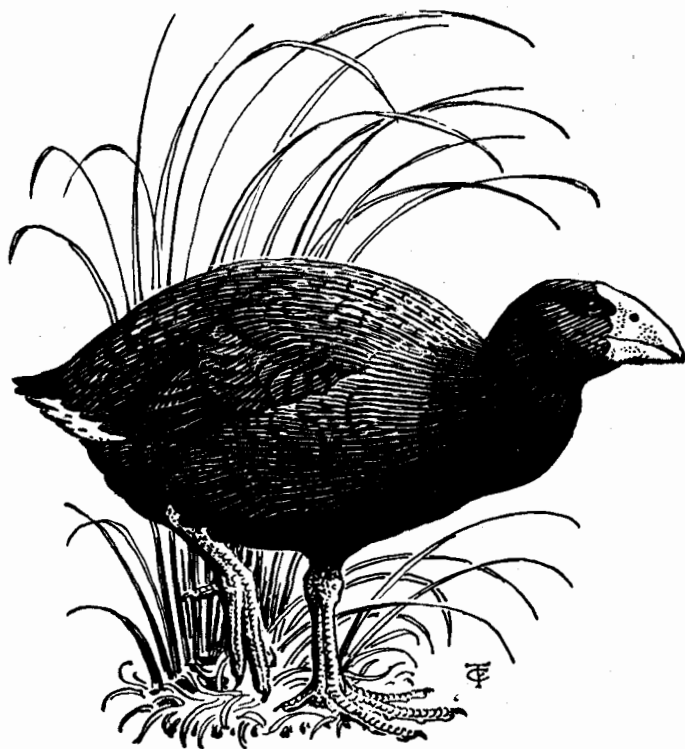


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CONTENTS

TARBURTON, M. K. The food of the White-rumped Swiftlet (<i>Aerodramus spodiopygius</i>) in Fiji	1
TAYLOR, R. H.; HEATHERBELL, E. G.; HEATHERBELL, E.M. The Orange-fronted Parakeet (<i>Cyanoramphus malherbi</i>) is a colour morph of the Yellow-crowned Parakeet (<i>C. auriceps</i>)	17
FITZGERALD, B. M.; MEADS, M. J.; WHITAKER, A. H. Food of the Kingfisher (<i>Halcyon sancta</i>) during nesting	23
CUNNINGHAM, J. B.; HOLDAWAY, R. N. Morphology and head colour in the Yellowhead	33
CLOUT, M. N.; GAZE, P. D.; HAY, J. R.; KARL, B. J. Habitat use and spring movements of New Zealand Pigeons at Lake Rotoroa, Nelson Lakes National Park	37
ONLEY, D. J. A method of ageing the Tui (<i>Prothemadera novaeseelandiae</i>) and its use in assessing body measurements	45
ROBERTSON, H. A. OSNZ Nest Record Scheme Instructions	53
Short Notes	
COLBOURNE, R.; KLEINPASTE, R. Seasonal song development of a North Island Kokako	16
OLSON, S.L. Emendation of the name of the fossil rail (<i>Rallus hodgeni</i>) Scarlett	32
MILLER, PAT and KAREN A beach-wrecked Red-tailed Tropicbird	50
BEAUCHAMP, A. J. A case of co-operative rearing in wekas	51
BUTLER, D. J. Hybrid parakeet on mainland	58
TENNYSON, A. J. D. Second record of a Manx Shearwater in New Zealand	59
BERGQUIST, C. A. L. Occurrence of disease in Tui	61
Reviews	
The technique of bird photography (J. Warham)	63
The birds and bird lore of Samoa (C. & S. Muse)	63
SAOS Checklist of Southern African birds (P. A. Clancey)	64
Contribution à l'Etude des Oiseaux de Polynésie orientale (D. T. Holyoak & J. -C. Thibault)	65
Obituaries	
Charles Archie D'Arcy Blackburn 1899-1984	66
Helen Oliver 1904-1985	68

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THE FOOD OF THE WHITE-RUMPED SWIFTLET (*Aerodramus spodiopygius*) IN FIJI

By M. K. TARBURTON

ABSTRACT

Diptera (flies), Homoptera (planthoppers), Hymenoptera (social insects), Isoptera (termites), and Coleoptera (beetles) were the most numerous prey in 32 food boluses being delivered by parent White-rumped Swiftlets (*Aerodramus spodiopygius*) to their chicks inside two Fijian caves. Numerically the main food items were flies (37%) and planthoppers (33%). Both the season and the habitat over which the birds had been feeding seemed to determine whether flies or planthoppers predominated in a particular bolus sample. Flies predominated in the prey of swiftlets foraging over open country, whereas planthoppers predominated in the prey of swiftlets foraging over both forest and open country.

The number of insects in each food bolus ranged from 47 to 750 (\bar{x} = 236). The average weight of a bolus was 0.225 g (range 0.1-0.43 g). The average length of all prey was 2.48 mm, which is larger than the average length of available prey (1.63 mm). The number of prey species ranged from 2 to 83 (\bar{x} = 30 per bolus). Altogether, 167 species were recorded in food boluses. The White-rumped Swiftlet bred during the wet season, when insects were more abundant.

This study, along with others (largely unpublished), shows for the first time that flies are often the most common insect in the prey of swifts, swiftlets and swallows.

INTRODUCTION

Swifts have been shown to collect more food on fine days than on wet days, although the reasons differ with latitude. Lack (1956) found that, in temperate latitudes, nestling Common Swifts grew more in wing length and weight on sunny warm days than on dull, cold, wet days. He also found that the food boluses fed to chicks contained larger insects on warm days than on wet days. Aerial tow netting showed that flying insects were in greater densities on warmer days and so the swifts could select larger prey (Lack & Owen 1955).

In the tropics, however, Hespeneide (1975) found from tow net sampling that flying insects were at higher densities in wet weather. Despite this, he found that swifts and swallows

1. Took the same average size of insects on both wet and dry days;
2. Caught a greater size range on wet days, probably because the rain reduced their foraging time, forcing them to be less selective;
3. Showed a preference for swarms, when present; and
4. Did not favour flies, presumably because flies manoeuvre better than other insects.

The preference for swarms applied particularly to the larger swifts.

From these findings, Hespeneide suggested that flies are scarce in the diet of all aerially feeding insectivores because they are harder to catch, being more manoeuvrable than other insects. He also proposed that certain behaviour, characteristic of each insect order, caused the average size of prey taken from each insect order to be significantly different.

This paper has two purposes. The first is to show the number, size and identity of the White-rumped Swiftlet's prey in Fiji. The second is to determine whether Hespeneide's findings apply to this swiftlet, which is widely distributed in the tropical south-west Pacific, or to other aerial feeders such as the swifts and swallows, as reported in other studies.

METHODS

In December 1981 and 1983, I studied the food of swiftlets nesting at Nasinu Nine-mile, 9 miles north of Suva. Of the two nesting colonies in separate caves at Nasinu Nine-mile, I chose that in the larger Waterfall Cave, where my longevity studies that had run since 1974 had shown that the birds are disturbed less by the public than those breeding in the smaller colony in Dry Cave.

Birds were captured as they carried their prey to their chicks, mostly in nests built in totally dark sections of the cave. I caught the birds in a butterfly net before they reached their nests because Lack (1956) and Fischer (1958) had found with the Common Swift (*Apus apus*) and the Chimney Swift (*Chaetura pelagica*) that disturbing birds at their nests made some desert.

Whenever a bird had its throat distended with a food bolus, I gently prised open its mandibles using my thumbnail and pencil and, holding the bird upside down, rolled the food bolus out with the pencil.

I collected the food boluses in the wetter of Fiji's two seasons, the season shown by other studies to have more abundant insects. I weighed each food bolus and then preserved it in formaldehyde. In the laboratory, I sorted the prey into orders and into unnamed but distinctive groups, presumably species, and then counted and measured them.

I sampled potential prey by the methods of Hespeneide (1975). The two areas sampled were the 4.3 km along Wainibuku Road from the Suva-Nausori road to near the entrances of Dry and Waterfall Caves, and in Tamavua, 10 km from the cave. The first area consisted of small horticultural farms, together with some young scrub regrowth and occasional trees. Farm crops were mainly pineapples, taro and cassava among scattered coconut trees. The

Tamavua area was a well-vegetated well-spaced residential area with food crops, flowering shrubs, trees and lawns. Swiftlets were feeding down to 0.5 m in both areas and at times were feeding while I was collecting samples in the tow net.

RESULTS

Identity of prey

Flies were found in all food boluses but one and were the most numerous prey in 16 of the 32 boluses taken in December (Table 1). Flies made up 43% of the total sample of 7433 invertebrates. Planthoppers were in all 32 food boluses and were the most numerous in seven of them. Planthoppers made up 24% of the total sample.

TABLE 1 — Composition of White-rumped Swiftlet prey in 32 food boluses. 1981 & 1983 combined

Order	No. Where Dominant	% Where Dominant	% Range In All Boluses	\bar{x} % of Samples Where Present \pm SE	No. of Boluses Present in	No. in Total Sample	% Individuals In Total Sample
Diptera	14	37 - 88	0 - 88	37 \pm 4.8	31	3176	43
Homoptera	7	37 - 100	1 - 100	33 \pm 6.2	32	1748	24
Hymenoptera	2	62 - 83	0 - 83	18 \pm 5.5	30	1615	22
Coleoptera	1	53	0 - 53	9 \pm 2.1	28	484	7
Isoptera	1	45	0 - 45	15 \pm 4.1	12	168	2
Heteroptera	0	0	0 - 2	<1.0	7	9	
Trichoptera	0	0	0 - 3	2 \pm 1.0	3	7	
Thysanoptera	0	0	0 - 3	1 \pm 1.0	8	23	
Megaloptera	0	0	0 - 1	1.0	1	3	
Lepidoptera	0	0	0 - <1	<1.0	2	4	1
Psocoptera	0	0	0 - 2	<1.0	4	6	
Ephemeroptera	0	0	0 - 1	1.0	1	1	
Neuroptera	0	0	0 - <1	<1.0	1	1	
Unidentified	0	0	0 - 1	<1.0	7	12	
Aranae	0	0	0 - 8	2 \pm 0.5	17	52	1

Social insects were in 30 of the boluses but were the most numerous in only two boluses. They made up 22% of the total sample. Termites and beetles were the most numerous in one bolus each, but beetles were present more often than termites. Although termites occurred in only 12 of the 32 boluses, they sometimes did so in reasonable numbers (17-43 or 9%-45% of total insects in the bolus). They are available to swiftlets only while swarming, when they are the preferred food. Spiders, although very small, were found in 17 of the 32 boluses.

The 1983 samples, which were collected on two days, had a very different composition. The averages for the six boluses taken on 11 December were 84% planthoppers and only 3% flies (one bolus containing 100% planthoppers). However, in only two of the six boluses collected on 5 December were planthoppers predominant (an average of 59%). Thus the diet of swiftlets cannot be adequately assessed by means of brief and intermittent sampling.

Size of prey

The largest prey found in this study were two adult moths 11 mm long. Two moth larvae 4.5 and 9 mm long were also well above average prey size. Termites were the largest of the common prey, averaging 4.5 mm, then planthoppers (2.5 mm), social insects (2.3 mm), flies (2.2 mm) and beetles

(1.9 mm). The average size of the prey was 2.48 ± 0.11 mm ($\bar{x} \pm SE$), which is significantly greater ($t=6.4$, $p<0.01$, $df=39$) than that of the prey available (1.63 ± 0.12). The data for total prey was based on the means of all 32 boluses rather than that of each type so that the extreme means of the uncommon types did not swamp those of the majority. The average size of the flies, social insects and beetles was each significantly larger than that available ($t=3.2-3.5$, $p<0.01$, $df=27-38$).

The average size of the smallest group of insects (beetles) commonly found in the prey was not significantly smaller than that of the flies ($t=1.63$, $p>0.1$, $df=54$). The flies were not significantly smaller than the Hymenoptera ($t=0.12$, $p>0.1$, $df=57$), which however were significantly smaller than the termites ($t=9.5$, $p<0.001$, $df=40$).

The average size of each major insect order found in the boluses, whenever it was predominant in a bolus, was compared with the size of the same order from boluses when it was in the minority. The size of insects from a swarm (arbitrarily decided by Hesperheide to be when more than 20 of a species occur in a bolus) was compared with the size of the same insect order when found in fewer numbers. None of the comparisons were shown to be significant, except that of beetles. In the one bolus where beetles were dominant (54%), their average size of 5.7 mm ± 0.2 was significantly greater than the average of all others (1.7 mm ± 0.09).

A significant difference in size ($p<0.001$) was found between three of the four major insect orders when the two samples, each of six boluses and each taken in December 1983, were compared. These are shown in Table 2. These two groups of samples had three important differences. Those taken on the 5th were collected earlier (1300-1555 hours) than those taken on the 11th 1900-1918 hours). The 5th was largely an overcast day, but the 11th was the fourth consecutive sunny day. Both these differences may be expected to cause those collected on the 11th to be larger (Lack 1956, Hesperheide 1975). In addition, the boluses on the 11th were taken one hour after sunset, when the swiftlets were probably catching dusk-flying insects, which have been shown to be larger than those flying during the day (Lewis & Taylor 1967, Hesperheide 1975). So then, both prey size and prey type show daily changes.

The range of 21 White-rumped Swiftlet boluses was 0.1-0.43 g, averaging 0.23 g ± 0.02 . A significant correlation was found between the number of insects in a bolus and the weight of a bolus (Spearman rank correlation $r_s = 0.66$, $p<0.002$, $n=21$). This, together with a negative correlation ($r_s = -0.84$, $p<0.001$, $n=21$) between the number and size of the insects in a bolus, indicates that a bird returns to feed its chicks when it has all it can hold.

TABLE 2 — Average size of common prey
(1983 sample in mm)

	5 December	11 December	Difference
Coleoptera	1.45 ± 0.084	2.35 ± 0.236	$p<0.001$
Hymenoptera	1.70 ± 0.110	3.66 ± 0.425	$p<0.001$
Homoptera	2.15 ± 0.150	2.86 ± 0.081	$p<0.001$
Diptera	2.16 ± 0.303	2.81 ± 0.482	N. S.

The almost spherical food boluses were about 6-7 mm in diameter. Some boluses were firm but others fell apart easily, making them hard to measure.

The number of insects in a bolus varied from 47 to 750. The average number for all 32 boluses was 236 ± 32 . The 1981 sample averaged 269 ± 44 ($n=20$) and the 1983 sample averaged 178 ± 36 ($n=12$).

Combining the data for December 1981 and December 1983, as shown above, hides certain information. Whereas flies were dominant in most of the combined sample of food boluses, they were exceeded by planthoppers in seven of the 11 boluses from the 1983 sample. Further analysis of the numbers of individuals and species in the major orders is shown in Table 3.

TABLE 3 — Frequency of major prey in food boluses ($\bar{x} \pm SE$)

	Individuals 1981 ¹	Species ⁴ 1981 ³	Individuals 1983 ²	Species 1983 ²
Diptera	123.9 \pm 31.0	12.4 \pm 1.7	58.4 \pm 25.4	11.4 \pm 3.1
Hymenoptera	71.2 \pm 15.9	7.3 \pm 1.8	16.3 \pm 5.6	7.2 \pm 1.0
Homoptera	40.2 \pm 12.4	3.9 \pm 0.4	84.9 \pm 19.4	4.9 \pm 1.0
Coleoptera	21.8 \pm 4.2	5.6 \pm 1.2	5.8 \pm 3.0	2.8 \pm 1.0
Isoptera	7.9 \pm 1.8	0.3 \pm 0.1	1.2 \pm 0.6	0.3 \pm 0.1
Total	269.2 \pm 44	32.6 \pm 5.2	170.0 \pm 33.7	29.25 \pm 7.4

NOTE: 1 Numbers in 20 boluses taken 2-24 December
 2 Numbers in 12 boluses taken 5,11 December
 3 Numbers in 12 boluses taken 2-24 December
 4 'Species' is not a named species but is ascribed to individuals that are morphologically similar

The decrease in total insects per bolus between the years was not significant ($t=1.79$, $p>0.1$, $df=30$, two-tailed). Neither was there a significant change in the number of species within each major order or the total number of species per bolus between the years. This uniformity suggests that further comparative analysis would be valid. Such analysis shows that the decrease in the number of individuals per order in a bolus between 1981 and 1983 was significant ($t=3.09-3.53$, $p<0.01$, $df=30$) in the social insects, beetles and termites. This decrease was offset by a significant increase in planthoppers ($t=2.23$, $p<0.05$, $df=30$). The number of flies did not decrease significantly ($t=1.63$, $p>0.1$, $df=30$).

The number of species found in a bolus varied from 2 to 83 and averaged 29 in 1983 and 33 in 1981.

DISCUSSION

Prey size compared with that of other swiftlets

Prey size has been positively related to the body size of insectivorous birds (Hespenheide 1971, 1975; Dyrce 1979). The White-rumped Swiftlet, with its light weight and small prey, fits into the general trend. It takes the smallest prey of any apodid so far studied (Table 4).

Table 5 shows that the White-rumped Swiftlet is typical of all aerial feeding birds studied to date (Hespenheide 1975, Waugh 1979) in that it takes larger prey than the average of that available.

TABLE 4 — Prey size of various Apodidae and Hirundinidae

Predator	\bar{x} Size (mm)	S.E.	Range	Mode	Source
White-rumped Swiftlet					
<u>Aerodramus spodiopygius</u>	2.48	0.11	0.3-11	-	This paper
Glossy Swiftlet					
<u>Collocalia esculenta</u>	2.6	-	-	-	Waugh & Hails 1983
Mossy-nest Swiftlet					
<u>Aerodramus vanikorensis</u>	3.05	-	c.1.5-12.5	-	Harrisson 1976
Black-nest Swiftlet					
<u>Aerodramus maximus</u>	3.05	-	c.1.5-12.5	-	Harrisson 1976
Barn Swallow					
<u>Hirundo rustica</u>	3.3	-	-	-	Waugh & Hails 1983
Horus Swift					
<u>Apus horus</u>	3.71	0.08	0.8-9.0	2.6-3.0	Collins 1980
Short-tailed Swift					
<u>Chaetura brachyura</u>	4.0	0.07	1-9	3	Collins 1968b
Chimney Swift					
<u>Chaetura pelagica</u>	c.4.0	-	-	<5	Fischer 1958
Common Swift					
<u>Apus apus</u>					
	Fine	3.5	<2-	-	Lack & Owen 1955
	Wet	6.5	->10	-	Lack & Owen 1955
Pacific Swallow					
<u>Hirundo tahitica</u>	4.8	-	-	-	Waugh & Hails 1983
House Swift					
<u>Apus affinis</u>	5.09	-	-	-	Waugh & Hails 1983
Chestnut-collared Swift					
<u>Cypseloides rutilus</u>	6.9	0.2	5-10	7-8	Collins 1968b
Black Swift					
<u>Cypseloides niger</u>	8.68	-	2-12	9-10	Collins 1968b
Grey-breasted Martin					
<u>Progne chalybea</u>	10.5	-	-	-	Dyrce 1984
Mangrove Swallow					
<u>Tachycineta albilinea</u>	15.7	-	-	-	Dyrce 1984

TABLE 5 — Size of prey of White-rumped Swiftlet (total sample)

	Actual prey			Potential prey		
	\bar{x}	S.E.	n	\bar{x}	S.E.	n
Diptera	2.21	0.11	31	1.64	0.14	9
Homoptera	2.47	0.10	32	-	-	-
Hymenoptera	2.38	0.15	29	1.80	0.10	9
Isoptera	4.50	0.19	11	-	-	-
Coleoptera	1.88	0.17	26	1.26	0.05	7
Trichoptera	3.06	0.65	5	3.3	-	1
Thysanoptera	1.49	0.14	11	1.38	0.03	4
Megaloptera	2.67	-	1	-	-	-
Lepidoptera	9.00	-	2	3.4	-	2
Psocoptera	3.45	0.61	4	3.3	-	1
Neuroptera	1.50	-	1	-	-	-
Ephemeroptera	3.00	-	1	-	-	-
Heteroptera	2.47	0.29	6	2.0	0.26	4
Unidentified	2.28	0.34	5	-	-	-
Aranidae	1.67	0.12	17	4.5	-	1
Total	2.67	0.11	32	1.63	0.12	9

Hespenheide (1975) expected that the average size of each insect order in a swift's prey would be significantly different from that of the other orders. He derived this by assuming that the different orders of insects have different average flight abilities and that the birds spend about the same amount of energy in capturing any given prey item. Hespenheide (1975) found some evidence for these expectations in the prey of other swifts. However, this study shows evidence to the contrary in that swarming insects can negate both of Hespenheide's assumptions. An insect is seldom using or likely to use its full flight capabilities (in terms of high speed and manoeuvrability) while swarming, and an aerial predator will expend less energy in procuring a bolus of any high-density collection of insects.

