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THE FORAGING BEHAVIOUR OF THE SOUTH ISLAND ROBIN

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ABSTRACT

The foraging behaviour of the South Island Robin *(Petroica australis australis)* was studied at Kowhai Bush, Kaikoura, from August 1976 to July 1978. Robins spent 90% of their foraging time on and within two metres of the ground. They spent 61.3% of their foraging time gleaning on the ground, 33.8% scanning, 4.5% gleaning amongst vegetation, 0.3% hawking and 0.1% flycatching. The proportion of foraging time devoted to the various foraging methods differed between adult and immature robins. The diurnal patterns of ground gleaning, scanning and above-ground gleaning for adults in the breeding and non-breeding seasons, and for immatures in the non-breeding season are described. Most foraging time was spent searching (93.7%), the rest killing, dismembering and eating prey. Robins relied largely on sight to find prey, but also seemed to stimulate prey movement by foot-trembling and tail- and wing-flicking. Most movements of foraging robins were hops and steps (88%), the rest being flights. About 8% of foraging time was spent flying. The robin's diet consisted of invertebrates, except in summer and autumn when some berries were taken.

INTRODUCTION

The South Island Robin *(Petroica a. australis)* is very suitable for detailed observations of its diet and foraging behaviour because it is approachable and hunts mainly on the forest floor. However, only brief comments on feeding are in the literature. Both Oliver (1955) and Falla *et al.* (1966) commented that robins spend much of their time hopping over the forest floor taking mainly earthworms and insects.

A 5-year study by Flack (1973) on the robins at Kowhai Bush revealed that the population there was almost wholly insectivorous, only occasionally eating berries. Flack (in prep.) reports that most hunting took place on or near the ground but that extended periods of searching at higher levels also occur. He describes robins as having a range of hunting methods including hawking and skilled flycatching. Activities associated with foraging include wing- and tail-flicking and foot trembling.

The present study aimed at describing the robin's foraging methods and feeding stations, and its searching, handling and eating activities. The effects of robin age, season, and time of day on foraging methods are described.

STUDY AREA

Kowhai Bush is a narrow strip of bush 7 km inland from Kaikoura (42°S, 174°E), in coastal south-eastern Marlborough. The bush of 240 ha lies on the north-eastern side of the Kowhai River within the Kowhai River Protection Reserve. It is bounded by river-bed and farmland at 60-150 m a.s.l. The low forest consists of a flood-induced patchwork of successional stages of varying age, structure and species composition often dominated by kanuka *(Leptospermum ericoides)* with a dense understorey (Flack 1973). The history, physical aspects, vegetation, flora and fauna of Kowhai Bush were described by Hunt & Gill (1979).

METHODS AND TERMINOLOGY

Individual robins were followed about their territories, and the time they spent using the various foraging methods, feeding stations and feeding levels was recorded.

Foraging behaviour: This was subdivided as follows:

Gleaning, the "search for prey not in flight by birds not on the wing" (Croxall 1977), was the main method of locating prey. In *ground gleaning,* robins search soil, litter, rotting logs and low-growing vegetation reachable from the ground. In *vegetation gleaning,* birds stand on plants to search their surfaces.

Scanning is the use of a vantage point to look for prey. Limbs, branches and boulders were commonly used perches, but if none was available robins clung vertically to trunks and stems. If no prey was sighted, the birds usually flew a few metres to another perch and repeated the scan. The movement between perches was included in scanning time.

Flycatching is the attempted capture of flying prey by a bird on the wing.

Hawking is the attempted capture of prey not in flight by a bird on the wing. The bird flies to vegetation after seeing prey while scanning and remains in flight to capture it. The bird may flutter

briefly to inspect the prey, but never does so to find it first; this sets hawking apart from hovering. Robins were never seen to hover while searching for prey. Usually, they hawked prey from trunks, leaves and terminal shoots, but occasionally took prey from spider webs and caterpillars suspended on silken threads.

The data were analysed to see whether time of day affected foraging methods. To simplify this analysis, the little time spent hawking and flycatching was combined with that spent in vegetation gleaning and called *above-ground gleaning.*

Feeding stations: Gleaning in vegetation was subdivided into five feeding stations:

1. Standing on and searching a branch, a limb, or among vines (B-B, branch to branch).
2. Standing on a branch, limb or vine and searching an adjacent trunk (B-T, branch to trunk).
3. Clinging to and searching a trunk (T-T, trunk to trunk).
4. Standing on and searching the top of a decaying stump (S-S, stump to stump).
5. Standing on and searching foliage and twigs (F-F, foliage to foliage).

