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BREEDING AND MORTALITY OF THE SOUTH ISLAND ROBIN IN KOWHAI BUSH, KAIKOURA

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ABSTRACT

The breeding of the South Island Robin at Kowhai Bush, Kaikoura, during the 1977-78 and 1978-79 seasons and the mortality from August 1976 to December 1979 are described. Most robins began laying in August and completed breeding in January. Thirty-four percent of their nests were relined "old" ones built in previous seasons by robins or *Turdus* species. Average time to build a "new" nest was 3.4 days, followed by a prelay period that averaged 4.2 days.

Eggs were laid at about 24-hour intervals. Mean clutch size was 2.7 eggs (range 2-4), being smallest in July and largest in October. Incubation averaged 17.7 days, and the females spent 81% of daylight time on the eggs; males did not incubate. In the two seasons, 63% of the eggs hatched and 23% were eaten by predators. Hatching success varied between seasons, months and the four age classes of females.

Both parents fed the nestlings, but only the female brooded. Nestlings averaged 20.8 days in the nest, with little or no brooding after day 15. Overall, 42% of the nestlings fledged; most of the rest were eaten by predators. The proportion that fledged decreased as the season progressed because the loss to predators increased. Pairs fledged a mean of 2.1 fledglings in 1977-78 and 2.9 in 1978-79.

Juveniles were fed by their parents from 24 to about 50 days, depending on the number of juveniles, how many the female cared for and how soon the next clutch hatched.

Mortality was highest in summer for immatures and autumn for adults. Immatures died more in summer, possibly because they were less efficient foragers than adults, but similar proportions of the two age classes died in autumn and winter, perhaps because predation was the main mortality factor.

INTRODUCTION

The South Island Robin (*Petroica australis australis*) is very suitable for detailed observations of breeding biology because it is approachable and its nests can be found readily (Soper 1976). Moncrieff (1932), Richdale (1941), Oliver (1955), Soper (1976) and Falla *et al.* (1978) made general observations of the species' breeding habits, and J. A. D. Flack studied its behaviour, breeding success and mortality at Kowhai Bush and on several offshore islands (Flack 1973, 1976a and b, 1979; Flack & Lloyd 1978).

During a study of the Robin's annual time-budget at Kowhai Bush, I recorded breeding behaviour and success for the 1977-78 and 1978-79 breeding seasons. In addition, monthly censuses were made of the individually colour-banded and known-age robins.

STUDY AREA

Kowhai Bush (40°54'S, 174°05'E) is in coastal south-eastern Marlborough, 7 km inland from Kaikoura. It is a narrow (700-1700 m wide) 240-ha strip of forest on the north-eastern side of the Kowhai River, 60-150 m a.s.l. The forest is a flood-induced series of successional stages of varying age, structure and species composition, often dominated by kanuka (*Leptospermum ericoides*) (Dobson 1979). For a detailed account of the geology, climate, flora and fauna of the study area, see Hunt & Gill (1979).

METHODS

I watched pairs at the nest from about 7 m away. Nests were visited daily to determine the dates of nest building, laying, hatching and fledging, and every second or third day during incubation and nestling rearing to check for predation.

Eggs were measured with vernier calipers to the nearest 0.1 mm and, the day they were laid, weighed with a spring balance to the nearest 0.1 g.

Each nestling was given an individual combination of a metal serial band and colour bands at about 13 days of age. Robins which immigrated into the study area were caught with a clap-trap or mist net and banded. I defined juveniles as young that had left the nest but were still being fed by their parents. Juveniles became immature robins once they were independent of parental care, and remained so until the start of breeding in late July.

To calculate the mean date robins began breeding each season I averaged the dates of the first egg laid by all females. When a laying date was not known it was estimated from the day of hatching, allowing 18 days for incubation.

The robin's breeding cycle was divided into six stages:

1. Nest building: From when the female first made repeated visits to a site with nest material and carried out "nest-shaping" movements (the female crouches into the nest cup, pushing outward with her wings and, apparently, scratching backward with her feet) to when she made fewer than 1 trip per hour to the nest with material.
2. Prelay: From the completion of the nest to the day before the first egg was laid.
3. Laying: Those days when an egg was laid and time spent incubating was less than 50%.
4. Incubation: From the first day the female spent more than 50% of her time incubating to the hatching of the first egg.
5. Nestling rearing: From the hatching of the first egg until the last nestling left the nest.
6. Juvenile rearing: From the day the nestlings left the nest to their independence.