The food bolus

Since Bartels (1931) demonstrated that the Alpine Swift fed its chicks infrequently with large boluses of food, such feeding behaviour has been shown for other Apodidae. The wet weight of the White-rumped Swiftlets' food boluses varied about as much (0.1-0.43 g) as those of the Common Swift (<0.7-2.5 g, Lack & Owen 1955), although less than those of the Edible-nest Swiftlet (*Aerodramus fuciphaga*) (0.13-1.08 g, Langham 1980) and the Chimney Swift (*Chaetura pelagica*) (0.2-0.9 g, Fischer 1958).

The average number of insects in a bolus (236) is much larger than the 94 average of 10 boluses from the same species in Queensland (Smyth 1980). From this one could predict (assuming that the above correlations between size and number of insects in a bolus hold) that the Queensland subspecies takes larger prey than the Fijian subspecies does. This is expected (Bergmann's rule) as the Queensland subspecies *A. s. terraereginae* is much larger (12.2 g) than Fijian birds (8.1 g). In the Edible-nest Swiftlet, which is similar in size, the prey numbered 100 to over 1200, with an average of more than 500 per bolus (Langham 1980). The much larger Common Swift usually has 300-1000 prey in a bolus, but the recorded range is 58-1500 (Lack & Owen 1955).

The number of species in a bolus varied from 2 to 83 and averaged 29 in 1983 and 33 in 1981. This is about half the number of species found in similarly sized samples from the stomachs of Short-tailed Swifts (Hespenheide 1975), perhaps because fewer species are available in Fiji than in Panama and Costa Rica, as one would expect by Fiji's small area and isolation. However, the average number of species taken by the White-rumped Swiftlets is lower than might be because 21 of the 24 birds apparently fed at swarms (as defined by Hespenheide 1975). The highest number of species in a bolus is only nine less than the highest in the Short-tailed Swift. One swiftlet had fed at six swarms and another at only two swarms, neither taking any other species. Five of the birds fed on fewer than 10 species to produce a bolus — a characteristic proposed for the larger swifts (Hespenheide 1975). The 24 boluses contained 167 species, of which 67 were flies, 44 social insects, 23 beetles, 18 planthoppers, 11 spiders, 5 each of sap-suckers (Heteroptera) and thrips (Thysanoptera), 2 book lice (Psocoptera) and 1 termite. An additional 29 species were taken in the tow net.

The above results show that only in one bolus, dominated by beetles, was the average size significantly different from the average for insects of the same order in all other boluses. In this case the beetles in the beetle-

dominated bolus were larger than in all other boluses. This is the reverse of that expected if a bird feeding on a swarm is less selective, as Hespeneide (1975) proposed. As only two of the 50 beetles in the bolus were below the mean size of beetles in all other boluses, this bolus seems to have resulted from nothing more than the chance location of a swarm of larger than average beetles.

Taxonomic comparison between available prey and captured prey

For the most valid comparison between potential prey as sampled by the tow net and actual prey from the food boluses, both samples should be collected in the same season. Although this means ignoring the mass of data from 1981, I have chosen to do so because several of the 1983 net samples were taken at the same time as the swiftlets were capturing the insects in the food boluses. On several occasions swiftlets were foraging in the same air space and at the same time as the net samples were being taken. The resulting data are shown in Table 6.

TABLE 6 — Taxonomic proportions of prey compared with aerial invertebrates

Order	$\bar{x} \pm s$ in Tow Net (Dec 83)	$\bar{x} \pm s$ in Food Boluses (Dec 83)	$\bar{x} \pm s$ in Hemiptera Dominated Boluses	$\bar{x} \pm s$ in Diptera Dominated Boluses
Diptera	66.9 ± 4.5	25.7 ± 8.3*	8.9 ± 3.0*	61.0 ± 2.5
Homoptera	3.8 ± 0.6	58.0 ± 9.8*	77.8 ± 7.0*	18.5 ± 0.44
Hymenoptera	11.1 ± 3.5	9.9 ± 2.9	8.9 ± 4.3	11.7 ± 1.1
Coleoptera	15.9 ± 4.7	2.5 ± 1.0-	6.7 ± 0.3*	6.2 ± 1.7+
Isoptera	0	1.6	2.5	0
Trichoptera	0.1	0.2		
Thysanoptera	1.2	0.2		
Lepidoptera	0.7	0		
Psocoptera	0.1	0.3		
Heteroptera	1.1	0.2		
Ephemeroptera	0.2	0		
Unidentified	1.3	0.2		
Araneae	0.1	1.3		

NOTE: * Shows significant difference to tow net samples ($t_p < 0.001$).
+ Shows significant difference to tow net samples ($t_p < 0.05$).

Because two planthopper species (both Delphacidae) formed a clear majority in 8 of the 12 boluses and only one of these species was rarely taken in the net, the birds with an abundance of planthoppers had apparently spent much of their foraging time in some other habitat than that sampled. Further confirmation of this is given by the significant difference between the percentage of flies in the boluses having mostly planthoppers and the percentage of flies in the tow net samples ($t=4.4$, $p<0.01$, $df=10$) and no significant difference between the percentage of flies, social insects or beetles in boluses dominated by flies and the percentage of them in the tow net samples. Taken together, these data suggest that the birds with predominantly flies in their food boluses had been feeding in the open habitats that I had sampled with the net, whereas those with predominantly planthoppers had been feeding over the forests (which I did not sample with the net) to the west of the caves.

Of the fly species in the net samples, a similar proportion was found in the fly-dominant boluses (44%) and the planthopper-dominant boluses (47%). This similarity may mean that the swiftlets feeding on planthoppers foraged over the fly-rich open habitats as well as over the planthopper-rich forests. This is confirmed in that the planthopper-dominant boluses contained a larger percentage (43%) of fly species not found in the fly-dominant boluses than the small percentage (24%) of fly species found only in the fly-dominant boluses. This conclusion is consistent with my observation that the swiftlets periodically feed in the open habitat on their way to the forest. It is also consistent with the finding that a greater number of insect species fly over forest, which has a greater diversity of plants than open habitat (Hespenheide 1975, Waugh & Hails 1983).

It is interesting that the average percentages of the three most common insect orders taken in the net are each very close to those taken in Costa Rica and Panama with a similar net by Hespenheide (1975). The largest deviations from any of his results (which varied by season and location) are flies 8.2%, social insects 8.5% and beetles 9.4%. The main interest in this comparison arises from two phenomena. The first is that it would seem unusual for oceanic islands such as Fiji to have a similar proportion of flying insect groups to a region that is attached to two large land masses. The second is that, whereas the two swifts and the swallow studied in Central America did not make proportionate use of flies, the most common insect order, the White-rumped Swiftlet, did in Fiji.

The most common group of flying insects available to Fijian swiftlets was the flies. Hespenheide suggested that flies are more manoeuvrable than most insects and that this helps explain their infrequent occurrence in the prey of large swifts in particular and in aerial predators in general.

He cited studies of six species of large swifts that took a small range of prey species with flies not a major component. He reasoned that, because the larger swifts have greater foraging ranges than smaller swifts, they may specialise on insects in mating or dispersal swarms. However, there are two problems with this argument. The first is that some studies (seven of which have not been previously published) have shown that flies can be the predominant prey of large swifts. Table 7 shows that flies have dominated in the studied diets of eight species, three of which were large swifts. By comparison, the social insects were found to be dominant in the prey of 11 species, planthoppers dominant in the prey of three species and beetles dominant in the prey of two species.

The second problem is that, if flies were more difficult to capture and the difficulty increased with the size of the swift, as proposed by Hespenheide, there should be a good negative correlation between the weight of the swift and the percentage of flies in its diet. There is however only a low negative correlation between the predator's weight and the proportion of flies in the prey for the 37 studies in Tables 7 and 8 that provide numerical data as percentages ($r_s = 0.28, 0.10 > p < 0.05$). It would appear that, regardless of the size of the predator, swifts, treeswifts or swallows do not show any preference for or against flies. The birds presumably take what is available, giving preference to swarms or other high-density concentrations, which are just as likely to

TABLE 7 — Percentage composition (numerically) of major prey of swifts

	Hymenoptera	Homoptera	Colcoptera	Isoptera	Diptera	Bird's Weight	Sample Size	Source
Philippine Spinetail	99	-	-	-	-	180	14	Morse & Laigo 1968
<u>Chaetura celebensis</u>								
Alpine Swift	4th	-	3rd	-	1st	100	-	Arn 1945
<u>Apus melba</u>	14	-	54	-	23	100	6	Arn 1945
White-collared Swift	94	<1	2	0	1	98	2	Rowley & Orr 1965
<u>Cypseloides zonalis</u>								
San Geronimo Swift	-	-	-	1st?	-	57	2	Carr & Dickinson 1951
<u>Panyptila sanctiheronymi</u>								
Black Swift	c.14	c.37	7	1	c.31	46	6	Rathbun 1925
<u>Cypseloides niger</u>	100	-	-	-	0	46	-	Collins & Landy 1968
Common Swift								
<u>Apus apus</u>	6	66	8	-	17	43	24	Lack & Owen 1955
	3rd	1st	4th	-	2nd	43	-	Koskimies 1950:25
	-	31	-	-	57	43	13	Collins pers. comm.
Zimmers Swift	-	-	-	-	0	39	1	Collins pers. comm.
<u>Cypseloides cryptus</u>								
White-throated Swift	1st	-	2nd	-	-	33	2	Hespenheide 1975
<u>Aeronautes saxatalis</u>	3rd	-	2nd	-	1st	33	21	Bent 1940
Fork-tailed Swift								
<u>Apus pacificus</u>	1st	5th	2nd	-	3rd	30	40	Litvinenko 1972
	97	-	-	-	<3	30	-	Chiba 1968
	1st	-	-	-	-	30	-	Lea & Gray 1945

TABLE 7 - continued

	Hymenoptera	Homoptera	Coleoptera	Isoptera	Diptera	Bird's Weight	Sample Size	Source
<u>Horus Swift</u>	17	41	6	19	8	27	-	Collins 1980
<u>Apus horus</u>								
<u>House Swift</u>	78	-	10	-	4	27	1	Wagh & Hails 1983
<u>Apus affinis</u>								
<u>Cayene Swift</u>	-	-	-	-	64	24	1	Collins pers. comm.
<u>Panyptila cayennensis</u>								
<u>Chimney Swift</u>	-	-	1st	-	2nd	24	12	Warren 1890; 183
<u>Chaetura pelagica</u>	3rd	2nd	-	-	1st	24	-	Fischer 1958
<u>White-rumped Swift</u>								
<u>Apus cafer</u>	1st	4th	2nd	5th	-	22	-	Moreau 1942
<u>Chestnut-collared Swift</u>								
<u>Cypseloides rufinus</u>	51	0	0	49	0	20	4	Collins 1968a
<u>White-tipped Swift</u>								
<u>Areonautes montivagus</u>	-	-	-	-	35	20	11	Collins pers. comm.
<u>Vaux Swift</u>								
<u>Chaetura vauxi</u>	-	1st	-	-	-	18	-	Davis 1937
<u>Short-tailed Swift</u>	-	-	-	-	31	18	10	Collins pers. comm.
<u>Chaetura brachyura</u>	29	2	8	5	42	18	17	Collins 1968a
<u>Grey-rumped Swift</u>	82	-	11	-	4	18	6	Hespenheide 1975
<u>Chaetura cineriventris</u>								
<u>Bond-rumped Swift</u>	-	-	-	-	27	16	7	Collins pers. comm.
<u>Chaetura spinicauda</u>	55	-	25	-	4	14	-	Hespenheide 1975
<u>Neotropical Palm Swift</u>								
<u>Reinarda squamata</u>	-	-	-	-	53	10	6	Collins pers. comm.

Note: 1st = most common, 2nd = second most common, etc.

TABLE 8 — Percentage composition (numerically) of major prey of swiflets and swallows

	Hymenoptera		Homoptera		Coleoptera		Isoptera		Diptera		Sample Size	
	%	N	%	N	%	N	%	N	%	N	Weight	Source
Purple Martin	2	0	68	0	0	20	51	c.10	Johnston 1967			
Grey-breasted Martin	75	0.3	-	-	5	33.5	65	Dyrcz 1985				
House Martin	32	1	41	0	3	51	c.9	Johnston 1967				
Delichon urbica	-	50	-	-	-	19.8	-	Bryant 1975				
Barn Swallow	82	-	6	2	8	19.5	-	Wagh & Hails 1983				
Mirafloja rustica	-	-	-	-	-	-	-	-	-			
Pacific Swallow	59	-	7	2	31	17.8	-	Wagh & Hails 1983				
Mirafloja fabulosa	-	-	-	-	-	-	-	-	-			
Black-nest Swiflet	60	-	-	27	<1	15.9	-	Harrison 1976				
Aerodramus maximus	69	-	23	-	4	13.7	-	Hesperheide 1975				
Rough-winged Swallow	31	-	-	-	-	15.75	-	Beal 1918				
Bank Swallow	33	8	14	-	27	14.6	-	Beal 1918				
Riparia riparia	6	24	3	-	32	14.6	-	Stoner 1936				
White-rumped Swiflet	7	13	11	-	69	14.6	-	Kaugh 1979				
Aerodramus spodiopygus	26	15	12	-	51	12.2	10	Smith 1980				
Mossy-nest Swiflet	10	48	3.5	0.5	36	8.2	12	This study				
Aerodramus vanikoroensis	60	-	-	27	<1	11.3	-	Harrison 1976				
Indian Edible-nest Swiflet	-	c.80	c.10	-	-	c.11.0	-	At & Dillon 1980				
Aerodramus unicolor	41	15	-	-	8	10.8	-	Lanham 1980				
Edible-nest Swiflet	-	-	-	-	-	-	-	-				
Aerodramus lucibhaga	48	15	-	-	26	8.3	-	Hails & Amirtudin 1981				
Grey-rumped Swiflet	55	12	34	2	2	8.3	-	Wagh & Hails 1983				
Aerodramus francica	94	3	-	-	<1	14.5	2	Ricklefs 1971				
Clayey Swiflet	20	-	-	-	26	-	-	Dyrcz 1984				
Edible-nest Swiflet	-	-	-	-	-	-	-	-				
Manrove Swallow	-	-	-	-	-	-	-	-				
Tachycineta albilinea	-	-	-	-	-	-	-	-				

be flies as any other group. This is not surprising because many flies congregate at feeding or mating sites and so attract feeding swifts, swiftlets and swallows.

To explain the greater dominance of social insects over beetles in prey taken than in prey available, Hespeneide pointed out that the social insects tended to congregate more and so the birds could presumably find such concentrations. There is a similar disproportion in the prey of the White-rumped Swiftlet and the same reasoning could apply. My observations of feeding swiftlets flying in 10-30 m diameter circuits confirms that they do feed on insects that are swarming or in other high-density concentrations.

Hespeneide (1975) found that swifts and swallows preferred the larger catchable prey of the range they could manage. If the same holds for swiftlets, flies, the most abundant but second smallest prey taken of White-rumped Swiftlets in Fiji, could not be taken because of their size alone. Flies must be chosen because they are easier to catch and/or more abundant.

Tow net samples taken in Costa Rica and Panama consistently demonstrated that, although flies were 70-75% of airborne insects, they were only 4% of swift prey in the comparable wet season (Hespeneide 1975). Hespeneide presumed that the flies were harder to catch than other prey. If this is true of flies in Fiji, either the White-rumped Swiftlet is better able to catch flies than the swifts, swallows and other swiftlets whose prey contains few flies or the other kinds of flying insects are far less abundant in Fiji than in Central America and Malaysia. The latter cannot be so because the taxonomic proportions of the Fijian tow net samples (Table 9) are very like those of Central America. So perhaps the White-rumped Swiftlet has greater ability in securing more manoeuvrable prey, although, as Tables 3 & 4 show, it is not alone in this ability.

A likely alternative for flies being chosen, other than their being easier to catch or more abundant, is that in Fiji they occur in high density in small areas. In Central America, flies may not have been in swarms or swarms of larger prey may have been more attractive to the swifts and swallows.

Published comments suggest that mosquitoes are fewer in Fiji than elsewhere because the swiftlets hunt them tirelessly (Wood & Wetmore 1926, Sibson *in* Belcher 1972, Allison 1978/79). I doubt these statements because mosquitoes were 2.5% (21/852) of free-flying insects but only 0.58% (43/7433) of the swiftlet's prey. In addition, four of the six places I have lived at or visited within the range of the swiftlet had large numbers of mosquitoes.

Food abundance and the timing of breeding

Some evidence suggests that the dry season is a better breeding time than the wet season for birds that feed on the wing. Hespeneide (1975) noted that the swallows and most other insectivorous birds nest in the dry season. He also suggested that, although in the wet season the density of flying insects is higher in cloudy but dry periods and ants and termites seem to swarm most, the more frequent rains must reduce the bird's foraging time. In Asia, the Edible-nest Swiftlet (Langham 1980), the Black-nest Swiftlet and the Mossy-nest Swiftlet (Medway 1962) hatch most eggs during the dry period November to March.

However, such is not always the case. The Indian Edible-nest Swiftlet *Aerodramus unicolor* (Abdulali 1942), the Pacific Swallow and the Glossy Swiftlet *Collocalia esculenta* (Waugh & Hails 1983) produce most of their first broods with the onset of the monsoon rains in May.

In Fiji, the White-rumped Swiftlet also breeds during the season of heavy rainfall. Nests are built in September and October, corresponding with an increase in rainfall (Table 9). I suspect that increase to be the trigger because the increase in both rain and nest building occur so soon after August, the driest month of the year. Laying in November and early December corresponds with a further increase in rainfall. The high level of rainfall continues to April and so covers the period that young are being fed in the nest and the critical period during which the young are learning to feed themselves on the wing.

TABLE 9 — Monthly rainfall averages in millimetres — Koronivia Research Station (1950-1979)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
367	300	399	359	239	183	171	154	204	221	305	296	3198

Further evidence that there is an increase in the number of flying insects during the wet season in Fiji is the high correlation ($r_s = 0.8$) between date and the number of insects caught in the aerial tow net during December. The raw data were 5 December 10 insects, 6 December 97 insects, 9 December 68 insects, 11 December 265 insects, 15 December 162 insects. Confirmation of this trend is needed from net samples taken in every month.

Although flies were dominant in most of the combined 1981 and 1983 boluses, that does not prove that this swiftlet specialises in flies. If I had taken more boluses in 1983, the overall result would probably show planthoppers as predominant because, as Table 10 shows, planthoppers made up 48% and flies only 36% of the total 1983 sample.

TABLE 10 — Composition of White-rumped Swiftlet prey

Order	% boluses dominant in		% boluses present in		% of total sample	
	'81	'83	'81	'83	'81	'83
Diptera	60	36	100	91	46	36
Homoptera	20	64	100	100	15	48
Hymenoptera	10	0	95	91	26	10
Coleoptera	5	0	95	73	8	3.5
Isoptera	5	0	40	27	3	0.5
					<u>382</u>	<u>98%</u>

Inadequate sampling or a real change in prey composition over time has led several workers to make generalisations which later study has shown to be incorrect. The large range of foods in boluses collected at the one time from this and other studies demonstrates how sampling could give biased results. The abundance of various insects can fluctuate greatly for various reasons such as current and past insect density, disease, predation, climate, and responses in prey or plant food species (Bos & Rabbinge 1976, Dixon & Barlow 1979, Anderson & May 1980, Barlow & Dixon 1980, Randall 1982). Such fluctuations are likely in many insects and will restrict the choice of prey for aerial feeders.