Feeding levels: From April to July 1978 the time was noted that robins spent at various heights above ground level gleaning in vegetation. Height intervals of half a metre were used from 0.1 to 5.1 metres, above which all observations were grouped. The height that a bird gleaned from vegetation was recorded and the time spent at each height interval noted.

As well as the time spent searching for prey, foraging time includes that spent handling and eating prey. During the 1978 breeding season (August to December), male robins whose mates were incubating were timed to determine what proportion of their foraging time was spent in searching, handling and eating activities. Robins were timed as involved in handling activity when killing and dismembering prey items greater than 5 mm long. Many small prey (< 5 mm) were eaten, but because such prey were picked up and swallowed immediately this probably went unnoticed much of the time.

To determine any diurnal patterns of foraging activities, each day was divided into six equal periods between sunrise and sunset, although robins were also active in twilight. To adjust the length of the day-periods to allow for the changing daylength, I used official sunrise and sunset data (*The Air Almanac,* USA Govt. Printing Office 1976) to calculate each month's mean daylength and, from that, each month's day-period length. Thus, I could assign observations to the appropriate day-periods and then combine the information from throughout the non-breeding season (January to July) or the entire breeding season.

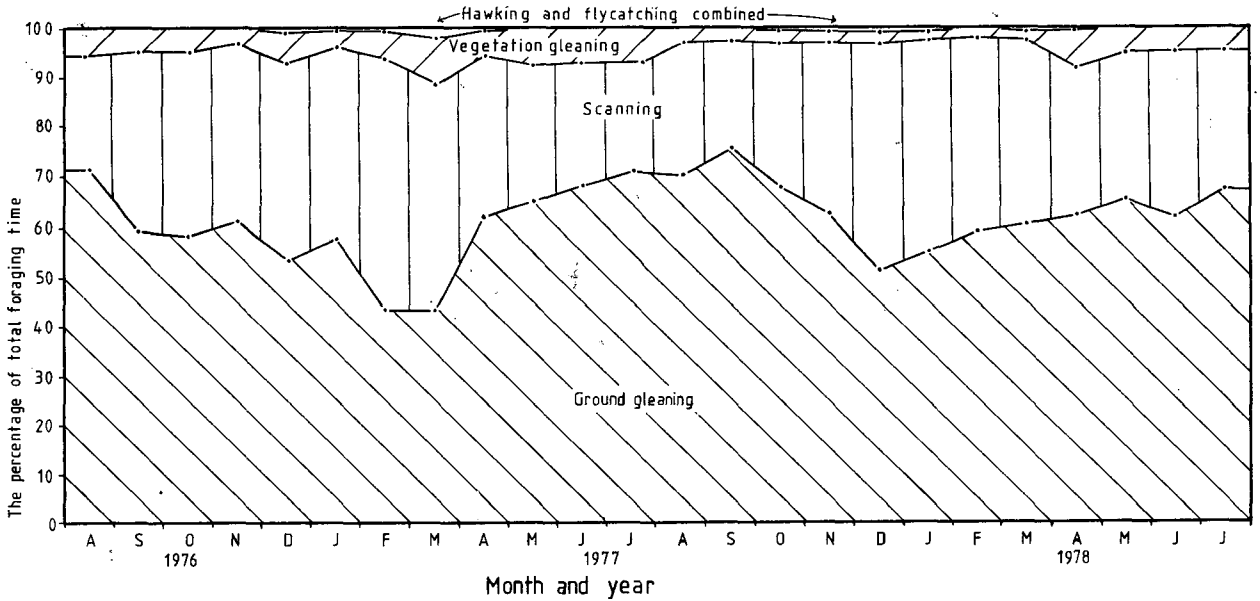

FIGURE 1 — The monthly percentage of foraging times in which robins used five foraging methods from August 1976 to July 1978.

Immature robins were defined as those independent of parental care but not yet of breeding age; that is, from about 4 weeks after leaving the nest up to the start of breeding at the end of July. At first, they were readily distinguished by their streaked crown feathers and their small area of white breast feathers, but by March the growth of more contour feathers made most of them indistinguishable from adults. From then until breeding began, they were recognised as immatures only from their band combinations.