Each month a record was kept of each banded robin seen. Towards the end of each month those not seen were searched for in their territories. Outside the breeding season (January to July), I sought banded robins beyond the study area. Only two dead adult robins were found, but many more disappeared. Therefore, to determine robin mortality, it was inferred that when a bird disappeared from the study area it had died. Adults in Kowhai Bush were very sedentary; few that had lived there were subsequently found elsewhere. Thus, if an adult disappeared it had probably died. However, if an immature disappeared I could not confidently assume its death because some immatures dispersed long distances.

RESULTS

Breeding season

The mean date that first eggs were laid was 16 August in 1977-78 ($n = 27$) and 13 August in 1978-79 ($n = 13$). The mean dates for the two years do not differ significantly ($P > 0.05$). The mean date for both seasons was 15 August (range 23 July-1 September). Since nest building and prelay together lasted an average of 11 days in August, the mean date robins began nest building was 4 August. Three-year-old females had the earliest mean date of starting to lay, followed by 2-year-olds, 1-year-olds and lastly those 4 years and older

TABLE 1 — Mean date of laying of first eggs of the breeding season for female South Island Robins of four age classes. Combined data from the 1977-78 and 1978-79 seasons

Female age	Mean date of laying	N	SD
1 year	15 Aug	15	10.4
2 years	14 Aug	7	11.3
3 years	7 Aug	6	12.3
4 years and older	18 Aug	12	9.7

(Table 1). When the mean dates of starting to lay are statistically compared for the various age classes of females, only those for 3-year-olds and those 4 years old and older were significantly different ($P < 0.05$).

The last clutches of the season were laid in early January. Pairs that hatched such late clutches and fledged the nestlings were still feeding juveniles in March. Therefore, a few pairs were breeding for over 7 months. However, most late eggs or nestlings were eaten by predators, and so most breeding finished by late January.

Nest sites

Common sites were trunk and branch forks, mistletoe (*Loranthus micranthus*), crowns of kanuka and in old *Turdus* and robin nests. Of 164 nests found in the two seasons, only once was a female known to re-use the same nest for successive clutches; she relined the nest between clutches. Thirty-four percent of the 164 nests were old nests of robins, Song Thrushes (*Turdus philomelos*) and Blackbirds (*T. merula*) made in previous seasons, which the robins relined. The proportion of nests per month that were old decreased, towards the end of the breeding season: 36% of 11 in July, 54% of 35 in August, 35% of 20 in September, 38% of 32 in October, 21% of 43 in November and 17% of 23 in December ($P < 0.001$).

The mean height of the 164 nests was 3.7 m (range 0.8-8.7 m) in a forest with a 5-12 m high canopy. Flack (1973) recorded nests as low as 0.5 m and as high as at least 11.0 m. There was a significant difference between the mean height of new robin nests (mean = 4.0 m, $n = 109$) and relined old ones (mean = 3.0 m, $n = 55$) ($t = 3.29$, d.f. = 162, $P < 0.01$). Song Thrushes and Blackbirds built nests lower (mean = 2.2 m, $n = 47$) than did robins ($t = 5.77$, d.f. = 154, $P < 0.001$).

Nest building

This was done solely by the female. On average she made 22.4 trips per hour with material to the nest (117 hours of observation) but the building rate decreased as the nest neared completion. Most

material was collected within a 50-m radius, usually from the ground and off tree trunks but sometimes from old robin and *Turdus* nests. While females built nests their mates fed them on average 3.2 times each hour (89 hours of observation).

Three stages were discernible in the building of a new nest. Firstly, coarse materials such as rootlets, twigs and strips of bark were brought to the site and bound together with cobwebs. Next, the nest was lined with finer material, particularly mosses, but no cobwebs were used. Finally, a thin layer was added of very fine material such as mosses, fern scales, dried grasses, papery bark, leaf skeletons and occasionally a few down feathers. The cups of completed nests were often full of this material which had not been pressed into place.