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SHORT NOTE

Seasonal song development of a North Island Kokako

The song of a male North Island Kokako (*Callaeas cinerea wilsoni*) was periodically listened to 10 times between April 1981 and June 1982 at Puketū State Forest, Northland. This bird, affectionately referred to as the 'pet bird', is known by Forest Service staff to have inhabited a ridge with large kauri (*Agathis australis*), pate (*Schefflera digitata*), makamaka (*Ackuma rosaefolia*) and heketara (*Olearia ranii*) for at least the last seven years. His song was recorded in October 1979 by John Kendrick, Wildlife Service. When we played this recording back to the 'pet bird' during each visit, he responded instantly and excitedly. He either ran or hopped quickly through the undergrowth or flew, with laboured flapping, a distance of up to 100 metres to the nearest perch, 10 metres or so above the tape recorder. He puffed himself up and broke into a chorus of chattering and song accompanied by wing beating. It soon became obvious that his wide repertoire was 'programmed': he was able to join his own song exactly, along with the wing-flapping sequences, in complete synchronisation with the tape. Often he was a fraction of a second ahead of the taped version.

The only variable part of the song was the number of *ko* syllables at the end of the song sequence. This part varied through the seasons as follows:

April 1981	<i>kawl kawl ka ko . . . ko . . . ko</i>
May, June, July	<i>kawl kawl ka ko . . . ko</i>
October, November	<i>kawl kawl ka ko . . .</i>
December, January	<i>kawl kawl ka</i>
May, June 1982	<i>kawl kawl ka . . . ko . . . ko . . . ko</i>

Song is primarily under the control of sex hormones and is in general concerned with the reproductive cycle (Thorpe 1984, *Singing in Thomson, A.L., A new dictionary of birds*, Nelson). The variable aspect of this bird's song is therefore probably related to differing levels of testosterone in the blood as the breeding season progresses. Oliver (1955, *New Zealand birds*, Reed) noted that the main laying period for Kokako is November-December.

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THE ORANGE-FRONTED PARAKEET
(*Cyanoramphus malherbi*)
IS A COLOUR MORPH OF THE YELLOW-
CROWNED PARAKEET (*C. auriceps*)

By R.H. TAYLOR, E.G. HEATHERBELL and E.M.
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ABSTRACT

Cyanoramphus malherbi (Souance 1857) is relegated to synonymy with *C. auriceps* (Kuhl 1820) after cross-breeding in captivity showed that both are colour morphs of one species. The resulting parent-offspring data can be most simply explained by the Mendelian theory of dominant/recessive inheritance at a single locus, the factor for yellow-crowned being dominant.

INTRODUCTION

The Orange-fronted Parakeet differs markedly in plumage coloration from the Yellow-crowned Parakeet. In the Orange-fronted Parakeet, the feathers of the frontal band above the bill and small coloured patches on either side of the rump are orange rather than red, the general body plumage is cold bluish green and the crown is pale lemon-yellow, in contrast to the yellowish green and golden yellow of the Yellow-crowned Parakeet

Orange-fronted Parakeets are very rare, having been recorded at fewer than 10 localities on South and Stewart Islands during the present century (Harrison 1970, Read & McClelland 1984).

In September 1980, some were found by the New Zealand Wildlife Service near the confluence of the Hope and Kiwi Rivers in Lake Sumner Forest Park, North Canterbury, where they occurred in a ratio of about one orange-fronted bird to 12 Yellow-crowned Parakeets. During visits to the area by Wildlife Service field parties between 1980 and 1983, both forms were often seen in small mixed flocks (Gray 1982), and nests of a pair of Orange-fronted Parakeets, of two pairs of Yellow-crowned Parakeets and of a mixed pair were found (A. Cox and D. Crouchley, pers comm., Taylor 1985a & b). More recently, in February and April 1984, orange-fronted birds were recorded in comparable concentrations among the parakeets of the Hawdon Valley, Arthur's Pass National Park (Read & McClelland 1984). However, in many other parts of New Zealand where Yellow-crowned Parakeets occur in good numbers, orange-fronted birds are much more rare, or unknown (Taylor 1985a & b).

The Orange-fronted Parakeet was first described by Souance (1857) and redescribed by Buller (1869). At first, Finsch (1869) considered it to be the immature form of the Yellow-crowned Parakeet, but later he was convinced of its specific status (Finsch 1875), and it has since been treated as a valid species by most authorities (Oliver 1955, Kinsky 1970, Harrison 1970, Falla *et al.* 1979, Taylor 1985a)

SPECIES OR COLOUR MORPH?

The first real doubts this century that the Orange-fronted Parakeet was not a good species were cast by Holyoak (1974) who, after studying the literature and museum specimens, concluded that it was probably a colour morph of the Yellow-crowned Parakeet, although direct proof was lacking. He found that the often-quoted differences between the two forms in body size and bill structure were based on too few specimens, mostly of unknown sex. He also considered that the colour differences could be explained in terms of small changes in carotenoid pigmentation, probably under simple genetic control.

In an attempt to clarify whether any real differences in size and shape could be found between Orange-fronted and Yellow-crowned Parakeets, Nixon (1981) used multivariate statistical techniques to re-examine measurements of all museum specimens of both birds available in New Zealand. He found no significant differences that would support the view that the two forms were separate species. He considered that the absence of orange-fronted birds from generations of Yellow-crowned Parakeets bred in aviaries was not contrary to the colour-morph hypothesis because caged birds may have originated from a small and geographically biased sample and thus lack rare alleles. Nixon (1981) also discussed the many other distinctions between the two birds that had previously been reported, and he concluded that "the differences between Orange-fronted and Yellow-crowned Parakeets appear to be not as great as once thought, but further field and aviary studies are needed to resolve fully the question of taxonomic status".

AVIARY STUDIES

During 1981 and 1982, the New Zealand Wildlife Service obtained five male and two female Orange-fronted Parakeets for breeding in aviaries at Hope, near Nelson. The reason for aviary breeding was two-fold. Firstly, if the Orange-fronted Parakeet was indeed a distinct species, the ability to manage and breed captive birds could be important for its long-term survival. Of more importance, however, was the need to resolve the bird's taxonomic status before considerable manpower and money could be invested in its conservation as a rare species. We therefore attempted not only to breed Orange-fronted Parakeets but also to cross-breed them with Yellow-crowned Parakeets.

All of the Orange-fronted Parakeets originated from the Hope/Kiwi Rivers area. Four were caught with mist nets, and three were hatched and reared by captive Yellow-crowned Parakeet foster parents from eggs removed from the nest of a pair of Orange-fronted Parakeets in the wild.

The first matings of two male orange-fronted birds with yellow-crowned females, of long-standing aviary stock, produced offspring that were all morphologically indistinguishable from Yellow-crowned Parakeets. This was strong evidence that one species only was involved because, when two morphologically and genetically distinct populations are crossed, the F1 offspring should show mixed characteristics sufficient for them to be recognisable as hybrids (Short 1969).

Genetic model

As well as supporting the colour-morph theory, the results of this initial cross-breeding suggested a further hypothesis: that the polymorphism follows the simple Mendelian theory of dominant/recessive inheritance at a single locus, the factor for yellow-crowned being dominant over the factor for orange-fronted.

The Mendelian theory of assortment at a single locus, applied to these parakeets, assumes that each egg or sperm contains a single factor linked to plumage pigmentation. As the factor for yellow-crowned birds is presumed to be dominant it is designated here by a capital Y and that for orange-fronted by a small o. An individual bird (zygote) formed by the union of sperm and egg contains two such factors, and its genetic constitution (genotype) may be Y/Y (homozygous for yellow), Y/o (heterozygous) or o/o (homozygous for orange). When Y is dominant over o, individuals that contain at least one Y factor will have the appearance (phenotype) of Yellow-crowned Parakeets, while those that contain no Y factor will be orange-fronted.

This hypothesis is illustrated in Fig. 1. It predicts the following events:

- (a) If two yellow-crowned birds from New Zealand's long-established aviary lineage are mated, they will breed true and the offspring will be yellow-crowned.
- (b) If two orange-fronted birds are mated, they will also breed true.
- (c) If an orange-fronted bird is crossed with a yellow-crowned bird from stock that has bred true for many generations, the first generation offspring (F1) will all be yellow-crowned.
- (d) If two of these F1 birds are mated together, both yellow-crowned and orange-fronted birds will be produced in approximate proportions of three yellow-crowned to one orange-fronted — the familiar Mendelian 3:1 ratio.
- (e) If the yellow-crowned birds from the F1 generation are crossed back to their parental yellow-crowned stock, the offspring will all be yellow-crowned.
- (f) If the yellow-crowned birds from the F1 generation are crossed back to orange-fronted, they will have yellow-crowned and orange-fronted young in about equal numbers.

Observed results

In the aviaries, birds have been paired to give all possible combinations of crossings between the three inferred genotypes (Y/Y, Y/o and o/o). Many pairs, including two of Orange-fronted Parakeets, have yet to breed, but some information is now available on the phenotypes of young produced by examples of all combinations. The data are as follows:

- (a) "A century's experience (more or less) of aviary breeding of *C. auriceps*" in New Zealand has produced only yellow-crowned chicks (Fleming 1980).
- (b) One brood resulting from an orange-fronted x orange-fronted mating in the wild produced three orange-fronted chicks.
- (c) Three broods resulting from orange-fronted x domestic yellow-crowned matings produced 11 yellow-crowned (F1) chicks.
- (d) Six broods resulting from F1 x F1 matings produced 18 yellow-crowned and 4 orange-fronted chicks.

- (e) One brood resulting from an F1 yellow-crowned x domestic yellow-crowned mating produced 3 yellow-crowned chicks.
 (f) Six broods resulting from orange-fronted x F1 yellow-crowned matings produced 13 yellow-crowned and 8 orange-fronted chicks.

Table 1 compares these results with those expected from the Mendelian theory of inheritance at a single locus. In all possible combinations of crossings, the observed frequencies of yellow-crowned and orange-fronted offspring provide a good fit with those expected.

CONCLUSION

The findings from cross-breeding Orange-fronted Parakeets with Yellow-crowned Parakeets are totally at variance with the argument that the orange-fronted birds are a distinct species. Not only are the F1 offspring indistinguishable from Yellow-crowned Parakeets, but also dimorphic phenotypes are produced from some backcrosses and in the F2 generation. In contrast, first-generation hybrids and intergrades (F2 or backcrosses) from the interbreeding of two distinct populations always show mixed characteristics, never dimorphism (Huxley 1964, Short 1969, Taylor 1975).

The parent-offspring data now available are, however, in complete agreement with the suggestion of Holyoak (1974) that the two forms are colour morphs of a single species. The data also provide a close fit with the hypothesis that the polymorphism follows the simple Mendelian theory of dominant/recessive inheritance controlled at a single genetic locus, the factor for yellow-crowned being dominant.

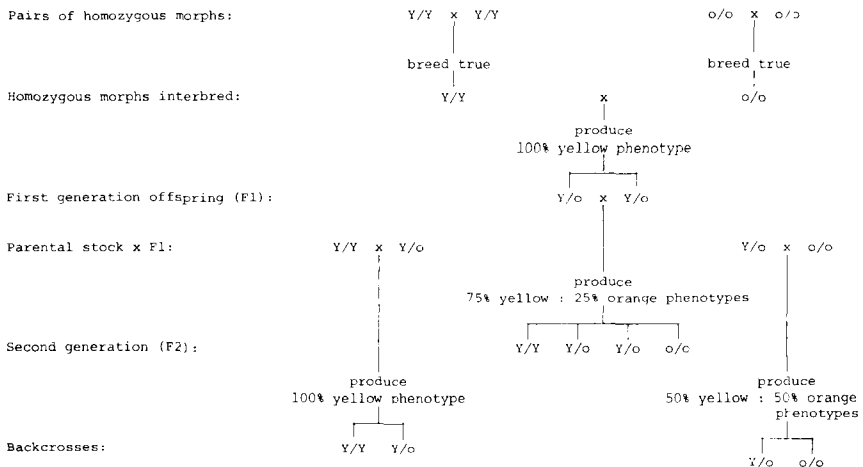


FIGURE 1 — Hypothetical model applying Mendel's theory of dominant/recessive inheritance at a single locus to the question of polymorphism in Yellow-crowned Parakeets. Y = yellow-crowned factor (dominant), o = orange-fronted factor (recessive)

TABLE 1 — Expected and observed frequency of yellow-crowned and orange-fronted offspring from various mating combinations (see text)

Forms crossed	Parents		Offspring frequencies						
	Inferred genetic factors	Genotype (%)	Expected		Observed		N		
			Yo	Yy	orange	yellow		orange	yellow
a) domestic yellow-crowned x domestic yellow-crowned	Yy x Yy	0	0	100	0	100	100	0	100
b) orange-fronted x orange-fronted	yy x yy	100	0	0	100	0	3	100	0
c) orange-fronted x domestic yellow-crowned	yy x Yy	0	100	0	0	100	11	0	100
d) F1 crossbred yellow-crowned x F1 crossbred yellow-crowned	Yy x Yy	25	50	25	25	75	22	18	82
e) F1 crossbred yellow-crowned x domestic yellow-crowned	Yy x Yy	0	50	50	0	100	3	0	100
f) orange-fronted x F1 crossbred yellow-crowned	yy x Yy	50	50	0	50	50	21	38	62

The combined findings of Holyoak (1974), Nixon (1981) and the present study clearly demonstrate that Orange-fronted Parakeets and Yellow-crowned Parakeets are colour morphs of one species. Consequently, *Cyanoramphus malherbi* (Souance 1857) should be deleted from the list of New Zealand birds and be relegated to synonymy with *C. auriceps* (Kuhl 1820).

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FOOD OF THE KINGFISHER (*Halcyon sancta*) DURING NESTING

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ABSTRACT

Food of Kingfishers in forest in the Orongorongo Valley, near Wellington, was identified from remains in pellets ejected by nestlings at four nests and from pellets and droppings of birds caught in mist-nets. Food items included a wide variety of invertebrates, with cicadas, dragonflies and chafers especially important. Lizards, small birds and mice were also important. The lizards identified were the forest gecko and common skink, and the small birds were the Rifleman, Grey Warbler and Silvereye.

Kingfishers were absent from the study area from June to September; it is suggested that the seasonal movements of Kingfishers are related to changes in the availability of food.

INTRODUCTION

The Sacred Kingfisher (*Halcyon sancta*) belongs to the subfamily Daceloninae, whose members are mostly generalised predators of small animals, taking a wide range of generally slow-moving or stationary invertebrates and small vertebrates from land or water (Fry 1980). *H. sancta* breeds in New Zealand and Australia, Norfolk Island, Lord Howe Island, New Caledonia, and the Loyalty Islands (Falla *et al.* 1979). Southern Australian birds (*H. s. sancta*) are migratory, wintering in northern Australia and islands to the north, in an area from the Solomon Islands in the east and Sumatra in the west to the southern Philippines in the north (Peters 1945). There is no clear evidence that birds of the New Zealand subspecies (*H. s. vagans*) migrate, but seasonal changes in the numbers of Kingfishers in some parts of New Zealand indicate that birds move from higher altitudes to winter in lowland and coastal habitats (Taylor 1966). The concentration of Kingfishers in the northern North Island in winter has been interpreted by Ralph & Ralph (1977) as evidence that some birds also move northward to winter there.

Taylor (1966) suggested that the seasonal movements of Kingfishers were responses to changes in the availability of food rather than directly to changes in temperature. However, until recently our knowledge of the food habits of New Zealand Kingfishers has been largely restricted to general descriptions or brief anecdotes. Oliver (1955) listed mice, small birds, lizards, fish, larger insects (crickets, grasshoppers, dragonflies and cicadas), freshwater crayfish, and crabs; Falla *et al.* (1979) noted "worms, insects and spiders, crabs and other crustaceans, shellfish, small fish, tadpoles, lizards, mice and occasionally small birds, even ducklings". Photographic studies (e.g. Moon 1979) well illustrate the range of foods taken. O'Donnell's (1981) observations on the food of Kingfishers include prey he identified from 14 pellets ejected by nestlings.

We have identified prey remains from pellets collected below four Kingfisher nests and from pellets and droppings of birds caught in mist-nets in forest of the Orongorongo Valley near Wellington. We were also able to relate food habits to seasonal changes in availability of prey and the seasonal movements of Kingfishers.

STUDY AREA

The Orongorongo Valley (41°21'S, 174°58'E) is a steep-sided forested valley on the western slope of the Rimutaka Range, 18 km east of Wellington. The lower slopes in the vicinity of the DSIR field station (120 m a.s.l.) have hard beech (*Nothofagus truncata*) forest on the ridges and rata-podocarp-broadleaf forest on the terraces (Campbell 1984). The climate is temperate; average annual rainfall for 18 years was 2420 mm, the wettest month (July) receiving about 2½ times as much rain as the driest (November) (Moed & Fitzgerald 1982). Mean monthly temperatures at Kelburn in Wellington vary from 16.4 °C in February to 8.1 °C in July (NZ Meteorological Service 1973).

The Orongorongo River flows over an unstable shingle bed and frequently changes its course; its larger pools and backwaters contain eels (*Anguilla* spp.) and brown trout (*Salmo trutta*). Side streams, often with the forest canopy closed over them, are more stable and have eleotrid and galaxiid fish and freshwater crayfish (*Paranephrops planifrons*) present.

Two species of gecko, the forest gecko (*Hoplodactylus granulatus*) and the green gecko (*Naultinus elegans*) are recorded in the research area and another species, the common gecko (*H. maculatus*), a few kilometres to the south. Of ten shed gecko skins collected in the research area since 1968 eight were from forest geckos and two from green geckos. Two species of skink have been recorded in the research area — the common skink (*Leiopisma nigriplantare*) is a diurnal species found in open places, and the copper skink (*Cyclodina aenea*) is a nocturnal bush dweller.

Common small birds (less than 20 g in weight) that might be preyed on by Kingfishers in the Orongorongo Valley are the Rifleman (*Acanthisitta chloris*), Whitehead (*Mohoua albicilla*), Grey Warbler (*Gerygone igata*), Fantail (*Rhipidura fuliginosa*), Tomtit (*Petroica macrocephala*) and Silvereye (*Zosterops lateralis*) (Robertson *et al.* 1983).

House mice (*Mus musculus*) are present in numbers that vary greatly from year to year (Fitzgerald 1978). Although mainly nocturnal, they are sometimes seen during the day.

METHODS

Pellets and prey remains were collected from beneath Kingfisher nest-holes in dead trees. A few pellets were intact but most were in pieces. At one nest used in two successive years we attached scrim around the base of the tree to catch the pellets, but at the other two nests we collected material from the ground after the chicks had fledged.

We identified prey by comparing the fragments from the pellets with specimens in the reference collections of Ecology Division, DSIR. Individuals were counted from the numbers of the most common distinctive fragments, e.g. head capsules, elytra, bones, or teeth. Numbers and species of lizards were identified from frontal, maxilla and dentary bones.

Information on seasonal changes in the abundance of prey species was taken from several sources. During intensive studies of invertebrates by A. Moeed and MJM, some prey species have been recorded from tree-trunk traps (Moeed & Meads 1983) and pitfall traps (Moeed & Meads 1985). A file of casual observations by staff and visitors at the DSIR Orongorongo field station yielded additional information for some species.

The file also provided some records of when Kingfishers were present in the area, but most information on the seasonal abundance of Kingfishers came from regular monthly mist-netting and banding of birds from 1969 to 1976 at seven mist-net rigs by AHW and BMF. Each rig consisted of six nets one above another that formed a continuous curtain of net from 1.5 m above the ground to 13.5 m in the forest canopy (Whitaker 1972, Robertson *et al.* 1983). From 1974 to 1976, faeces and pellets were collected from mist-netted birds and then treated as described by Moeed & Fitzgerald (1982).

RESULTS

A nest with young calling loudly was found about 15 m up a dead beech tree in hard beech forest on 26 January 1972; a Kingfisher was seen carrying a lizard to the nest. When the nest was visited again on 22 February the young had gone but pellets and remains of prey were collected on the ground below the nest-hole.

In December 1973, Kingfishers were active around a dead rimu (*Dacrydium cupressinum*) near the Field Station. Three fresh Kingfisher eggshells found on the ground below the nest-hole in the rimu on 22, 23 and 24 January 1974 indicated that the chicks had just hatched. An adult was seen carrying food to the nest on 23 January 1974. We attached scrim to the base of the tree on 26 January and collected pellets until 19 February 1974.

