight nets over a flat area of about 1 ha surrounded by ridges on three sides. The nets were usually set from 0800 h to 1300 h, weather permitting, and checked at hourly intervals. At Wailoku, I did netting for two days each month, at the same sites, for one year from July 1980 to June 1981. I did further netting in the same area from April to June 1982 to provide additional records. Also, at Wailoku, I used another site, 1 km distant, in July and August 1979 and again in September and October 1982 for comparison and to check for movement by recapture of banded birds. Further netting which I did during brief visits to montane forest at Nadarivatu, Viti Levu, over the same period, has been included for comparison with other islands. Mist-netting was used in forest on the three other islands – Vanua Levu, Taveuni and Rabe – to reveal whether any species too shy to allow observation were present.

RESULTS

A total of 17 passerine species was observed in the Fijian rainforest (Table 1). No study area contained all 17 species during the period of observations, but 15 of the species observed were recorded at Wailoku, Viti Levu.

In addition, mist-netting revealed the presence of the Black-faced Shrikebill *(Clytorhynchus nigrogularis)* and the Red-headed Parrotfinch *(Erythrura cyanovirens)* at Wailoku. Although the Pink-billed Parrotfinch *(E. kleinschmidti)* has been recorded at Wailoku (W. Beckon, pers comm; Clunie 1973), I have only seen a single bird at Nadarivatu on a dakua salusalu *(Decussocarpus vitiensis)*; it is not included in this study. Similarly, a Black-faced Shrikebill seen on Mt Victoria is not included.

TABLE 1 — The rainforest passerines observed on three islands in Fiji

Species	*Island*		
	Viti Levu	*Vanua Levu*	*Taveuni*
Pied Cuckoo-shrike or Polynesian Triller (*Lalage maculosa*)	✓		
Island Thrush (*Turdus poliocephalus*)	✓		
Fiji Warbler (*Vitia ruficapilla*)	✓	✓	✓
Spotted Fantail (*Rhipidura spilodera*)	✓	✓	✓
Slaty Flycatcher (*Mayrornis lessoni*)	✓	✓	✓
Fiji Shrikebill (*Clytorhynchus vitiensis*)	✓	✓	✓
Vanikoro Broadbill (*Myiagra vanikorensis*)	✓	✓	✓
Blue-crested Broadbill (*Myiagra azureocapilla*)	✓		✓
Scarlet Robin (*Petroica multicolor*)	✓		
Golden Whistler (*Pachycephala pectoralis*)	✓	✓	✓
Layard's White-eye (*Zosterops explorator*)	✓	✓	✓
Grey-backed White-eye (*Zosterops lateralis*)	✓	✓	✓
Orange-breasted Honeyeater (*Myzomela jugularis*)	✓	✓	✓
Wattled Honeyeater (*Foulehaio carunculata*)	✓	✓	
Giant Forest Honeyeater (*Gymnomyza viridis*)	✓		✓
Taveuni Silktail (*Lamprolia victoriae victoriae*)			✓
Vanua Levu Silktail (*L. v. kleinschmidti*)		✓	
Polynesian Starling (*Aplonis tabuensis*)		✓	✓

The vertical foraging zones are recorded in Figures 1, 2 and 3. As mentioned above, more species were seen during the longer period of study at Wailoku, Viti Levu, than on Vanua Levu and Taveuni. The observations from Nadarivatu on Viti Levu and from Rabe Island were too few to be included.

Among the insectivorous/nectarivorous passerines, the Island Thrush is the only species which feeds frequently on the ground. The Fiji Warbler was the predominant insectivore in the undergrowth in all three forest areas but was equally common in the lower zone at Kubulau. At Wailioku, the Blue-crested Broadbill was perdominant species foraging in the lower storey, but on Taveuni this species shared the lower zone with the Spotted Fantail and Fiji Shrikebill. At Kubulau, the Blue-crested Broadbill was absent, but Spotted Fantails, Fiji Shrikebill, Grey-backed White-eyes and Wattled Honeyeaters foraged in this zone.

In the middle zone, the Golden Whislter and Slaty Flycatcher were common in all three study areas. The Vanikoro Broadbill also spent most time forging in the middle and canopy zones in all three areas. The three species of honeyeater most frequently foraged in the middle and the canopy

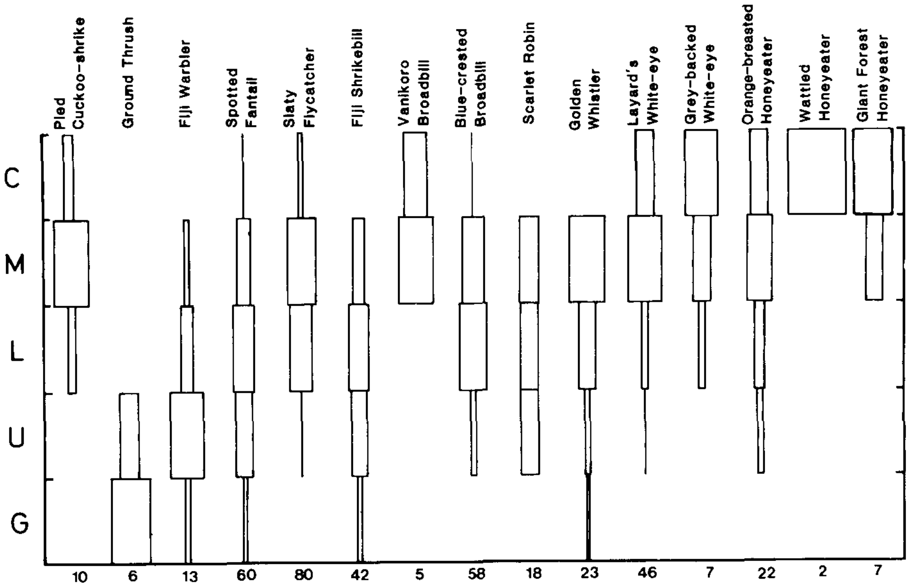

FIGURE 1 — Vertical feeding zones of Fijian rainforest passerines at Wailoku, Viti Levu. C = Canopy M = Middle zone L = Lower zone U = Undergrowth G = Ground. Numbers represent sample size

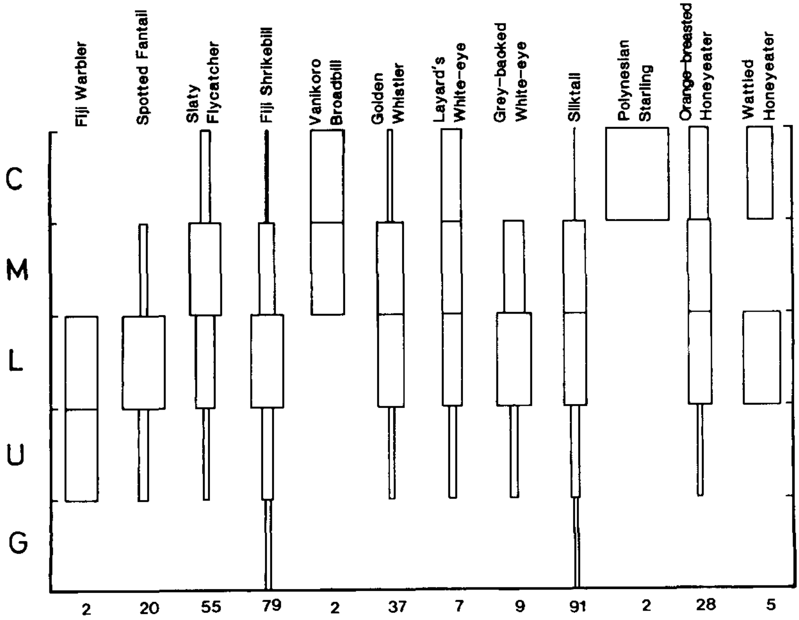

FIGURE 2 — Vertical feeding zones of Fijian rainforest passerines at Kubulau, Vanua Levu. Key as for Fig. 1. Numbers represent sample size.

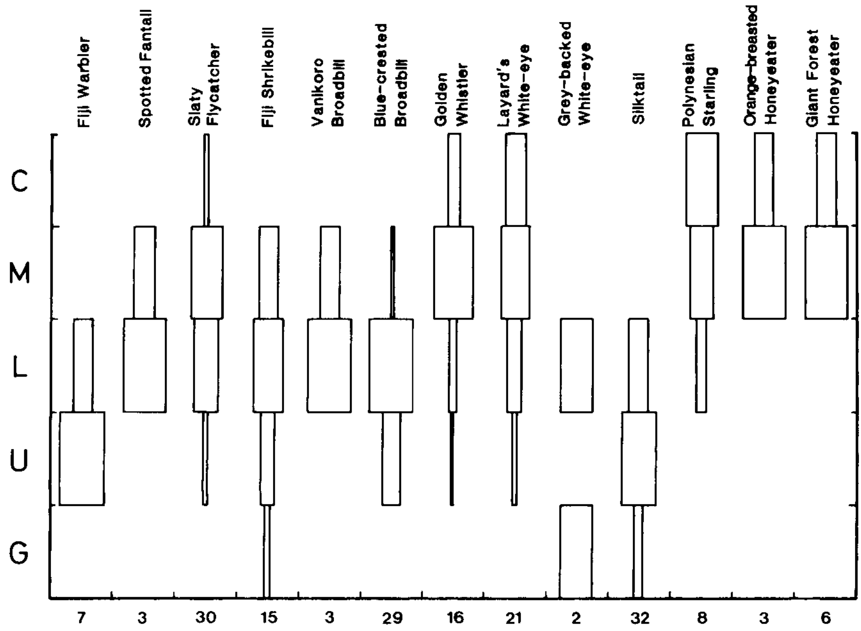

FIGURE 3 — Vertical feeding zones of Fijian rainforest passerines at Tutu, Taveuni. Key as for Fig. 1. Numbers represent sample size

zones, although the smaller Orange-breasted Honeyeater frequently descended to lower zones to visit flowering cauliflorous* trees. Layard's White-eye foraged in the upper two zones, and the Polynesian Starling was recorded only in the canopy.

Some species foraged over several zones. The Spotted Fantail at Wailoku, and the Fiji Shrikebill and Silktail at Kubulau, were seen in five vertical zones. The Slaty Flycatcher, Golden Whistler and Layard's White-eye were seen in four zones in all three study areas. The Fiji Shrikebill and the Orange-breasted Honeyeater were seen in four zones at Wailoku and on Taveuni. The Blue-crested Broadbill and the Fiji Warbler were seen in four zones at Wailoku.

Most species tended to occupy the same vertical zones in each of the three forest areas considered, the exceptions being the Blue-crested Broadbill and the two Silktail subspecies. The Taveuni Silktail was heavier and bigger than the Vanua Levu subspecies (Heather 1977, Langham 1987) and occupied a significantly lower foraging zone ($X^2 = 20.5$, $P < 0.001$ for 4 d.f.). Similarly, the heavier Blue-crested Broadbill on Taveuni (Langham 1987) tended to forage in lower zones than the Viti Levu subspecies at Wailoku.

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* Flowers borne on trunk

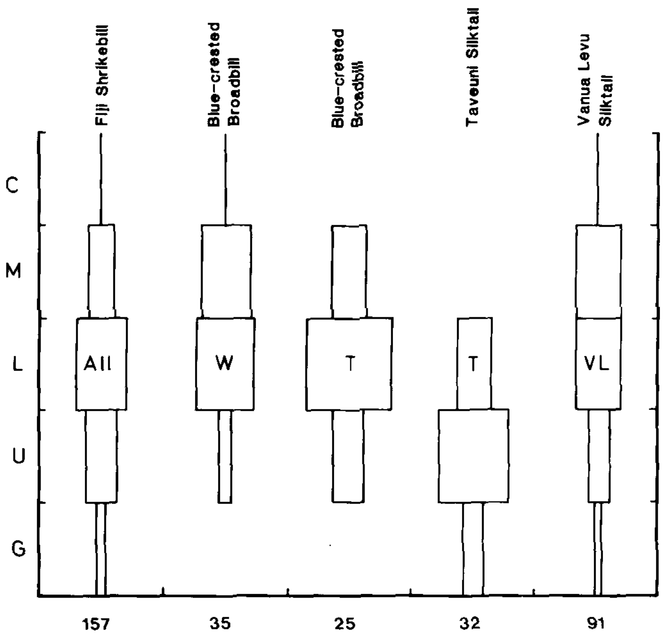

FIGURE 4 — Vertical feeding zones of Fiji Shrikebill, Blue-crested Broadbill and Silktail. Numbers represent sample size. W = Wailoku, Viti Levu, T = Tutu, Taveuni, VL = Kubulau, Vanua Levu

In Figure 4, the zones occupied by these two species are compared with that occupied by the Fiji Shrikebill, a likely competitor. Although there was considerable vertical overlap between the Fiji Shrikebill and the Blue-crested Broadbill on Taveuni, their foraging methods were different (see later). The Blue-crested Broadbill was absent from the Vanua Levu study area. The Fiji Shrikebill had less vertical overlap with the Taveuni Silktail than with the Vanua Levu Silktail.

Horizontal zonation

The horizontal foraging zones of the main species varied little between the islands and the results have been combined (Figure 5). Apart from the Fiji Shrikebill and the Silktail, forest passerines tended to forage in the middle and outer zones. The Viti Levu Blue-crested Broadbill preferred the middle zone (53%, n = 15), rather than the inner zone (20%) and the outer zone (27%). Although the Taveuni subspecies preferred to forage close to the inner zone (56%, n = 25), rather than the middle (28%) and outer zones (16%), the differences between the horizontal foraging zones in the two subspecies were not statistically significant.

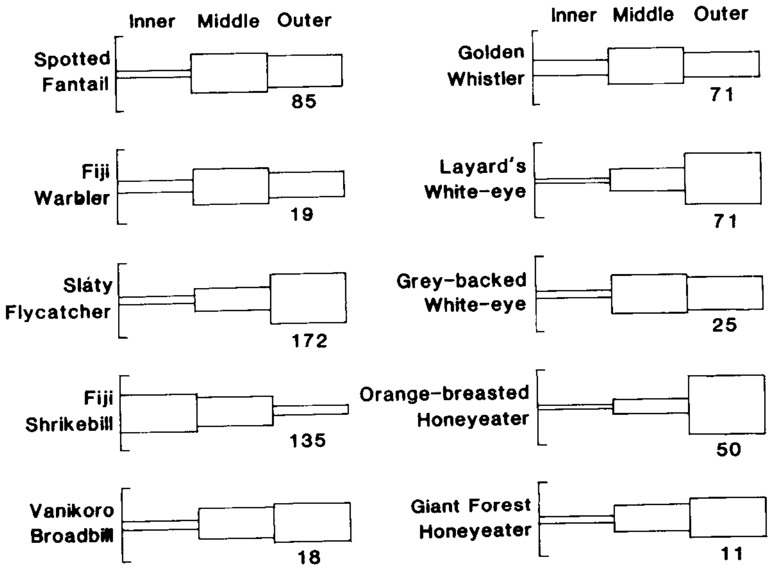

FIGURE 5 — The horizontal feeding zones of 10 Fijian rainforest passerines. Numbers represent sample size

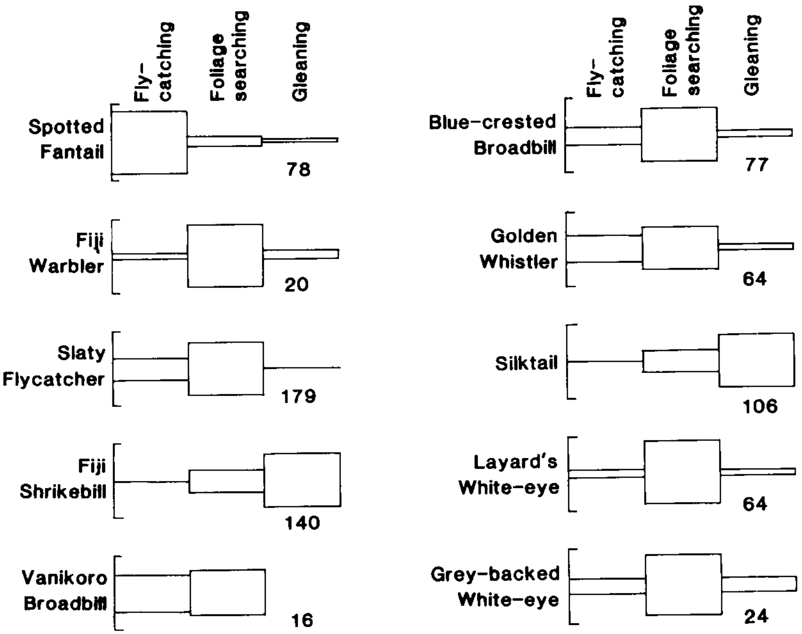

FIGURE 6 — The foraging strategy of 10 Fijian rainforest passerines. f = Flycatching, f/s = Foliage/searching, g = Gleaning. (See text for more details.) Numbers represent sample size

Foraging methods

Two species fed mainly in the air: the Spotted Fantail (79%, n = 78) and the Vanikoro Broadbill (50%, n = 16). Other species which fed on flying insects were the Scarlet Robin (47%, n = 17) and the Golden Whistler (31%, n = 64). The aerial-feeding Polynesian Triller and Wood Swallow (*Artamus leucorhynchus*) were rare in the forest, and the latter species was more common on the drier west coast than in the wetter parts of Viti Levu. The Orange-breasted (54%, n = 28) and Wattled (40%, n = 5) Honeyeaters were also seen catching aerial insects.

Most of the other species were foliage searchers, and picked insects off foliage while hovering or briefly alighting (Figure 6.) In the Fiji Shrikebill and the Silktail, gleaning comprised 69% (n = 140) and 73% (n = 106), respectively. Although the Vanua Levu Silktail spent more time gleaning (75%, n = 76) than the Taveuni subspecies (53%, n = 30), the differences were not statistically significant. The Fiji Shrikebill and the Vanua Levu Silktail gleaned only in the zones below the canopy and the Taveuni Silktail only below the middle zone (see Figures 3 and 4).