New nests took a mean of 3.4 days to build (range 2-6 days, $n = 27$). However, nest building sometimes took longer because females occasionally abandoned sites after building in them for several hours, once for 2 days. The sites abandoned were often so open that material kept falling out of them when the bird made nest-shaping movements. If it rained heavily soon after building began, females had difficulty forming the base of the nest. The coarse material did not bind together, perhaps because the cobwebs were wet. Although I found no females starting to build in old nests, this relining seemed to take less than a day. The number of days taken to complete a new nest decreased during the season: 4.8 days for 5 nests in July, 4.5 for 4 in August, 3.0 for 6 in September, 2.6 for 5 in both October and November, and 2.5 for 2 in December ($P > 0.5$).

Although most pairs were capable of raising three broods a season, many pairs built more than three nests to replace clutches eaten by predators. Over the two breeding seasons, 40 females built

TABLE 2 — Mean length (days) of the prelay stage, the frequency of clutch sizes and the mean clutch size for robins in each month of the breeding season. Combined data from the 1977-78 and 1978-79 seasons

	N	Prelay stage		Frequency of clutch sizes			Mean clutch size
		Mean length	Range	2	3	4	
Jul	4	6.8	8-5	4	-	-	2.0
Aug	12	5.1	6-4	28	8	-	2.2
Sep	5	4.8	7-3	1	19	-	2.9
Oct	5	3.6	4-3	1	27	2	3.0
Nov	13	2.9	4-2	7	29	1	2.8
Dec	5	3.6	5-2	7	16	-	2.7

• NS = not significant

and laid in an average of 4.1 nests (new and old) per season. Twelve females built 3 nests each, 14 built 4, 11 built 5 and 3 built 6.

Prelay

This lasted on average 4.2 days (range 2-8 days, $n = 44$). The monthly mean duration varied, being longest in July and shortest in November ($P > 0.7$, Table 2). The male continued to feed his partner regularly during this stage, but only 1.5 times per hour (48.3 hours of observation), half the rate of that to females building nests.

Laying

This stage lasted for only 1 or 2 days because most clutches were of two or three eggs, eggs were laid at 24-hour intervals and full incubation began the day the last egg was laid. Most eggs were laid within 3 hours of sunrise. On two occasions an egg was laid several days after the previous one. A third case involved an egg being laid in a nest containing nestlings 10 days old. Twice, the first egg of a clutch was preyed on in the afternoon or night after it had been laid without shell or yolk being left in the nest or the nest cup being dishevelled. The subsequent eggs of these birds were also eaten within 24 hours of being laid in the same nests.

Females with incomplete clutches spent 13.8% of daylight time on their eggs (31.6 hours of observation). During the laying stage they were fed, on average, 2.5 times per hour by their partners (35.0 hours of observation), nearly twice as often as during the prelay stage.

The ovoid eggs were variously coloured, ranging from white without any markings to pale brown with brown, purplish brown, or black blotches and spots evenly distributed over them. Most eggs were chalky white with brownish markings concentrated at the larger end. The mean length and maximum breadth (\pm SD) of 363 eggs were 24.9 ± 0.10 mm and 18.6 ± 0.04 mm, extremes being 21.8×18.2 mm, 28.2×18.4 mm, 26.6×17.6 mm and 24.0×20.0 mm. The mean fresh weight of 126 eggs was 4.5 ± 0.27 g. Since the average weight of 18 adult female robins was 35.1 g in spring (J. A. D. Flack, pers. comm.), the mean egg weight represents 12.9% of the female's body weight. This is slightly above the average of 10% for a passerine of that body weight (Lack 1968: 184).

The mean clutch sizes for the two seasons (1977-78: mean 2.74 ± 0.51 , $n = 100$; 1978-79: mean 2.62 ± 0.49 , $n = 50$) do not differ significantly ($t = 1.39$, 148 d.f., $P > 0.05$). Thus, the two seasons' data were combined, giving a mean of 2.70 eggs per clutch. The monthly mean clutch size changed during the course of the breeding season (Table 2). From no 3-egg clutches in July, the proportion increased to a maximum in October, and then declined. Flack (1979) found the same monthly trend of mean clutch size in his earlier study of the Kowhai Bush robin population. The mean clutch sizes of the four age classes of female robins did not differ significantly for their

TABLE 3 — Frequency distribution and means of clutch sizes for the four age classes of female robins for the first clutches of the breeding season, and for all clutches laid during the season. Combined data from the 1977-78 and 1978-79 seasons

Age class	Frequency distribution and means of First clutches				All clutches			
	2	3	4	Mean	2	3	4	Mean
1 year	12	3	-	2.2	21	36	1	2.7
2 years	6	1	-	2.1	10	16	-	2.6
3 years	4	2	-	2.3	5	16	1	2.8
4 years and older	8	4	-	2.3	12	31	1	2.7

first clutches of the season or for all clutches laid during the breeding season (Table 3).