In October 1974, Kingfishers were again active around the dead rimu, and on 6 November a Kingfisher was observed at the previous year's nest-hole. On 16 December, a broken eggshell (not from a hatched egg) was found beneath the nest. Although this nesting attempt apparently failed the birds must have relaid because on 19 February 1975 pellets were found on the scrim and further material was collected until 24 February.

On 23 January 1982, a Kingfisher was observed feeding young at a nest in the dead top of a hard beech tree on the bank of the Orongorongo River. Pellets, mainly in fragments, were collected below this nest on 11 February, after the young had fledged.

A wide variety of prey was identified in the pellets from these four nests (Table 1). Large insects were particularly common, especially chorus cicadas (*Amphipsalta zelandica*), giant dragonflies (*Uropetala carovei*) and mumu chafers (*Stethaspis longicornis*). Beetles were well represented by at least 20 species from seven families. Vertebrates (lizards, small birds and mice) were mainly recorded in the 1972 nest; eight of the nine geckos were confirmed as forest geckos and two of the three skinks as *Leiopisma* sp.. In the 1974 nest material, one of the four skinks was confirmed as *Leiopisma* sp.; the other lizards could not be identified beyond family. The birds recorded were five Riflemen, two Grey Warblers and a Silvereye.

TABLE 1 — Prey identified from pellets ejected by nestling Kingfishers at four nests

	Approx. length (mm)	1972	1974	1975	1982	Total
Insecta						
Odonata						
<u>Procordulia smithii</u>	90			1		1
<u>Uropetala carovei</u>	88	28	11	27	11	77
Blattodea						
<u>Parellipsidion sp.</u>	14		1			1
Orthoptera						
Stenopelmatidae						
<u>Hemideina crassidens</u>	45	2	1	2		5
Phasmatodea						
Phasmatidae						
<u>Acanthoxyla sp.</u>	90		2	7	1	10
Hemiptera						
Cicadidae						
<u>Amphipsalta zelandica</u>	27	6	133	142	32	313
<u>Kikihia scutellaris</u>	18		5			5
<u>Kikihia sp.</u>		1	8			9
Coleoptera						
Carabidae						
<u>Holcaspis vagepunctata</u>	17		1			1
<u>Mecodema simplex</u>	28	6				6
<u>Megadromus vigil</u>	20	13		2		15
<u>Plocamostethus planiusculus</u>	26	22		2		24
indet. spp.			8	2		10
Lucanidae						
<u>Dorcus novaezealandiae</u>	18	2				2
<u>Lissotes reticulatus</u>	17	21	2		3	26
Scarabaeidae						
<u>Odontria magnum</u>	17	5	1			6
<u>Odontria piciceps</u>	14				1	1
<u>Pyronota festiva</u>	10		1			1
<u>Stethaspis longicornis</u>	21	2	7	28	8	45
Elaeteridae						
<u>Corymbites megops</u>	21	1				1
<u>Geranus lineicollis</u>	15	1				1
<u>Ochrosternus zealandicus</u>	18	2				2
<u>Thoramus foveolatus</u>	20	3				3
<u>Thoramus wakefieldi</u>	30	1				1
Tenebrionidae						
<u>Artystona erichsoni</u>	12	1				1
<u>Uloma tenebrionoides</u>	13	1				1
Cerambycidae						
<u>Hexatricha pulverulenta</u>	17	7				7
Curculionidae						
<u>Platyomida hochstetteri</u>	13				1	1
<u>Psepholax barbifrons</u>	8	1				1

TABLE 1 — continued

	Approx. length (mm)	1972	1974	1975	1982	Total
Diptera						
Tabanidae						
<u>Dasybasis opla</u>	14		1			1
<u>Dasybasis transversa</u>	11		1			1
<u>Scaptia adrei</u>	15		1			1
Lepidoptera						
Hepialidae						
<u>Trioxycanus enysii</u>	38		1			1
indet. sp.				1		1
Hymenoptera						
Ichneumonidae						
<u>Certonotus fractinervis</u>	31	2				2
Pompilidae						
<u>Salius monachus</u>	22		1			1
<u>Salius wakefieldi</u>	20		1			1
Colletidae						
<u>Apis mellifera</u>	15		7			7
Arachnida						
Araneida						
Dipluridae						
<u>Porrhothele antipodiana</u>	37	3	1			4
Araneidae						
indet. spp.			1	7		8
Agelenidae						
<u>Cambridgea foliata</u>	30	1	4		3	8
Crustacea						
Decapoda						
Cambaridae						
<u>Paraneoprops planifrons</u>	>40	4	1			5
Oligochaeta						
Terricolae						
indet. sp.			1+			1+
Vertebrata						
Reptilia						
Gekkonidae						
<u>Hoplodactylus granulatus</u>		8				8
indet. sp.		1	1	1		3
Scincidae						
<u>Leiopisma</u> sp.		2	1			3
indet. sp.		1	3			4
Aves						
<u>Acanthisitta chloris</u>		5				5
<u>Gerygone igata</u>		2				2
<u>Zosterops lateralis</u>		1				1
Mammalia						
<u>Mus musculus</u>		7		1		8

The invertebrates varied greatly in length, from some species of less than 10 mm to others of 90 mm (Table 1, Fig. 1), the modal size category of species being 10-20 mm. However, most individuals taken were of species somewhat longer than 20 mm, their modal size category being 20-30 mm.

Although invertebrates formed a high percentage of the individual prey identified, if biomass of prey is considered the few vertebrates taken were important as they represented 46% of the weight of prey consumed (Table 2).

A pellet regurgitated by a bird mist-netted on 21 November 1974 contained remains of four beetles: one *Hexatricha pulverulenta* (Cerambycidae), one *Metablax acutipennis* (Elateridae) and two *Lissotes reticulatus* (Lucanidae).

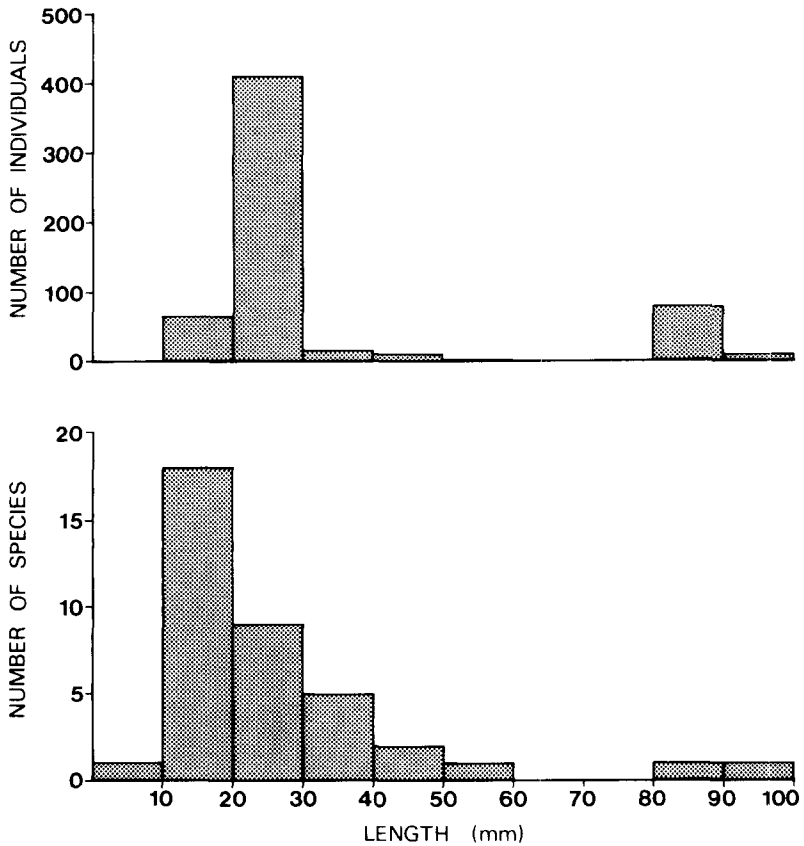


FIGURE 1 — Size distribution of prey by species and number of individuals for all nests combined

TABLE 2 — Numbers and weights of the main groups of prey and the biomass of each. Estimates of the weights of prey species are taken from Fitzgerald & Karl (1979) and Robertson *et al.* (1983). The weight for Silvereye is the average January-February weight (BMF, H. A. Robertson & AHW, unpubl. data).

	No.	Wt (g)	Biomass (g)
<u>A. zelandica</u>	313	0.68	212.8
<u>Uropetala</u>	77	1.00	77.0
<u>Stethaspis</u>	45	0.65	29.2
Weta	5	1.67	8.3
Other insects	153	0.25	38.2
Spider	20	0.50	10.0
Freshwater crayfish	5	10.00	50.0
Lizard	18	10.0	180.0
Rifleman	5	7.0	35.0
Grey Warbler	2	6.4	12.8
Silvereye	1	12.0	12.0
Mouse	8	15.5	124.0
Total invertebrate			425.7
Total vertebrate			363.8
Overall total			789.5

A pellet from a bird caught on 19 February 1975 contained remains of at least three cicadas. Most of these species were also recorded from material at nests.

Seven droppings from Kingfishers caught in mist-nets contained finely fragmented material which was more difficult to identify than remains in pellets. All four droppings collected in October and November contained scales from Lepidoptera, whereas single droppings collected in December, February and March did not. Those in February and March contained fragments of cicada.

The large insects that are important in the diet are all seasonal species recorded from late spring to autumn. Chorus cicadas are recorded in the Orongorongo Valley from the end of November to May; Moed & Meads (1983) collected them in trunk traps from January to April with peak numbers

in February. The smaller cicada *Kikihia scutellaris* has a slightly later peak. Giant dragonflies are recorded from late October to mid-April. The giant dragonfly and chorus cicada are frequently eaten by feral cats in the Orongorongo Valley, and they were found in cat droppings from December to April and November to April respectively with peak numbers in February and March (Fitzgerald & Karl 1979). Mumu chafers have been recorded from December to March but were caught in mist-nets only in December, January and February, with highest numbers in January.

DISCUSSION

Large invertebrates were important foods for nestling Kingfishers in the Orongorongo Valley, and some of the same species or genera were recorded by O'Donnell (1981) in pellets from a nest near Taumarunui. This indicates that our results are probably representative of the diet of Kingfishers in forest. Vertebrates, although comprising only a small proportion of the number of animals caught, were so much larger than the invertebrates that they too were important prey.

The predominance of geckos rather than skinks in the diet is noteworthy. References to Kingfishers preying on lizards have been compiled by AHW as part of a bibliography of New Zealand lizards (AHW, unpublished); of 20 records that identified the prey to family, 19 were of skinks and one of a gecko. This contrasts with 7 skinks and 11 geckos from the Kingfisher nests in the Orongorongo Valley.

The foods from the 1972 nest differed somewhat from those from the other nests, having more vertebrates, many more species of beetles, but far fewer cicadas. These differences may reflect differences in the availability of prey between years, differences between habitats (only the 1972 nest was in extensive hard beech forest), or different hunting techniques or preferences by individual birds. Remains of mice were most frequent in the 1972 nest, and mice were more common in the forest then than in 1974, 1975 or 1982 (Fitzgerald 1978, BMF and B.J. Karl, unpubl. data).

The high proportion of droppings containing Lepidoptera compared with only two moths among the insects in the pellets may indicate seasonal differences in diet rather than a bias in the method, as droppings with Lepidoptera were collected in October and November — earlier than any of the pellets. Seasonal changes in the diet of Kingfishers were also noted by Guthrie-Smith (1927 p.63) at Lake Tutira; the first broods in December were fed lizards and the second broods in February, dragonflies.

In forest, Kingfishers probably capture much of their food in the forest canopy. In our mist-netting, Kingfishers were caught mainly in the two uppermost nets of the rigs, in or near the canopy; 79% of 56 birds were caught there and only 4% in the bottom two nets (AHW & BMF, unpubl. data). Stead (1932) described Kingfishers catching insects from flowering shrubs by taking the insect in passing or by diving straight on to the foliage, "stopping themselves from penetrating too far by keeping their wings spread".

Kingfishers are absent from the research area in winter and return in September. The earliest bird of the season was recorded on 15 September, although birds were not caught in the mist-nests until October, and no birds

were caught in the mist-nets after June. The only direct evidence that Kingfishers move away from the Orongorongo Valley is a bird mist-netted there on 19 December 1975 that was recovered dead on 25 April 1976 at Seatoun, Wellington Harbour, 11 km away. Of 27 Kingfishers banded in the Orongorongo Valley, five were recaptured in the following breeding season, presumably having moved out of the area for the winter and returned. Birds probably move out of the Orongorongo Valley for winter because large invertebrate prey that are active by day are scarce in the forest then and geckos and skinks are likely to be torpid.

Taylor (1966) interpreted his counts of Kingfishers as showing movement of birds from higher altitudes to lower altitudes and coastal habitats for the winter. Ralph & Ralph (1977) recorded the numbers of Kingfishers in winter through parts of New Zealand from the Bay of Plenty and East Coast to Canterbury and found them to be most common in the northern half of the North Island, at low altitudes, and in open habitats. They suggested that Kingfishers may be partially migratory, many birds moving to northern parts of New Zealand for the winter, but their results need to be compared with ones in other seasons. Records of Kingfishers in the *Atlas of Bird Distribution* (Bull *et al.* 1985), made throughout the year but especially in spring, show that Kingfishers are common in the North Island and scarce in the South Island. This pattern would be less clear if many birds wintering in the north returned to southern parts of the South Island in spring.

Our findings support the suggestion by Taylor (1966) that the seasonal movements of Kingfishers are largely determined by changes in their food supplies. Over the area in which Taylor made his counts most Kingfishers moving out of forest into other habitats where food is more plentiful in winter are also likely to be moving to lower altitudes. As the DSIR field station in the Orongorongo Valley is only 120 m above sea level, the Kingfishers moving out of the valley for the winter are shifting to other habitats rather than to substantially lower altitudes. This indicates that seasonal movements are primarily between habitats and only secondarily between altitudes.

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We are indebted to many people working at the Orongorongo Valley field station who contributed records to various facets of this study; especially P.D. Gaze and B.J. Karl, who helped with mist-netting, G.D. Ward, who collected pellets, and J.A. Gibb, who found the 1982 nest. We also thank Trevor Worthy for identifying the lizard bones, H.A. Robertson and R.H. Taylor for comments on the manuscript, and A.D. Pritchard for editorial assistance.

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SHORT NOTE

Emendation of the name of the fossil rail *Rallus hodgeni* Scarlett

An extinct species of flightless rail now known to have been widely distributed in the North and South Islands of New Zealand was originally described from postcranial elements from Pyramid Valley Swamp as *Rallus hodgeni* by Scarlett (1955). It was placed in various genera (see synonymy in Olson 1977) until specimens of skulls and mandibles showed that it belonged with the "*Tribonyx*" group of gallinules in the genus *Gallinula* (Olson 1975).

In the original description, Scarlett (1955:266) named the species "after Messrs J. and R. Hodgen, owners of Pyramid Valley swamp." Species-group names formed from personal names are to be formed in accordance with the rules of Latin grammar (ICZN 1985: Article 31a). Hence, because the species was clearly dedicated to more than one person, the genitive ending must be plural and *hodgeni* must be regarded as an incorrect original spelling (see the example given with ICZN Article 31c, which deals with a nearly identical case). Therefore, Scarlett's name should be emended to *Rallus hodgenorum* and the species should henceforth be known as: *Gallinula hodgenorum* (Scarlett).

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MORPHOLOGY AND HEAD COLOUR IN THE YELLOWHEAD

By JAMES B. CUNNINGHAM and R. N. HOLDAWAY

Soper (1972) and Falla *et al.* (1966, 1979) have implied that Yellowheads (*Mohoua ochrocephala*) can be sexed by differences in nape colour: canary yellow in adult males and yellow, shaded or tinged with olive-brown, in females and juveniles. Soper also suggested that the olive-brown markings are more extensive in young birds.

While examining study skins of Yellowheads in the Canterbury Museum collection, we noted that some birds labelled as females lacked olive-brown markings on their napes. If they were labelled correctly, nape colour may not be a consistently reliable means of sexing Yellowheads. As is usual for older skins, sex was not noted on many labels; someone had altered the sex on one label, presumably because of nape colour.

Cunningham (1984) showed that male Brown Creepers (*Finschia novaeseelandiae*) are larger than females, and Robertson *et al.* (1983) suggested that the same is true for the Whitehead (*Mohoua albicilla*). As these two species are considered to be closely related to the Yellowhead, male and female Yellowheads may also differ in size.

To determine whether the method of sexing Yellowheads proposed by Falla *et al.* (1966, 1979) can be used with confidence, we studied the relationship between size and nape colour in museum specimens.

METHODS

We examined 45 study skins (22 from the Canterbury Museum, Christchurch; 15 from the Auckland Institute and Museum, Auckland; and 8 from the National Museum of New Zealand, Wellington) and classified each as having a 'yellow' or 'brown' nape. 'Yellow-naped' birds had a yellow crown and some brown edging on the otherwise yellow nape feathers (as shown in the plate in Falla *et al.* 1966, but not in that in Falla *et al.* 1979). 'Brown-naped' birds had brown feathers on the nape and up on to the crown. All specimens we examined were placed in one of the two groups; a few birds (some of which were labelled as juveniles) had brown lines which ran along the feather rachis and joined with the brown tip.

After classifying each specimen by colour, JBC took the following measurements: bill length (chord of exposed culmen), bill depth (at base of exposed culmen), bill width (at base of exposed culmen), length of tarsometatarsus (from tibio-tarsal joint to anterior edge of last complete tarsal scale), and wing length (unstraightened chord of the flattened wing from carpal flexure to tip of longest primary).

We also examined rectrice wear on the 22 Canterbury Museum birds to establish the approximate timing of their moult. RNH examined (binocular microscope, 25X magnification) those specimens with collection dates for pigment distribution and wear on crown and nape feathers.

In this study, we have assumed that the original labels were correct.

RESULTS AND DISCUSSION

All measurements (means \pm 1SD) are given in Table 1. We found no significant differences between yellow-naped and brown-naped birds for any of the characters measured (t-test, $p > 0.05$) and the groups had similar variances (F-test, $p > 0.05$).

TABLE 1 — Measurements (mm) of 'yellow-naped' and 'brown-naped' Yellowheads. (Mean \pm 1SD).

	Bill			Tarsus	Wing
	Length	Depth	Width	Length	Length
Yellow-naped	11.5 \pm 0.63	5.1 \pm 0.35	5.2 \pm 0.28	25.2 \pm 0.84	79.2 \pm 2.55
Number	20	18	19	22	21
Brown-naped	11.0 \pm 0.75	4.9 \pm 0.36	5.3 \pm 0.38	25.4 \pm 0.98	77.7 \pm 2.94
Number	22	22	23	21	18

If, as Falla *et al.* suggested, birds with yellow napes are males and those with brown napes are females or juveniles, and if male Yellowheads are larger than females, the two colour 'forms' should differ in size. Our measurements did not support this prediction.

We subjected the data to principal component analysis (PCA) as a more sensitive test to see if there were any size groupings and if such groups were correlated with nape colour. In PCA, the original measurements are transformed into independent linear combinations (principal components) of the variables measured. The first linear combination is so constructed that it describes the greatest possible proportion of the total variability. Each subsequent combination accounts for the largest proportion of the remaining variation.

The loadings of the five variables for the four principal components calculated are shown in Table 2. Most of the variation in principal component 1 was attributable to bill length and depth, tarsus length, and wing length. Most of the variation in principal component 2 was contributed by bill width.

The first two principal components are plotted in Figure 1. The data can be separated into two non-overlapping clusters of points. In one cluster there are large birds with 1st principal component scores greater than -0.75; the other consists of small birds with 1st component scores of less than -1.0. Yellow-naped and brown-naped birds occur in both clusters. If the larger birds were males and the smaller were females, these results would suggest that birds with yellow napes are not necessarily adult males.