Mist-netting

Mist-netting confirmed my observations on the vertical zonation of species feeding at the lower zones. Of the birds captured, 60% were of five species: Fiji Shrikebill (23% of birds), Island Thrush (10%), Blue-crested Broadbill (9%), Golden Whistler (9%) and Orange-breasted Honeyeater (9%) (Table 2). Fiji Shrikebills moved from stem to stem of tree ferns and Island Thrushes fed mainly on the ground and so were likely to be captured. At Wailoku and on Taveuni, Blue-crested Broadbills foraged in the lower zone and so were often caught. In all areas, only adult male Golden Whistlers were caught. About 90% of the observations were of adult males, which may include a bias caused by their more conspicuous plumage, but this does not explain why no females or juveniles were caught, unless they foraged higher up. The mist-netting of Orange-breasted Honeyeaters was probably due to flowering in the lower stories. The declining capture rate from continued use of the same sites each month at Wailoku prevents an analysis of seasonal patterns.

If the differences in mist-net catches between islands are examined (Table 3), the Fiji Shrikebill was the most frequent species by number of captures in all localities. However, only at Wailoku and Nadarivatu on Viti Levu were Island Thrushes the next most frequent species; they were followed by Blue-crested Broadbills. At Kubulau, adult male Golden Whistlers were the second most frequent species caught. On Taveuni, the Silktail was the second most abundant species in the nets, supporting the observations of its foraging nearer to the ground than the Vanua Levu subspecies. On Taveuni, the next most frequent species was the Blue-crested Broadbill, which was absent at Kubulau.

The Rabe sample was too small for adequate analysis, but Fiji Shrikebills contributed 44% of the captures and the Grey-backed White-eye 28%. The Fiji Warbler was rare in localities other than Wailoku. Also, the Scarlet Robin was caught only at Wailoku and Nadarivatu. Both the Black-faced Shrikebill

TABLE 2 — The total number of individuals and captures of rainforest passerines on four islands in the Fiji Group

Species	No. Individuals	No. Recaptures	Total Captures
Island Thrush	25	14	39
Fiji Warbler	15	3	18
Scarlet Robin	7	3	10
Spotted Fantail	16	3	19
Blue-crested Broadbill	23	8	31
Slaty Flycatcher	11	2	13
Fiji Shrikebill	56	12	68
Black-faced Shrikebill	4	1	5
Silktail	11	4	15
Golden Whistler	22	2	24
Grey-backed White-eye	6		6
Layard's White-eye	5		5
Orange-breasted Honeyeater	23	2	25
Wattled Honeyeater	13	1	14
Red-headed parrotfinch	8	1	9

juveniles and Layard's White-eye were caught only at Wailoku, although the latter was observed high in the canopy at Kubulau and on Taveuni. Other species such as honeyeaters were not mist-netted on Taveuni but were seen there. This suggests that they may descend to netting levels only when flowering occurs in the lower zones, but this requires further knowledge of the phenology of Fijian forests and observations on such species.

Comparison of observations and mist-netting

The Island Thrush was the main species foraging in the forest floor litter, although it was not recorded at Kubulau. I made few observations of it at Wailoku but frequently caught it in mist nets. I captured it also on Taveuni, although I did not see it there (Table 3). The Taveuni Silktail was caught more frequently in mist nets than the Vanua Levu Silktail because the latter fed higher up. Although the Fiji Warbler was the main species foraging in the undergrowth, its skulking nature and low flight speed resulted in few captures, except at Wailoku, and very few recaptures (Tables 2 and 3).

Several species foraged commonly in the lower storey: the Spotted Fantail, the Fiji Shrikebill, and the Blue-crested Broadbill. They were well represented in the mist-netting samples, although Blue-crested Broadbill was

TABLE 3 — Total captures of rainforest passerines on four islands in the Fiji Group

Species	Island				Total
	Viti Levu*	Vanua Levu	Taveuni	Rabe	
Island Thrush	35		4		39
Fiji Warbler	17	1			18
Scarlet Robin	10				10
Spotted Fantail	17	1	1		19
Blue-crested Broadbill	24		7		31
Slaty Flycatcher	8	1	2	2	13
Fiji Shrikebill	38	13	9	8	68
Black-faced Shrikebill	5				5
Silktail		7	8		15
Golden Whistler	8	12	3	1	24
Grey-backed White-eye		1		5	6
Layard's White-eye	5				5
Orange-breasted Honeyeater	19	6			25
Wattled Honeyeater	12	2			14
Red-headed parrotfinch	6	2		1	9

*includes Nadarivatu

not recorded at Kubulau. In all areas, the Fiji Shrikebill was the most frequently mist-netted species, although it was recaptured less often than the Island Thrush (Table 2). The Spotted Fantail was caught frequently only at Wailoku and was not often recaptured (Table 2). The Slaty Flycatcher Golden Whistler, and Orange-breasted Honeyeater foraged mainly in the middle zone, although the honeyeater frequently foraged in the canopy as well. The Slaty Flycatcher and Golden Whistler were less restricted in their foraging zones, but mist-netting and observations showed that only adult male whistlers descended to the lower zones. Female and juvenile Golden Whistlers were seen foraging mainly in the canopy and were not caught by the nets. At Kubulau, the Vanua Levu Silktail foraged in the middle and lower zones, like the Scarlet Robin at Wailoku.

The Giant Forest Honeyeater was recorded only at Wailoku and Taveuni, where it foraged only in the canopy and middle zones. The Wattled Honeyeater was found at Wailoku and Kubulau foraging in the canopy, but it also descended to the lower zones and featured in the mist-net samples. Both Wattled and Orange-breasted Honeyeaters were found also in the open areas, including gardens. Other open-country species included the Wood Swallow, Grey-backed White-eye and Red-headed Parrotfinch, all rarely recorded or mist-netted in the forest. Also in this group were the Polynesian Starling and Vanikoro Broadbill, which frequented open areas and were found only in the clearings or the canopy zone of the forest. The absence of some species from Kubulau, Tavenui and Rabe study areas can be attributed to the short period of observations and mist-netting, especially on Taveuni and Rabe. The lack of some Vanua Levu birds at Kubulau may be a result of its isolation from the main areas of remaining forest on Vanua Levu. Such species as the Island Thrush, Blue-crested Broadbill and Scarlet Robin were not seen or caught in this area. The absence of the Giant Forest Honeyeater could be attributed to the extensive logging in this small area of forest. Similar absences were noted by ornithologists in 1973 and 1975 (Heather, pers. comm.).

DISCUSSION

As described by Karr (1979, 1981), mist-netting and observations are complementary in the study of forest bird communities and this has also been so in the present study in Fiji. Both mist-netting results and observations showed that the Island Thrush was the principal passerine foraging on the forest floor. Observations showed this species did not forage above the undergrowth, in contrast to the observations in the Nausori highlands by Brown & Child (1975). Observations and mist-netting on Tavenui showed that the Silktail frequently descended to the ground to forage, unlike the Vanua Levu subspecies, which foraged in the middle and lower storeys, as recorded previously by Heather (1977). Brown & Child (1975) found that the Spotted Fantail and Fiji Shrikebill foraged higher up than they did in the areas considered here.

Open-area species, such as the Wattled and Orange-breasted Honeyeaters, the Wood Swallow, the Grey-backed White-eye, the Red-headed Parrotfinch, and the Vanikoro Broadbill were found only in forest clearings or in the canopy zone. Pearson (1971) recorded this pattern for similar species in the neotropics.

Two of the commonest species, the Shrikebill and Blue-crested Broadbill, occupy similar zones (Figure 5). Comparison of their foraging methods, however, clearly separates the two species; the Shrikebill is predominantly a gleaner, stripping dead leaves and bark off plant stems, whereas the Broadbill searches the foliage, flying to leaves to pick off insects. At Wailoku the Broadbill preferred middle (53%) and outer (27%) zones, but the Shrikebill foraged mainly in the inner (65%) and middle (35%) zones and was not seen in the outer zone at all.

On Taveuni, the Silktail was also a gleaner (53%) occupying the inner zone (75%), although frequently gleaning on vines. It mainly occupied the undergrowth (56%), thus reducing competition with the Shrikebill, which used the lower storey (47%) and the middle zone (27%) and foraged less in the inner zone (44%). On Vanua Levu, although the Blue-crested Broadbill was absent at Kubulau, the smaller Silktail subspecies fed higher up in the lower storey (36%) and the middle zone (36%), compared with 49% and 33% respectively, for the Fiji Shrikebill. The Silktail occupied similar feeding zones – inner (49%) and middle (29%) – to those of the Shrikebill (41% and 41%, respectively). Both fed mainly by gleaning (Silktail 73% and Shrikebill 66%). The overlap probably means that the larger Fiji Shrikebill (29.2 g, n = 74) displaces the smaller Vanua Levu Silktail (11.3 g, n = 5), which could be one of the factors contributing to the rarity of the Silktail on Vanua Levu, as suggested by Heather (1977).

These conclusions are only tentative and more detailed descriptions of the forest, especially its phenology, are required. Although, superficially, the forests had a similar structure and shared many plant species, there are probably some significant differences to account for some of the results presented here.

ACKNOWLEDGEMENTS

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SHORT NOTES

The only flightless passerine; the Stephens Island wren
(*Traversia lyalli* : Acanthisittidae)

ABSTRACT

New anatomical evidence shows that New Zealand's extinct Stephens Island wren (*Traversia lyalli*) had a much reduced wing skeleton, short, rounded, soft-quilled wings and an almost acarinate sternum. It was therefore the only known completely flightless passerine.

New Zealand's so-called Stephens Island wren (*Traversia lyalli* Rothschild, 1894) holds a unique place in the history of extinct birds, having been discovered but also soon afterward exterminated, it is alleged, by the lighthouse keeper's cat. Only 16-18 specimens were collected, all within a short period in late 1894, but perhaps not all by the cat. Of these just 12 can now be located in museum collections, all of them study skins or mounts, though at least two of them, and another now untraced, were initially preserved as whole birds in spirit.

The Stephens Island lighthouse keeper, D. Lyall, was apparently the only one to have seen the bird alive and then just twice. His unique, though limited, observations have led to much speculation and debate on the habits and, in particular, the flying ability of *Traversia.* Rothschild (1894), from his examination of the type, commented only that the weak character of the wing and the very soft and loose nature of the plumage "pointed to flightlessness" but later, having learned through H.H. Travers of Lyall's observations, stated that the species "ran like a mouse" and "did *not* fly at all". This last statement was rephrased in less definite terms by Oliver (1955) as, "it was never seen to fly", while other authors, speculating without recourse to detailed anatomical examination, pronounced the species variously as "not flightless" (Buller 1896), showing "no clear evidence of flightlessness" (Fitzgerald 1985) or "flightless" (Stanley 1979, Feduccia 1985).

Flightlessness is widespread among various orders of birds, but although the Central American Wren-thrush (*Zeledonia coronata*) and several neotropical rhinocryptids have been described, tantalisingly, as "flightless or nearly so" (Feduccia 1985), as yet there has been no unequivocal proof of complete loss of flight in any of the Passeriformes. To prove whether or not *Traversia* was capable of flight, Lyall's meagre observations need to be supplemented by morphological and functional analysis of the wing and pectoral girdle. Such an analysis has hitherto been impossible because none of the existing specimens (which all lack trunk skeletons) has a sternum, a coracoid or a complete humerus.

In 1976 subfossil remains of *Traversia* were, for the first time, identified from mainland New Zealand (Millener 1984), and they are now known from four North Island and three South Island sites of Late Pleistocene/Holocene age. In August 1988 several more almost complete skeletons, including for the first time intact sterna, were found at one of these South Island sites, the Honeycomb Hill cave system in northwest Nelson.

Examination of these subfossil specimens of *Traversia* has established that the elements of the wing and shoulder girdle are relatively shorter and less robust than those of other acanthisittids (Millener 1988). Reduction of the wing skeleton is shown by comparison of ratios of combined wing bone lengths (humerus + ulna + carpometacarpus) to femur length in the various acanthisittids. For the fully volant Rifleman (*Acanthisitta chloris*) this ratio is 3.26:1, for the weak-flying Rock Wren (*Xenicus gilviventris*) and Bush Wren (*X. longipes*) 2.68:1 and 2.56:1 respectively, and for *Traversia* 2.05:1. The coracoid (Fig. 1b) and humerus (Fig. 1d) are distinctively slender in *Traversia.* In measures of 'relative stoutness' obtained by expressing 'breadth of proximal extremity' and 'minimum shaft breadth' as percentages of shaft length, these elements of *Traversia* are at least 20% more slender than those of any other acanthisittid (cf. *X. gilviventris*, Fig. 1a, c).

The short, rounded wings and soft-plumaged "ralline" appearance of *Traversia* were interpreted by Rothschild (1894) and Buller (1896) as trends toward but not definite evidence of flightlessness. My examination of the relaxed wings of two mounted specimens of *Traversia* showed that, relative to body weight, they are somewhat shorter than those of the other acanthisittids, the wing area is 45-70% less, and the wing loading is correspondingly higher. However, it is in the structure of the flight feathers themselves that *Traversia* is particularly distinctive. In typical flying birds the primary feather vanes, in the outermost primaries particularly, are strongly asymmetrical, the outer vane being reduced almost to nothing (Feduccia 1979). However, in *Traversia*, but not in the other acanthisittids, *all* the primaries show much greater symmetry, having outer vanes at least half the width of the inner. In addition, because the barbules of adjacent barbs scarcely overlap, the webs of its primaries lack the smooth sheen and continuous, airtight surface typical of volant forms. *Traversia's* wing feathers are thus, in many ways, remarkably similar to those of flightless rails such as the weka (*Gallirallus australis*).

While reduction in wing size and degeneration of flight feathers suggest flightlessness, it is the conformation of the hitherto unknown sternum which provides the final proof. In Fig. 2, a *Traversia* sternum (b,d) is shown beside that of *X. gilviventris* (a,c), chosen because it is, among the acanthisittids, the closest to *Traversia* in body size. In ventral view one can see that, in *Traversia*

(1) The sternal body is somewhat broader, yet markedly shorter than that of *X. gilviventris*, thus providing a lesser area for attachment of pectoral muscles;

(2) The manubrial spine (spina externa), large and bifid in *X. gilviventris*, is entirely absent, indicating a lesser development of the sternocoracoclavicular membrane;

(3) The regions of sternocoracoidal articulation are narrower (and the coracoidal sulci less excavated), indicating a less rigid attachment of the markedly more slender coracoids to the sternum.

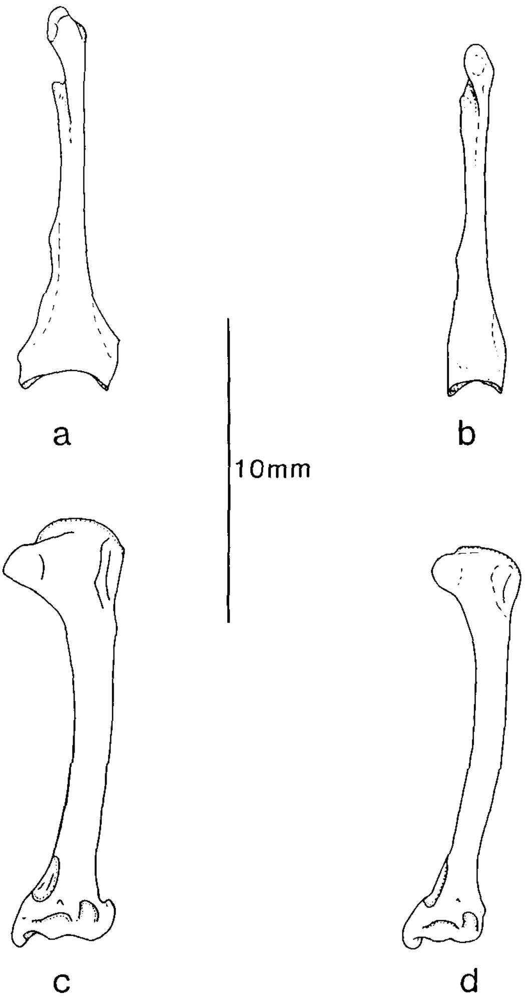

FIGURE 1 — Left coracoids (a,b) and humeri (c,d) of *Xenicus gilviventris* (a,c — BMNH.1940,12.8.144) and *Traversia lyalli* (b — NMNZ.S22797, d — NMNZ.S22800)

In lateral view (Fig. 2c,d) the differences between the two taxa, particularly in the size of their sternal carinae (shaded) are dramatic. In *X. gilviventris* the carina extends for over 85% of the length of the sternal body, but in *Traverisa* for only 30%. In *X. gilviventris* the maximum depth of the carina (x = 3.52 mm, n = 5) is 43% of the minimum breadth of the sternal body (measured behind the posterior costal notch), whereas in *Traversia* (carina depth: x = 0.70 mm, n = 3) the equivalent figure is a mere 8%. This extraordinary degree of carinal reduction in *Traversia* is emphasised by

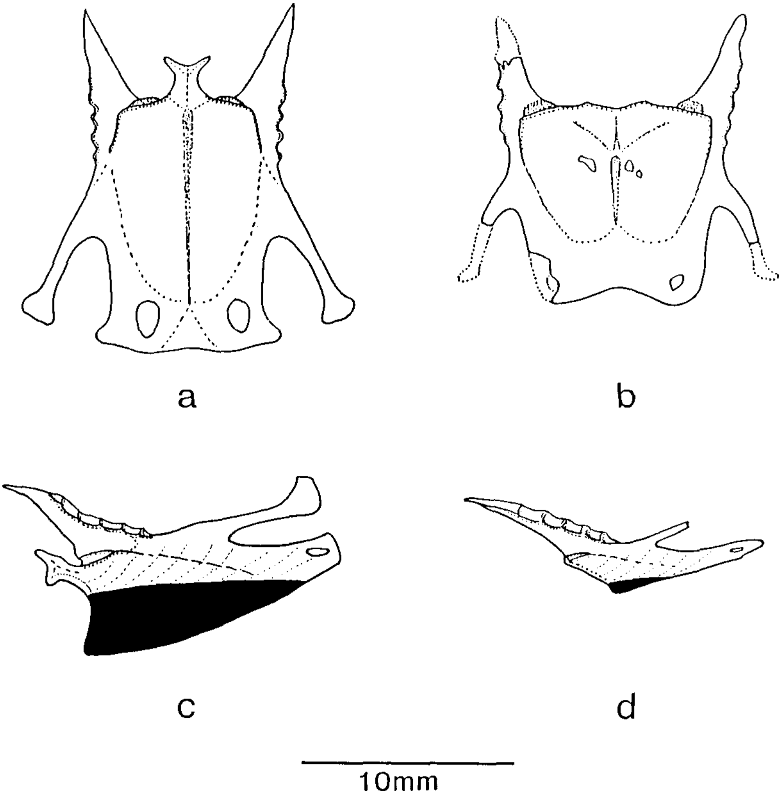

FIGURE 2 — Ventral (a,b) and left lateral (c,d) views of sterna of *Xenicus gilviventris* (BMNH.1940.12.8.144) and *Traversia lyalli* (NMNZ.S25593)

comparison with *Atrichornis rufescens*, the almost flightless Rufous Scrub-bird of Australia, for which the figure is 23% (data from Rich *et al.* 1985). The sternal carina provides a key attachment area for pectoral muscles and its size largely determines a bird's flight muscle mass. Perhaps the most telling comparison to be made between *Traversia* and *X. gilviventris* is that the surface area of the sternal carina in *Traversia* is less than 6% of that of *X. gilviventris.* As noted previously, the surface area of the sternal body available for attachment of flight muscles is also very much reduced in *Traversia*, and so its flight muscle mass was probably no more than 2-3% that of *X. gilviventris*. As the Rock Wren is itself a weak flyer, "usually covering only five or six metres in one stretch" (Shaw 1985), the functional consequences of *Traversia* having such reduced flight muscles are obvious.