RESULTS AND DISCUSSION

Foraging methods

Figure 1 shows the proportion of time robins devoted to the five foraging methods from 923 hours of observing foraging robins. Overall, 61.3% of foraging time was devoted to ground gleaning, 33.8% to scanning, 4.5% to vegetation gleaning, 0.3% to hawking and 0.1% to flycatching.

In winter, when the soil was moist, robins spent most foraging time gleaning on the ground. Gleaning from vegetation also became more important in winter than during the other seasons. However, the data for this foraging method showed no consistent pattern of seasonal variation: it was used more than usual from April to July in both 1977 and 1978, but also a great deal during the spring of 1976 and summer of 1977. When gleaning from vegetation, birds searched in crevices, fissures, holes, among dead foliage and tangles of vines, and at branch and trunk axils where debris collected. The rough-barked surfaces of trees are important places for insect larvae and pupae to overwinter. Thus, the coarse-textured and flaky bark of kanuka provided many opportunities for robins to find overwintering and sheltering invertebrates. Scanning, hawking and flycatching activities diminished during the course of winter, presumably because aerial and arboreal prey was then less numerous and active. Similarly, South Island Fantails *(Rhipidura fuliginosa fuliginosa)* fed on the ground and in the lower understorey more frequently in winter than in the other seasons (Ude Shankar 1977).

The time spent using the various hunting methods changed markedly from winter-spring to summer. Scanning, hawking and flycatching increased with the increase of aerial and arboreal invertebrates. During late November and December, swarms of March flies *Philia negrostigma* (Bibionidae) were present, which the robins caught by hawking and flycatching. Cicadas, which emerged in January and remained in great profusion until mid-March, were also caught by hawking and flycatching. Caterpillars were hawked from terminal shoots, and a variety of invertebrates, especially moths, was hawked from trunks. In late summer, berries were often taken by hawking because the slender twigs on which they grew did not support a robin's weight. To some extent the increased time spent scanning and hawking during summer was forced on the robins. Low rainfall and dry soil

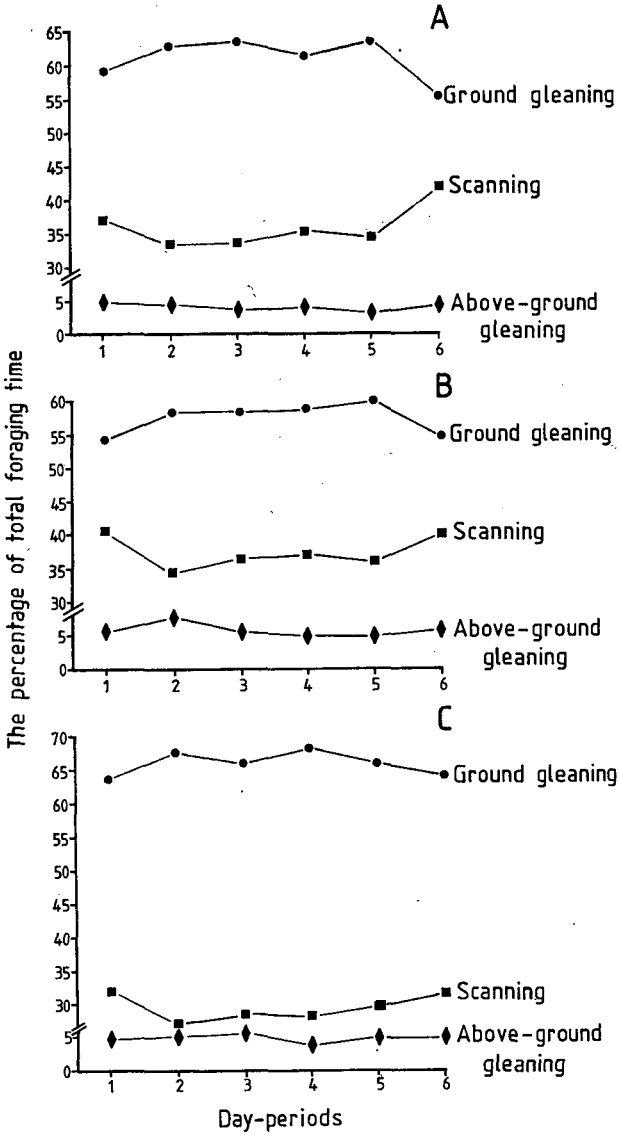

FIGURE 2 — The diurnal patterns of three foraging methods used by:
A. *Adults in the breeding season*
B. Adults in the non-breeding season
C. Immatures in the non-breeding season

Day-periods: The division of the daylight hours into six day-periods of equal length.

conditions meant few prey were active in the upper soil and litter, and so the birds had to turn to arboreal prey. More time was spent flycatching in summer than at other times of the year, presumably because in the warm calm weather insects flew more.