Incubation

Only the female robin incubated. Females became fully attentive (i.e. spent about 80% of time incubating) the day they laid their last egg, but after August some did so the day they laid the penultimate egg of 3-egg and 4-egg clutches. On average, they spent 81.0% of daylight time incubating (236 hours of observation). Incubation lasted 17 ($n = 10$ clutches), 18 ($n = 19$) or 19 days ($n = 1$), with a mean of 17.7 days. Similarly, Flack (1979) found that the robins incubated for about 18 days.

In total, males made 2.5 visits per hour with food to their incubating partners (236 hours of observation). However, this rate depended on whether the male was feeding juveniles from a previous nest (1.1 visits per hour, 58 hours of observation) or not (2.9 visits per hour, 178 hours of observation). Incubating females that received food less often incubated less (78% of 58 hours) than did those that were fed at the higher rate (83% of 178 hours, $P < 0.01$).

Table 4 shows that 63% of robin eggs hatched and 23.3% were eaten by predators. According to the evidence left at the nest (Flack & Lloyd 1978), stoats (*Mustela erminea*) and weasels (*M. nivalis*) took 88.3% of the eggs eaten and ship rats (*Rattus rattus*) and house mice (*Mus musculus*) took the rest.

Nearly 22% more eggs hatched in 1978-79 than in 1977-78, mainly because fewer eggs were preyed on in 1978-79 (Table 4). From the combined results for the two seasons, fewer eggs were abandoned, remained unhatched or had unknown fates as the season progressed, but predation increased. Clutches were abandoned most often in bad weather, particularly when heavy rain and strong winds continued for 2 or 3 days. If the female disappeared (died) during incubation, the clutch was abandoned, but if a male disappeared, the female continued incubating ($n = 3$). Unhatched eggs included those that were infertile

TABLE 4 — The fates of South Island Robin eggs (% of total laid) in total, and on the basis of breeding season, month, and female age

	No. of eggs	Egg fates (%)					
		Preyed on	Fell from nest	Abandoned	Unhatched	Unknown	Hatched
Total	405	23.2	1.5	3.9	6.2	2.2	63.0
Season							
1977-78	274	29.5	2.2	3.3	6.6	2.9	55.5
1978-79	131	11.3	0.0	5.2	5.3	0.8	77.4
Month							
Jul	8	0.0	0.0	0.0	25.0	12.5	62.5
Aug	80	2.5	3.7	7.5	7.5	5.0	73.8
Sep	59	0.0	0.0	5.1	11.8	1.7	81.4
Oct	91	22.0	3.3	3.3	6.6	2.2	62.6
Nov	105	38.1	0.0	1.9	2.9	0.9	56.2
Dec	62	53.1	0.0	3.1	1.6	0.0	42.2
Female age							
1 year	154	26.6*	3.9	2.6	7.1	2.6	57.2
2 years	68	8.8	0.0	5.9	5.9	1.5	77.9
3 years**	62	43.6	0.0	4.8	6.5	4.8	40.3
4 years and older	121	16.5	0.0	4.1	5.0	0.8	73.6

* Apparent large differences in the proportion of eggs preyed on from the female age categories are not real. The female age categories were unevenly represented in the two seasons when predation levels differed

** Not present during the 1978-79 season

or in which the embryo died during development. More eggs remained unhatched early in the season because some complete first clutches were infertile.

Three-year-old females hatched 40.3% of their eggs, significantly fewer than the other three age categories did ($P < 0.05$, Table 4). This apparent poor ability of 3-year-old females to hatch eggs is not real because there were no females of this age in the 1978-79 season, when a smaller proportion of eggs were preyed on than in the previous season. One-year-olds hatched a smaller proportion of their eggs than did 2-year-olds ($P < 0.05$) and those 4 years old and older ($P < 0.05$). In general, a similar proportion of eggs from the four female age classes was abandoned, remained unhatched or had unknown fates. Two 1-year-old females lost eggs because of unstable nests, which fell from their sites.