Such compelling anatomical evidence, supplementing the meagre historical observations of a bird which was "never seen to fly", leads one to the inescapable conclusion that *Traversia lyalli* was the only known completely flightless member of the Passeriformes.

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A 1973 record of Chestnut-breasted Shelducks

While going back through my notes of field observations recently, I came across one dated 20 January 1973 about what were at the time two puzzling shelducks, seen on the bed of the Hokitika River downstream of the Kaniere township bridge. My notebook has notes and a sketch of one bird, plus a comment that both birds had similar plumage.

Having knowledge now of the Chestnut-breasted Shelduck *(Tadorna tadornoides)*, I submitted the record to the Rare Birds Committee, which has accepted the record as the first sighting for New Zealand. The sketch and description show that one bird was a male, and the other may have been also.

This note should be read in relation to the article by Heather (1987; The Chestnut-breasted Shelduck in New Zealand 1983-1986, *Notornis* 34: 71-77), as it brings to light a record that was not available to him.

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THE BIRD FAUNA OF NIUE COMPARED WITH THOSE OF TONGA, SAMOA, THE SOUTHERN COOKS, AND FIJI

By J.A. GIBB, P.C. BULL, W.M. McEWEN and I.J. SEWELL

Several people interested in birds visited Niue Island in 1986-87. Our combined observations amplify or confirm those of Wodzicki (1971), made in November 1968 and July-August 1969, and of Kinsky & Yaldwyn (1981), made in June 1971 and August-September 1972. Wodzicki (unpubl.) also visited Niue in June-July 1976 but added no new species to his earlier list.

We visited most habitats and different parts of the island by road, by rough vehicle track or on foot, and spent some time gazing out to sea. Yet we added no new species to the checklist of Kinsky & Yaldwyn (1981). We suppose that no other, unrecorded bird species are resident on Niue and that local lore is now unlikely to reveal other species recently extinct. Much remains to be done for Niuean ornithology, but in particular the status of the Wedge-tailed Shearwater needs to be explored and a search for fossil bones in caves should be rewarding; almost nothing is known about the breeding biology of the resident birds.

This paper is in two sections. In the first, we record our limited field observations; in the second, we suggest reasons for the few species of birds breeding on Niue and compare the breeding bird faunas of the different island groups.

GEOGRAPHY

The quality of Niue as a bird habitat is largely dictated by its geography. Niue (19°02'S, 169°52'W) is a raised coral atoll of 258 km^2 and is roughly circular (21 x 18 km). It lies about 1320 km east of Viti Levu, the largest of the Fijian Islands, 525 km east of Tongatapu in the Tongan Islands, 600 km south of Apia in Western Samoa, and 1080 km west of Rarotonga in the Southern Cook Islands. The nearest land is the Vava'u Group of the Tonga Islands, 430 km west of Niue.

Niue is saucer-shaped in section: its interior (the former lagoon) is surrounded by twin terraces (the former reef) rising to about 70 m a.s.l. The rest of the topography is flat or gently undulating. The ground is rocky limestone and porous, in places studded with sharp pinnacles up to about 5 m tall. The cliffs are precipitous and pierced with many caves. There are no natural harbours or sandy beaches. The island is nearly surrounded by an intertidal platform up to 100 m wide, with fine rock pools and a veneer of coral. There is no surface water of any kind, no proper reef or lagoon, no inshore shallow water, offshore stacks or sandbars; and the sea runs deep close inshore.

The climate is broadly tropical. The mean annual temperature is 24.7 °C and the rainfall about 2050 mm. Southeast trade winds blow for much of the year. Niue lies on the edge of the cyclone belt; the last destructive hurricane hit the island in February 1968, and before that others in 1959 and 1960. The natural vegetation (Sykes 1970) consists of rainforest with a canopy reaching to about 20 m. Many of the trees are heavily buttressed or supported by stout aerial roots, and so they remain standing though utterly defoliated when hurricanes strike (J.M. McEwen, pers. comm.). Frost & Berryman (1966, *The timber resources of Niue Island*, unpubl. NZ Forest Service report) classified the forest resources of Niue as comprising about 5500 ha of merchantable forest, 14 000 ha of light scattered forest, 2400 ha of coastal scrub, and 3900 ha of fernland (resulting from overcropping and burning). The shallow soil is moderately fertile and supports a labour-intensive shifting agriculture. Typically, the bush 'gardens' are broken in (recently with bulldozers), planted and cropped for 1-3 years, and then abandoned for 10 years or more. Consequently much of the island is now a mosaic of forest in varying stages of regeneration, interspersed with cultivated or freshly abandoned gardens. There are also scattered coconut plantations, three small farms with some open ground, and a few citrus orchards.

Niue may have been inhabited by Polynesians for 2000 years (J.M. McEwen, pers. comm.). Fourteen small villages are strung along the road encircling the island. The population exceeded 5500 in about 1960 but is now about 2000 and still falling. Eales (1965, 1968)* and Given (1968) collected insects on Niue, and Whitaker (1969)* described four species of lizard. Wodzicki (1969)* surveyed the rodents (*Rattus exulans* and *R. rattus*), and Wodzicki & Felten (1975) described the fruit bat (*Pteropus tonganus*). Domestic dogs and both feral and domestic cats are common.

* *Unpubl. DSIR reports:* Eales, A.C. 1965, 1968. First and second interim reports on the insects of Niue Island. Whitaker, A.H. 1969. Lizards collected on Niue Island, 15 November - 4 December 1968. *In* Wodzicki, K. 1969. A preliminary survey of rats and other land vertebrates of Niue Island, South Pacific, 2 November - 4 December 1968.

BIRD OBSERVATIONS ON NIUE, 1986-1987

The following visited Niue on the dates given and contributed to these notes: Andrew and Mary McEwen, 10-22 May 1986, and, with Alison and David McEwen, 22 August-5 September 1987; Ian J. Sewell with Hilary Chapman, Stephanie Gemmell and Nigel Haskins (from Cambridge University), 3 July-25 August 1987; Peter and Mary Bull, 31 July-7 August 1987; and John and Judy Gibb, 22 August-5 September 1987.

WEDGE-TAILED SHEARWATER, *Kalangi*

Not seen; birds are unlikely to have come ashore until October, after we had left (Falla *et al.* 1979). Kinsky & Yaldwyn (1981) reported *kalangi* with eggs on cliffs near Namukulu and Vaiea in December; they saw none in June or August-September.

WHITE-TAILED TROPICBIRD, *Tuaki*

Seen commonly at sea, less commonly inland; nowhere abundant. Breeds solitarily in trees in the forest.

FERAL FOWL, *Moa*

Free-ranging fowl have the run of the villages. Small groups of feral birds were seen through the forest and bush gardens, and cocks were often heard crowing. Kinsky & Yaldwyn (1981) reported a tibia excavated by M.M. Trotter, of Canterbury Museum, near Pulaki in 1974, carbon-dated at 1270 ± 40 years BP. Its length corresponded to that of a female Jungle Fowl from Fiji in the New Zealand National Museum.

BANDED RAIL, *Veka*

Ubiquitous and common, often seen crossing the road or running for cover in open or partially cleared country, and on the hotel lawn. The species has staged a remarkable recovery since being reported as extinct by Smith (1902, quoted by Wodzicki 1971) and still very scarce in 1953 (Wodzicki 1971).

PURPLE SWAMPHEN, *Kale*

In the 1950s *kale* were very common (J.M. McEwen, pers. comm.); Kinsky & Yaldwyn (1981) described them as "locally common". We saw only a few birds, singly, running for cover beside the road, mostly in the northern half of the island. We agree with Wodzicki (1971) that they are now much less common than *veka*. They are unpopular, and shot, because of the damage they do to taro.

GOLDEN PLOVER, *Kiu*

A. and M. McEwen found *kiu* much more numerous in May 1986 than in August-September 1987. We probably left Niue (in September 1987) before the first birds of the year arrived. Most of those we saw were on village greens, the airport and other open spaces, including the hotel lawn; only one or two were seen on the shore.

WANDERING TATTLER, *Kiu-tahi*

Small numbers were seen on tidal rocks, for example, near Namukulu and Avatele. Presumably we left before the main influx.

COMMON NODDY, *Ngongo*

A few seen at sea off the southeast coast. No evidence of breeding, now or in the 1950s (J.M. McEwen, pers. comm.).

WHITE TERN, *Taketake*

Seen at sea and over the island, but less often than tropicbirds. No positive evidence of breeding, though single birds and pairs were displaying (prospecting for nest sites?) in coastal forest in late August. In the late 1950s *taketake* nested in trees behind the New Zealand Residency at Tapeu (J. M. McEwen, pers. comm.).

PACIFIC PIGEON, *Lupe*

Not abundant, but frequently seen flying over the forest in the early evening, and probably heard calling in the forest. Served to some of us when we were guests in a village home, though "protected".

PURPLE-CAPPED FRUIT DOVE, *Kulukulu*

Common in the forest and bush clearings; much more often heard than seen.

BLUE-CROWNED LORY, *Henga*

Single birds seen by IJS in regenerating bush near Lapeka and near the airport, and another by PCB near Avatele.

BARN OWL, *Lulu*

Seen almost daily hunting over bush gardens and around the villages in early evening. One was perched statuesquely on a roadside gravestone in mid-morning.

WHITE-RUMPED SWIFTLET, *Pekapeka*

Locally very common, especially along certain stretches of road, in forest clearings, along forest tracks and in other semi-open places. They usually hunt below the tree-tops. No breeding sites were visited.

POLYNESIAN STARLING, *Miti*

Common in most types of vegetation, though not greatly abundant; often in pairs.

POLYNESIAN TRILLER, *Heahea*

Common, and noisier than *miti*; often seen around gardens and other open places in villages as well as in the interior. On 3 August 1987 PCB saw an adult carrying food to a nest c. 12 m up an almost leafless tree and remain as if brooding young.

THE AVIFAUNA OF NIUE

Compared with those of Tonga, Samoa, and the Southern Cooks, the Niuean avifauna is sparse. The only introduced species is the feral fowl. Year-round watching (lacking on Niue) would no doubt extend the list of visiting sea and shore birds. Holyoak (1980), for instance, added nine Procellarii to the Cook Islands' list when cruising in July-September 1973, and he suggested that 30 more seabirds (and some waders, Holyoak 1976) could be added by sustained observation.

Table 1 lists the bird species recorded on Niue and the neighbouring islands of Tonga, Samoa and the Southern Cooks, excluding Procellarii seen only at sea.

It includes the status of these species on Fiji. Despite its isolation, with no other land within 430 km, its considerable size and its dense cover of vegetation, Niue has only 3 breeding seabirds and 11 breeding landbirds (including the feral fowl). For comparison, Tonga has 13 (+ 4 unconfirmed) breeding seabirds and 23 (+ 2?) others; Samoa has 12 (+ 4?) breeding seabirds and 32 (+ 2?) others; while the Southern Cooks have 13 (+ 2?) breeding seabirds and 15 others. The three seabirds breeding on Niue are the Wedge-tailed Shearwater, obviously scarce, and the White-tailed Tropicbird and White Tern, both of which nest in trees and are moderately common. Wedge-tailed Shearwaters breed also on Tonga and Samoa but probably not on the Southern Cooks, and the White-tailed Tropicbird and White Tern breed on all three island groups besides Niue.

TABLE 1. List and status of birds (excluding non-breeding Procellarii) recorded on Tonga, Samoa, Niue and the Southern Cooks, with their status on Fiji (after Ashmole 1963, Dhondt 1976, Holyoak 1976, 1980, Kinsky & Yaldwyn 1981, Watling 1982). B = Breeding, V = Visitor,* = Introduced

Species	Tonga	Samoa	Niue	S. Cooks	Status in Fiji
Tahiti Petrel *Pterodroma rostrata*				V(B?)	
Phoenix Petrel *Pterodroma alba*	B			V	
Herald Petrel *Pterodroma arminjoniana*	B			V(B?)	
Wedge-tailed Shearwater *Puffinus pacificus*	B	B	B	V	B
Audubon's Shearwater *Puffinus lherminieri*	B	B		V	B
White-throated Storm Petrel *Nesofregatta albigularis*		B		V	B
Red-tailed Tropicbird *Phaeton rubricauda*	B?	B?	V?	B	B
White-tailed Tropicbird *Phaeton lepturus*	B	B	B	B	B
Brown Booby *Sula leucogaster*	B	B		B	B
Blue-faced Booby *Sula dactylatra*		B		B	B
Red-footed Booby *Sula sula*	B?	B?		B	B
Greater Frigatebird *Fregata minor*	B?	B?	V	B	B?
Lesser Frigatebird *Fregata ariel*	B	B		B	B
Reef Heron *Egretta sacra*	B	B	V?	B	B
Grey duck *Anas superciliosa*	B?	B?	V?	B	B
Australasian Harrier *Circus approximans*	B				B
Peregrine *Falco peregrinus*		V			B
Niuafo'ou Megapode *Megapodius pritchardii*	B				
*Jungle (Feral) Fowl *Gallus gallus*	B		B	B	B

Banded Rail *Rallus philippensis*	B	B	B		B
White-browed Crake *Poliolimnas cinereus*		B			B
Spotless Crake *Porzana tabuensis*	B	B	B	B	B
Purple Swamphen *Porphyrio porphyrio*	B	B	B		B
Grey Plover *Pluvialis squatarola*				V	
Golden Plover *Pluvialis dominica*	V	V	V	V	V
Curlew *Numenius arquata*		V	V		V
Bristle-thighed Curlew *Numenius tahitiensis*	V	V	V	V	V
Bar-tailed Godwit *Limosa lapponica*	V	V	V	V?	V
Yellowlegs *Tringa melanoleucos*	V	V	V	V	V
Wandering Tattler *Tringa incana*	V	V	V	V	V
Turnstone *Arenaria interpres*			V	V	V?
Pectoral Sandpiper *Tringa melanotus*		V?	V		
Sanderling *Calidris alba*				V	V
Common Tern *Sterna hirundo*				V	V
Roseate Tern *Sterna dougallii*	V				
Black-naped Tern *Sterna sumatrana*	B	B?		B	B
Sooty Tern *Sterna fuscata*	B	B		B	B
Crested Tern *Sterna bergii*	B?	V		V	B
Grey Noddy *Procelsterna cerulea*	B	B		B	B?
Common Noddy *Anous stolidus*	B	B	V	B	B
Black (White-naped) Noddy *Anous tenuirostris*	B	B		B	B

White Tern *Gygis alba*	B	B	B	B	B
*Feral Pigeon *Columba livia*	?	?		B	B
White-throated Pigeon *Columba vitiensis*		B			B
Friendly Ground Dove *Gallicolumba stairii*	B	B			B
Pacific Pigeon *Ducula pacifica*	B	B	B	B	B
Tooth-billed Pigeon *Didunculus strigirostris*		B			
Many-coloured Fruit Dove *Ptilinops porphyraceus*	B	B	B		B
Cook Island Fruit Dove *Ptilinops rarotongensis*				B	
Blue-crowned Lory *Vini australis*	B	B	B		B
Tahiti Lory *Vini peruviana*				B	
Red-breasted Musk Parrot *Prosopeia tabuensis*	B				B
Long-tailed Cuckoo *Eudynamis taitensis*	V	V	V	V	V
Barn Owl *Tyto alba*	B	B	B		B
White-rumpted Swiftlet *Collacalia spodiopygia*	B	B	B		B
Atiu Swiftlet *Aerodromus sawtelli*				B	
White-collared Kingfisher *Halcyon chloris*	B	B			B
Flat-billed Kingfisher *Halcyon recurvirostris*		B			
Chattering Kingfisher *Halcyon tuta*				B	
Mangaia Kingfisher *Halcyon ruficollis*				B	
Pacific Swallow *Hirundo tahitica*	B				B
*Red-vented Bulbul *Pycnonotus cafer*	B	B			B
Island Thrush *Turdus poliocephalus*		B			B

Cook Is Warbler *Acrocephalus kerearoko*				B	
Rarotonga Flycatcher *Pomarea dimidiata*				B	
Samoan Fantail *Rhipidura nebulosa*		B			
Fiji Shrikebill *Clytorhynchus vitiensis*	B	B			B
Samoan Broadbill *Myiagra albiventris*		B			
Scarlet Robin *Petroica multicolor*		B			B
Golden Whistler *Pachycephala pectoralis*	B				B
Samoan Whistler *Pachycephala flavifrons*		B			
Polynesian Triller *Lalage maculosa*	B	B	B		B
Samoan Triller *Lalage sharpei*		B			
Samoan White-eye *Zosterops samoensis*		B			
Cardinal Honeyeater *Myzomala cardinalis*		B			
Wattled Honeyeater *Foulehaio carunculata*	B	B			B
Mao (honeyeater) *Gymnomyza samoensis*		B			
Red-headed Parrotfinch *Erythrura cyaneovirens*		B			B
*European Starling *Sturnus vulgaris*	B				B
Polynesian Starling *Aplonis tabuensis*	B	B	B		B
Samoan Starling *Aplonis atrifusca*		B			
Rarotongan Starling *Aplonis cinerascens*				B	
*Jungle Mynah *Acridotheres fuscus*		B			B
*Indian Mynah *Acridotheres tristis*				B	B

The 11 breeding landbirds on Niue include only two passerines (endemic races of the Polynesian Starling and Triller). This compares with 8 passerines among 23 landbirds breeding on Tonga, 17 passerines among 32 landbirds on Samoa, and 4 passerines among 15 landbirds on the Southern Cooks. In addition, the Long-tailed Cuckoo appears as a migrant on all groups and Niue (where it calls harshly).