Crown-feather pigmentation pattern

The rachis and barbs of all crown feathers are usually yellow; pigment intensity varies and some shafts may be almost white, particularly near their base. Most barbules along the length of each barb are also yellow, but near

the barb tip the barbules are olive-brown. These are seen in the whole feather as an olive-brown (here 'brown') tip. Examination of the few dated specimens indicates that the progressive yellowing of the crown and nape in adults may be caused by both the loss of the brown barbules and by the breaking of the barbs at a point proximal to the change in barbule colour. Feathers further down the nape have longer sequences of brown barbules, and the intensity of coloring therefore increases from the forehead to the nape. Wear may be more rapid and extensive immediately above the bill and on the crown as the bird forages and preens; this would give the effect of a progressively rearward change in head hue through autumn, winter and spring.

TABLE 2 — Loading of the five characters measured, for the four principal components calculated.

Character	Principal component			
	1	2	3	4
Bill length	0.824	0.231	0.331	-0.346
depth	0.891	-0.013	0.353	0.067
width	0.546	-0.831	-0.069	-0.033
Tarsus	0.718	0.170	-0.624	-0.242
Wing	0.821	0.187	-0.124	0.508

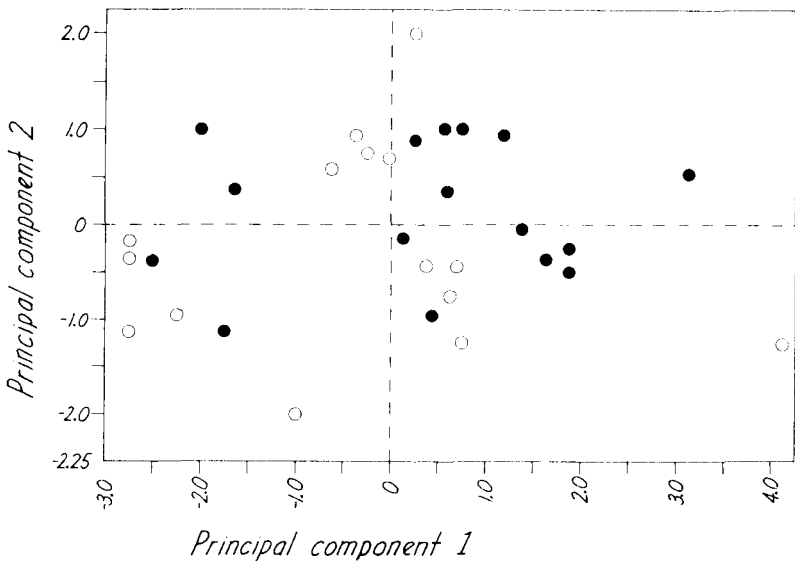


FIGURE 1 — Distribution of ordinate values for principal components 1 and 2. Open circles, brown-naped birds; closed circles, yellow-naped birds. Note broad segregation into two clusters.

Some skins, including those marked 'juvenile' in the Canterbury Museum, have another, very narrow, band of brown barbules right against the rachis (on each side), which appears as a central band joining the brown tip. These feathers occur up on to the crown and produce the most marked 'brown-naped' condition. They probably indicate a first-year bird, as one (CM AV. 1001) was taken on 24 July and another (CM AV. 1005) is dated 8 October, probably too early for a bird of the year.

Moult

If we assume that juveniles have brown napes, it appears that the 'brown-naped' plumage lasts at least until the breeding season after fledging, which agrees with Soper's observations. Yellowheads probably undergo a sequence of moults as follows (nomenclature from Humphrey & Parkes 1959): natal down (October-November-December), prejuvinal moult, juvenal plumage, first prebasic moult (January-February-March), first basic (immature) plumage, second prebasic moult (January-February-March), second basic (adult) plumage, and so on. The single moult is supported by the pattern of progressive wear, including shaft breakage, seen on dated skins.

More work is obviously necessary, preferably on live known-age birds in which the course of moult and changes in head colour can be followed through the year. The results presented here do, however, indicate that care is necessary in sexing Yellowheads (and other 'well-known' birds) by sight and in drawing behavioural and ecological conclusions from such decisions. For example, the "polygamy" noted by Soper (1972) may have been an instance of a juvenile (of either sex) helping at the nest, rather than another female mated to the male as Soper suggested.

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HABITAT USE AND SPRING MOVEMENTS OF NEW ZEALAND PIGEONS AT LAKE ROTOROA, NELSON LAKES NATIONAL PARK

By M.N. CLOUT, P.D. GAZE, J.R. HAY and B.J. KARL

ABSTRACT

Monthly counts of New Zealand Pigeons (*Hemiphaga novaeseelandiae*) in lakeside habitat at Lake Rotoroa (Nelson Lakes National Park) over 20 months showed that they were most abundant from June to September. Pigeons were seen to feed exclusively on fruits from February to May, but mainly on foliage from June to January, when kowhai (*Sophora microphylla*) leaves were the main food (96 of 126 observations). Kowhai leaf fall in October/November coincided with a marked drop in pigeon counts, which was possibly caused by birds leaving the area. Two pigeons captured while feeding in lakeside kowhai in June and August 1984 were fitted with radio transmitters. Both were initially sedentary, but they left the lakeside area in October/November 1984 and travelled at least 2.8 km and 11 km respectively, outside the National Park, to areas of silver beech (*Nothofagus menziesii*) forest at over 1100 m a.s.l. One of the radio-tracked birds nested unsuccessfully at this altitude, where it fed on strawberry fungus (*Cyttaria gunnii*) parasitising silver beech. Both radio-tracked birds returned to the kowhai at Lake Rotoroa in 1985 (by July and September respectively). The lakeside habitat may be an important overwintering area not only for local pigeons, but also for some which breed in forests outside the National Park.

INTRODUCTION

New Zealand Pigeons (*Hemiphaga novaeseelandiae*) are characteristic inhabitants of lowland forest throughout New Zealand and regular visitors to farmland and suburban gardens with nearby native forest. They eat the fruits, leaves, buds and flowers of a wide variety of plants (McEwan 1978), and probably play a major role in dispersing the seeds of large-fruited native trees.

Although New Zealand Pigeons are conspicuous, widely distributed birds and are of considerable ecological interest, their behaviour, movements and breeding biology remain little studied. They are generally regarded as being highly mobile, but this opinion is based only on casual observations and on seasonal fluctuations in the numbers of pigeons counted in native forest during general avifaunal studies (e.g. Dawson *et al.* 1978, Clout & Gaze 1984). These studies have shown that apparently fewer pigeons are in forests in late winter and spring, when there is an influx of birds to more open lowland habitats, such as farmland and riverbanks, where they feed on the leaves and buds of leguminous and deciduous plants. Long-distance movements can only be inferred from this sort of information; to confirm them and to find how far pigeons travel it is necessary to mark and follow individual birds.

In this study we investigated the seasonal use of lakeside habitat by New Zealand Pigeons and fitted radio transmitters to two birds to follow their movements.

STUDY AREA

Our study was conducted at Lake Rotoroa (455 m a.s.l.) in the Nelson Lakes National Park around the base of Mt Misery (41°56'S, 172°41'E) and the mouth of the D'Urville River at the southern end of the lake (Fig. 1). This end of Lake Rotoroa is the main focus of pigeon distribution within the Nelson Lakes National Park (D. Butler pers. comm.). The vegetation consists of a lakeside fringe of kowhai (*Sophora microphylla*), flax (*Phormium tenax*) and low shrubs, small areas of matai (*Prumnopitys taxifolia*)/kahikatea (*Dacrycarpus dacrydioides*) forest on river silts, and extensive sequences of beech (*Nothofagus* spp.)/podocarp and pure beech forest on the surrounding slopes.

METHODS

Transect counts: Previous surveys of the altitudinal distribution of bird species on Mt Misery over a 10-year period had revealed that pigeons occur there mainly in lakeside vegetation and beech/podocarp forest less than 5 m above lake level (R.H. Taylor, pers. comm.). On the basis of this information we established a transect for monthly counts of pigeons in lakeside vegetation, podocarp forest and beech/podocarp forest around the mouth of the D'Urville River and the base of Mt Misery. This transect (Fig. 1) comprised a 1.5 km stretch of lakeshore, a 300 m length of track passing through lakeside forest of matai, kahikatea and kowhai and a 1.3 km length of track passing through beech/podocarp forest and stream-bank vegetation.

From June 1983 to January 1985 we counted pigeons along the transect in mid-morning (0930-1100 NZST) and mid-afternoon (1430-1600) on at least one day at the end of each month. This usually involved two observers, each doing one morning and one afternoon count, for a total of four separate counts per month. The lakeshore part of the transect was observed from a motorboat cruising at 6 km/h about 15 m offshore. The forest tracks were traversed slowly on foot. For each pigeon seen, we recorded its location, activity and (where applicable) the trees species it was using.

Plant phenology: The phenology of 16 plant species which were known pigeon foods was recorded at the end of each month by noting the degree of leaf production, flowering and fruiting of six tagged plants of each species.

Radiotelemetry: Pigeons were captured in mist nets set among kowhai trees near the mouth of the D'Urville River. Two birds were each tagged with a coloured leg jesse of PVC-coated nylon (orange and pink respectively) and fitted with a radio transmitter. Each transmitter package weighed c. 19 g and was mounted on the bird's back by a nylon harness containing a cotton link which was designed eventually to abrade, rot or snap and so release the harness and transmitter from the bird. The transmitters were on different channels on the 160 MHz waveband and delivered pulsed signals which were received on AVM or 'Merlin' receivers via a collapsible three-element yagi antenna. The theoretical life of each transmitter was c. 6 months, with a 'line of sight' range of up to 10 km. Each bird carrying an active transmitter was located at least once per month and its position and behaviour were recorded.

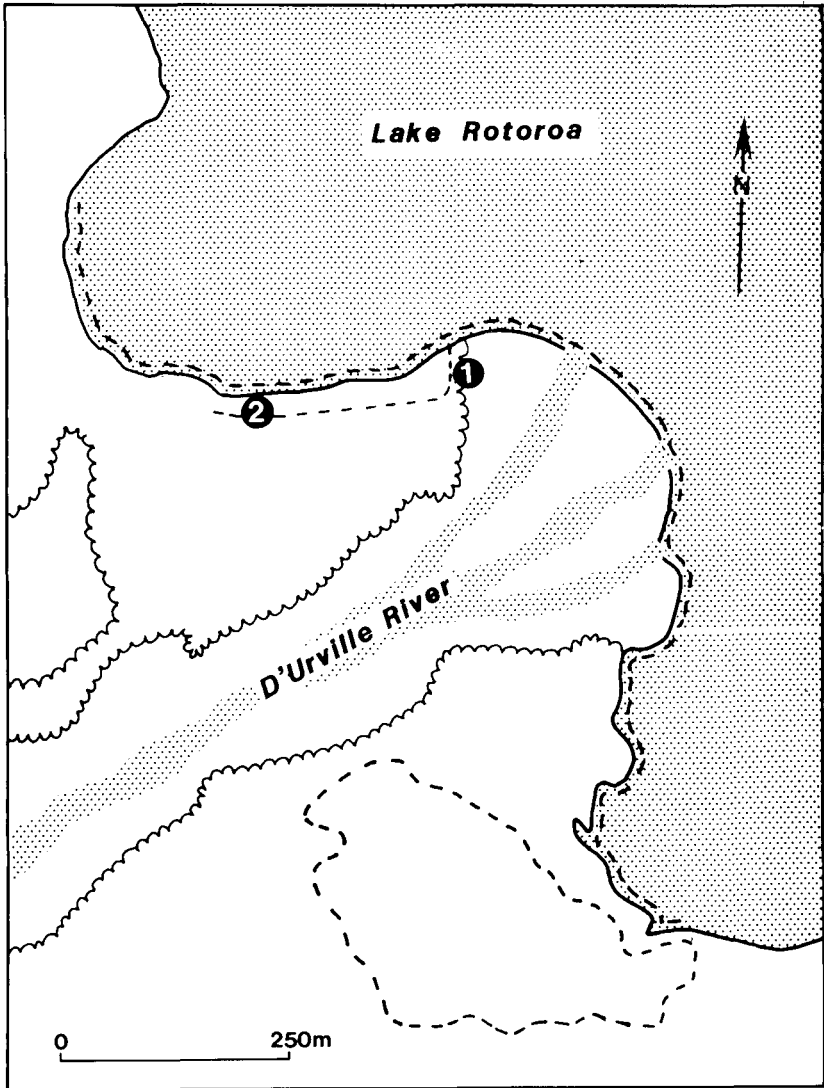


FIGURE 1 — The southern end of Lake Rotoroa, showing the study transect (dotted line) and capture sites of bird 1 (●) on 28 June 1984 and 26 October 1984 and bird 2 (●) on 28 August 1984.

RESULTS

Pigeon numbers and activity

The mean number of pigeons counted on the transect varied from 14.5 in June 1984 to 1.5 in November and December 1984 (Fig. 2). A marked seasonal pattern was evident, with transect counts being significantly higher from June to September than in other months (Mann-Whitney 'U' = 1314.5, $p < 0.005$). This pattern largely reflected the heavy use of kowhai by pigeons from winter to early spring.

Of the 423 separate observations of pigeons along the transect, 146 were of birds feeding. The diet revealed by these observations was exclusively fruits from February to May (23 observations) and almost exclusively leaves from June to January (123 observations). Foods seen to be eaten from February to May were fruits of *Fuchsia excorticata* (8 observations), *Coprosma rotundifolia* (4), *Pseudowintera colorata* (3), matai (3), *Carpodetus serratus* (2), *Prumnopitys ferruginea* (1), *Aristotelia serrata* (1), and *Griselinia littoralis* (1). Foods eaten from June to January were leaves of kowhai (96 observations), *Coprosma rotundifolia* (13), *Parsonsia heterophylla* (5) and *Clematis* sp. (1), together with kowhai leaf buds (5) and kowhai flowers (3), which were both eaten only in late September and October.

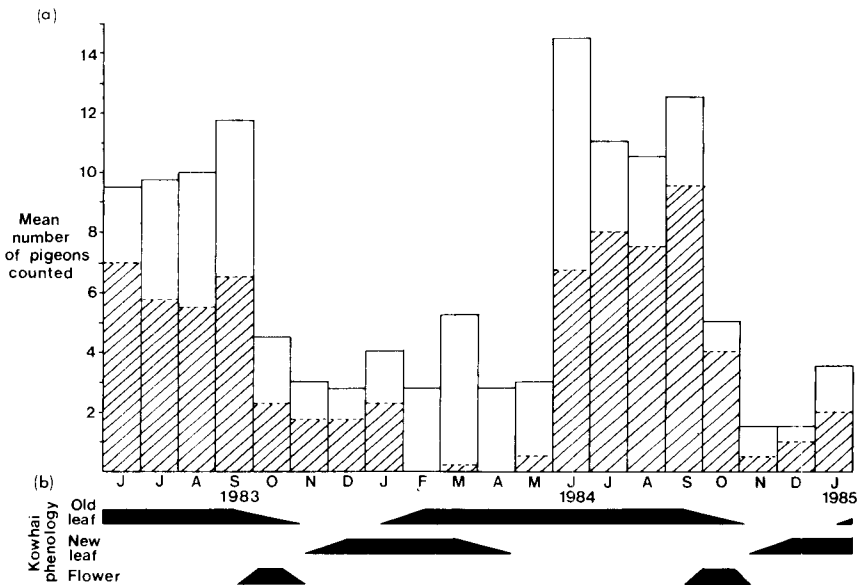


FIGURE 2 — (a) Mean number of pigeons counted in the study transect from June 1983 to January 1985. Hatched part of each column shows the proportion which were in Kowhai trees.

(b) The phenological state of Kowhai at Lake Rotoroa from June 1983 to January 1985, assessed from 6 tagged trees in the study area. Solid bar indicates presence of each phenological stage.

Pigeons were seen eating kowhai leaves in every month from June to January, apart from October, when kowhai feeding was restricted to flowers and leaf buds in both 1983 and 1984. This is a consequence of the phenological pattern of kowhai in the study area. By the end of October in both years, these trees had lost their old leaves and bore only leaf buds and flowers (Fig. 2). From June to September, pigeons fed on old kowhai leaves, whereas from November to January they consumed young newly expanded foliage. By February, the fruits of *Fuchsia excorticata*, *Aristolelia serrata* and *Coprosma rotundifolia* were available and the local pigeons apparently abandoned kowhai feeding for the rest of the fruiting season, returning to it in June.

Pigeon movements

The seasonal pattern of pigeon abundance on our study transect in 1983 suggested that some of the birds using the kowhai fringe from June to September left the area in October (or thereabouts). As a preliminary test of this hypothesis we fitted transmitters to two pigeons caught in the kowhai fringe on 28 June 1984 (bird 1) and 28 August 1984 (bird 2) (Fig. 1).

Bird 1 (orange jesse) weighed 560 g when caught, but its sex was unknown because New Zealand Pigeons cannot be sexed from plumage or measurements. It was radio tracked on 29 June, 11-13 July, 16 August, 25 August, 28-29 August, 11-13 September and 26-28 September 1984. On each occasion it was located within 50 m of its capture site at the mouth of the D'Urville River (Fig. 1). The bird was feeding mainly on kowhai leaves, but also took some *Parsonia heterophylla* foliage and (on 26-28 September) flower buds of kowhai. On 23 October 1984 the transmitter from bird 1 was found on the ground at the mouth of the D'Urville River, but the bird was seen c. 30 m away, feeding on kowhai flowers, in close association with another pigeon. It was recaptured in a mist-net on 26 October and fitted with a new transmitter. It then weighed 595 g, appeared very healthy and active, and was seen feeding on kowhai flowers about 2 h after release. Bird 1 was radio tracked and observed with another bird in the same localised area on 29-31 October (feeding on kowhai leaf buds), but on our next visit to the area (13-15 November) it had gone. A strong transmitter signal from the NE slopes of Mt Hutton (Fig. 3) on 14 November indicated that the bird had moved about 2 km from its previous location, but no sighting was made. On 29 November the transmitter from bird 1 was found detached and lying on the ground in silver beech (*Nothofagus menziesii*) forest at 1100 m a.s.l., about 1.5 km to the north of the summit of Mt Hutton (Fig. 3). The bird itself was not seen again until 30 July 1985, when it was feeding on kowhai leaves at the mouth of the D'Urville River, less than 30 m from its original capture site.

Bird 2 (pink jesse) weighed 680 g when caught on 28 August 1984 among lakeside kowhai, c. 250 m west of the D'Urville River mouth (Fig. 1). It was radio tracked and observed on 29 August, 11-13 September and 26-28 September 1984. On each of these occasions it was located in the same group of kowhai trees, within 20 m of its capture site. It was seen to feed on kowhai leaves and was always accompanied by another pigeon. On 23 October we again visited the study area, but could not find bird 2, although at a point high on Mt Misery we eventually detected its transmitter signal coming from the northwest of Lake Rotoroa. We subsequently discovered that the bird had

been seen at the northern end of the lake on 11 October 1984, feeding on willow (*Salix* sp.) foliage at the source of the Gowan River (Fig. 3) (J. Gould, pers. comm.). On 30 October, we returned to Lake Rotoroa to search for bird 2 and eventually found it at 1150 m a.s.l. in pure silver beech forest to the northwest of Lake Rotoroa, over 11 km from its capture site (Fig. 3). The bird was seen feeding on the expanding leaf buds of silver beech. When it was next located, on 14 November 1984, it was within 100 m of this feeding site, accompanied by another pigeon and building a nest in a silver beech tree on a steep eastern-facing slope. The surrounding habitat was a dense stand of pure silver beech with a sparse understorey. On our next visit to the area, 27-30 November, bird 2 and its mate were sharing incubation on the nest. Bird 2 was radio tracked when off the nest on the morning of 30 November and was seen to feed on young silver beech leaves and the fruiting bodies of strawberry fungus (*Cyttaria gunnii*). This fungus is restricted to silver beech, and its fruiting bodies were abundant on outer branches of many of the trees in the vicinity. The bird did not travel more than 200 m from the nest while being radio tracked.

We next radio tracked bird 2 on 17-18 December 1984 and once again found it near the nest site, accompanied by another pigeon and feeding on strawberry fungus. However, neither bird visited the nest itself, which was partly collapsed and had obviously been abandoned. We found no remains of an egg or a chick nor any sign of a predator at the nest site, and so the cause of the nest failure remains uncertain. Bird 2 made some long flights downslope from the nest area on 18 December, travelling at least 1.5 km on one occasion. On 8 January 1985 there was no signal from the transmitter on bird 2. We searched extensively around both ends of Lake Rotoroa but did not find the bird again until 13 September 1985, when it was seen (without its transmitter) in lakeside kowhai trees at the mouth of the D'Urville River, less than 20 m from where it had been captured the previous year.