Nestlings

A brood usually took from a few hours to a day to hatch. Once nestlings were present, the male brought food mostly to the young instead of to the female. However, while the nestlings were 1-3 days old, he sometimes passed food to the female, which then fed it to the young. During heavy rain, when the female spent most of her time sheltering the nestlings, she occasionally accepted food

from the male while on the nest, rather than move aside to let the nestlings be fed.

Only the female brooded nestlings. In general, females brooded for about 80% of daylight time when the nestlings were 1-2 days old. The amount of brooding gradually declined as the nestlings aged, and when about 15 days old, they were not brooded during the day. Nestlings left the nest after an average of 20.8 days (range 19-22, $n = 19$ broods). Three broods that fell from collapsed nests when 12, 15 and 16 days old were fed on the ground until they could fly.

For both seasons combined, similar percentages of nestlings were preyed on (46.3%) or fledged (42.0%) (Table 5). Of the rest (11.7%), nearly equal proportions fell from the nest and died, died in the nest, or had unknown fates. By the criteria of Flack & Lloyd (1978), mustelids took 94% of the nestlings preyed on and rodents took the rest. Thus of the eggs and nestlings eaten, mustelids took a slightly greater proportion of nestlings than eggs ($P > 0.05$).

Between the two seasons, there was no significant difference in the proportion of nestlings that were preyed on, fell from the nest and died, died in the nest, had unknown fates or successfully left the nest (Table 5). Of the completed clutches (i.e. those not preyed on during laying) and broods, 61.3% were eaten in 1977-78 ($n = 119$) and 48.2% in 1978-79 ($n = 54$). This difference between the seasons is significant ($P < 0.05$) and may reflect a change in predator numbers between the seasons. These figures are within the range (44-66%)

TABLE 5 — The fates of South Island Robin nestlings (% of total) in total, and on the basis of breeding season, month, and female age

	No. of nestlings	Nesting fates (%)				
		Preyed on	Fell from nest and died	Died in nest	Unknown	Fledged
Total	255	46.3	3.5	3.9	4.3	42.0
Season						
1977-78	152	48.0	2.0	3.3	4.6	42.1
1978-79	103	43.7	5.8	4.8	3.9	41.8
Month						
Jul	5	0.0	0.0	0.0	0.0	100.0
Aug	59	11.9	3.4	16.9	3.4	64.4
Sep	48	35.4	4.2	0.0	4.2	56.2
Oct	57	54.4	7.0	0.0	7.0	31.6
Nov	26	61.5	0.0	0.0	7.7	30.8
Dec	27	77.8	3.7	0.0	0.0	18.5
Female age						
1 year	88	50.0	7.9	2.3	6.8	33.0
2 years	53	48.1	3.8	1.9	3.8	43.4
3 years*	25	32.0	0.0	8.0	0.0	60.0
4 years and older	89	46.1	0.0	5.6	3.4	44.9

*Not present during the 1978-79 season

of the proportion of robin nests whose contents were preyed on during the six previous breeding seasons at Kowhai Bush (Moors & Flack 1979).

Fewer nestlings fledged and more were preyed on from month to month (Table 5). Similarly, the proportion of nestlings whose fates were unknown increased during the season, except in December. The proportion that died in the nest or that died after falling from the nest shows no obvious monthly trend.

In 1977-78, 30 pairs averaged 2.1 fledglings per pair. In 1978-79, 15 pairs averaged 2.9 fledglings per pair. Over the five seasons 1971-2 to 1975-6, Flack (1976b) found that robins fledged on average 3 fledglings per pair each season.

Three-year-old females fledged the greatest proportion of nestlings, but the difference was not significantly greater than that for the other age classes (Table 5). One-year-old females raised fewer nestlings than did either 2-year-olds ($P < 0.05$) or those 4 years old and older ($P < 0.05$).

Juveniles

On leaving the nest, juveniles had short tails, a few down feathers on the crown, flew poorly, and perched at one place for several hours. However, by a fortnight after leaving the nest they flew proficiently, following an adult about and quickly flying to it for food when called. At this age they began foraging, mainly on the ground.