Niue has eight species of visiting waders confirmed, compared with five on Tonga, five (6?) on Samoa, and eight (8?) on the Southern Cooks. These are few enough considering the variety reaching New Zealand (Falla *et al.* 1979). Five of the eight Niuean species are recorded also on Tonga, six (7?) on Samoa, and five (6?) on Southern Cooks. The Reef Heron is not confirmed from Niue, though it breeds on the other three island groups.

The fact that Niue is a solitary raised atoll only 20 km across, while the other islands are archipelagos spanning several hundred kilometres, must be largely responsible for its sparse bird fauna. So it is instructive to compare the bird fauna of Niue with that of Rarotonga (67 km^2), which, though much smaller, is the largest of the Southern Cooks. Both islands are inhabited (Rarotonga more densely than Niue), largely forested and partly cultivated. Holyoak (1980) placed the breeding birds of Rarotonga in three categories of abundance and we attempt to do the same for Niue (Table 2).

Where Niue has three breeding seabirds, the Southern Cooks as a group have 13 (15?); where Niue has 11 other breeding species, the Southern Cooks have 15. However, Rarotonga alone has only four breeding seabirds and seven breeding landbirds (Table 2). Thus the two single-island avifaunas differ much less in number of breeding species than Niue and the whole Southern Cooks, especially among the seabirds.

THE FIJIAN CONNECTION

The islands of Fiji, 500 km WNW of Tonga (Fig. 1), provide by far the largest land mass and diversity of habitat in the Southwest Pacific.

The seabirds of the Southwest Pacific are mostly widespread tropical species: of the 18 species confirmed as breeding in Fiji (Fig.1), 10 definitely breed also on Tonga, and 11 each on Samoa and the Southern Cooks. All three species breeding on Niue also breed in Fiji, Tonga and Samoa, and two of them (White-tailed Tropicbird and White Tern) on the Southern Cooks; while 10 of the 12 confirmed breeding seabirds on Tonga, all 11 of those on Samoa and all 11 on the Southern Cooks also breed in Fiji. The Phoenix and perhaps the Herald Petrels (but see Turbott 1977) are the only species apparently restricted to a single island group, i.e. Tonga. The Grey Noddy, which breeds on Tonga, Samoa and the Southern Cooks, is not confirmed from Fiji.

The 'other' species (mainly landbirds) in Table 1 have differentiated more extensively than the seabirds, even if we ignore subspecies. Of 63 species of birds breeding in Fiji (Watling 1982), 22 also breed on Tonga and 22 also on Samoa (16 are common to both); but of these 63, only seven are included in the small total of 15 'others' in the Southern Cooks. All 11 of the landbirds breeding on Niue also breed on Tonga and Fiji, and 10 of

TABLE 2. Breeding birds of Niue (this paper) and Rarotonga (Holyoak 1980).
+ = Uncommon, + + = Moderate numbers, + + + = Common

Species	Niue	Rarotonga
Wedge-tailed Shearwater	+	
Red-tailed Tropicbird		+
White-tailed Tropicbird	++	++
Reef Heron		+
Jungle (Feral) Fowl	+++	++
Banded Rail	+++	
Spotless Crake	+	
Purple Swamphen	+	
Common Noddy		+
White Tern	++	+
Many-coloured Fruit Dove	+++	
Cook Island Fruit Dove		+++
Pacific Pigeon	++	+++
Blue-crowned Lory	+	
Barn Owl	++	
White-rumped Swiftlet	+++	
[Rarotongan Kingfisher (undescribed)		Extinct by 1940]
Rarotonga Flycatcher		+
Polynesian Triller	+++	
Polynesian Starling	+++	
Rarotongan Starling		+++
Indian Mynah		+++

them (not the feral fowl) on Samoa too; but only three (the fowl, Spotless Crake and Pacific Pigeon) on the Southern Cooks. Of the 23 'other' species breeding on Tonga and 33 'others' on Samoa, 22 from each group breed on Fiji.

As Mayr (1945) pointed out, about two-thirds of the landbirds of the South Pacific are on only one island group. Consequently there is a longish list of landbirds, but not of seabirds, that breed on one or other of the other island groups, but not on Fiji:

Tonga:	Niuafo'ou Megapode (restricted to this far northern volcanic outlier).
Samoa:	Tooth-billed Pigeon, Flat-billed Kingfisher, Samoan Starling, Samoan Fantail, Samoan Broadbill, Samoan Whistler, Samoan Triller, Samoan White-eye, Cardinal Honeyeater, and Mao (a large honeyeater): total 10 species.

Southern Cooks: Cook Is Fruit Dove, Tahiti Lory, Atiu Swiftlet, Chattering and Mangaia Kingfishers, Cook Is Warbler, Rarotonga Flycatcher, Rarotonga Starling: total 8 species.

Niue: None

Combining sea with landbirds, 32 (88.9%) of the 36 confirmed breeding species on Tonga definitely breed on Fiji, 33 (75.0%) of the 44 on Samoa, 14 (100%) of the 14 on Niue, but only 18 (64.3%) of the 28 on the Southern Cooks. Of the 14 species breeding on Niue, all breed on Tonga and Fiji and all except the fowl on Samoa, but only 5 on the Southern Cooks.

DISCUSSION

Slud's (1976) massively comprehensive summaries of the number of landbirds resident on single islands, and island groups, in the 'warmer oceans' of the world placed Niue low on the list, with only about one-third as many species as the average for islands of its size, and with notably few passerines. According to biogeographic theory (e.g. MacArthur & Wilson 1967), the number of species in any large taxonomic group that inhabits an island is held within narrow limits by forces balancing the rates of colonisation and extinction. It is worth examining the bird fauna of Niue in this context.

King (1973) and Hay (1986) have stressed that petrels and shearwaters are among the first of the seabirds to be displaced by man on newly inhabited islands, and Niue has few Wedge-tailed Shearwaters. Moreover, the numerous cats and rats, as well as dogs and people, are likely to have excluded burrowing petrels, especially where the soil is shallow and there are no high mountains (e.g. for *Pterodroma* spp.), as there are on Fiji.

Niue's isolation should be no deterrent for breeding seabirds or migratory waders; but the lack of surface water, any proper reef, lagoon or other shallow water, offshore islets or sand-bars must make it inhospitable for wetland and shorebirds alike, and for some terns that frequent shallow water. Hunting by Niueans may also restrict the numbers of tropicbirds and White Terns, which breed solitarily; and there is no safe resort for ground-nesting or colonial seabirds.

Sheer isolation is likely to be more of an obstacle to colonisation by vagrant landbirds than by seabirds; and it is the smaller passerines that are so conspicuously missing from these islands. The larger islands should be more readily encountered by chance than smaller ones, and they should offer more diverse habitats; also, as a rule, they should carry larger populations of landbirds, which should be less likely to become extinct. Mayr (1941b) does not rule out the destructive effects of hurricanes in limiting the bird fauna of small islands; and J.M. McEwen (pers. comm.), who saw the devastation caused by hurricanes on Niue in 1959 and 1960, recalls the complete stripping of all green vegetation, which must have drastically reduced the numbers of forest birds (and fruit bats).

Yet the chances of small passerine birds ever reaching small remote islands must be exceedingly slender. Landbirds on tropical islands are notoriously sedentary; for, as Mayr (1941b) put it, they "use their ability to fly less for active spreading than to return to their home island in heavy storms". The open sea lets pass only the small minority of strong-flying species.

If potential colonists with the ability to reproduce soon after arrival (Mayr 1941b) did reach Niue, the forest and forest edge habitats might prove acceptable to a greater variety of landbirds than is now present. Judging from the birds already on neighbouring groups of islands, new settlers might include (not in order of probability) a forest kingfisher, the Island Thrush, a flycatcher, shrikebill, whistler, white-eye or honeyeater.

On Niue, the reduction in area of the primary forest, for cultivation, must have already reduced the numbers of pigeons and lories; but it may have favoured the Banded Rail, the Barn Owl and perhaps the swiftlets, which frequent more open country. Wodzicki (1971) warned of the effects of introduced *Rattus rattus* as predators on smaller birds: a timely warning in view of current research on the breeding of the Rarotonga Flycatcher (R. Hay, pers. comm.).

Legislation ostensibly limiting the use of firearms is either weak or weakly enforced; and nestling tropicbirds, White Terns and pigeons are still taken as food. The population of Banded Rails, thriving in the face of heavy predation by cats and rats, remains anomalous.

Despite the shift in habitats from primary forest to cultivation, the development of second-growth forest and fernland, and the recent widespread use of firearms, the species composition of the resident Niuean avifauna has apparently not changed in historical times.

Figure 1 shows that many of the seabirds breeding in Fiji are common to the other island groups to the east, including the Southern Cooks, and that these smaller groups share many of the same species too. Thus, of the 18 seabirds breeding in Fiji, 10 breed in Tonga, 11 in Samoa and 11 in the Southern Cooks; and of the 13 breeding in Tonga and 12 in Samoa, 9 from each group also breed in the Southern Cooks.

By contrast, most of the landbirds breeding in Tonga, Samoa, Niue and the Southern Cooks are at least subspecifically distinct from their congeners in Fiji, and many of them are endemic species. Samoa, in particular, an older island group with a relatively rich landbird fauna (Slud 1976), has several endemic passerines derived from Fiji. Of the 63 'other' species breeding in Fiji, just 22 breed in Tonga and Samoa (16 being common to both) and only seven in the Southern Cooks.

This high degree of endemism confirms the very slow turnover of landbirds in the island groups. The much weaker link between the landbirds of the Southern Cooks and the other groups upholds Mayr's (1941b) placing of the Southern Cooks in the Eastern Polynesian subdivision, and Fiji, Tonga, Samoa and Niue in the Central subdivision, of the Polynesian subregion.

Finally, the landbirds breeding on Niue may have island-hopped from Fiji via Tonga or Samoa. Recent taxonomic study suggests that the Banded Rail (Ripley 1977) and White-rumped Swiftlet (Kinsky & Yaldwyn 1981) are fairly recent arrivals on Niue from Samoa. On the other hand, the

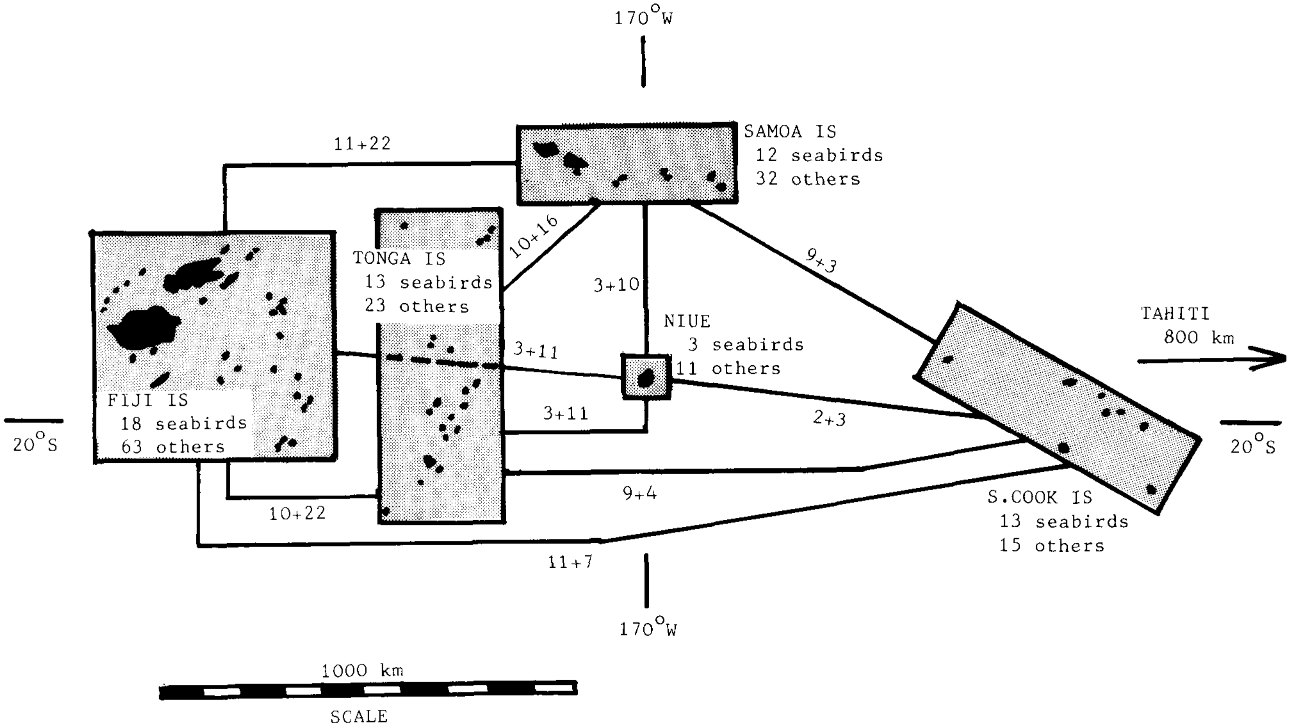

FIGURE 1 — Sketch map showing the central position of Niue relative to Fiji, Tonga, Samoa and the Southern Cooks, together with the total number of sea and other species of birds breeding in each group. The figures printed on the lines joining the island groups refer to the numbers of sea + other breeding species of birds common to each group; e.g. of the 12 species of seabirds breeding in Samoa, 11 are shared with Fiji, 10 with Tonga, 3 with Niue and 9 with the Southern Cooks

nominate race of the Many-coloured Fruit Dove on Niue is identical with birds on Tonga and some of the Fijian islands but differs from those on Samoa (Kinsky & Yaldwyn 1981). The Niuean subspecies of the Polynesian Triller (*L. m. whitmeei*) more closely resembles birds from Samoa than from Tonga (Mayr 1945).

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SEABIRDS FOUND DEAD ON NEW ZEALAND BEACHES IN 1987, AND A REVIEW OF *PROCELLARIA* SPECIES RECOVERIES SINCE 1960

By R. G. POWLESLAND

ABSTRACT

In 1987, 3776 kilometres of coast were patrolled and 4124 dead seabirds were found, well below the average for the previous 17 years (10 624). Unusual finds were a White-bellied Storm Petrel *(Fregetta grallaria)*, a Kermadec Petrel *(Pterodroma neglecta)* and a Red-tailed Tropicbird *(Phaethon rubricauda)*.

A summary is given of the coastal and monthly distributions for *Procellaria* species found during the 1960-1986 period. The most frequently recovered species was the Black Petrel *(P. parkinsoni)*, the number found annually varying markedly.

INTRODUCTION

This paper records the results of the Ornithological Society of New Zealand's Beach Patrol Scheme for 1987. All sections of coast were patrolled except Fiordland. Some beaches on the Chatham Islands were patrolled and the results for these are given under the heading "Outlying Islands". In total, 563 Beach Patrol Cards and 10 Specimen Record Cards were submitted.

Kilometres "travelled" are the total lengths of coast patrolled; kilometres "covered" are the lengths of coast patrolled monthly. Hence, if 1 km of beach is patrolled twice in one month, 2 km have been travelled but only 1 km covered per month. For a detailed description of methods for beach patrolling see Powlesland & Imber (1988).

The nomenclature used is that of Kinsky (1970, 1980), except that I have followed Imber (1985a) for the Kerguelen Petrel *(Lugensa brevirostris)*.

RESULTS AND DISCUSSION

In 1987, the total length of coast travelled was 3776 km and 4124 seabirds were found by 238 members of the Ornithological Society of New Zealand and their friends. The average number of birds per kilometre of coast covered was 1.15 (Table 1). The total distance travelled was slightly less than the average (3954) for the past 17 years (1970-1986), but much fewer birds were found (average 10 624). Only in the period 1960-1969, when much less patrolling was done (average = 1569 km travelled per year), were fewer than 4000 birds found in a year (average = 2283 birds). The average number of birds found per kilometre covered in 1987 (1.15) was also much less than for the previous 17 years (3.1). In addition, Table 1 gives the kilometres covered and the number of seabirds found per month and in total for the various coasts, plus the number of birds picked up per kilometre covered for each coast. Table 2 gives the coastal and monthly distributions of the less commonly found species (1-20 birds in 1987), and Tables 3 and 4 give these for the more commonly found species.