Adult and immature robins at Kowhai Bush spent different proportions of their foraging time using the various foraging methods (Table 1). In the same year the two age classes of robins devoted significantly different proportions of time to the five foraging methods ($p < 0.01$). Both age classes spent a similar time vegetation gleaning and flycatching, but adults did more scanning and hawking than immatures. Immatures preferred to forage on the ground, perhaps because they were less proficient at finding arboreal prey by scanning than were adults.

Figure 2A and B shows that the diurnal pattern of ground gleaning, scanning and above-ground gleaning was similar for adults in both the breeding and non-breeding seasons. The time spent gleaning above the ground was fairly stable during the course of the day, with a slight increase during mid-morning and late afternoon. Ground gleaning was a relatively constant percentage of foraging time from mid-morning to mid-afternoon inclusive, but was used less in the early morning and late afternoon. For scanning the reverse was true, for the following possible reasons.

While robins avoided open areas, they did venture into sparsely vegetated areas during twilight. Many of their territories bordered on to relatively open habitats such as the edges of the Kowhai River riverbed and grazed parkland covered with scattered trees and a sparse ground cover or pasture. Robins venturing into these areas

TABLE 1 — The percentage of time spent by adult and immature robins using five foraging methods in the non-breeding season (January-July).

Year	Ground Gleaning	Vegetation Gleaning	Scanning	Hawking	Flycatching	Total Foraging Time (h)
Adult						
1977	56.59	6.76	36.09	0.48	0.08	211.9
1978	58.14	3.65	37.92	0.25	0.04	183.3
Immature						
1977	64.94	6.77	28.03	0.17	0.09	81.1
1978	66.02	3.73	29.97	0.22	0.06	162.7

spent most of their time scanning with brief flights to the ground to catch and eat prey. This behaviour is similar to that of the Yellow-breasted Tit *(Petroica macrocephala macrocephala)* (Falla *et al.* 1966) and Pied Tit *(P. m. toitoi)* (Gibb 1961). Possibly in the low light intensities at dawn and dusk the robin's dull plumage afforded them some protection from predators, so enabling them to use open areas. Kacelnik (1979) found that captive Great Tits *(Parus major)* were less efficient foragers in light intensities comparable with those that occur for one and a half hours after sunrise. Therefore, it is likely that robins, which spent much time foraging on the ground, would also be less successful foragers in the bush at dawn and dusk. Perhaps by venturing out into open habitat while the light was poor in the bush, robins were able to spend a greater proportion of the day foraging profitably.

Robins within the forest also spent more time scanning in the early morning and late afternoon, possibly to find prey which were active at dawn and dusk. Invertebrates damaged during the night, those that had failed to conceal themselves adequately before dawn, and those that became active just before sunrise (e.g. cicadas) would have been most vulnerable then. Scanning would enable the greatest area of territory to be searched quickly.

The diurnal patterns of foraging methods used by adult and immature robins were similar during the non-breeding season, even though immatures scanned less than adults ($p < 0.01$). The peaks of scanning in the early morning and late afternoon were lower for immatures than for adults, probably because immatures ventured less into open habitats.

Feeding stations and feeding levels

Table 2 shows that, when vegetation gleaning, robins spent most time gleaning from branches (39.5%) and trunks (37.97 + 20.27 = 58.2%) of trees. Little time was spent gleaning from decaying tree stumps and amongst foliage and twigs. Perhaps this was because robins were too heavy and lacked the precise agility and balance of

TABLE 2 — The percentage of time robins spent gleaning from five feeding stations on vegetation.

Feeding Stations[a]					Total Foraging Time (h)
B-B	B-T	T-T	S-S	F-F	
39.47	37.97	20.27	2.01	0.28	19.8

[a] B-B = branch to branch; B-T = branch to trunk; T-T = trunk to trunk; S-S = stump to stump; F-F = foliage to foliage.