In the five known cases, male and female robins each fed particular juveniles. This division of the brood seemed to happen within the first week of leaving the nest. When the number of juveniles was odd, the male usually took care of the extra one. Once the female began nest building, and certainly by the time she started incubating, the male fed all juveniles.

The number of days parents fed juveniles varied greatly. Juveniles whose parents re-nested were fed usually until the next clutch hatched, which varied according to the number of juveniles present, how many the female cared for and how soon the next clutch hatched. When there was only one juvenile, the male took sole charge of it ($n = 12$), and the female often started to build her next nest within 3 days of the juvenile having left the nest. The single juvenile was often fed for a few days after the clutch hatched but was then driven from the territory, having received only about 24 days of parental care since leaving the nest. At the other extreme, females that cared for two juveniles sometimes delayed re-nesting for up to 35 days, or if their next clutches were preyed on, the juveniles were fed for up to 50 days before being ousted from the territory (Flack 1979, pers. obs.).

Mortality

Immatures: In 1979, and for the combined 1978 and 1979 data, mortality was highest in summer (Fig. 1). From the combined data, more immatures disappeared per month in summer than did adults ($P < 0.05$), but in autumn and winter the differences were not significant (Table 6). Of the 118 juveniles produced in the two breeding seasons (Fig. 1), only 16.9% (8 males and 12 females) were present at the start of their first breeding season. Flack (1979) found that the survival to first breeding was highly variable between years (10-90%). By comparison, for the period August 1977 to August 1979, an average of 38.6% of 114 adults survived annually during this study. Thus, although adult survival was greater than that of immatures ($P < 0.05$), it was much lower than that recorded by Flack (1979) from 1971 to 1976, when it varied around 70% per annum.

Adults: In 1977, 1978 and the three years combined (total), adult mortality was highest in autumn and lowest in the breeding season (Fig. 1), as was found by Flack (1976b, 1979). For the combined years' data, a similar proportion of adult males and adult females died each season, except in winter ($P < 0.05$), when a greater proportion of bachelors (unpaired adult males) (40% of 10) died than did paired adult males (13.3% of 60, $P < 0.05$). In contrast, only 10.9% of 46 adult females died in winter.

TABLE 6 — Percentage of adult and immature robins that disappeared (died) per month in summer, autumn and winter for 1978 and 1979

Age	Summer	Autumn	Winter
Adult	6.2 (91)*	11.5 (74)	11.4 (57)
Immature	14.2 (118)	11.8 (34)	11.5 (26)

*Number alive at the start of the season

DISCUSSION

Breeding season

Like Flack (1973, 1979), I found that South Island Robins in Kowhai Bush regularly started laying in late July-August and that most pairs had finished breeding by late January. In addition, Flack recorded the laying of three clutches in May and June. This 6-month-long breeding season differs from the 3-4-month season (late August to November) for the robins on Outer Chetwode Island at the head of Pelorus Sound (J. A. D. Flack, pers. comm.). When some robins from the island were released on to nearby Motuara Island, which had had no robins, the transferred birds began laying from August to December (Flack 1975). The Outer Chetwode Island robins had a smaller territory size range (0.2-0.6 ha per pair) than did the Kowhai Bush robins (1-5 ha per pair). Therefore, the island pairs may have been prevented by limited food from laying earlier (Powlesland 1981).