NOTORNIS 36: 299-310 (1989)

TABLE 1 — Numbers of dead seabirds recovered and kilometres covered on each coast in 1987

COAST	CODE		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL KM	TOTAL BIRDS	BIRDS/KM /COAST
AUCKLAND WEST	AW	KM	213	153	197	162	158	170	130	183	172	120	143	112	1913		
		BIRDS	190	135	78	95	108	88	115	37	201	144	118	188		1497	0.78
TARANAKI	TA	KM	21	6	7	7	18	14	13	10	6	13	3	6	124		
		BIRDS	31	8	2	14	13	7	12	6	6	23	-	4		126	1.02
WELLINGTON WEST	WW	KM	14	31	6	36	45	40	23	38	61	22	4	60	380		
		BIRDS	24	169	18	51	46	51	29	77	192	77	5	199		938	2.47
AUCKLAND EAST	AE	KM	107	12	51	18	41	10	35	45	17	20	16	30	402		
		BIRDS	122	17	35	21	37	8	32	38	18	27	53	122		530	1.32
BAY OF PLENTY	BP	KM	35	10	3	11	8	7	3	15	8	14	10	26	150		
		BIRDS	36	7	2	7	2	3	3	22	5	31	10	78		206	1.37
EAST COAST NI	EC	KM	1	14	14	26	14	12	15	26	10	14	18	1	165		
		BIRDS	3	11	15	20	6	10	17	52	2	8	27	4		175	1.06
WAIRARAPA	WA	KM	6	-	-	-	-	-	6	6	-	-	-	-	18		
		BIRDS	1	-	-	-	-	-	-	5	-	-	-	-		6	0.33
WELLINGTON SOUTH	WS	KM	-	5	32	-	2	50	35	17	8	1	1	-	151		
		BIRDS	-	10	58	-	1	16	19	10	15	2	1	-		132	0.87
NORTH COAST SI	NC	KM	-	-	-	-	-	-	1	4	1	-	4	25	35		
		BIRDS	-	-	-	-	-	-	1	7	1	-	8	18		35	1.00
WESTLAND	WD	KM	-	4	-	1	-	6	-	-	4	-	-	4	19		
		BIRDS	-	-	-	2	-	2	-	-	1	-	-	1		6	0.32
CANTERBURY NORTH	CN	KM	4	-	2	-	-	-	30	6	1	-	18	11	72		
		BIRDS	10	-	4	-	-	-	153	12	5	-	105	21		310	4.31
CANTERBURY SOUTH	CS	KM	1	-	-	-	10	-	20	-	1	1	1	-	34		
		BIRDS	9	-	-	-	28	-	31	-	1	2	2	-		73	2.15
OTAGO	OT	KM	10	7	8	6	12	9	6	6	6	8	8	8	94		
		BIRDS	10	12	5	-	4	4	-	-	-	4	7	11		57	0.61
SOUTHLAND	SD	KM	5	-	1	-	-	-	-	-	-	-	-	1	7		
		BIRDS	12	-	10	-	-	-	-	-	-	-	-	1		23	3.29
OUTLYING ISLANDS	OI	KM	3	-	1	-	-	-	-	-	-	2	11	-	17		
		BIRDS	2	-	1	-	-	-	-	-	-	6	1	-		10	0.59
TOTAL KILOMETRES TRAVELLED			444	263	331	266	321	329	333	367	310	242	243	327	3776		
TOTAL KILOMETRES COVERED			420	242	322	267	308	318	317	356	295	215	237	284	3581		
TOTAL SEABIRDS RECOVERED			450	369	228	210	245	189	412	266	447	324	337	647		4124	
BIRDS/KM COVERED/MONTH			1.07	1.52	0.71	0.79	0.80	0.59	1.30	0.75	1.52	1.51	1.42	2.28			1.15

Unusual finds

A Kermaded Petrel picked up from Anawhata Beach (AW) in September is only the third record for the Scheme (Table 2). The previous specimens were found on Auckland West beaches too; Muriwai Beach in April 1981 and Maunganui Bluff Beach in March 1986. This species' nearest breeding locality is at the Kermadec Islands on Macauley and the Herald Islands (Kinsky 1970). Considering that Kermadec Petrels nest throughout the year on the Herald Islets (Falla etal. 1979), it is interesting that only three birds have been found on New Zealand beaches. They are not seen at sea off the New Zealand coast, and the Tasman Front (Heath 1985) seems to limit them in normal conditions to warm, unmixed waters of subtropical origin (J.A. Bartle, pers. comm.).

TABLE 2 — Seabirds of which 1 to 13 specimens were found in 1987

SPECIES OR SUBSPECIES	NUMBER FOUND	COAST(S)	MONTH(S)
Megadyptes antipodes	6	WS, OT(4), SD.	MAR(2), MAY, JUN(2), NOV.
Eudyptula minor albosignata	8	WS(2), CN(5), OT.	FEB, JUN, JUL(2), AUG, OCT, DEC(2).
Eudyptes chrysocome	1	OI.	MAR.
pachyrhynchus	3	WW(2), WD.	SEP, DEC(2).
sclateri	1	OT.	FEB.
Diomedea exulans	5	AW(2), TA, WS(2).	FEB, MAR(2), MAY, OCT.
epomophora	3	WW, WS, OI.	MAR, MAY, OCT.
melanophrys	4	AW(4).	MAY, SEP, NOV(2).
bulleri	7	AW(7).	MAR, APR, MAY, JUN, JUL(3).
cauta subspp.*	4	AW(2), WW(2).	OCT(2), DEC(2).
salvini	3	WW, BP, WS.	JUN, OCT, DEC.
Phoebetria palpebrata	5	AW(4), WW.	JUN(3), SEP(2).
Thalassoica antarctica	9	AW(4), TA(2), WW(3).	JUL, SEP(7), OCT.
Pterodroma spp.*	7	AW(3), TA(2), BP, WS.	MAR(2), APR, JUL, OCT(2), NOV.
neglecta	1	AW.	SEP.
pycrofti	1	AE.	DEC.
nigripennis	6	AW(6).	JAN, FEB(2), MAR, DEC(2).
Pachyptila salvini	13	AW(6), WW(3), AE, EC(3).	JAN, APR, MAY, JUN(2), JUL(2), AUG(4), SEP, DEC.
crassirostris	11	EC(3), CN(2), CS(6).	JUL(8), AUG(3).
Procellaria spp.*	1	WW.	APR.
cinerea	1	AW.	AUG.
parkinsoni	7	TA, AE(6).	APR(2), JUN, DEC(4).
westlandica	4	AW(4).	JAN(3), DEC.
aequinoctialis	5	AW(3), EC, CN.	FEB, MAR, NOV(2), DEC.
Puffinus pacificus	2	AW, AE.	MAR, NOV.
gavia/huttoni	13	WS, CN(9), CS(3).	JAN(3), JUN, JUL(4), NOV(5).
Fregetta grallaria	1	OT.	JUN.
Phaethon rubricauda	1	AW.	FEB.
Phalacrocorax spp.*	3	AW, AE, BP.	JAN, MAY, OCT.
sulcirostris	4	WW, AE(2), BP.	JAN, FEB, JUN, JUL.
brevirostris	9	AW(4), AE, EC(2), OT(2).	JAN, FEB, MAY(2), JUN, JUL, AUG, OCT, DEC.
Leucocarbo carunculatus chalconotus	7	OT(6), SD.	JAN, FEB. MAR(4), NOV.
Stercorarius skua lonnbergi	1	OI.	JAN.
parasiticus	2	AW, CS.	MAR, MAY.
Hydroprogne caspia	12	AW(4), AE(6), BP, NC.	JAN, MAY, JUN AUG, SEP(2), OCT, NOV(3), DEC(2).
TOTAL	171		

* Species or subspecies was not identified by the patroller.

Presumably it takes exceptionally strong north-easterly winds to blow these birds as far south as New Zealand.

Eleven Fulmar Prions (*Pachyptila crassirostris*) were found in 1987. Only in 1985 (63) and 1986 (16) were more Fulmar Prions found in a year. The 1987 prions were found on East Coast North Island (3), Canterbury North (2) and Canterbury South (6) beaches in July (8) and August (3). From bill measurements, J.A. Bartle and M.J. Imber (pers. comm.) thought most of these prions immatures of the *pyramidalis* subspecies from the Chatham Islands. For a review of the Fulmar Prions found before 1987, see Powlesland (1989).

A White-bellied Storm Petrel found on Hampden Beach (OT) in June

TABLE 3 — Coastal distribution of the seabirds more commonly found dead in 1987

SPECIES OR SUBSPECIES							COASTS									
	AW	TA	WW	AE	BP	EC	WA	WS	NC	WD	CN	CS	OT	SD	OI	TOTAL BIRDS
Eudyptula minor subspp*	113	11	58	100	37	4	1	9	10	-	2	1	10	4	3	363
Diomedea spp.*	3	-	7	-	-	-	-	3	-	-	-	1	-	-	-	14
chrysostoma	20	-	2	1	-	-	-	-	-	-	-	-	-	-	-	23
cauta cauta	20	-	7	1	-	-	-	3	-	-	-	-	-	-	-	31
Macronectes spp.*	21	1	3	-	2	-	-	1	-	1	-	-	-	-	-	29
Fulmarus glacialoides	43	-	13	-	-	-	-	2	-	-	-	-	-	-	1	59
Daption capense	18	1	7	2	1	5	-	3	-	-	5	-	1	-	-	43
Lugensa brevirostris	40	3	14	4	-	-	-	1	-	-	1	-	-	-	-	63
Pterodroma macroptera	18	3	2	3	7	-	-	-	-	-	-	-	-	-	-	33
lessonii	58	6	9	1	-	-	-	1	-	1	-	1	-	-	-	77
inexpectata	16	-	2	-	-	1	-	-	-	-	-	-	-	-	-	19
cookii	5	-	2	20	-	-	-	-	-	-	-	-	-	-	-	27
Halobaena caerulea	47	-	6	-	1	-	-	-	-	-	1	1	-	-	-	56
Pachyptila spp.*	41	7	206	2	-	-	-	9	-	-	3	9	-	7	-	284
vittata	8	-	10	-	1	-	-	1	-	1	5	-	2	-	-	28
desolata	14	-	-	1	-	6	-	-	-	-	-	-	-	-	-	21
belcheri	5	-	3	-	2	3	-	1	-	-	5	1	-	-	-	20
turtur	108	11	204	36	18	37	3	7	5	-	83	14	-	2	1	529
Puffinus spp.*	5	1	2	-	-	-	-	-	-	-	3	8	-	-		19
carneipes	17	-	1	38	12	1	-	-	-	-	-	-	-	-	-	69
bulleri	59	5	22	27	6	6	-	13	-	-	-	-	-	-	-	138
griseus	158	9	44	58	19	18	-	5	2	-	38	12	2	4	2	371
tenuirostris	72	7	55	10	5	2	-	-	2	-	2	2	1	-	-	158
gavia	152	12	46	41	12	1	-	6	-	-	21	1	-	-	-	292
huttoni	10	-	25	1	1	2	-	2	-	-	2	-	1	-	-	44
assimilis	6	1	4	2	4	-	-	-	-	-	1	-	-	-	-	18
Pelagodroma marina	5	-	-	1	8	-	-	-	-	-	-	-	-	-	-	14
Pelecanoides urinatrix	38	4	46	36	28	2	-	5	-	-	2	-	-	-	-	161
Sula bassana	141	9	4	55	14	15	-	3	2	-	-	-	-	-	-	243
Phalacrocorax carbo	5	-	5	3	-	3	1	2	1	-	2	-	-	-	-	22
varius	11	-	-	26	5	-	-	-	2	-	1	-	-	-	-	45
Stictocarbo punctatus punctatus	1	1	-	-	-	-	-	-	3	-	20	6	3	-	-	34
Larus spp.*	-	-	-	-	-	-	-	1	-	-	14	-	-	-	-	15
dominicanus	120	21	103	26	6	47	1	35	6	1	48	2	15	1	-	432
novaehollandiae	20	4	7	10	10	3	-	7	-	-	23	1	6	-	-	91
bulleri	-	-	2	2	-	7	-	-	-	-	4	1	1	3	-	20
Sterna striata	20	3	3	4	2	3	-	3	1	-	7	2	-	-	-	48
TOTALS	1437	120	924	512	201	166	6	123	34	4	293	63	42	21	7	3953

* Species or subspecies was not identified by the patroller.

(Table 2) is the second record for the Scheme. The first specimen was found on Piha Beach (AW) in May 1985. For a brief review of the biology of this storm petrel and of specimens found but not reported on beach patrol cards, see Powlesland (1987).

The other unusual find was a Red-tailed Tropicbird, which was found on Ninety Mile Beach (AW) in February. Only two specimens of this species have been found previously by patrollers; Toreparu Beach (AW) in October 1963

TABLE 4 — Monthly distribution of the seabirds more commonly found dead in 1987

SPECIES OR SUBSPECIES	MONTH												TOTAL BIRDS
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Eudyptula minor subspp.*	72	34	25	7	16	10	7	22	21	22	18	109	363
Diomedea spp.*	-	-	2	1	3	2	1	2	1	-	-	2	14
chrysostoma	1	-	-	-	-	-	7	3	8	3	1	-	23
cauta cauta	2	1	1	2	5	8	4	-	1	3	1	3	31
Macronectes spp.*	1	1	-	1	1	4	8	3	7	2	-	1	29
Fulmarus glacialoides	-	-	-	-	-	-	6	-	23	20	6	4	59
Daption capense	1	1	-	-	-	1	6	5	13	4	7	5	43
Lugensa brevirostris	3	-	-	-	-	-	20	6	20	12	-	2	63
Pterodroma macroptera	11	5	-	3	-	4	-	2	2	1	-	5	33
lessonii	2	3	1	2	1	5	4	2	26	25	1	5	77
inexpectata	3	5	2	-	1	-	-	-	-	-	-	8	19
cookii	5	1	1	1	1	-	-	-	-	2	7	9	27
Halobaena caerulea	-	-	-	-	-	1	7	2	31	9	5	1	56
Pachyptila spp.*	11	57	15	10	10	13	14	19	71	24	5	35	284
vittata	1	1	2	3	-	2	1	1	3	4	-	10	28
desolata	-	-	-	3	1	4	1	5	5	1	1	-	21
belcheri	1	-	-	-	-	1	8	7	2	1	-	-	20
turtur	33	82	11	4	9	8	121	84	81	36	19	41	529
Puffinus spp.*	3	-	1	2	6	-	2	2	-	-	1	2	19
carneipes	5	4	10	8	6	3	2	-	-	5	1	25	69
bulleri	15	18	15	13	13	9	-	1	1	22	15	16	138
griseus	43	17	16	17	43	11	4	1	6	24	92	97	371
tenuirostris	20	6	-	4	9	1	4	-	1	2	1	110	158
gavia	50	33	10	37	31	10	20	12	14	16	29	30	292
huttoni	2	1	2	-	1	1	-	-	12	16	6	3	44
assimilis	4	-	1	-	-	-	1	-	5	-	2	5	18
Pelagodroma marina	6	1	1	1	-	-	1	-	1	1	1	1	14
Pelecanoides urinatrix	42	8	2	2	8	10	16	12	12	8	12	29	161
Sula bassana	35	15	21	16	22	8	33	13	18	30	17	15	243
Phalacrocorax carbo	1	1	2	-	2	1	4	2	3	2	2	2	22
varius	6	-	-	3	2	3	4	4	3	4	10	6	45
Stictocarbo punctatus punctatus	3	-	-	-	2	1	6	5	1	1	14	1	34
Larus spp.*	-	-	-	-	-	-	14	1	-	-	-	-	15
dominicanus	33	46	46	53	32	44	41	31	33	7	30	36	432
novaehollandiae	11	17	14	4	4	3	13	6	6	2	8	3	91
bulleri	5	-	-	4	2	2	4	-	-	1	-	2	20
Sterna striata	5	1	10	3	3	4	4	2	1	2	9	4	48
TOTAL	436	359	211	204	234	174	388	255	432	312	321	627	3953

* Species or subspecies was not identified by the patroller.

and Maunganui Bluff Beach (AW) in April 1984. However, a few other Red-tailed Tropicbirds have been reported: Lake Taupo in February 1936, Muriwai Beach in May 1942 and off Taranaki in April 1961 (Kinsky 1970).

In the New Zealand region, the Red-tailed Tropicbird nests only on the Kermadec Islands. Although a few birds return to Raoul Island in winter, most remain at sea. They return to the island at the end of October and during November, and on Norfolk Island nest mainly on the ledges of cliffs near the shore (Tarburton 1979). Between mid-December and mid-January a single egg is laid, which hatches about one month later. The chicks remain at the nest for three months, leaving in April and May. Although the birds disperse from their breeding sites in winter, they remain in tropical and subtropical waters, well north of New Zealand. Specimens on New Zealand beaches have been found mainly after northerly gales, which presumably forced the birds south from their usual foraging zone. That this occurs regularly, even if infrequently, was known by the North Cape Maori, who searched the nearby beaches for Amokura (tropicbirds) to obtain their prized tail streamers (Best 1942, Newman & Kinsky 1985).

A feature of the 1987 results was the very low rate at which dead seabirds were found in August (Table 1), when only 37 were recovered on Auckland West beaches from 183 km travelled. The monthly rate of recovery is often greatest in August (Powlesland 1986, 1989). Probably this result can be explained by the milder than usual weather in July and August 1987 (Hickman 1987). South-westerlies prevailed in July, particularly in the first 10 days over the South Island. In August a notable feature was the lack of strong, cold southerly winds. Although south-westerly winds prevailed on to North Island beaches, these winds were less frequent and weaker than usual.

Miscellaneous birds

Birds other than seabirds recovered in 1987 totalled 222. There were 73 magpies, 19 Mallards, 13 Black Swans, 11 duck species, nine Pukekos, eight each of South Island Pied Oystercatchers, Rock Pigeons and Goldfinches, six each of Starlings and Indian Mynas, five each of Western Wekas and Knot, four each of domestic geese, Paradise Shelducks, Grey Ducks and Australasian Harriers, three each of Cattle Egrets, New Zealand Pigeons, passerine species and Tuis, two each of Royal Spoonbills, Canada Geese, Variable Oystercatchers, North Island Kakas, New Zealand Kingfishers and Blackbirds, and one each of Mute Swan, New Zealand Shoveler, California Quail, pheasant, Wrybill, Bar-tailed Godwit, Morepork, New Zealand Pipit, Grey Warbler, Greenfinch and House Sparrow.

Procellaria RECOVERIES 1960-1986

The following is a summary of the coastal and monthly distributions of the *Procellaria* species found by patrollers in the past 28 years. To test whether the annual pattern of recovery for each species depicted in Figure 1 differed from the theoretical situation whereby an equal number of birds were found each month, I used the Kolmogorov-Smirnov one-sample test (Siegel 1956, p. 47).