DISCUSSION

This short term study shows the potential of radiotelemetry for studying the habitat requirements of large highly mobile birds such as New Zealand Pigeons. It also illustrates the value of combining this technique with the more conventional one of standardised counts.

Our transect counts (Fig. 2) and observations of feeding birds emphasise the likely importance of kowhai as a food source for New Zealand Pigeons in the Nelson Lakes region. Further evidence for this is that, at Lake Rotoiti (15 km east of Lake Rotoroa), kowhai does not occur naturally and New Zealand Pigeons are infrequent visitors only. Kowhai foliage was the main food of pigeons in our Lake Rotoroa study area from June to January and especially important from June to September when pigeon numbers were at their peak. The abrupt fall in pigeon abundance on our transect, which occurred in October of both years, coincided with the period when the kowhai trees were almost bare, before the growth of new leaves. It also coincided with the departure of our two radio-tracked birds from the lakeside habitat (bird 1 between 31 October and 13 November; bird 2 between 28 September and 11 October), which lends weight to the argument that the fall in numbers revealed by counts was caused by a real exodus of birds from the area.

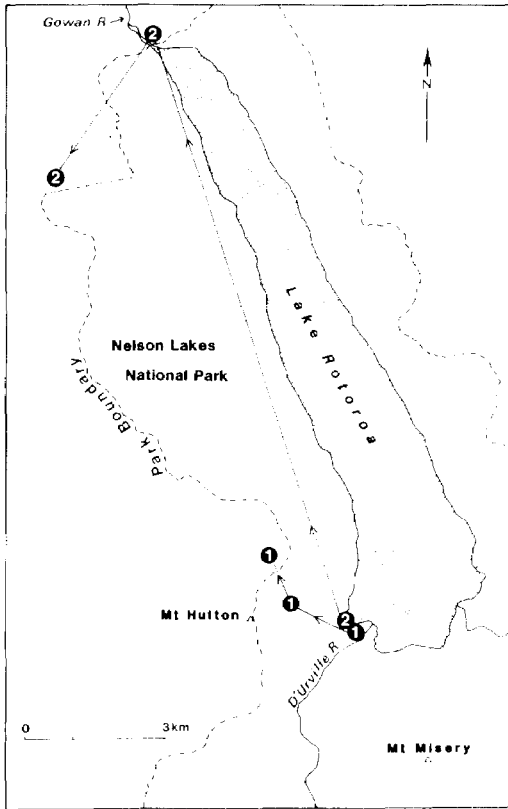


FIGURE 3 — The Lake Rotorua district, showing long-range movements of radio-tracked pigeons. ① = bird 1 between 31 October 1984 and 29 November 1984. ② = bird 2 between 28 September 1984 and 30 October 1984. Arrowed lines show the direction and sequence of movement.

Kowhai leaf fall in the spring may cause most pigeons to abandon these trees temporarily, but this should not by itself prompt them to travel over 11 km, as bird 2 did. Other likely factors prompting this movement were the onset of the breeding season and the availability of strawberry fungus in high-altitude silver beech stands at that time of year. Strawberry fungus has been recorded before as food of New Zealand Pigeons (McEwan 1978), but its

potential importance as a seasonal food of pigeons in beech forest has not previously been realised. We were surprised to discover bird 2 feeding in high-altitude beech forest, and even more surprised when it attempted to breed in this habitat, because New Zealand Pigeons are normally regarded as birds of lowland forest. However, the fact that the transmitter from bird 1 was shed in very similar habitat suggest that, in this region at least, the spring movement of pigeons to high-altitude silver beech forest may not be as unusual as we had thought. This view is further supported by data from the long-term study of the altitudinal distribution of birds on Mt Misery, where the only pigeons recorded above 650 m a.s.l. were two birds in high-altitude beech forest at 1150 and 1250 m a.s.l. on 22 November 1976 and 30 November 1977 respectively (R.H. Taylor, pers. comm.). In a more recent record from Mt Misery, a pigeon was seen in silver beech at 1150 m a.s.l. on 30 November 1983, feeding on strawberry fungus (B.W. Thomas, pers. comm.).

A few pigeons were present in the lakeside habitat throughout the summer and autumn, and so not all behaved like bird 2. At least some remained to breed locally, because on 8 January 1985 a newly fledged pigeon (with a dark bill and downy feathers on the head) was seen feeding on young kowhai foliage at the mouth of the D'Urville River. This young bird could fly only short distances and must therefore have been raised very close to where it was seen.

It is most likely that the long movements which we recorded for bird 2 and (less conclusively) for bird 1 represent abandonment of their winter feeding range and a return to their summer breeding range. For some pigeons these two ranges may be in the same local area, but for bird 2 (and possibly bird 1), they were widely separated. According to this interpretation of our results, the lakeside area at the head of Lake Rotoroa, with its kowhai trees and other foliage foods such as *Parsonia heterophylla* and *Coprosma rotundifolia*, may be vital winter habitat, not only for local pigeons, but also for some which breed many kilometres away. At least some of these latter birds use areas outside the current boundaries of the Nelson Lakes National Park. A larger sample of radio-telemetered pigeons would be necessary to find what proportion of the pigeons overwintering at Lake Rotoroa travel outside the park to breed.

ACKNOWLEDGEMENTS

We thank Cathy Pettigrew and Jacqueline Beggs for field assistance. Jocelyn Tilley for drafting, Tony Pritchard for editing, Hugh Robertson, Richard Sadleir and Rowley Taylor for constructive criticism, and Merle Rae for typing. We also acknowledge the co-operation of Nelson Lakes National Park staff in running our research programme at Lake Rotoroa.

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A METHOD OF AGEING THE TUI (*Prothemadera novaeseelandiae*) AND ITS USE IN ASSESSING BODY MEASUREMENTS

By D. J. ONLEY
(Received May 1984)

Ageing and moult

Adult TuIs have a narrow eighth primary*, with a notch out of the inner web, an adaptation which probably causes their loud whirring flight. While examining TuIs in the National Museum of New Zealand, I noticed that juvenile birds, with brown body plumage, do not have this notch on the eighth primary and that the feather is also wider. Figure 1 shows these differences and also illustrates the variation in the size and shape of the adult notch. Despite this variation, the differences between a juvenile and an adult primary were always easy to see. When I looked at all adult plumaged TuIs in the Auckland, Canterbury, Otago and National Museums, I found that 26 of the 132 birds lacked a notch on the eighth primary.

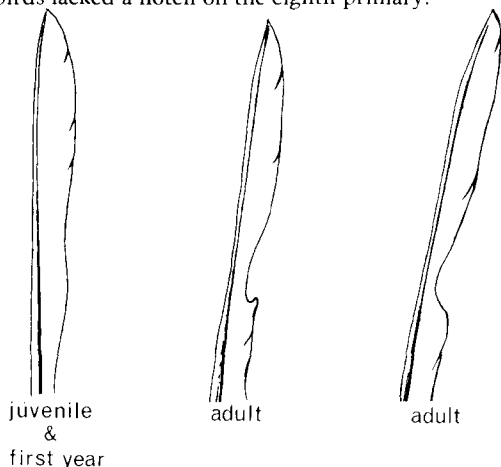


FIGURE 1 — Examples of the shape of the eighth primaries of TuIs

Most temperate passerine species undergo only a partial moult in their first autumn, replacing their juvenile body feathers and wing coverts but retaining their main flight and tail feathers (Ginn & Melville 1983). For example, in the male Blackbird (*Turdus merula*), the retained browner juvenile primaries stand out well against the glossy black adult body feathers. The two moulting juvenile TuIs in the museum collections were moulting their body feathers

*Primaries are numbered descendantly, that is, starting from the innermost.

only, suggesting that Tuis, like many other temperate passerines, retain their juvenile primaries until their second autumn, when they undergo a complete moult. The retention of these unnotched primaries allows us to recognise first-year Tuis throughout their first winter and summer, even though they are otherwise in adult plumage. I therefore concluded that the 26 adult-plumaged birds without wing-feather notches were first-year birds.

Enough moulting Tuis with dates are in the museum collections to show that birds moult mainly in February and March. Based on this information, supplemented by the occurrence of worn specimens in summer, fresh specimens in early winter and my own observations of live juvenile birds, Figure 2 summarises the Tui moult sequence and timing.

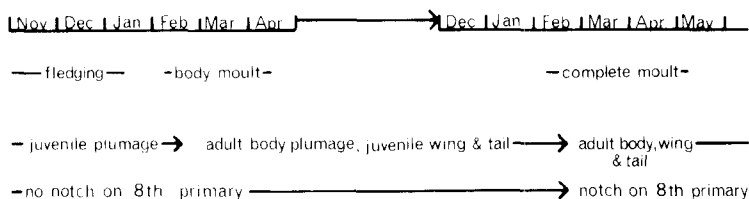


FIGURE 2 — Molt sequence of Tuis

Measurements

Measurements of Tuis are distributed bimodally, females being smaller than males, but some overlap occurs (Craig *et al.* 1981, Robertson *et al.* 1983). Distinguishing males from females has required retrospective analysis of data using a combination of several measurements (Robertson *et al.* 1983). Craig *et al.* (1981) put forward three measurements that could be used to distinguish the sex of Tuis, but Robertson *et al.* (1983) pointed out that the limits were not applicable to the birds in the Orongorongo Valley. This situation was clarified when I measured the wings, tails, tarsi and bills of the museum specimens from the mainland and assigned them to the age categories by means of the wing notch criterion.

Table 1 gives these results. Wing length emerged as a suitable discriminator of the sex of Tuis, as long as the bird is aged first. Overlaps in Craig *et al.*'s and Robertson *et al.*'s data were caused by the inclusion of first-year birds in their samples. Figure 3 illustrates this point.

Craig *et al.* (1981) said that head and bill length, weight and tarsus (tarsometatarsus) seem to be good discriminators of the sex of Tuis. Head and bill length is difficult to measure accurately on museum specimens because of the differing treatments of the skulls and the variety of poses and extreme contortions of some skins and mounts. Many of the museum specimens had not been weighed. I was unable therefore to check these results, but tarsus length, which I did measure, overlapped between sexes in 64% of cases for adults but not at all for juveniles or first-year birds, possibly because the sample was small.

The measurements of wing, tail and tarsus of Craig *et al.*'s birds on Tiritiri Matangi Island and the adjacent mainland are shorter on average than

TABLE 1 — Measurements of museum specimens of Tuís

	Wing	Tail	Tarsus	Bill
Adult Male				
Mean	154.3	123.2	40.3	24.5
Range	149-163	115-133	37.0-42.8	22.9-27.7
s.d.	3.1	3.5	1.4	2.6
n	79	76	79	79
1st-year Male				
Mean	147.7	117.9	39.7	24.8
Range	145-151	112-122	39.0-40.7	22.4-26.6
s.d.	2.0	3.6	0.5	1.2
n	12	11	12	12
Juvenile Male				
Mean	145.0	114.6	40.6	23.0
Range	141-150	114-115	39.1-42.5	21.2-25.8
s.d.	4.1	0.5	1.6	1.8
n	5	5	5	5
Adult Female				
Mean	138.4	112.8	36.5	22.4
Range	130-146	105-125	34.1-41.2	20.4-26.0
s.d.	3.8	4.1	1.7	1.3
n	27	27	27	27
1st-year Female				
Mean	130.6	107.1	35.8	22.0
Range	127-134	102-113	34.0-38.3	20.7-23.2
s.d.	1.9	3.6	1.2	0.9
n	14	14	14	11
Juvenile Female				
Mean	132	105	36.2	23.1
Range	131-133	104-106	36.0-36.4	23.0-23.2
s.d.	-	-	-	-
n	2	2	2	2

mine. Shorter wing and tail measurements would be expected due to the inclusion of first-year and juvenile birds in their sample, but this does not account for all the variation because the averages and ranges for their birds are similar to those of first-year and juvenile birds that I measured. It would appear, therefore, that the birds measured by Craig *et al.* (1981) are in fact smaller than those I measured. Robertson *et al.* (1983) found that Orongorongo Valley Tuis were larger than those on Tiritiri Matangi. The consequence of this is that the discriminatory boundaries for determining the sex of Tuis given by Craig *et al.* (1981) cannot be used throughout New Zealand and apply

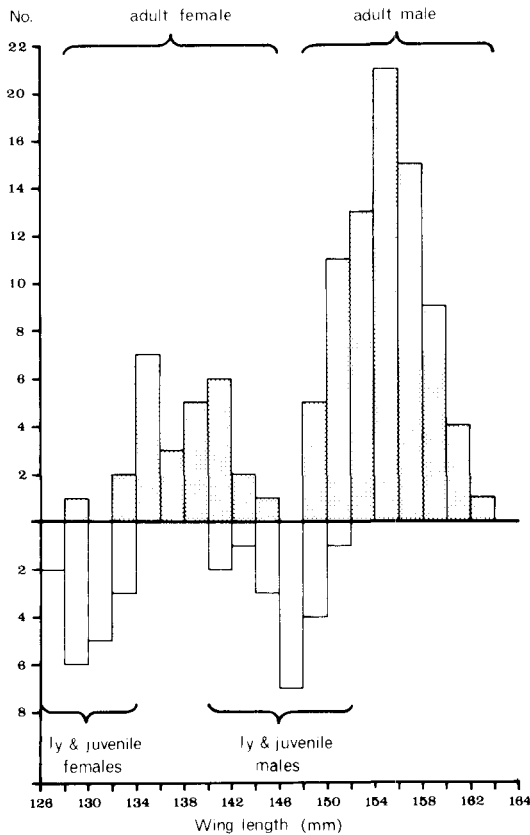


FIGURE 3 — Distribution of wing lengths of Tuis. 1y = first year

only to the populations they measured on Tiritiri Matangi Island and the adjacent mainland. That these northern birds are smaller is not surprising for there is a north-south increase in size (Bergmann's Rule) for Bellbirds *Anthornis melanura* (J. A. Bartle and P. M. Sagar pers. comm.) and Tomtits *Petroica macrocephala* (Fleming 1950), and Tuks from the Kermadec Islands, their most northerly locality, are smaller than those from the mainland (pers. obs. of museum specimens).

In contrast, my measurements are very similar to those from the Orongorongo Valley. Again, the differences in means of wing and tail can be attributed to the inclusion of first-year and juvenile birds in the Orongorongo sample. The ranges of the Orongorongo samples are similar to those of my measurements for first-year and adults combined. Slightly larger bill and tarsus measurements for the Orongorongo birds are probably due to the drying out of museum specimens and consequent shrinkage (e.g. Kinsky & Harper 1968). I am preparing a paper on the size differences of Tuks throughout New Zealand, which should clarify the comparisons above.

I compared the sizes of Tuks of differing age and sex classes using the museum measurements. First-year and adult male Tuks were, on average, larger than females of the same age by 9-13% for wing, tail, tarsus and bill measurements. On Tiritiri Matangi and the adjacent mainland the difference between the sexes (summed difference between the means) was 16%, which is slightly greater, but as Craig *et al.* (1981) pointed out this may be a consequence of the small sample.

Adult birds had longer wings and tails than first-year birds of the same sex by 4-6%, but tarsus and bill measurements were similar. The small sample of juveniles had similar measurements to first-year birds.

Conclusion

Adult Tuks have a notch on the inner web of the eighth primary and first-year birds can be recognised by the absence of a notch. The sex of a bird, aged in this way, can be determined by its wing length.

I hope that this illustration of the usefulness of ageing Tuks will encourage the investigation of ageing techniques for other New Zealand native birds.

ACKNOWLEDGEMENTS

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SHORT NOTES

A beach-wrecked Red-tailed Tropicbird

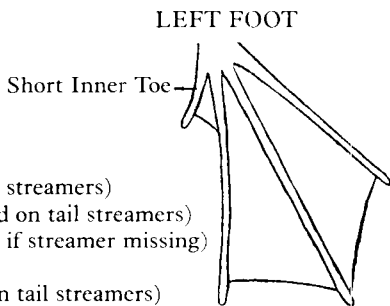
On 14 April 1984, we found a Red-tailed Tropicbird (*Phaethon rubricauda*) washed up on Northland's west coast half-way between the Schick's Road access and Tikinui Stream, south of Te Kopuru. The bird was dead but in good condition.

Description: White with pink tinge. A black mark extending from gape, up in front of eye, through eye and 12-13 mm behind eye. Feathers on top and back of head with black bases when parted (feather and quill base). These are not visible normally. Underwing white. Black markings on longer feathers at back of elbow (tertiaries). A few grey and black marked feathers on flanks under wings. Eight primaries. Primary quills white below, black above, except for the thin tips (last 25-35 mm of quill). Quills of tail feathers white below and black above, except for the streamers which have black quills above and below. The tail streamers are white at the base and red on the part that protrudes beyond the rest of the tail feathers. A few black marked feathers on rump and sides of tail. Feet black. Webbing between all four toes as in shags, gannets and pelicans, but the innermost toe is reduced in length compared with other Pelecaniformes (see sketch).

Bill red with black nostrils and nasal groove.

Measurements (mm)

Bill:	Length:	69.16	
	Width:	14.80	
	Depth:	24.02	
Foot:	Tarsus:	32.85	
	Mid-toe & claw:	50.80	
Body:	Wing:	358	
	Wing span:	1170	
	Length:	770 (to end of tail streamers)	
		536 (to start of red on tail streamers)	
		521 (to end of tail if streamer missing)	
Tail:		100 (tail proper)	
		115 (start of red on tail streamers)	
		348 (end of streamer)	



Ectoparasites

Two species of ectoparasites were collected and sent to the DSIR for identification.

- 1 *Saemundssonina hexagona* (Giebel 1874), a species of Mallophaga or bird louse. The sample contained four males, nine females and four nymphs. It "represents the first record for the New Zealand mainland and the second for the New Zealand subregion, the first being a single female from the Kermadecs. Actually *S. hexagona* has never been found in large numbers and the total holdings among major museums of the world are not more than a few dozen!" (Ricardo Palma, pers. comm.)
- 2 *Laminalloptes simplex* (Trouessart 1885), a feather mite. This species' genus is currently placed in the superfamily Analgoidea family Alloptidae. The

genus *Laminalloptes* is ectoparasitic on tropicbirds (*Phaethon* spp.) and frigatebirds (*Fregata* spp.) but this species has only been found on the three tropicbird species *P. aethereus*, *P. lepturus*, and *P. rubricauda*. "Nothing has been documented from field work," but it is suspected "that these mites occur on the ventral surfaces of the flight (and possibly tail) feathers" (W. T. Atyeo).

We are grateful to Ruud Kleinpaste of the MAF Plant Protection Centre for organising the identification of the ectoparasites and to Ricardo Palma of the National Museum and Professor Warren Atyeo of Georgia University, USA, for identifying them.

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A case of co-operative rearing in wekas

Polygamous associations are frequent in some species of gallinules (Craig 1974, Garnett 1980), and polygamy or helping has been observed in other species, including the Inaccessible Island Rail *Atlantisia rogersi* (Watson 1975), the European Coot *Fulica atra*, the Red and White Crake *Latterallus leucopyrrhus*, and the Black Crake *Porzana flavirostra* (Krekorian 1978). Guthrie-Smith (1914) is the only author to report a non-monogamous association in wekas. He found a male with two females and thought that they might be raising chicks.

In the first four years of a study of the weka *Gallirallus australis* on Kapiti Island (Beauchamp 1986) no polygamous matings were found in the 36, 47, 48 and 49 bonds examined in the respective years. Breeding and parental care seldom overlapped and subadults generally deserted parental territories before their parents' later breeding attempts. Any chicks of the previous clutch that stayed in the parental territory were chased out by their parents when chicks appeared, precluding helping.

When I returned to the study area for a quarterly visit in December 1983 I found a trio of colour-banded birds together raising a chick 18 ± 3 days old. The male, which had occupied the territory for at least 6 years, was associated with two females. The older was a 4-year-old bird he had paired with in March-April 1980 and remained with since, raising a chick in the summer of 1981-82. The other female had entered the population as a subadult in January 1981 and thereafter maintained a home range which included part of this territory.