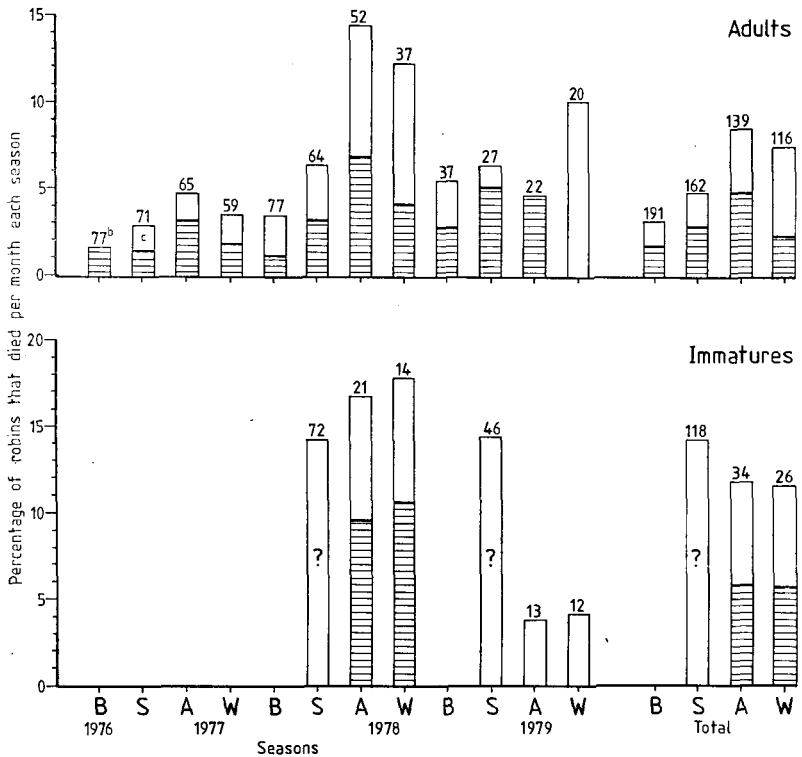


FIGURE 1 — The average percentage of adult and immature South Island Robins that died (disappeared) per month each season at Kowhai Bush from the 1976 breeding season to the 1979 winter, and also in total.

B = breeding season (August-December)

S = summer (January-March for adults and November-March for juveniles)

A = autumn (April-May for both age classes)

W = winter (June-July for both age classes)

The figure above each column is the number of robins present at the start of each season.

The blank part of each column is the proportion of dead robins that were male and the cross-hatched part is the proportion that were female.

? = the proportion of males and females not known

Robins were the first passerines to start breeding each year in Kowhai Bush. Several factors may have contributed to the early start. The robins' main prey, soil invertebrates, were apparently readily available in July and August. Their food storing (Powlesland 1980) may have enabled them to start breeding before Blackbirds and Song Thrushes, which also forage mainly on ground invertebrates in winter and spring. Male robins may have used food stored at times when prey was temporarily abundant to feed their mates and young when prey was less available. Also, female robins, unlike female Blackbirds and Song Thrushes (Witherby *et al.* 1938) are fed regularly by their mates while building nests, forming eggs and incubating.

Nests

Old nests not only need less material and are quicker to build than new ones — only a few hours instead of several days — but also were of proven stability and strength. None fell or disintegrated while in use, but seven new nests did, with the loss of two clutches and two of five broods. Why the use of old nests declined as the season progressed is not known, but increased daylength may have enabled robins to build new nests more quickly later in the season than earlier. More trips with material to the nest site could be made per day in December, for example, than in August, and with warmer weather later in the season, feeding for maintenance may have needed less time, leaving more time for nest building.

Prelay

During yolk formation in passerines most nutrients must be taken in, rather than derived from stored deposits in the body (Ankney & Scott 1980). Yolk formation in the robin occurs during nest building and prelay (pers. obs.). Thus, it is of note that females were fed less often by their mates in the prelay stage than when nest building. Two factors may explain this unexpected situation. Firstly, the robins foraged mainly by hopping over the ground and scanning from perches, activities which would be little hindered by the extra weight of developing eggs. Secondly, the female robins had time to forage for the extra food needed for egg formation. Time budgets showed that females hoarded surplus food and spent significantly more time resting and in body maintenance (preening, bathing, scratching and stretching) in the prelay stage than when nest building ($P < 0.05$). Resting and body maintenance are low-priority activities and time spent in them was inversely related to that spent foraging (Powlesland 1981). Therefore, female robins during the prelay period were probably able to meet more of their food requirements than when nest building.

The prelay period became shorter as the breeding season progressed probably because, with increasing daylength, females could forage longer each day and, needing less energy for maintenance in the warmer weather, could put more nutrients into egg formation. Also, with more hours of daylight, it was likely that a female received more food from her mate each day.