In total, 420 *Procellaria* petrels were found between 1960 and 1986, of which only 14 were not identified to species. The remaining 406 comprised all four *Procellaria* species (Table 5).

GREY PETREL *P. cinerea*

In the New Zealand region, the Grey Petrel breeds on Antipodes Island,

TABLE 5 — Monthly rate of recovery (number found dead per 100 km of beach covered) of four *Procellaria* species during 1960-1986

SPECIES	AW	TA	WW	AE	BP	EC	WS	NC	WD	CN	CS	OT	SD
P. cinerea	0.17	0.06	0.05	0.03	0.54	0.11	0.09	-	-	0.05	0.06	-	-
P. parkinsoni	0.09	-	0.02	1.11	0.34	-	0.03	0.14	-	-	-	0.06	-
P. westlandica	0.17	0.03	0.06	-	-	-	0.61	0.28	0.17	0.10	0.13	-	0.08
P. aequinoctialis	0.23	-	0.04	0.02	0.07	0.22	0.21	-	-	0.10	0.06	-	0.17

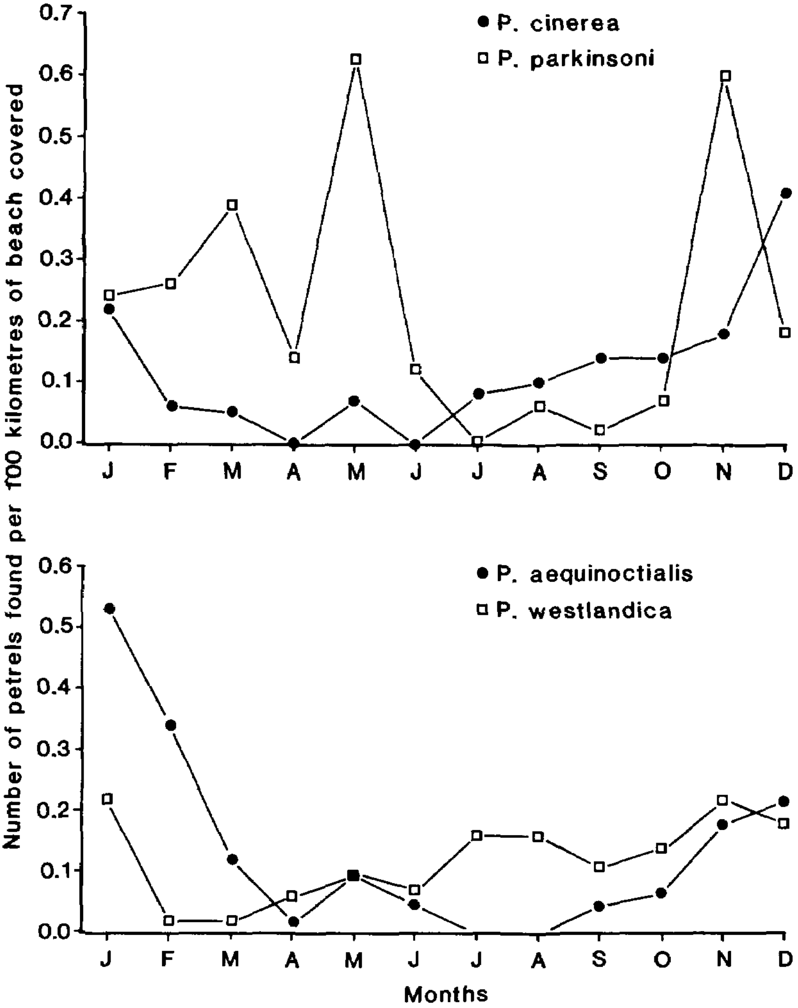

FIGURE 1 — Monthly rate of recovery (number found dead per 100 km of beach covered) of four *Procellaria* species during 1960-1986

Bollons Island, Campbell Island and Jacquemart Island (Warham & Imber 1985). In addition, there seems little doubt that the species formerly nested on Macquarie Island (Warham 1969, Brothers 1984). Beyond the New Zealand region, Grey Petrels nest on Gough Island and the Tristan da Cunha group in the South Atlantic Ocean, and on the Crozet, Prince Edward, Marion and Kerguelen Islands in the Southern Indian Ocean (Warham & Imber 1985).

This petrel is a winter breeder but no major study of its breeding biology has been made. From the few sightings of adults and fledglings on Bollons and Antipodes Islands (Warham & Bell 1979, Imber 1983) it seems that the timing of the breeding cycle approximates that of the birds at Gough and Tristan da Cunha (Imber 1983). At Tristan da Cunha, the Grey Petrel has a long egg-laying period, extending from early April to June, and the chicks depart in October and November (Elliott 1957). The Grey Petrels on the more southerly Crozet Islands (Jouventin *et al.* 1985) nest about a month earlier than those on Tristan da Cunha.

During 1960-1987, patrollers found 83 Grey Petrels. About four petrels were found per year from 1970 to 1986, the lowest and highest annual totals being zero in 1979 and 10 in 1971. Overall, the average rate of recovery was 0.12 birds per 100 km of coast covered. Of the coastal regions, Bay of Plenty had the highest rate of recovery (0.54 birds / 100 km of coast covered), followed by Auckland West (0.17) and East Coast North Island (0.11) (Table 5). This result probably reflects the dispersal of Grey Petrels from the large colony on Antipodes Island to the northeast of New Zealand, rather than into the Tasman Sea.

Figure 1 shows that the monthly rate of recovery changed significantly during the year ($p < 0.01$), being greatest in summer and least in autumn. As the chicks leave the colonies in October- November (Elliott 1957, Imber 1983), the summer peak in mortality is probably the result of recently fledged young dying. Mortality is least in autumn possibly because this is the laying period when most Grey Petrels would be at their breeding islands, well away from New Zealand's mainland coasts.

BLACK PETREL *P. parkinsoni*

Although this petrel bred on mountain ranges of the North Island and northern South Island in European times (Imber 1987, Olsen 1988), it now breeds only on Little Barrier and Great Barrier Islands in the Hauraki Gulf. The Black Petrel is uncommon, its total numbers being estimated at 3000-4000 birds (Imber 1987). In contrast to the Grey Petrel, the Black Petrel is a summer breeder, returning from winter quarters in the eastern tropical Pacific in October-November (Imber 1987). Eggs are laid in November-January and the young depart mainly in May-June (Imber 1987).

The number of Black Petrels found each year by patrollers has varied markedly. In only two years between 1960 and 1971 was the species found. However, since then Black Petrels have been found each year, except in 1976, the most being 39 in 1984. During 1960-1986, 146 of these petrels were found at an average rate of 0.21 birds per 100 km of beach covered. As expected from the distribution of its breeding colonies, most Black Petrels were found on Auckland East beaches (1.11 birds per 100 km of coast covered). The coast with the next highest rate of recovery was Bay of Plenty (0.34) (Table 5).

The monthly rate of recovery, as shown in Figure 1, changes significantly through the year ($p < 0.01$). The recoveries of Black Petrels from New Zealand beaches increase in October-November (Figure 1), when the birds first return to Little Barrier Island from their wintering quarters (Imber (1987). Just four birds were found in each of August and October, and only one in September. The August and September corpses were probably late fledglings because chicks have been seen on Little Barrier Island late in July (Imber 1987). The November peak in recoveries may reflect the return of large numbers by then to their breeding sites. Why there should be increased recoveries in March is unknown because mainly breeding adults would be about the breeding islands, the non-breeders having already departed. The high mortality in May coincides with the departure of many chicks to sea.

WESTLAND BLACK PETREL *P. westlandica*

The Westland Black Petrel has a very restricted breeding distribution, nesting in coastal forest between the Punakaiki River and Lawson's Creek, north Westland (Best & Owen 1976). In 1972, its total population was estimated at 8000 ± 2000 birds (Bartle 1974), and by 1982 there were 14,000 ± 5000 birds (J.A. Bartle, pers. comm.).

Although the first birds return to the colony in February, it is not until May that eggs are laid (Bartle 1985). The chicks hatch two months later and leave the burrows in November and December (Baker & Coleman 1977, Bartle 1985). During the breeding season Westland Black Petrels range over continental shelf waters between Cape Egmont and Foveaux Strait to the west of New Zealand, and between East Cape and Banks Peninsula to the east (Bartle 1974, 1985). After the breeding season the birds probably disperse eastward because in December 1987 good numbers of Westland Black Petrels, including juveniles, were seen around the Chatham Islands (M.J. Imber, pers. comm.).

Generally, 5-10 Westland Black Petrels have been found annually during the past 10 years, 11 in 1978 being the most. The species had a very poor breeding season in 1978 (J.A. Bartle, pers. comm.) and so more young than usual may have fledged in poor condition that year. From 1960 to 1986, 86 petrels were found at a rate of 0.13 birds per 100 km of coast covered. Of the coastal regions, Wellington South had the greatest rate of recovery (0.61 birds/100 km of coast covered), followed by North Coast South Island (0.28)(Table 5). These results were as expected from the petrel's distribution at sea during the breeding season (Bartle 1985).

The monthly rate of recovery of Westland Black Petrels increased gradually, from a low in February-March to a peak in November-January (Figure 1, $p < 0.05$). During February-March (low rate of recovery) few birds were seen at the colony (Bartle 1985) or about Cook Strait (Bartle 1974). The peak period of mortality in summer coincides with the departure of the nestlings (Bartle 1985). Most beached birds found in December-January on the North Coast South Island are newly fledged birds (J.A. Bartle, pers. comm.).

WHITE-CHINNED PETREL *P. aequinoctialis*

The White-chinned Petrel is widespread and abundant throughout the

Southern Ocean, in both the breeding and non- breeding seasons. In the New Zealand region it breeds on Auckland, Adams, Disappointment, Campbell, Dent, Antipodes and possibly Jacquemart Islands. In addition, it breeds at South Georgia, the Falkland Islands, Marion and Prince Edward Islands, Iles Crozet and Kerguelen, and Inaccessible Island (Imber 1985b). At sea the species ranges from Antarctic waters to about 30 S. About New Zealand it is more abundant to the south and east than in the Tasman Sea, reaching the latitude of Cook Strait in summer and the Auckland coasts in winter (Imber 1985b).

No detailed study of the breeding biology of White-chinned Petrels has been made in the New Zealand region. However, the little information about the population on Antipodes Island (Imber 1983) suggests it breeds at the same time as the South Georgian population (Imber 1985b). At Bird Island, South Georgia, White-chinned Petrels return to the island in September and lay eggs about two months later, from mid-November to mid-December (Hall 1987). Eggs hatch in January-February, and the nestlings leave the colonies three months later in April and early May (Hall 1987).

During 1960-1987, patrollers found 91 White-chinned Petrels. About five petrels were found in most years from 1970 to 1986, the highest annual total being 14 in 1983. Overall, the average rate of recovery was 0.13 birds per 100 km of coast covered. Of the coastal regions, Auckland West (0.23 birds/100 km of coast covered), East Coast North Island (0.22) and Wellington South (0.21) had the greatest rates of recovery (Table 5).

Figure 1 shows that the monthly rate of recovery changed significantly during the year ($p < 0.01$), being greatest in summer and least in winter. Given the petrel's annual cycle, the monthly pattern of recovery on New Zealand beaches is unexpected. Instead of a peak in mortality after nestling departure in April-May, the peak apparently coincides with the dispersal of non-breeders into northern waters after hatching in January-February (J.A. Bartle, pers. comm.). Presumably, few birds are found on our beaches in autumn and winter because they disperse mainly to the east (Imber 1985b), where tides and prevailing winds seem less suitable for washing seabirds ashore than on the west coast.

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SHORT NOTE

California Quail distracts a stoat

For 23 years (1926-1951), I was on a farm in the Norsewood district of southern Hawke's Bay. During a farm muster, while waiting for part of the muster to catch up, I was on an elevation overlooking a clearing about 40 metres wide in the scrub. A file of 10-12 California Quail (*Lophortyx californica*) chicks emerged from the scrub and set a swift course for the opposite side of the clearing. About 12-15 paces behind the chicks an adult bird emerged from the scrub and moved hesitantly after the chicks. A third of the way across the clearing it stopped and looked back. A stoat came out of the scrub, following the birds, its nose to the ground.

As soon as the stoat appeared, the adult quail moved off almost at right angles to the direction taken by the chicks. When the stoat reached the point of divergence, it stopped, looked about the clearing, and then continued as before. The adult quail had also stopped. As soon as the stoat moved after the chicks, which had just reached cover across the clearing, the adult ran towards the stoat until 2-3 paces from it.

The stoat hesitated and then made for the adult, which fled but did not fly. Seeing the adult's speed, the stoat returned to the trail of the chicks,but the quail countered by moving back towards the stoat. The stoat seemed confused but, after some hesitation, chased the quail again, which again retreated. This sequence happened three more times before the quail reached the scrub with the stoat in pursuit. Each time the stoat had hesitated and looked back towards the chicks, the adult quail had also stopped and cautiously approached the stoat, and each time the stoat resumed the chase the quail retreated, but without flying.

I did not see the quail or its chicks again; and a second adult quail did not appear. The bird gave no call of warning or alarm; the whole incident was silent.

MALCOLM OLSEN, *11 Kennedy Drive, Levin*

VERTICAL DISTRIBUTION OF BIRDS MIST-NETTED IN A MIXED LOWLAND FOREST IN NEW ZEALAND

By B. M. FITZGERALD, H. A. ROBERTSON, and A. H. WHITAKER

ABSTRACT

Birds in forest in the Orongorongo Valley near Wellington were caught over a 7-year period (1969-76) in mist-net rigs consisting of six nets one above another, forming a continuous curtain of nets from near ground level to the forest canopy. We recorded which net in the rigs each bird was caught in, and described the vertical distribution of 14 species of bird. Hedgesparrows, Fantails, Tomtits and Blackbirds were caught more often in the lower nets, Kingfishers, Silvereyes and Bellbirds were caught more often in the upper nets, and Moreporks, Riflemen, Whiteheads, Grey Warblers, Song Thrushes, Tuis and Chaffinches were caught more or less evenly at both levels. The vertical profiles differed between rigs. For the three species caught most commonly (Silvereye, Blackbird and Bellbird), the mean height of capture varied with time of day and with season. The vertical distribution is a useful characteristic in helping to define the niches of these birds.

INTRODUCTION

The partitioning of food resources within a bird community may result, in part, from the segregation of species vertically into different feeding zones (Cody 1974, Dickson & Noble 1978). Several studies have related the spatial distribution of birds within habitats to that of the vegetation, and concluded that birds select habitats largely on the basis of vegetation structure (e.g. James 1971, Pearson 1971, Anderson *et al.* 1979, Terborgh 1980). The vertical segregation of forest birds in New Zealand into feeding zones has been studied by recording heights above ground of feeding individuals of single species (e.g. Atkinson 1966, Merton 1966, Powlesland 1981) and of assemblages of species (Gibb 1961, Gravatt 1971, Gill 1980, O'Donnell & Dilks 1986, H.A. Robertson unpubl.). Each species occupied a more or less distinct feeding niche, with feeding height an important characteristic in segregating the various species.

Although the vertical distribution of birds is usually described from systematic observations of foraging birds, we have described the vertical distribution of birds in forest from the height at which birds were caught in mist-nets on rigs carrying a continuous curtain of six nets from near ground level to the forest canopy (Whitaker 1972). Using this system, Ecology Division staff studied many aspects of the ecology of birds in lowland forest for 7 years (1969-76) in the Orongorongo Valley, near Wellington. This was the first study in New Zealand in which large numbers of forest birds were caught during a long and intensive mist-netting programme. Morphometric data and information on the foods of the insectivorous birds obtained from this study have been published (Robertson *et al.* 1983, Moeed & Fitzgerald 1982).

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By recording the height of capture of each bird, we were able to investigate the vertical distribution of captures within the forest for the 14 species (9 native, 1 recently self-introduced and 4 introduced) caught more than 30 times. Variations in vertical distributions between nets, between seasons and through the day were investigated for the three species caught more than 300 times – Silvereye, Blackbird and Bellbird. Scientific names of birds are given in Table 1.

STUDY AREA

The study area was about 4 ha of mixed rata/podocarp/hardwood forest on a raised river terrace (130 m a.s.l.) near the research station of Ecology Division, Department of Scientific and Industrial Research, in the Orongorongo Valley (41° 21'S, 174 °58'E) in the southern Rimutaka Range, 18 km east of Wellington.

The forest structure has been described by Daniel (1972), Fitzgerald (1976) and Moeed & Fitzgerald (1982). The vegetation has emergent trees up to 40 m tall, mainly *Metrosideros robusta, Dacrydium cupressinum, Prumnopitys ferruginea* and *P. taxifolia*. The canopy, between 6 and 20 m, is composed of *Elaeocarpus dentatus, Laurelia novae-zelandiae, Melicytus ramiflorus, Hedycarya arborea, Knightia excelsa, Weinmannia racemosa, Schefflera digitata* and *Pseudowintera axillaris* and many tree ferns (*Cyathea* spp. and *Dicksonia squarrosa*). The dense subcanopy and shrub layer consists of young canopy trees and shrubs such as *Coprosma* spp., *Carpodetus serratus, Geniostoma rupestre* var. *ligustrifolium, Macropiper excelsum, Myrsine australis,* and *Olearia rani*. The large trees support epiphytes, including *Astelia solandri, Collospermum hastatum* and *Griselinia lucida*, and lianes such as *Ripogonum scandens, Metrosideros* spp. and *Freycinetia baueriana* ssp. *banksii*. The forest floor is open, with ferns and seedlings covering about 40% of the area.

METHODS

From June 1969 to August 1976, seven permanent mist-net rigs (Whitaker 1972) were operated for four days each month except during rain. Six of these rigs consisted of six standard (9 m x 2 m) 38-mm-mesh mist-nets set one above the other, forming a continuous curtain from 1.5 m above the ground to 13.5 m in the canopy layer; the remaining rig held five, or sometimes six mist-nets. Being placed between large trees that could support them, the net rigs varied in aspect, exposure to sunlight, and amount of surrounding vegetation. The rigs were 57 m to 76 m apart.