TABLE 3 — The percentage of time robins spent on vegetation gleaning at various heights.

	Height (m)										Total Time (h)
	0.1 ↓ 0.6	0.7 ↓ 1.1	1.2 ↓ 1.6	1.7 ↓ 2.1	2.2 ↓ 2.6	2.7 ↓ 3.1	3.2 ↓ 3.6	3.7 ↓ 4.1	4.2 ↓ 4.6	4.7 ↓ 5.1	>5.1	
%:	23.8	13.0	18.4	15.1	9.0	7.2	4.6	3.7	1.8	1.8	1.6	29.1

smaller birds. Although capable of clinging to coarse-textured trunks, they preferred to perch on branches while foraging from trunks.

About 70% of time when gleaning amongst vegetation was spent within 2 metres of the ground (Table 3). Little time was spent foraging above 4 metres, even though the bush grew to 7-12 metres. Robins may have gleaned from vegetation mainly within 2 metres of the ground partly because the number of crevices, holes and bark furrows decreases with height up trunks (Travis 1977), and partly because of their wariness of open spaces. Robins were very wary of Bellbirds *(Anthornis melanura)*, magpies *(Gymnorhina tibicen)*, New Zealand Kingfishers *(Halcyon sancta)* and Australasian Harriers *(Circus approximans)*, whose presence often caused them to give alarm calls and to flee into the lower understorey vegetation.

Although the heights of scanning perches were not measured, they seemed similar to those for vegetation gleaning, and so 90% of the robin's foraging time was spent on the ground and within 2 metres of it. Similarly, Gravatt (1971) found that from 43 observations of foraging North Island Robins *(Petroica australis longipes)*, 93% of occasions involved the birds on the ground and within 3 metres of it.

Searching activity

During the incubation stage of the breeding cycle, male robins spent 93.7% (n = 12.8 h) of their foraging time searching for prey. They were never seen systematically turning over an area of litter, as Blackbirds *(Turdus merula)* and wekas (*Gallirallus* spp.) do, but seemed to rely largely on sight. In contrast, Gravatt (1971) described the North Island Robin as raking the litter with its beak and turning over leaves to disturb small animals. In their searching, South Island Robins hopped and stepped over litter and vegetation or scanned from a vantage point. They moved litter and bark aside only to retrieve prey that they had seen retreat underneath them.

Special movements of the feet, wings and tail seemed to stimulate prey to move and to enhance their detection. Flack (1973) and Soper (1976) noted foot-trembling by robins. One foot was placed on the ground slightly forward of the other and vibrated up and down rapidly. This foot movement was either continuous or discrete pulses with the two feet being used alternately. On dry litter a distinct rustle

could be heard as the robin's foot vibrated upon it. Robins foot-trembled mainly when on the ground, but occasionally did so while foraging on branches. All foraging robins foot-trembled, and some juveniles made these movements when only 12 days out of the nest.

Foot-trembling by several *Petroica* species has been reported. Hobbs (1954) observed the behaviour in Flame Robins *(P. phoenica)* feeding near Deniliquin, Australia. Best (1975) noted that Black Tits *(P. macrocephala dannefaerdi)* quivered one leg up and down rapidly. Similarly, Kearton (1979) found that Yellow-breasted Tits occasionally foot-trembled on branches. Sparks (1961), making reference to feeding shorebirds, hypothesised that foot movements were adopted " to exploit the properties of intertidal muddy sand, in order to expose or incite movement in cryptic invertebrates of the intertidal zone." Thus, foot-trembling by robins may have been to stimulate movement from hidden prey by transmitting vibrations.

Wing- and tail-flicking made by robins as they foraged on the ground and branches also seemed to flush prey. Wing-flicking " is the quick extension and replacement of the hand and primary feathers out to either side of the body " (Horwich 1965). The tail was similarly flexed to form a fan and sometimes cocked up and down. Few birds tail-flicked, but all wing-flicked. Wing-flicking was very rapid; several flicks were given in quick succession, after which the bird moved a few hops before repeating the action. During 20.3 hours of foraging observations, robins averaged a wing-flick every 51 seconds.