The greater mortality of bachelors in winter than of paired adult males may have been related to the significantly less time the bachelors foraged — 70% of 28.4 hours of observation and 90% of 54.9 hours of observation respectively ($P < 0.01$). The 20% extra time which paired adult males spent feeding, bachelors spent singing. Singing seemed to be to attract a mate because, once a bachelor robin became paired, he stopped almost all song. Therefore, if by singing so much bachelors spent only sufficient time foraging to meet daily maintenance requirements, perhaps their high mortality was because their bodily energy reserves were too low to sustain them during periods of bad weather. A study of the weight changes of bachelor and paired adult male robins during the non-breeding season might resolve this question.

Flack (1976b, 1979) considered that the regular increase of adult mortality in autumn was related to competition between adults and immatures for territories. The population in Kowhai Bush has been as high as 94 adults, but over the 3 years of this study it declined from 77 to 26. In late July 1981 only 16 robins (8 pairs) were present, compared with 23 (11 pairs and 1 bachelor) at the same time in 1980, the lowest counts since censuses were started in 1971. Thus, much of the forest formerly occupied by robins was unoccupied, leaving ample habitat for immature birds. The male establishes and defends the pair's territory. Therefore, if robin deaths in autumn were related to immatures competing for space with adults finishing their moult, more males would be expected to die than females. However, a statistically similar proportion of adult females (22.3% of 59) and adult males (12.5% of 80, $P > 0.05$) died in autumn.

Several other observations suggested that territorial disputes were not an important cause of the higher adult mortality in autumn during this study. No adult, male or female, was ousted from its territory or dominated by a non-territorial immature. The opposite occurred; any immature that trespassed on to the territory of an adult male that had completed his moult was chased to the boundary. Moulting adult males chased intruders, even if rather ineffectively, but not *vice versa*. Most immatures had territories by April. In summer and autumn, when adult males died immatures did not shift into the vacant territories, and so competition for "prime" habitat did not seem to be a factor in the mortality.

Adult mortality in autumn may have been caused by predators. Three adult female robins were killed on their nests by rodents in Kowhai Bush (Flack & Lloyd 1978). In addition, because robins were exterminated in only 2 years by ship rats on Big South Cape Island (Flack & Lloyd 1978) (and many robins live more than 4 years), rats can probably take roosting robins. As rodent populations reach peak numbers in autumn (Moors 1979), they may be responsible for some adult robin mortality. Flack & Lloyd (1978) concluded that rodents blundered on to nests while foraging but that mustelids were

active hunters. Therefore, mustelids can be expected to take more roosting birds than rodents and be the greater cause of adult robin mortality.

In 1976 the robins had contiguous territories, but by 1980 the population was in two parts with about half at each end of the study area. Immature birds seemed attracted to areas where other robins were present and took up territories near those of established birds. Although a 50-m wide floodway bisects Kowhai Bush, it did not directly divide the robin population. Robins flew over the floodway and immatures occupied habitat on the side opposite to their natal territory. If immature robins are attracted to areas where adults are present, this may explain the discontinuous distribution of robins in the South Island and their absence from seemingly suitable habitat between areas of occupied forest.

To identify the causes of higher adult mortality in autumn and thus the gradual decline of the Kowhai Bush robin population, the monthly mean weights of birds during the non-breeding season should show when they weigh least and so are most likely to die, directly or indirectly, from food shortages. In addition, the trapping of stoats, weasels and ship rats in the non-breeding season may show their role in robin mortality.

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SHORT NOTE

WELCOME SWALLOWS AT THE AUCKLAND ISLANDS

In early April 1983 I undertook a short tour of duty to the subantarctic islands in HMNZS *Otago*. On the approach to Enderby Island, in the Aucklands group, at 0930 on 11 April 1983, in company with P. Wilson and P. D. Gaze (Ecology Division, DSIR), we saw a flock of six Welcome Swallows flying towards the island. This was fairly close inshore at Sandy Bay, the weather being fair with some sun and little wind. Later, while ashore on Enderby Island I observed a single Welcome Swallow "hawking" overhead.

Dr M. W. Cawthorn (Fisheries Research Division, MAF), who was studying Hooker's Sealion on Enderby for 10 days before the above sightings, informs me that he had observed a flock of 20 Welcome Swallows working the cliffs and sward between East Bay and South East Point a few days earlier. He also had a record of the possible sighting of six swallows in the same area in late January 1982.

Apart from the 1943 record of the Welcome Swallow at the Auckland Islands mentioned in the New Zealand checklist and the field guide, these appear to be the only published records of the species at the Aucklands.

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