We recorded in which of the six nets (but not which shelf within the net) each bird was captured (net 1 = 1.5-3.5 m, net 2 = 3.5-5.5 m, etc.), so records are accurate only to within 1 m. Data are presented from only the six-net rigs in the main analysis, but additional data from the other rig are included in the analysis of seasonal and diurnal patterns for the three most commonly caught species because the bias due to the missing net should be constant.

For all the analyses of diurnal patterns, daylight hours were divided into 12 equal periods. In June (shortest days) these periods were of 46 minutes and in December (longest days) they were of 76 minutes. For comparative purposes these periods were assigned to the 'standard times' 0600 to 1800 h irrespective of the time of year.

RESULTS

Differences between species

For seven species the observed vertical distribution in the nets differed significantly (i.e. $p < 0.05$) from an equal chance of capture in each tier (Kolmogorov-Smirnov one-sample test). Hedgesparrows, Fantails, Tomtits and Blackbirds were caught more often in the lower nets, and Kingfishers, Silvereyes and Bellbirds more often in the higher nets (Figure 1, Table 1). No species was caught significantly more often in the middle nets.

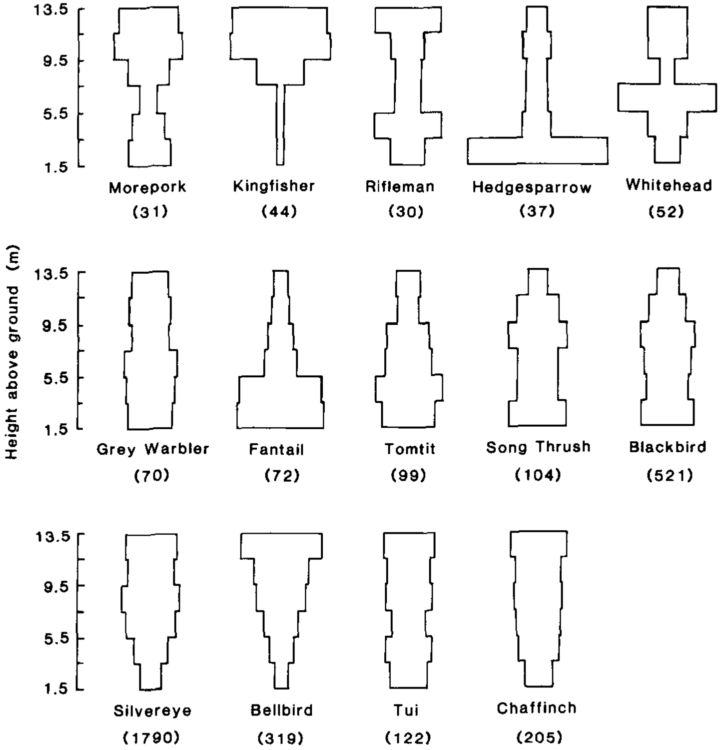

FIGURE 1 —Vertical distribution of captures of the 14 most commonly caught species, in 2 m intervals from 1.5 m above the ground. Sample size is given in brackets

TABLE 1 — Mean net of capture, for all records from 6-net rigs (1 = lowest, 6 = highest)

Species	$\bar{x}$	*sd*	*n*
Kingfisher (*Halcyon sancta*)	5.05	1.03	56
Bellbird (*Anthornis melanura*)	4.45	1.50	374
Silvereye (*Zosterops lateralis*)	4.03	1.54	2093
Morepork (*Ninox novaeseelandiae*)	3.94	1.77	36
Chaffinch (*Fringilla coelebs*)	3.88	1.66	230
Tui (*Prosthemadera novaeseelandiae*)	3.83	1.69	155
Whitehead (*Mohoua albicilla*)	3.68	1.57	59
Rifleman (*Acanthisitta chloris*)	3.68	1.88	31
Grey Warbler (*Gerygone igata*)	3.49	1.68	84
Blackbird (*Turdus merula*)	3.24	1.63	609
Song Thrush (*Turdus philomelos*)	3.15	1.61	121
Tomtit (*Petroica macrocephala*)	3.07	1.56	119
Fantail (*Rhipidura fuliginosa*)	2.67	1.58	94
Hedgesparrow (*Prunella modularis*)	2.33	1.72	42

Of the six small insectivorous species, Hedgesparrows, Fantails and Tomtits were caught significantly more often in the lower nets, and Riflemen, Whiteheads and Grey Warblers were caught at all levels. Of the two larger insectivorous species (that also take some small vertebrates), Kingfishers were caught almost exclusively in the top three nets (above 7.5 m); Moreporks were caught rarely, but at all levels.

TABLE 2 — Mean nets of capture of males and females of the sexually dimorphic species

	Males			*Females*			χ^2
	$\bar{x}$	*sd*	*n*	$\bar{x}$	*sd*	*n*	
Rifleman	3.61	1.69	18	3.81	2.09	11	3.4
Whitehead*	3.38	1.71	16	3.59	1.56	32	1.7
Tomtit	3.04	1.64	70	3.10	1.45	49	7.6
Blackbird	3.27	1.63	295	3.30	1.59	263	3.2
Bellbird	4.43	1.50	231	4.47	1.52	139	1.3
Tui	3.68	1.68	92	4.07	1.71	58	5.7
Chaffinch	3.80	1.63	126	3.96	1.71	102	1.6

* Whitehead sex based on plumage

Although two of the nectar-feeders (Silvereye and Bellbird) were caught significantly more often in the upper nets, Tuis were distributed fairly evenly. Of birds with a mixed diet of invertebrates and fruit, Song Thrushes and Blackbirds had similar height distributions (Spearman rank correlation $r_s = 0.81$, $0.05 < p < 0.10$), although the vertical stratification was significant for only the Blackbird. Chaffinches were caught fairly evenly at all heights.

The vertical distributions of captures of males and females of the seven commonly caught species that are sexually dimorphic were not significantly different (Table 2).

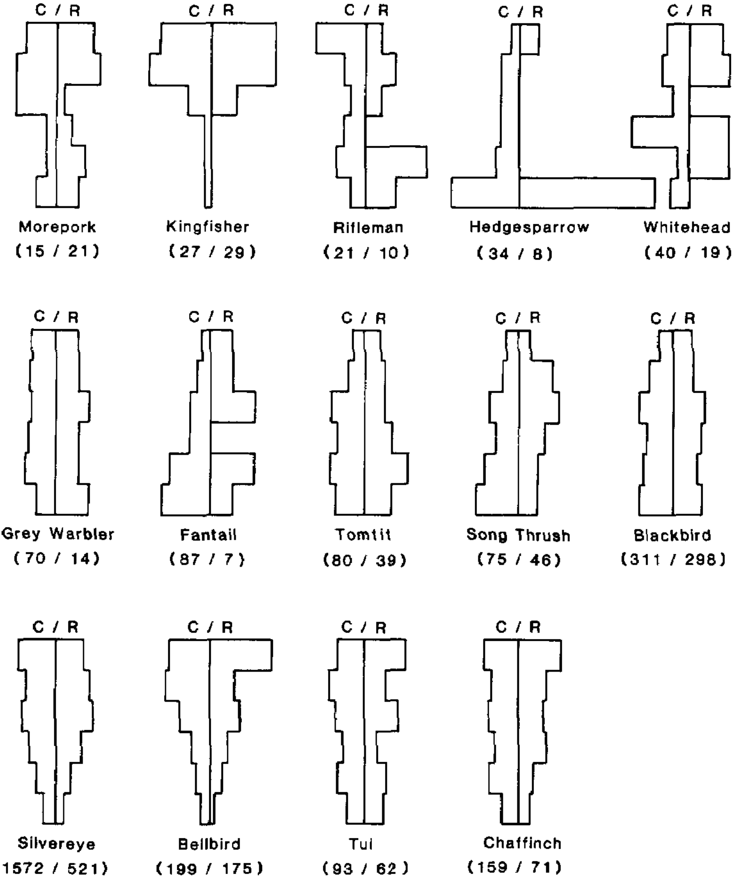

FIGURE 2 —Vertical distribution of first captures (on left) and recaptures (on right) of the 14 most commonly caught species

In some species the vertical distributions of birds caught for the first time differed from the distributions when they were recaptured (Figure 2). Of the three species caught most often, the distributions of first captures and recaptures of Silvereyes and Bellbirds differed significantly ($x^2 = 12.21$, $p < 0.05$, and $x^2 = 12.19$, $p < 0.05$, respectively). Some other species show differences, but the numbers of recaptures were very small. The difference is greatest for Hedgesparrows (only one of the eight recaptures of six individuals was higher than the first net) and the number of captures and recaptures in net 1 compared with the upper five nets is significant (Fisher's exact test $p = 0.03$). This suggests that transient birds may pass through the forest at a different level from that in which resident birds forage or sing.

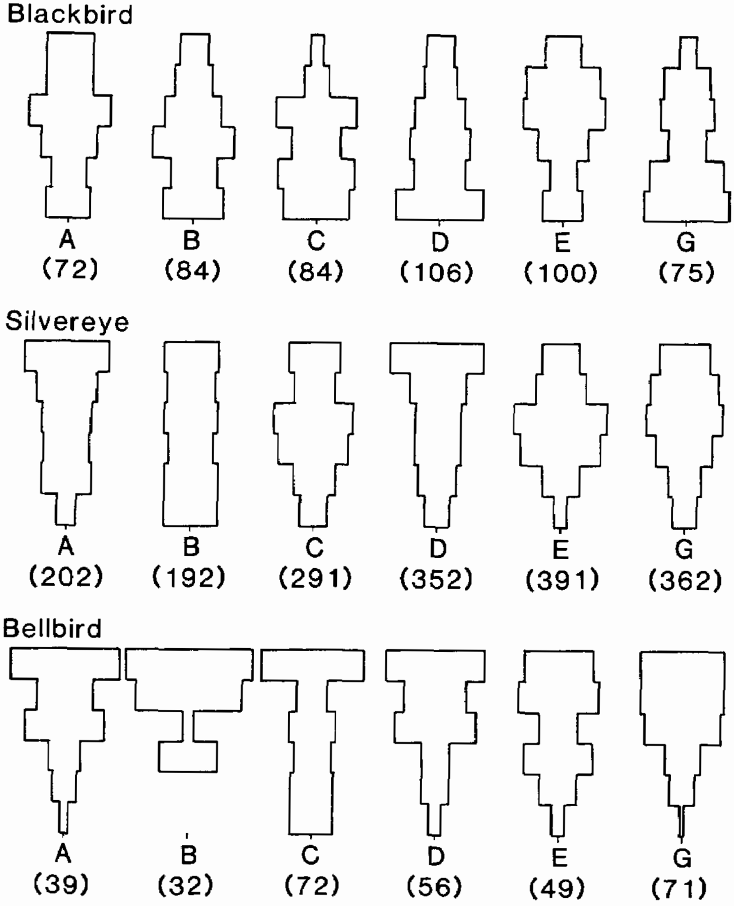

FIGURE 3 — Vertical distribution of the three most commonly caught species (Blackbird, Silvereye, and Bellbird), showing differences in the vertical distribution by net-rig site

Differences between net-sites

The height profiles given in Figure 1 were averaged over six mist-net rigs; however, for some species the shape of the profile differed significantly between rigs. Blackbirds and Silvereyes were captured at heights significantly different between nets (Figure 3) (Kruskal-Wallis $H = 27.1$, $p < 0.001$ and $H = 31.7$, $p < 0.001$ respectively). At net G, for instance, 51% of Blackbirds were caught between 1.5 m and 5.5 m, but in net E only 22% were caught at similar heights.

The differences in the vertical distributions between mist-net rigs are not consistent between species of birds (see Figure 3 for Blackbird, Silvereye and Bellbird), and it is likely that several factors interact to produce these differences between rigs. They may include: 1) differences in the local topography of trees and foliage around the nets, making parts of some rigs remain in sunlight and therefore visible longer than others; 2) differences in height of natural "flight-lines" through the forest that are intercepted by each rig; 3) differences in spatial distribution of important food resources near each rig; and 4) variations in the vegetation profile through the forest, making the top of some rigs nearer to the canopy-subcanopy boundary than others.

Variations with standard time of day

The vertical distribution of the three most commonly caught species varied with the time of day similarly (Kendall coefficient of concordance, $W = 0.65$, $x^2 = 23.4$, $p < 0.05$). Birds were caught highest in the early morning (before 0700 h) and the late afternoon (1600-1800 h) and lowest around midday (1000-1500 h) (Figure 4). The changes in heights through the day were significant for Blackbirds (Kruskal-Wallis $H = 21.1$, $p < 0.05$)

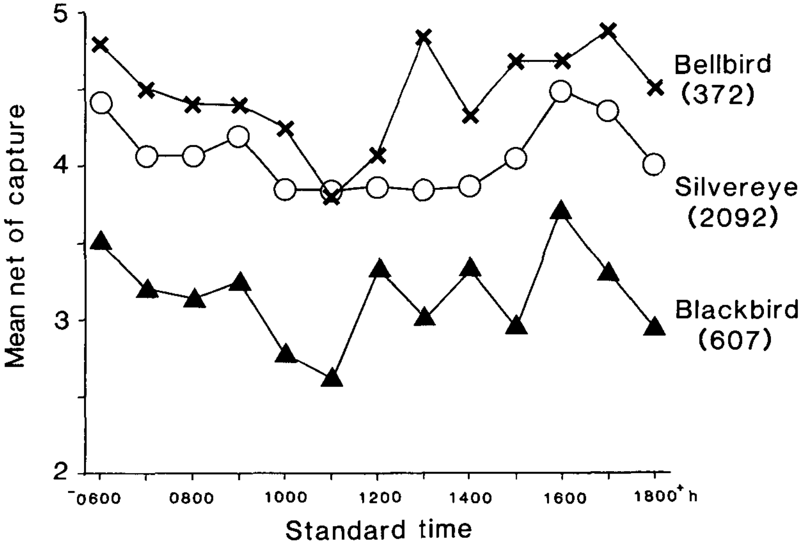

FIGURE 4 —Variation in the mean height of capture of Bellbirds, Silvereyes, and Blackbirds through the day. (Daylight was divided into 12 equal periods of 'standard time' with sunrise at 0600 and sunset at 1800 h.)

and Silvereyes (Kruskal-Wallis H = 36.7, $p<0.001$), but although Bellbirds showed a pattern of change similar to that of the other two species, the differences through the day were not statistically significant when grouped into 2-hour intervals (Kruskal-Wallis H = 11.5, $0.05< p<0.10$).

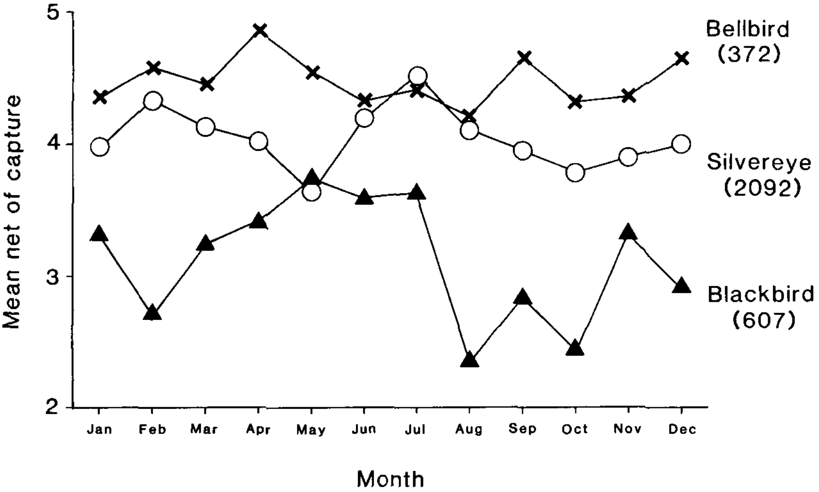

FIGURE 5 — Seasonal variation in the mean height of capture of Bellbirds, Silvereyes, and Blackbirds

Seasonal variations

Heights of mean monthly captures are shown in Figure 5 for the three most commonly caught species. The overall patterns of the three species were not similar (Kendall coefficient of concordance W = 0.41, x^2 = 13.7, n.s.). Blackbirds and Silvereyes showed highly significant changes in their height distribution throughout the year (Kruskal-Wallis H = 42.5, $p <0.001$ and H = 55.6, $p <0.001$ respectively), whereas Bellbirds did not (H = 5.6, $p >0.05$). Blackbirds were caught more often in high nets from April to July inclusive, and in low nets from August to October inclusive. The mean 'net of capture' in each mist-net rig dropped very sharply between July [$\bar{x}$ = 3.64 (= 6.8 m), n ≈ 42] and August [$\bar{x}$ = 2.37 (= 4.2 m), n = 30]. Silvereyes were caught higher in the forest in February and from June to August inclusive, but low down in May and from September to January inclusive. The mean capture height increased sharply between May [$\bar{x}$ = 3.64 (= 6.8 m), n = 460] and June [$\bar{x}$ = 4.20 (= 7.9 m), n = 269], with the mean height increasing at six of the seven mist-net rigs.

DISCUSSION

The 14 species for which vertical distributions are presented here include most of the species that we mist-netted in the forest in the Orongorongo Valley. Half of them had vertical distributions that differed significantly from even distributions. A few native species (New Zealand Pigeon, Shining

Cuckoo and Long-tailed Cuckoo), and some introduced species that mainly frequented grass and scrublands (Robertson *et al.* 1983), were caught infrequently and were not included in the analysis.

The vertical distributions of birds in New Zealand forests have been described previously, by recording either the structural level in the forest in which they feed (canopy, understorey, floor, etc.) or the site at which they feed (leaves, twigs, branches, trunk, floor, etc.) (Gibb 1961, Gravatt 1971, Gill 1980, O'Donnell & Dilks 1986). Results from mist-netting cannot be compared directly with those from observations of feeding height but the patterns are broadly similar. One exception is that we caught Bellbirds mostly in the upper nets and Tuis fairly evenly at all levels, whereas Gravatt (1971) and O'Donnell & Dilks (1986) recorded Bellbirds more often at lower levels and Tuis more often at higher levels in the forest. Moeed & Fitzgerald (1982) noted that individuals of several species of birds living in pine forest (Gibb 1961), mixed native forest (Gravatt 1971), and kanuka forest (Gill 1980) fed to about the same extent on different substrates (trunk, branch, leaf, ground, etc.), despite the differences in the structure of the forests. This suggests that the feeding niches are well-defined, being little affected by habitat differences, and that the height distributions of forest birds are a useful coarse measure of differences in the niches that they occupy.