Much controversy exists on the role of wing movements for feeding passerines: for example, wing-flashing in Mockingbirds *(Mimus polyglottos)* (Hailman 1960, Horwich 1965). Wing-flashing is the extension of the wings up to about an 85° angle to the horizontal and completely extending the remiges. Thus, this movement consists of a prolonged extension without any hesitations until the wings are quickly brought down to the sides. Hailman (1960) considered that the flashing of white wing patches startled insect prey into revealing themselves. However, Horwich (1965) noted that 69% of all observations of wing-flashing by Mockingbirds were associated with a situation in which birds showed escape tendencies or ambivalent behaviours such as slight fear or uneasiness. Wing-flicking by robins often took place at sites that could have concealed predators and so been flight intention movements, but they were never given in a crouched stance as though preparatory for flight. Ude Shankar (1977) concluded that the tail fanning, flicking and flashing of foraging South Island Fantails provided maximum thrust during take-off and balance while hopping about on branches and the ground. However, Warham (1956) suggested that the wing- and tail-flicking of Willy Wagtails *(R. leucophrys)* were made to scare " camouflaged prey into revealing flight or movement." Prey startling by robin wing movements may be enhanced by the flashing of a narrow pale band on the underside of the wings. Wing-flicking was seen only from foraging birds, and then usually while they

were near or under overhanging vegetation. These wing movements did not seem to be used for balance since both wings were moved equally out from the body and at the same angle to it, hardly balancing movements, which typically are irregular and erratic.

Nearly 88% of foraging movements were hops and steps, the rest being flights (Table 4). This would be expected for a species that spends much of its foraging time on the ground. Sixty-six percent of flights ended with robins landing on branches compared with 30% ending on the ground (Table 4). This was because of the many short flights made by scanning robins from perch to perch. Few flights ended on the ground and trunks where prey items were usually captured. This behaviour was also true of Black Robins *(Petroica traversi)* (Flack MS). Almost all flights (90%, n = 2289) made by foraging robins were over distances of less than 6 metres. Most flights were too brief to time with a stopwatch accurately. However, a one-metre flight took about one second and, multiplying by the number of metres flown, I calculated that nearly 8% of foraging time was spent flying.

Although most pecks were made by robins foraging on the ground (Table 4), this may not indicate the effectiveness of pecking in capturing prey. Most pecks made while robins were on branches and trunks seemed to be at prey, whereas some made while they were on the ground included pecks to move litter aside and to probe into the soil to catch retreating animals. More pecking occurred on trunks than on branches because trunks were more furrowed and so were better sources of food.

Handling and eating activities

The time robins took to kill, dismember and eat prey depended on the prey's size and defensive actions. Of 12.8 hours of foraging time robins spent 6.3% in mainly handling activity and some in eating activity. Small items (< 5 mm long) were swallowed whole and seemed to be killed merely by being crushed between the mandibles. Large invertebrates were killed by quick stabbing and pinching movements of the beak. Once the prey was subdued, it was carried to a protected place for breaking into smaller portions. Such places were on the ground and under vegetation giving seclusion from other birds. Male robins occasionally took prey from their mates during the non-breeding season.

TABLE 4 — The percentage of movements and pecks by robins at three feeding stations.

	Feeding Stations			
	Ground	Branches	Trunks	N
Hops and Steps	86	13	1	16438
Flights	30	66	4	2289
Pecks	94	2	4	6083

TABLE 5 — The time taken by South Island Robins to kill, dismember and eat some prey animals.

Animals and their Length	N	Mean Time (min)	Range	SD
Amphipsalta zelandica (cicada) 3-4 cm	27	2.2	1.0 - 4.0	0.71
Earthworm <4 cm	16	0.3	0.1 - 0.9	0.06
Earthworm 4-14 cm	13	1.3	0.4 - 2.4	0.32
Earthworm >14 cm	14	6.0	3.4 - 13.6	11.81
Stick-insect 8-15 cm	25	1.8	0.4 - 4.6	1.32
Slug 2-4 cm	14	2.5	0.4 - 4.8	1.46
Snail 1.5 - 3.0 cm	3	5.1	4.6 - 5.5	0.17
Hemideina femorata (tree weta) 3.5 - 5.0 cm	10	5.0	2.8 - 8.4	3.45