During December 1983, all three exchanged contact and territory calls together, performed the well-known evening-chorus spacing call as a trio and uttered contact and distress calls to the chick. The older female undertook most of the immediate parental care.

To my knowledge the adults had no close kin relationship. The younger female was not a chick of the older birds as they had not bred successfully the year she was raised. However, there is a slight possibility that the adults were fairly closely related, as my previous work has shown that some young take up territorial positions near their parents' territory. Most of the young dispersed further.

As I was not on the island when the bond was formed I can only speculate as to how it formed. All previous observations indicated that a male would tolerate the presence of a non-territorial female in his territory, especially if she assumed the normal submissive postures and gave submissive calls at his approach. The established female would not tolerate any other female in her territory, unless fights led to a situation where neither female was excluded. In all territorial challenges between females, the male played a subservient role until late in the challenge, when he would intervene to chase the challenging female away, often after the females had fought for up to an hour. If neither female was capable of excluding the other and the male did not intervene, a trio could result.

The mean expected condition, as expressed by weight for size, for the older female was 624 g and the younger 565 g (Beauchamp 1986).

During the period when the trio was formed, the territorial female was in poor condition (550 g) and was probably courting or incubating, while the non-territorial female was in slightly better condition (600 g).

When I returned in January 1984, the juvenile was at the stage of becoming independent (73 ± 3 days). Both females were present and moving around together, exchanging contact calls and territorial booms. Most spacing calls were still given as a trio. The older female was in slightly better condition (575 g).

When I returned for a week-long visit in February, I could not find the younger female. All spacing calls were given as a duet by the original pair. Both birds were in full moult. The male weighed 875 g, while the female was in better condition than throughout the trio period and was estimated from body size to be 650+ g. Food seemed to be plentiful within the territory, and three just-independent subadults were in residence. The pair was not trying to exclude them. If the younger female was resident I would have found her. It appeared that the trio had broken up.

In May 1984, I returned to the territory and found the trio was in existence again and looked forward to seeing whether they would breed in the summer and autumn of 1984-85. In two visits during this period I have been unable to find the younger female, and no breeding occurred in this territory.

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OSNZ NEST RECORD SCHEME INSTRUCTIONS

By HUGH A. ROBERTSON

The Nest Record Scheme aims to provide comprehensive information on the breeding biology of New Zealand birds. Since the Scheme began in 1950, about 17 000 cards have been received up to 1985, covering 130 species. The breeding information in the Scheme is used for research and management. Many papers and books have used data from the Scheme and so you can feel confident that your records are put to good use.

In 1985, a new design of Nest Record Card was introduced to improve the amount of data collected for each nest and to allow the data to be transferred to a computer more simply. Instructions for the use of the new card are given here. These instructions are based on those used in the nest record schemes of the British Trust for Ornithology and the Royal Australasian Ornithologists Union.

Participation in the Scheme

Most participants are members of OSNZ, but records are welcome from all people with an interest in the breeding of birds. You may also submit cards completed by friends as long as you have checked their accuracy and include your own name on each card. Nest Record Cards are obtainable free from the Nest Record Scheme Organiser. When you send in completed cards, you will receive fresh ones for use in the next season.

Your contribution

Complete a card for every nest for which you have accurately counted the contents on one or more occasions, or for which you have evidence that birds are currently breeding, e.g. you see birds building a nest or you see an inaccessible nest at which young are being fed. Do not record old nests or nests that failed before you found them, unless there was something unusual about the record, e.g. an old Welcome Swallow nest in a moored boat.

If possible, search for nests from the earliest time that you think birds are likely to be nesting and right through the season until all species have stopped breeding; otherwise the Scheme's records may become biased towards early spring and school holidays. Contributions from rural, forest and island habitats are very useful because most records are from around people's homes, generally in suburban surroundings.

Although cards are needed for ALL nests, regardless of the number of visits, the most valuable information comes from nests visited more than once. Two observations of a nest have more than twice the value of a single one, even if the nest is abandoned shortly after you find it.

You need not visit nests daily, especially if you expect no change in contents. A few well-planned visits can provide maximum information. For instance, for most birds, two afternoon visits during laying are enough for recording the date of the first egg and the laying sequence (not necessarily

an egg laid every day); a visit during incubation gives the clutch size, after which a couple of visits around hatching time will give the approximate incubation period and hatching success. A few visits during the nestling stage will give details of growth, nesting success and fledging periods. If you can, try to follow the successive nesting attempts of each pair through the whole breeding season.

Visiting nests

You must exercise a sense of responsibility and *always* put the welfare of the birds first if a visit might endanger the nest. The three main risks are

- (a) Accidentally damaging the nest,
- (b) Causing desertion or premature fledging of young, and
- (c) Revealing the nest to predators.

Accidental damage: To cause least disturbance, to avoid effort and to save time, as well as to inspect inaccessible nests, use a small mirror adjustably fixed to a pole. Use a torch with a narrow beam to inspect nests in enclosed spaces, e.g. Welcome Swallow or Starling nests. Handle small eggs and young delicately. Young chicks are generally helpless — always replace them well within the nest cup.

Desertion and premature fledging: Whether to flush a sitting bird depends on a variety of factors. Do not flush it if you can gain no useful new information, and some species are best left undisturbed when sitting, at any rate at certain stages. Many species leave their nests unattended while feeding; you can then inspect the nest safely. In general, it is best NOT to flush birds in fading evening light. If the bird is to be flushed, give it ample time to slip off quietly by tapping branches or by whistling as you approach. A bird sitting tightly may leave quietly if you turn your back for a while. If a bird sits really tight, it might be in the process of laying or hatching and should be left undisturbed. Tap a nestbox from below to give the bird a chance to leave before you look in. Do not pick up sitting adults, particularly during the egg stage. If you do handle an adult accidentally, e.g. in mistake for a well-grown nestling, release it some distance away; the bird then seems to 'forget' the circumstances of its capture.

Many species can be sensitive to disturbance and so should be treated with extra care (1) at the start and finish of their breeding season, (2) in the early stages of each nesting attempt, (3) to a lesser extent, about the time of hatching, (4) in bad weather such as cold, heavy rain, and (5) at times of food shortage, often associated with (4). Young inexperienced breeders are as a rule more sensitive than mature established pairs.

When partly feathered, the young develop an instinct to scatter ('explode') on the close approach of a possible predator. This gives a chance of survival for at least part of the brood, but once out of the nest the survivors are vulnerable to chill and to ground predators. In small birds this fear of intruders often develops when the primary feathers have emerged about 6 mm from their quill sheaths — a stage many passerines reach at about 9 days. The young of hole-nesters do not tend to 'explode' until somewhat older. If a brood becomes accustomed to handling, for instance, if you weigh them daily, they lose much of this fear reaction, but nestlings should not normally

be handled after the young are partly feathered. Therefore, inspect large young cautiously from a distance.

If you accidentally cause an 'explosion', quickly gather the young, keep them together, and replace them gently but firmly in the nest cup, the smallest on top. Cover them with your hand or a handkerchief. Give the nestlings time to settle, and withdraw the cover smoothly. If they leave again despite this, you will do more harm than good by staying; the more the parents 'scold', the more the fledglings will scatter, and perhaps get lost. Fledging ground-nesters (e.g. ducks and waders) leave the nest before they can fly, but they are adapted to survive.

Risk of predation: People often fear that they may increase predation by leaving a track or scent trail to nests, but in Britain a two-year investigation showed that nests visited frequently in bushes, hedges and thick undergrowth had a similar success rate to others left undisturbed between laying and fledgling.

Obviously you must not inspect a nest while a predator is nearby and can watch you. A commoner danger is that, if you flush a parent and it does not return immediately, the nest remains exposed to searching predators.

Although natural predators do not seem to be assisted by tracks, children are, and so try not to make tracks, and cover up any traces of your visits.

In case parent birds are watching, approach nests casually, as if by chance, rather than directly or deliberately. Birds are then likely to regard you as harmless (much as they would a passing sheep), not as a predator intent on robbing the nest. Never give a sitting bird a sudden fright, as this might cause it to desert. Therefore, as you approach try to see if a parent is sitting; a bird crouching low on a nest above eye-level can very easily be missed. Occasionally, in dense cover, if a bird returns and only then sees you examining its nest, it may be so startled as to desert. Therefore, keep yourself in view while making the inspection. Never take an entire clutch or brood away from the nest because a bird is much more likely to desert if it returns to an empty nest.

BE CAREFUL NOT TO ENDANGER YOUR OWN LIFE OR LIMBS!

Filling in Nest Record Cards

1. RECORD FACTS ONLY: MAKE NO ESTIMATES OR GUESSES.
2. Use a separate card for each nesting attempt — staple two cards together if you run out of space, and mark each with your own reference number. If a nest is used more than once use a separate card for each attempt and cross-reference the cards.
3. For visits on which you note no major change (e.g. eggs hatching, nest deserted), show the dates under Remarks.
4. Use an ink that will not smudge, and please print clearly.

Instructions

- (1) *Observer* — Give your name. If the nest is recorded by a friend, please add your own name. Please put your address on at least one card each year.

- (2) *Obs Code* — Observer's code number — please leave blank for allocation of a personal reference number.
- (3) *Species* — Record the common or Latin name of the species — add subspecies if relevant. See (23) *Outcome of nest* for dealing with parasitised nests.
- (4) *Sp. Code* — Species code — please leave blank for allocation of a species and subspecies reference number.
- (5) *Locality* — Give a locality that pinpoints the area in which you made the breeding record. Give distance and approximate direction to the nearest town or geographical feature.
- (6) *Altitude* — Give the approximate altitude above sea level in metres (100 ft = 30 m).
- (7) *Latitude & Longitude* — To locate the position of the breeding record accurately please give latitude and longitude coordinates to the nearest minute. Note that the Chathams are in the Western Hemisphere.
- (8) *Habitat* — Place a cross in the square that most appropriately describes the general area where the bird is living. For example, if a Blackbird nested in a clump of apple trees in the garden of a country house this would be best placed as farmland rather than horticultural or residential.
- (9) *Site* — Place a cross in the appropriate square and briefly describe the site, e.g. macrocarpa shelterbelt, cabin of moored boat.
- (10) *Height of nest* — Record the height above ground to the nearest metre.
- (11) *Height of nest plant/cliff/structure* — Record the height of the plant, cliff or structure (e.g. building) that the nest is in.
- (12) *Height of tallest vegetation over nest* — Record this whenever the nest is in or under vegetation.
- (13) *General Notes* — Record information such as band numbers, egg dimensions, weights and colour, any unusual features of the nest, e.g. type of construction or nest materials; note the presence of parasites such as fleas or mites. Note also any cuckoo parasitism or host species, and the presence of any helpers at the nest, i.e. three or more birds attending the nest.
- (14) *Observer's Reference No.* — Use any system of numbering to keep for your own notes.
- (15) *Ref. No. of other nests of same pair* — Put down your own observer's reference numbers of previous nests of the same pair in the same season.
- (16) *Date* — Record this at each visit.
- (17) *Time* — Use the 24 hour clock, e.g. 5.30 p.m. = 1730 h. Don't correct for NZ Summer Time — that will be done later by computer.
- (18) *Eggs* — Record the number of eggs known to be in the nest. Make no guesses, but if you know that eggs were present but you couldn't count them, mark this column with a tick.
- (19) *Young* — Record the number of young in the nest. If you know that young were present but you couldn't count them, mark this column with a tick. If any were out of the nest, note them in the Remarks column.
- (20) *Bird on* — If a bird was sitting or flushed from the nest, enter one of these codes: Y = unknown sex, M = male, F = female. If a bird

was not on, N unless you determined that the eggs were
W = warm or C = cold.

- (21) *Age of young* — It is important to record the age as it helps analysts to deduce the date of laying and to calculate success. Record the age in days, if known, or use categories shown on the card to help to age nestlings. If you know the age precisely, please note eye condition and wing feather growth in the Remarks column as this information will help to age those chicks in other nests whose age was not accurately known.
- (22) *Remarks* — Note anything special at each visit, e.g. stage of nest construction, weights of chicks, reasons for eggs or young failing if the whole nest didn't fail (e.g. 1 egg broken).
- (23) *Outcome of nest* — Put a cross in the box that describes the fate of the nest. A successful nest is defined as having at least one chick leave successfully. Of four eggs, for example, three may hatch and only one chick leave. If the dates of your last two visits to the nest were so far apart that you can't determine whether the nest was successful, mark the box 'Evidence inconclusive'. If the nest was still occupied at your final visit, put a cross in the box 'Observations not continued' unless the chicks were 'Ready to leave', i.e. you judged them capable of fluttering away.

If a nest fails, it is usually obvious which box to mark, but sometimes you have to mark more than one box. For instance, if a Blackbird nest contained three newly hatched chicks on one visit but only one dead 'injured' chick the next day, mark both 'Young gone' and 'Young injured'. The category of 'Young injured' is used mostly for when you find remains of young eaten by predators.

The 'Other' category could include such events as the adults dying or the nests parasitised by cuckoos. If a pair of Grey Warblers raises a Shining Cuckoo chick, their own nest has failed, even though they have successfully raised the cuckoo chick. In this example, use separate cards for Grey Warbler and Shining Cuckoo, with each suitably cross-referenced.

Bird colonies

It is often valuable to select a few nests in a colony and visit the same ones on a subsequent visit, but if you visit a bird colony and cannot follow individual nests, use a 'Colonial Nest Record Card'. These cards are designed to record a SINGLE VISIT to the nests of a SINGLE SPECIES. In mixed-species colonies, use a separate card for each species (but cross-reference them). Normally these cards are used for casual visits to seabird colonies and the colonies of shags, herons and some waders.

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SHORT NOTES

Hybrid parakeet on mainland

On the afternoon of 26 November 1985, during a bird survey of Big Bush State Forest c. 55 km south-west of Nelson, I played taped calls of Yellow-crowned Parakeets (*Cyanoramphus auriceps auriceps*) along a road through native forest characterised as hard beech/ red-silver beech (*Nothofagus truncata*/ *N. fusca* - *N. menziesii*) (D Hunt, pers. comm.). One bird responded, calling and flying into the top of a large beech and then down to a dead tree 10 metres above the ground and about 30 metres from me. Observing it for several minutes in excellent light with 7 x binoculars I noted the following: crown red above bill grading into orange by three-quarters of the way back, last quarter yellow; a patch of red in front of the eye joining the red of the crown, a spot behind the eye distinctly orange (both sides seen). Other plumage features noted were blue on the wing coverts, rump patches either red or orange (not seen clearly) and a general green colouring as in Yellow-crowned Parakeets. A visit to this site on 22 November 1985 had elicited responses from two birds clearly identified as Yellow-crowned Parakeets and this bird appeared similar in size to the smaller of these. In responding to the tape it came down lower than they did.

It is considered that this bird must have been a hybrid between the Yellow-crowned Parakeet and the Red-crowned Parakeet (*Cyanoramphus novaezelandiae novaezelandiae*) and most resembles a first cross hybrid between the two — sharing features of the head colour of each species (R. H. Taylor, pers. comm.). Hybrids have been observed on the Auckland Islands and on Mangere Island in the Chathams, where they showed considerable variation, including individuals that were clearly 'closer' in plumage to one or other species than this bird (Taylor 1975). Veitch (1979) observed a male Yellow-crowned Parakeet sharing a nest with a female Red-crowned Parakeet on Little Barrier Island, but it is not known whether young were reared. However, although aviculturists will hold some hybrids, there are no apparent records of hybrids in the wild on the mainland.

Different habitat preferences and ecological differences normally keep the two species from hybridising in unmodified habitats (Taylor 1985). Suggested factors leading to hybridisation on Mangere Island were a highly modified environment conferring no survival value to parental forms over hybrids, together with low numbers of colonists of each species (Taylor 1975). Similar factors could well be involved in the Nelson region. Firstly, much of the region's original lowland forest cover has been removed and the area of this observation is typical of the pattern of vegetation remaining. It was within a block of c. 2200 ha of native forest (at 590 m altitude a.s.l.) bounded to the north and west by c. 3500 ha of exotic plantation forest (mostly *Pinus radiata*) and to the south and east by farmland except for a narrow strip 2-3 km wide connecting to a further larger area of beech forest. Secondly, recent surveys have shown that one of the species, the Red-crowned Parakeet, occurs in only very low numbers in the region. Bull *et al.* (1985) list seven records for the Nelson Province 1969-79, one in Nelson City in 1971 and probably an escapee, two at Nelson Lakes on Mt Robert (one of which was doubtful — M. Clarborough, pers. comm.) and four in Mt Richmond State Forest.

NOTORNIS 33: 58-62 (1986)

During my involvement in a bird survey of Nelson Lakes National Park (Butler, in prep.) the 43 parakeets identified to species were all Yellow-crowned, as were the five others seen to date in Big Bush. This was the only species observed at Mt Misery, Lake Rotoroa, during ten recent years of bird surveys by DSIR Ecology Division, Nelson. The one known recent sighting of a Red-crowned Parakeet in the region was made by the author in beech forest on the east side of the St Arnaud Range in the Upper Wairau, Marlborough, on 18 September 1985, a single bird accompanied by two Yellow-crowned Parakeets.

It is considered that Red-crowned Parakeets now occur in such low numbers in the Nelson region (note: little information available for North-west Nelson Forest Park) that some interbreeding with Yellow-crowned Parakeets is a likely consequence. A significant pure-bred population of Red-crowned Parakeets has yet to be found here.

I am grateful to Rowley Taylor for his comments on this note.

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Second record of a Manx Shearwater in New Zealand

On 25 January 1985, Mrs B. A. Tennyson found a decaying medium-sized shearwater on Waikanae Beach, Wellington west coast, after several days of strong northwesterly winds. This bird was later identified as a Manx Shearwater (*Puffinus p. puffinus*). Comparisons with skins in the National Museum confirmed the identification (J. A. Bartle, M. J. Imber, A. J. D. Tennyson).

Description

Many feathers from the head, neck and inner wing were missing. Otherwise the plumage was fairly complete.

Head and body: Forehead, back, scapulars, rump and remaining crown, nape and hindneck feathers sooty brown. Breast, belly, flank and remaining throat feathers white.

Wings: Upperwing coverts, secondaries and primaries sooty brown. Inner vanes of primary undersurfaces somewhat silvery. Underwing coverts white, except for the conspicuous dark feathering along the leading edge, widest at the elbow region and poorly developed past the carpal joint. Some dark dusting of the greater-underwing-covert tips. Long axillaries white with pointed tips, terminally black for 2 cm, nearly reaching the trailing edge of the wing. Shorter axillaries white with black tips.

Tail: Upper tail-coverts and tail feathers sooty brown. Exposed under tail-coverts mostly with black on outer vane, some with a dusting on the inner.

Otherwise, exposed under tail-coverts white. Remaining longest concealed under tail-covert almost entirely dark grey.

Bill: Grey, a little paler on rami-corn and lower lateri-corn. Rami meet 2 cm from tip of lower mandible.

Legs and feet: Outer edge of tarsus black distally; otherwise pale pink. Inner toe pale pink; middle toe pale pink; on inner side, mostly black on outer side; outer toe black. Webs very pale pink. Claws black.

Mouth: No active moult and some wear of wing, tail and contour feathers. Several remaining feathers on the hindneck emerging from sheaths.

Measurements (mm)

Culmen	35.6	Wing	237
Tail	77.3	Tarsus	45.6
Mid-toe and claw	52.6		

Foot: Six specimens (3 males and 3 females) of *Halipeurus (H.) diversus* (Kelllogg, 1896) were collected by R. L. Palma from the shearwater.

Discussion

This specimen is the third Australasian and second New Zealand record of a Manx Shearwater. The first Australasian record was a British-banded bird found dead at Venus Bay, South Australia, in November 1961 (Spencer 1962). The other New Zealand record was a bird found dead near Pukerua Bay, Wellington west coast, in June 1972 (Kinsky & Fowler 1973).

The appearance of this specimen closely agrees with that given by Kinsky & Fowler (1973). The presence of a dark triangular area in the elbow region of the underwing coverts, described and figured by them, is still not clearly given in standard works (e.g. Cramp & Simmons 1977; Harrison 1983). J. Warham (pers. comm.) confirms that the wing linings of Welsh Manx Shearwaters often have smudgy grey suffusions on the anterior third of the underwing.