Oceanic islands generally have fewer species of landbird than mainland areas of equivalent size, and island birds tend to have wider niches than their mainland counterparts (Van Valen 1965, Lack 1976). Bull & Whitaker (1975) stated that the landbirds of New Zealand lack diversity and occupy broad niches. They used the Fantail as an example; it was, until recently, the only bird species feeding mainly on flying insects and it occupies a wide range of habitats throughout the country. It is also one of the few New Zealand birds that is common in farmland habitats created after European settlement last century (Turbott 1961). The species is widespread, being found also in Tasmania, mainland Australia, New Guinea, New Caledonia, and Vanuatu (Ford 1981), and in some places it occupies a narrower range of habitats than in New Zealand. Diamond & Marshall (1977) reported that in Vanuatu a second species of fantail (*R. spilodera*) is also present on some islands, where *R. fuliginosa* is confined to forest edge and open habitats and *R. spilodera* occupies closed forest. However, on islands where *R. fuliginosa* alone is present it is found in forest as well as more open habitats – a pattern similar to that in New Zealand where the Fantail has no congeneric competitors and occupies a wide range of habitats, including forest. If the Fantail is primarily a bird of open habitat and forest edge, and only secondarily occupies forest, this may explain why it adapted so readily to farmland habitat.

The niche of a species, as defined by Hutchinson (1957), is based on measurement of the range of values within which a species can survive and reproduce, for any number of independent biotic and abiotic characteristics. Usually the niches of two species can be separated on just two or three of the many characteristics (Hutchinson 1978). Do the New Zealand forest birds occupy niches that are broad in all characteristics, or only in some, and is vertical distribution an important characteristic of their niches?

In southeastern Australia, guilds of forest birds (groups of species with similar foraging habits) separate firstly by differences in foraging height and bird weight and secondly by foraging methods and food substrate (Holmes & Recher 1986). This implies that the heights at which birds forage, and therefore the heights at which they are caught in mist-nets, are useful, measurable dimensions of the niches of birds in forest. The study of Holmes & Recher included two species, the Grey Fantail and the Silvereye, that are also in New Zealand and *Petroica multicolor*, the closest relation of the Tomtit (Fleming 1950). A comparison of the proportion of foraging sites used by these species in Australia (Recher *et al.* 1985) with the proportion used by the New Zealand forms (Gibb 1961, Gravatt 1971, O'Donnell & Dilks 1986) does not suggest that this aspect of their niches is narrower in Australia than in New Zealand. Detailed comparative work on Fantails or Silvereyes in similar habitats in Australia and New Zealand is needed.

Our study shows that the species of forest birds in the Orongorongo Valley differ significantly in the height at which they are active and are caught in the mist-nets. It also shows that the height of capture varies with the time of day, time of year, and with capture or recapture. Because of the differences in the vertical distributions of birds caught in different net-rigs, we emphasise that it is important to use several rigs to obtain representative average profiles of the captures. Also, because of the differences between distributions of first captures and recaptures, analyses should use all captures, not just first captures, to describe the height distribution of the whole population.

Future studies should attempt to identify the factors that are most important in influencing the height of capture of forest birds. These might include the vegetation profile within the forest, seasonal changes in the distribution of food, changes in the incidence of sunlight, temperature profile and wind velocity through the forest, and the proportions of residents and transients in the populations.

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SHORT NOTES

Antiparasitic behaviour in New Zealand parakeets (*Cyanoramphus* species)

A range of body maintenance activities has been described for *Cyanoramphus novaezelandiae novaezelandiae* by Dawe (1979) for both captive and wild birds. Of particular interest, however, are recent observations of behaviour that may have an antiparasitic function.

A number of parasites are known to be associated with members of the genus *Cyanoramphus*. Of the ectoparasites, the most commonly recorded are the chewing lice (*Forficuloecus pilgrimi* Guimarães, 1985 : Mallophaga) (Nixon 1982, Pilgrim & Palma 1982, pers. obs.), along with smaller numbers of mites (Nixon 1982, pers. obs) and hippoboscid (or louse) flies (pers. obs.).

Little is known of the distribution and host specificity of endoparasites in wild populations of New Zealand parakeets. However, the presence of cestodes and ascarid (nematode) worms in captive parakeets and in parakeets on the Chatham Islands makes it highly likely that they are also present in wild populations on mainland New Zealand (Nixon 1982).

My observations of captive Red-crowned Parakeets (*C. n. novaezelandiae*) and Yellow-crowned Parakeets (*C. auriceps auriceps*) revealed distinctive behaviour patterns when leafy branches of kanuka (*Kunzia ericoides*) and manuka (*Leptospermum scoparium*) were placed in their aviaries. The parakeets removed several leaves from the branches and thoroughly chewed them. Each parakeet would then fluff itself up, spread its tail feathers, take preen oil from the gland on the rump, and draw individual feathers from the base to the tip through its mandibles, presumably spreading the "mixture" over them. They paid particular attention to the primaries and tail feathers, although in intense preening sessions contour feathers on the breast and rump also received much attention. This preening usually lasted for 5-10 minutes, along with numerous changes of chewed leaves and preen oil. On one of the few occasions that I saw this kind of behaviour in the wild (9/6/89), I saw six parakeets (4 Red-crowns and 2 Yellow-crowns) on Hen Island preening in this fashion for more than 20 minutes.

How this behaviour benefits the feathers of a parakeet is not known, although the biochemical evidence is highly suggestive. Chemical analysis of manuka foliage has revealed the presence of leptospermone, "an insecticide like valone" (Brooker *et al.* 1981). The effect of this chemical on ectoparasites may therefore be similar to that observed for formic acid (from ants) on live mallophaga, killing most in a few minutes (Simmons 1966). Observations have been made of Red-crowned Parakeets and Yellow-crowned Parakeets chewing and apparently swallowing the bark and leaves of manuka and kanuka.

"Triterpene acids have been isolated from the bark" and leptospermone, if ingested, "has anthelmintic properties" (Brooker *et al.* 1981). It is therefore plausible to suggest that endoparasites may also be controlled by the ingestion of specific parts of manuka and kanuka.

Although circumstantial, the evidence suggests some external and/or internal antiparasitic action for kanuka and manuka. Whether birds could use other components of New Zealand's native flora for similar reasons is not known. Identical behaviour has been observed when captive parakeets were given Australian bottlebrush (*Callistemon* species) which, like kanuka and manuka, is highly aromatic. Other chemical components, such as tannins and terpenoids, may also provide some antibiotic and/or fungicidal protection, which may supplement the characteristics of the bird's own preen oil (Simmons 1966, Ehrlich *et al.* 1986).

Similar behaviour patterns have also been noted for Orange-fronted Parakeets (*C. malherbi*) and, surprisingly, for Antipodes Island Parakeets (*C. unicolor*) in captivity (E. & E. Heatherbell, pers. comm.). Although manuka was used by both of these species, beech and willow leaf galls containing willow grub larvae were also used. Obviously, further study is needed on both the incidence of this behaviour in parakeets and parrots and the identification of other potential insecticides and their potency on both ecto- and endoparasites.

I am grateful to E. & E. Heatherbell for informing me (through J. Hawkins and B. Heather) of their own observations, R. Palma for providing the Guimarães reference and R.G. Powlesland for commenting on the initial draft of this note.

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More distribution records of Buller's Shearwater in New Zealand waters

We were prompted by Jenkins's (1988) interesting account of Buller's Shearwater *(Puffinus bulleri)* in New Zealand seas to present some more information about its distribution.

From 12 to 14 September 1988, we travelled from Auckland (37°S 175°E) to the southern Kermadec Islands (30°S 179°W). Buller's Shearwaters were common, as singles or in small groups of up to c. 20 birds, from near Cuvier Island to the southern Kermadec Islands. All were flying in the direction of their breeding grounds at the Poor Knights Islands, off the north-east of the North Island. On our return journey between 25 and 27 September 1988, we noted only about 10, and all those in flight were also heading towards the northern North Island. A comparison of our hourly 10-minute bird counts revealed that Buller's Shearwaters were about 15 times more numerous on the outward voyage than on the return trip. These observations support Harper's (1983) and Jenkins's (1988) findings that many birds return to New Zealand waters in early September. They also show that large numbers arrive from a direction well to the north-east of New Zealand. Jenkins (1988) speculated that the main migration path approaches New Zealand from the east.

Jenkins (1988) stated that "Although there are few records, probably some birds feed out towards the Chatham Islands . . . from November until they leave on migration". We know of some additional records from near the Chatham Islands (44°S 176°W) from November/December through to March (Murphy 1930, Dawson 1955, Bell & Sibson 1979, Tennyson 1986), which support his suggestion. It is also worth noting that Buller's Shearwaters may once have bred on the Chatham Islands (Bourne 1967).

On 16 March 1986, GAT saw 10 Buller's Shearwaters off Breaksea Island, Fiordland (46° S 166°E). Morrison (1985) recorded hundreds in the same area on 14 April 1984. Therefore some birds are present in the south of the Tasman Sea later than Jenkins (1988) suggested.

Jenkins (1988) saw thousands of Buller's Shearwaters off Little Barrier Island (off the north-east of the North Island) on 17 May 1979. We have two similar records. GAT observed thousands between Tiritiri Matangi Island and Hen Island on 20 May 1987, but on 25 May he saw none in the same area. On 16 May 1988, we recorded thousands off Little Barrier Island, but by the next day we saw none. These observations show that birds form large flocks near their breeding grounds during mid-May, shortly before beginning their northward migration.

We thank the crew of HMNZS *Tui* for transport to and from the Kermadec Islands. We are indebted also to the late John Jenkins for his useful discussion on our manuscript.

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Incubation by female Great Spotted Kiwis

In most species of ratite, including the North Island Brown Kiwi (McLennan 1988) and Little Spotted Kiwi (Jolly, pers. comm.), the male alone incubates the eggs and cares for the offspring. Ostriches were thought to be the only exception, but Eason's (1988) recent observations suggest that females of another ratite, the Great Spotted Kiwi (*Apteryx haastii*), may also help care for eggs and young.

Eason noticed that the female of a captive pair of Great Spotted Kiwis at Mt Bruce usually went into the nest when her mate emerged to feed and stayed there until he returned some four hours later. Eason did not look into the nest for fear of disturbing her and so could not confirm that she actually brooded the egg.

In the last 18 months we have radio-tagged about 20 Great Spotted Kiwis in two areas of Northwest Nelson – at Kahurangi Point, where the birds live in diverse coastal forest, and in the upper Saxon River, where the predominant vegetation is subalpine beech forest and red tussock. In following the activity of several pairs during two breeding seasons, we have established that female Great Spotted Kiwis do help in incubation.

In both study areas, females usually relieve males on the nest in the second hour of darkness and remain there until their mates return, often in the last hour before dawn. On the two occasions when we inspected a nest at night, the female was incubating.

Furthermore, in exceptional circumstances, female Great Spotted Kiwis may incubate unaided by the male, as the following account illustrates. At Kahurangi on 5 October 1988, "male 28" was found on a nest in the side of a small hillock. The entrance was about 30 cm wide and 15 cm high, and the male and a single egg were just beyond this, in an enlarged cavity lined with grass and fern fronds. The entrance was conveniently angled, and so we could see into the nest from about 2 metres without disturbing the incubating bird. Male 28 was on the nest when it was checked again on 7 October. His mate was not radio-tagged, and so we do not know whether she was nearby or took over when he emerged each night.

On 2 November, male 28 was found dead about 30 m from his nest. He was pinned under a branch of a fallen tree and had probably been dead for about three days. We checked the nest and found a female, presumably his mate, sitting on the egg. She was still there on 3 November, and again during the next two inspections on 30 November and 2 December. We watched the nest with night-viewing equipment until 2330 h on 2 December, hoping to examine its contents after the female emerged – but she did not come out.

On 22 December, when it was next inspected, the nest was empty. There were a few shell fragments in the nest lining, some of which had small feathers adhering to them, perhaps from a chick. The nest was checked daily in the following week and several times in early February, but each time it was empty.

We suspect that a chick was produced. The egg could have been laid up to 28 days before we found it, and it would therefore have been incubated for 59 to 87 days when the female was last seen on 2 December. She alone incubated it for at least 30 days, assuming that she was in the nest on all days between our visits. Incubation takes about 70 days in captivity (Eason 1988).

Our results show that female Great Spotted Kiwis do incubate, and indeed may be able to hatch eggs successfully with little or no help from their mates. Even in normal circumstances, when both members of a pair are present, the female spends most of the night incubating the egg.

We do not know why the incubation behaviour of Great Spotted Kiwis should differ so markedly from that of the other kiwi species. It is unusual to find such variation within the same genus.

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Forbes' Parakeet on Chatham Island

The Chatham Island Yellow-crowned Parakeet or Forbes' Parakeet (*Cyanoramphus auriceps forbesi*) is found only on the Chatham Island group. Formerly on Mangere, Little Mangere and Pitt Islands (Oliver 1955), this subspecies is now confined to Mangere and Little Mangere Islands in much reduced numbers, largely as a result of deforestation and associated hybridisation with Chatham Island Red-crowned Parakeets (*C. novaezelandiae chathamensis*) (Taylor 1985). Since the early 1980s there have been several sightings of parakeets with yellow crowns in the southern, forested part of Chatham Island – an area where they had not previously been recorded.

The first of the known sightings was provided by L. Hutchison, who recalled seeing "a bright green bird with a yellow and red head" foraging in a bed of "Chatham Island lilies" while living in Waitangi during 1975 and 1976. This bird was later identified as a Forbes' Parakeet (R. Taylor, pers. comm.). Several years later D. Melville saw a yellow-crowned parakeet in the vicinity of the Tukuatamatea River during December 1982 (Melville 1984). More sightings have followed over the last two years during intensive searches for the breeding burrows of the Chatham Island Taiko (*Pterodroma magentae*) in the Tuku Reserve.

During the 1987 Taiko expedition, a parakeet with a yellow crown was seen on the edge of the *Dracophyllum* forest north of the Tukuatamatea River (NZMS 260 (2) 419446) (B. Simpkin, pers. comm.). Several photographs were taken of this bird, which on the basis of this evidence was tentatively identified as a Forbes' Parakeet.

Members of the 1988 Taiko expedition (October-December) also saw a parakeet with a yellow crown on several occasions in the vicinity of the 1987 sighting. Close observation was possible as the parakeet was attracted by imitations of its chatter or by other unfamiliar noises in the area the bird frequented. The morphological and behavioural characteristics of this parakeet can be summarised as follows:

Size equivalent to that of male Chatham Island Red-crowned Parakeets in the vicinity;
A pronounced yellow crown;
A narrow crimson frontal band which did not appear to reach the eyes;
No red on the ear coverts;
Prolonged chases, accompanied by vigorous chattering, of Chatham Island Red-crowned Parakeets that flew near it; and
Seen to feed on spittle-bug larvae (*Philaena trimaculata*) in *Coprosma chathamica* trees.

The highly territorial nature of the bird, its eating insects and its appearance seem to agree with much that has been written about Forbes' Parakeet (Taylor 1975, 1985 and Nixon 1982) and would appear to confirm its identity.

However, several questions remain. The most obvious of these are how and when this bird (or birds) arrived on Chatham Island. The most likely explanation is that a bird was blown north from Mangere or Little Mangere Island by strong winds, a feature for which the region is noted. Less likely is that Forbes' Parakeets have always been in the forested areas of Chatham Island and a remnant population has been "discovered" as ornithologists have entered the forest north of the Tukuatamatea River.

The little evidence suggests that a very small number of Forbes' Parakeets is on Chatham Island. Observations in 1988 were almost certainly of the same male bird, but other birds may be in the area. Fleeting glimpses were caught of what was thought to be a parakeet with a yellow crown following a Chatham Island Red-crowned Parakeet, and several Forbes'-like calls were heard in the area. In a short visit to the same area for two weeks in April 1989, R. Colbourne (pers. comm.) saw no sign of this parakeet.

This note would not have been possible without the generosity of Mike Imber and the help of the members of the 1988 Taiko expedition, especially those who "did time" at North Burrows camp. Many thanks to R. G. Powlesland for reading the initial draft and R. H. Taylor for access to his correspondence with L. Hutchison.

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Silvereyes hunting insects on the wing

On 8 April 1989, at 6.30 a.m. of a still and misty morning, I noticed small birds making short hovering flights from the shrubs and fruit trees of my garden. With binoculars I identified the birds as Silvereyes (*Zosterops lateralis*) and could see that they were going after insects. These were some kind of clear-winged insect (not flying ants) which were rising in columns above each bush. During the following half-hour I watched 20-30 Silvereyes and several House Sparrows preying on these flies. Each bird would fly one or two metres, hover briefly, snap at an insect, and return to the same bush. The snap of the bill was quite audible. I could not see whether an insect had been caught but, unlike a Fantail in pursuit of flies, the Silvereyes seemed to make only one attempt at capture on each brief flight. Often several birds were in the air at the same time, and I noted that they popped out of the foliage and dropped back into the bush. That is, they were not using and returning to vantage points after the usual style of flycatchers. The Silvereyes may also have been capturing the insects on the foliage, but I could not confirm this. A pair of Grey Warblers which passed through the garden during this time took no part in this feeding, and although I could hear a Fantail it remained some way off and out of sight.

Silvereyes are well known to be opportunistic feeders but I have not seen this behaviour before. B. Brown (1988) has recorded 20 + feeding like sparrows on a lawn for several hours and there is a report by A. Blackburn (1981) from Gisborne on 14/8/79 of the species "taking larger insects in typical flycatcher manner". It is not clear whether this latter note refers to one or several birds.

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