Prey was dismembered by being smashed against a log or the ground. Prey was grasped in the middle or at one end and repeatedly swung from side to side with a downwards and sideways movement of the head, until a portion broke off that was small enough to swallow. Sometimes caterpillars found above ground-level were broken up on a branch. Table 5 shows the mean time taken to kill, dismember and eat some common prey animals. Robins took a lot of time dealing with slugs, snails and large earthworms because of their bulk and sliminess. Before being broken up, slimy prey was thoroughly rubbed on a log or over the ground to remove most of the slime that may otherwise have fouled the robin's plumage. Caterpillars were vigorously bashed until macerated. Many berries were broken up even when they were small enough to be swallowed whole. This apparently separated the indigestible seeds from the fleshy exocarp, although some seeds were also ingested (Powlesland 1979).

Few invertebrates could deter robin attacks. Ground beetles (*Megadromus* and *Mecodema* spp.) were usually ignored, presumably because they emitted an " acrid, pungent and offensive smell when disturbed " (Sharell 1971) and had strong exoskeletons. However, they were seen being eaten on three occasions, two *Megadromus wallacei* being taken by the same robin, which ate only the viscera. Stick-insects occasionally deterred attacking robins by waving their long spiny legs. Similarly, tree wetas *(Hemideina femorata)* were able to ward off robins by raising their large spiny legs. Their vigorous thrashing movements, accompanied by a rasping noise, and their strong exoskeleton combined to deter some robins, especially immatures, from killing them.

Associated with catching soil-burrowing prey such as earthworms, robins used the " head-cock " and " beak-pounce " (Heppner 1965). When a robin sighted a likely hole, it stood still, cocking its head from

side to side. If prey was seen the bird straightened its head and jumped forward with both feet off the ground, thrusting its beak into the soil with considerable force and speed. Repeated beak-pounces were made whenever prey retreated out of reach or an earthworm broke in two, leaving a portion in the hole.

Large items of the robin's diet

The robin's diet at Kowhai Bush was almost wholly invertebrates, and some berries. The large invertebrates, which seemed to form the bulk of biomass eaten, included earthworms (Oligochaeta), spiders (Arachnida), wetas (*Hemideina* and *Hemiandrus* spp.), stick-insects (*Acanthoxyla* and *Clitarchus* spp.), cicadas (*Amphipsalta zelandica* and *Kikihia subalpina*), snails and slugs (Mollusca), all stages of moths and butterflies (Lepidoptera), and beetles (Coleoptera). Many small invertebrates were also eaten by robins, but as I was usually several metres away, I could not identify them.

Most food species varied seasonally in the diet. During winter and spring, when the soil was moist, earthworms, slugs, snails and larvae of the March Fly predominated. However, by late spring-early summer, increasing numbers of larval and adult stages of Lepidoptera were eaten. During January, the cicada *(Amphipsalta zelandica)* emerged in profusion, and some adult robins seemed to feed on it almost exclusively. Few cicadas remained by early April, when the robins began feeding on stick-insects, but as soon as autumn rains activated soil-inhabiting invertebrates the stick-insects were largely ignored. In addition, during autumn, mushrooms and toadstools (Agaricales) were broken up by robins to get at the small invertebrates in them.

Many instances of berry eating by robins were seen. The berries of *Astelia fragrans, Coprosma rhamnoides, C. robusta, C. propinqua, Coriaria arborea* and *Cyathodes fasciculata* were most often eaten, but others included *Carpodetus serratus, Corokia cotoneaster, Melicytus ramiflorus, Muehlenbeckia australis, Pittosporum eugenioides, Pseudopanax arboreus* and *Rubus fruticosus.* Most berries were eaten in summer and autumn.

Vegetable matter has a lower nutritive value and poorer digestibility than animal matter. Therefore, the proportion of vegetable food ingested is likely to increase when insufficient animal food is available. This seems to be the main reason for berry eating by robins in summer. Invertebrate prey was scarce in summer when dry conditions inhibited the activity of soil-inhabiting animals and prevented robins from probing into the soil.

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SHORT NOTE

TRANS TASMAN CATTLE EGRETS

Recently I was told that shortly after leaving Sydney on 1 March 1980 seven large white birds were noticed following *Union Hobart.* They stayed with the vessel, intermittently landing on board, until 4 March when a few miles off Farewell Spit. From descriptions and photographs taken atthe time the birds are identifiable as Cattle Egrets *(Bubulcus ibis).*

JOHN JENKINS