This specimen is immature, like both previous Australasian records (Spencer 1962; Kinsky & Fowler 1973). The nominate race of the Manx Shearwater breeds in the North Atlantic and most migrate to the southwest Atlantic from July onwards, returning mainly in March (Blake *et al.* 1984). Immature birds do not return to the North Atlantic colonies in their second year (Cramp & Simmons 1977) and thus have more time to wander widely in the southern oceans than adults do. However, this must be a tentative hypothesis because most beach specimens of shearwaters are immature (J. A. Bartle, pers. comm.).

Lice collected from this specimen support its identification as a Manx Shearwater. Known host species of *Halipeurus (H.) diversus* are Sooty Shearwater (*Puffinus griseus*), Short-tailed Shearwater (*P. tenuirostris*), a supposed race of Little Shearwater (*P. assimilis boydi*) and three races of Manx Shearwater (*P. puffinus*, *P. p. yelkouan* and *P. p. newelli*) (R. L. Palma, pers. comm.). Of these, the Waiakanae specimen resembles only *Puffinus p. puffinus*. Several plumage features, such as colour of axillaries and under tail-coverts, preclude this specimen from being any other race of Manx Shearwater (J. A. Bartle, M. J. Imber, pers. comm.).

Kinsky & Fowler (1973) suggested that Manx Shearwaters may associate with flocks of Fluttering Shearwaters (*P. gavia*) while in New Zealand waters. From 1985 Beach Patrol Cards so far received (R. G. Powlesland, pers. comm.) there is no evidence of any unusual seabird species being off the Wellington west coast at the time this specimen was found. However, low numbers of at least six shearwater species were found, including Fluttering Shearwaters.

Manx Shearwaters closely resemble Fluttering Shearwaters and Hutton's Shearwaters (*P. huttoni*), and New Zealand beach specimens may easily be confused. A useful table for distinguishing between these species is presented by Kinsky & Fowler (1973). Features most helpful in distinguishing this specimen from Fluttering and Hutton's Shearwaters were

- (a) Relatively white underwing,
- (b) Extensively black-tipped white axillaries,
- (c) Exposed under tail-coverts with lateral black bars, and
- (d) Longer wing and tail measurements.

The record has been accepted by the OSNZ Rare Birds Committee, with whom a report and photographs are filed. I am grateful to J. A. Bartle, J. F. M. Fennell, M. J. Imber, R. L. Palma, R. G. Powlesland and J. Warham for their help and encouragement, and to J. A. Bartle for his comments on and modifications to this note.

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Occurrence of disease in Tui

During a study on the behaviour of colour-banded Tui (*Prosthemadera novaeseelandiae*) on Auckland's North Shore during 1984 a number of unexplained Tui deaths occurred. In July and August 1984 two banded Tui were found dead below trees where they had been feeding. No obvious cause for death could be found in birds of otherwise good condition (Colwyn Smith, veterinary surgeon). At the end of November, a Tui rescued from a cat in Beachhaven, Auckland, was found to be suffering from some disease, the symptom being inability to perch firmly, reluctance to fly, and wing shuffling, head flicking and, later, clouding of the eyes. Four more cat-killed banded Tui were reported between August and November 1984, one from the Whangaparaoa Peninsula and three in Birkenhead, Auckland.

During the same period two Tui were found unable to fly by the ranger on Little Barrier Island. One of these later died, and one seemed to recover and was released.

Further reports of similar symptoms and deaths came in from Birkdale, Coatesville, Whenuapai, Titirangi, Hillsborough and Remuera, all within 30 km of Auckland. In three of these instances the Tui, which was feeding, suddenly dropped to the ground and then convulsed or appeared partly paralysed. The symptoms common in sick birds were inability to fly or perch followed by

twitching or paroxysm and breathing difficulty with excess mucus in the throat and nostrils. One banded Tui in Birkenhead had the initial symptoms of breathing difficulty and clumsy flight during July and August 1984 but has since fully recovered in the wild and is still healthy to date (October 1985).

In December 1984 a fledgling was received from Sunnyvale, Auckland, with all the typical symptoms of paralysis, excess mucus and breathing difficulty. Shortly after death this bird, together with two further fresh and two frozen Tui also suspected of disease, was sent to the Whangarei Animal Health Laboratory for investigation.

The specimens were received by M. P. Kearns (District Veterinary Officer) and examined by J. Sutherland (Veterinary Clinical Pathologist). J. Sutherland reported that, in two of the fresh specimens, large spirochaetes (15-25 μ long) were found that were morphologically consistent with *Borrelia* spp. (probably *B. anserina*). Both these birds had congested livers and mucus in the intestines. In the two frozen specimens no spirochaetes were found but both had congested and distended spleens and livers and one had mucoid hyperplasia in the small intestine. The symptoms and post-mortem appearance were consistent with avian spirochaetosis.

Avian spirochaetosis caused by the spirochaete *Borrelia anserina* has not been identified in New Zealand before (M. P. Kearns, pers. comm.) but is known in Australia (Seddon 1953). *Borrelia* is a blood parasite requiring a vector between hosts (Hungerford 1969). The usual vector is the fowl tick (*Argas persicus*) but this tick does not occur in New Zealand (Kearns, pers. comm.). However, *Culex* mosquitoes have been known as carriers of the spirochaete (Zuelzer 1936) and can act as true carriers in much the same way as the fowl tick. The red mite *Dermanyssus avium* has been shown to be an effective mechanical vector (Hungerford 1937, Hart 1937) and probably any bloodsucking insect may mechanically transmit the disease (Hungerford 1969).

It is not known whether the spirochaetosis found in Tui is specific or can occur in other avian species nor whether it is endemic or, if not, whether it is a recent introduction or has been in the population for some time but unidentified.

I am grateful for the help of officers of the Ministry of Agriculture and Fisheries, in particular M. P. Kearns and J. Sutherland for identifying the cause of disease and providing relevant literature, and to the Auckland Bird Rescue Organisation and the public of Auckland for their reports and specimens of Tui. This report was prepared during a study with the University of Auckland.

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*Syn. *Borrelia anserina*

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REVIEWS

The technique of bird photography, by John Warham. 4th edition. Focal Press.

What a wealth of information this book contains. It is large, nearly 300 pages, and covers almost every aspect one could think of for using both still and movie cameras. When I began to photograph birds seriously, I bought a copy of the first edition of this book and was impressed then with the information given. This latest edition, completely rewritten and reillustrated, must surely be the most comprehensive book available on this topic. It has about 30 colour plates, 60 b/w pictures and 70 very useful line drawings.

Besides a thorough coverage of the basics such as cameras, lenses, accessories, hide construction, nest photography, use of artificial light, details are also given of

Photography for the field ornithologist such as time-lapse techniques, bird census work, food analysis, and behaviour

Planning the shooting and editing of movies

Expedition photography; what to do in the tropics, in polar regions, deserts, swamps, and so on.

A chapter is devoted to the history of bird photography, and for those interested in entering their best bird pictures in photographic salons there is a section on birds as pictures. Perhaps in more than any other field of natural history photography, the cameraman concentrating on birds is most likely to disturb his subjects and their environment. A chapter on ethics covers this important aspect.

Naturally, this book is not aimed primarily at New Zealanders, as shown by the appendices covering British birds for which you need a permit for photography and a guide to photographing British birds at their nests. The data in these appendices applies to several New Zealand species also. A valuable reference list is given to books and papers quoted in the text.

The bulk of the book covers those aspects the average bird photographer needs most to know. Over 100 pages are about stalking birds, birds on the wing, filming birds in flight, use of baits and lures, remote control, nest finding, placing of hides, "gardening", working single-handed, stills and cine together, automated nest photography, pylon hides, combating wind, photographing birds underground, electronic flash at night/ in daylight/ in the rain, and so on and so on.

After 20 years of bird photography in New Zealand and in the tropics, I found myself nodding in agreement on almost every page and thinking "I wonder if the beginner will realise just how useful that information is?" This book is excellent, comprehensive and thorough in its coverage; the fruit of a lifetime in the field with a camera. I highly recommend it.

Don Hadden

The birds and bird lore of Samoa, by Corey and Shirley Muse. 156 pages, 70 col. ill., maps. Sponsored by National Audubon Society. Pioneer Press, Walla Walla, Washington 1982. (Copy in OSNZ library).

The authors have set out not just to provide a guide to all the birds of the Samoa archipelago but also to incorporate the bird lore; the stories, legends and proverbs of the Samoan people. I found that these stories, interspersed throughout the text, enhanced the book's value and made delightful reading. No doubt the life-lister dashing from one Pacific island to the next, ticking off the various endemics, would ignore these fascinating tales, but the visitor who wants an appreciation of how Samoan people view their birds will get useful background information from these legends.

The bulk of the text deals with the birds under the headings of Seabirds, Migratory Birds, Waterfowl, Marsh and Landbirds, and Accidental Occurrences, together with legends and proverbs. Appendices cover suggestions for successful birding in Samoa, the language, a checklist of the birds, footnote citations, and a bibliography. The section on birding deals well with the need for the inquisitive birder to respect local customs when away from the main tourist areas. Anyone who has lived in the Pacific would endorse the comments made.

Each bird is described, its breeding is commented on, and sometimes we're told where best to go to see it. The treatment seemed inconsistent at times. For example, the "Common Tropicbird" (*Phaethon aethurus*), a dubious record, is given a heading in the text and listed in the checklist but the sightings of Peter Child (*Notornis* 26) of the Little Tern and Siberian Tattler are omitted or mentioned only in passing. With few birds to deal with, the authors could have included every species given in the literature and simply commented on its status. Thus, the unconfirmed sighting of Cattle Egret in American Samoa, as well as Child's observations, would rate a mention, and the early records that now appear to be errors.

An intriguing entry for New Zealanders is the paragraph about an *Apteryx*: ". . . smaller than the New Zealand *Apteryx* but resembles it in other respects . . ." a quote from an 1897 book by Stair.

The authors' love of Samoa, its birds and its people is obvious throughout the book. It is not just a stark field guide. It is a very good field guide and so is warmly recommended. It will also appeal to those with an interest in the peoples of the Pacific and the special role of birds in their cultures.

Don Hadden

SAOS Checklist of Southern African Birds, edited by P. A. Clancey, Sigma Press, Pretoria, 1980.

In these somewhat out-of-joint times, bigots are apt to ask "Can any good thing come out of South Africa?" For ornithologists the answer is an emphatic "Yes". This hefty and forthright Checklist reflects both the breathtaking variety of birds over a vast subregion and the hard work and scholarship of the members of the SAOS Committee.

Name almost any family or tribe of African or Eurasian birds from eagles to sunbirds, from bustards to barbets and bulbuls, from ciconia to cisticola, and the chances are that, in the great land-mass covered by this checklist, it is represented by many species or subspecies, resident, migratory or both. Then there are the notable oddities, such as Ostrich, Bateleur, Secretary Bird, Promerops. A veritable gallery of bee-eaters, kingfishers, hoopoes, rollers, louries, starlings add brilliant colour, all logically catalogued, reduced to

trinomials and with a concise note on their known distribution, supported most helpfully as the need arises by a map. Nor, of course, are the "little brown jobs" neglected. *Anthus novaeseelandiae* is represented by eight subspecies and earns a map (p. 233). It is also worth noting that it has to compete with nine other species of pipit.

By contrast, New Zealand's remote insular avifauna makes a very modest showing. Only at sea with all our penguins, tubenoses and cormorants do we remain hard to beat. The long Hypothetical List suggests that South African ornithologists still have much to learn about their oceanic migrants and visitors. How satisfying, incidentally, to see *Catharacta* not *Stercorarius* used for the generic name of the big austral skuas.

All worthwhile checklists contain some curious scraps of information. That wayward nearctic sandpiper, *Calidris fuscicollis*, is on both the SA and the NZ lists. But the only one so far recorded in South Africa (p. 365) became a victim of botulism at a sewage works near Cape Town. Does this sound a warning for coprophilous birdwatchers on the Auckland Isthmus?

Just as on the football field Springboks have proved that they can run straight and kick goals, so the team which compiled this checklist has mastered a vast subject and revealed a meticulous attention to detail. Is it churlish to point out that on p. 298, *epomorpha* should be *epomophora*? The Royal Albatross is the 'epaulette wearer'. Even if we remember the ancient adage *Ex Africa semper aliquid novi*, the SAOS Checklist of 1980 will be an indispensable tool for very many years and not without significance for serious NZ ornithologists.

R.B. Sibson

Contribution à l'Etude des Oiseaux de Polynésie Orientale, by D.T. Holyoak and J.-C. Thibault. Mémoires du Muséum National d'Histoire Naturelle, Series A, Zoology, Vol. 127. 1984. 209 pp., maps. Available from La Bibliothèque centrale, Muséum National d'Histoire Naturelle, 38, rue Geoffroy-Sainte-Hilaire, 75005 Paris.

Anyone contemplating a birdwatching trip to the eastern Pacific, from Samoa eastwards, should get a copy of this book.

This modest publication, printed on non-glossy paper, is the most valuable guide to the birds of these areas at present available.

Not only does it give distribution maps and specific island information as to what bird is on what island, but it also gives early records, many of which go back to Captain Cook.

The book does not contain illustrations of the birds but gives adequate descriptions as to size, colour, song and habitat. As such it could be described as an elaborate checklist.

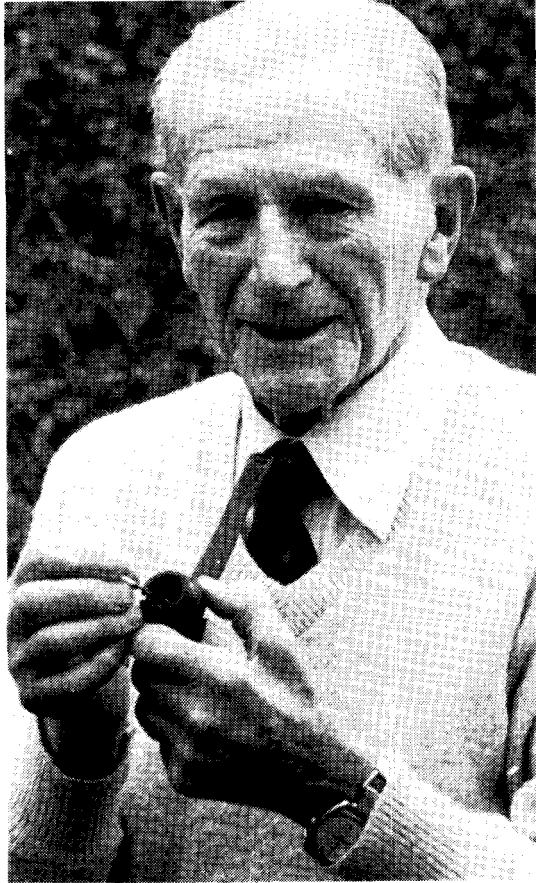
Already, as with most publications, it needs updating as it does not record the Red-vented Bulbul (*Pycnonotus cafer*) on Tahiti or Moorea or the Zebra Dove (*Geopelia striata*) on Borabora. However, these introduced species on these islands do not constitute a serious omission.

The only problem with this book for many New Zealand birders is that it is in French. Nevertheless, it is well to take the time and translate it for its value is immense.

Stuart Chambers

OBITUARY

CHARLES ARCHIE D'ARCY BLACKBURN
1899-1984



When Archie died on 6 December 1984, the Society lost yet another of its long-serving octogenarians. Archie was born in Hamilton in 1899 but the family moved to Gisborne and it is with Gisborne that his name is especially associated. He received his early education at Gisborne Boys' High School of which he was Dux in 1916. His chosen career took him to Duntroon Military College from 1917 to 1920. The change of scene and the teasing variety of Australian birds in comparison with those of his native land conspired to turn him into an ornithologist. He returned to New Zealand in time to become a Foundation Member of the Forest and Bird Protection Society. In 1922 he resigned from the Army to qualify as a chartered accountant.

The outbreak of World War Two saw him smartly back in uniform, commanding the 19th (Wellington) Infantry Battalion. He saw active service in Greece and Crete, was mentioned in despatches and earned a decoration. Back in New Zealand he commanded the First Army Tank Battalion and rose to the rank of Colonel. Forty years later he was one of those New Zealanders selected to revisit the scenes of historic battles in the Eastern Mediterranean.

In 1955 Archie succeeded in landing on some difficult islets off the East Coast and his resultant article (*Notornis* 7: 15-16) put an unrecorded gannetry on the map. After his retirement in 1958 he was able to devote more time to fishing, bird-watching, the exploration of offshore islands and trips to wild Australia. From time to time on the mountain streams of Hikurangi he was able to pursue Blue Ducks and trout at the same time.

Because Archie combined an observant eye with a ready pen right to the end — his letters were written in a neat disciplined copperplate — he produced a steady stream of articles, notes and reviews which illuminate the essentials of field ornithology in New Zealand. His study of North Island Fantails in a garden, Muttonbird Island's Diary, Codfish Island Fernbird, reports on insular avifaunas, such as Codfish, Cuvier, Fiji, show the breadth of his vision and the depth of his understanding. His wide Australian experience and discerning eye enabled him to add Satin Flycatcher (1963) and Black Falcon (1983) to the New Zealand list.

In collaboration with the Wildlife Service he visited numerous offshore islands, playing a leading part in the surveys which led to the successful transfers of Saddlebacks from Hen to Red Mercury and Cuvier Islands, a bold concept and experiment which triggered a new development in the salvaging of rare and endangered species. As President of the Society from 1960 to 1968, and a member of the Fauna Protection Advisory Council, he was in a position to back his judgement with authority. It is now difficult to recall a time when he was not also the Society's assistant editor and unofficial liaison officer with Te Rau Press. He was suspicious of the direction of some recent research which talked glibly of 'strategies' and 'time-budgets'.

Archie found ornithology an ideal hobby which presented a challenge and helped him to face, with cheerful fortitude, the illness which assailed him during the last quarter of his long life. For his many services the Society in 1982 honoured him with the Falla Memorial Award.

He is survived by his wife, Mollie, and a large family of children and grandchildren to whom the Ornithological Society gratefully extends the warmest sympathy.

R.B.S.

OBITUARY

HELEN OLIVER 1904-1985

Helen Oliver died on 8 November 1985 at the age of 81. Younger members will not realise how much the Society owed to her. During the period of rapid expansion she acted as Assistant Treasurer in 1951 and 1952, as well as taking part in banding activities.

Born on 12 March 1904 of a well-respected Wairarapa farming family, Helen Laing, as she was, attended Solway College in Masterton, being Dux in 1920. After an office career she attended the Library School for a year in 1950 and became a librarian in the Masterton Public Library. She spent some years overseas: in the U.K. in 1937 and 1969, and in 1955 tracing family history: in the Himalayas (1945), and during the war with the Ministry of Supply, the Middle East, of which she used to recount many lurid tales. In 1956 she married Dr W.R.B. Oliver, Director of the Dominion Museum, and further cemented her interest in ornithology. After he died in 1957 she joined the Wildlife Division of Internal Affairs and was again involved in library work.

Her greatest contribution to ornithology was the compilation of the *Annotated Index to Some Early New Zealand Bird Literature* (1968, Wildlife Pub. No. 106, Dept. Int. Aff.). I am not aware that this has ever been reviewed but it is a 222 page (plus x) bibliography of important ornithological literature from 1843 to 1900. Every mention of species is indexed (with a precis of the information) from ten works, including G.R. Gray's *List of Birds . . . with their Synonyms* (IN Dieffenbach 1843, *Travels in New Zealand*); *Catalogue of the Birds of New Zealand* (Hutton 1871); and the *Transactions and Proceedings of the New Zealand Institute* (Vol. 1-33, 1868-1900). The latter in particular contain much information not known about or ignored by many modern ornithologists, who would be well advised to study these references. The *Annotated Index* is in four sections: Systematic, Geographic Distribution, Subject and Author. There is also a Glossary of the meanings of the scientific names. The work may be regarded as extremely accurate as every entry was checked by Sir Charles Fleming or the late Sir Robert Falla (and the Glossary by R.B. Sibson).

Helen Oliver was an active member of the Royal Forest and Bird Protection Society and members of the Wellington group of the Ornithological Society will remember her participating in many of their field outings and evening meetings.

J.M.C.