

THE STRATIFICATION OF PASSERINES IN FIJIAN FORESTS

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ABSTRACT

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

INTRODUCTION

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

STUDY AREAS

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

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

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

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

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

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

METHODS

The native insectivorous/nectarivorous passerines were investigated in the study areas by direct observation and by mist-netting. Observations were made with 10 × 40 binoculars between 0800 h and 1630 h. Birds were allocated to one of five vertical zones: (1) ground, (2) undergrowth, (3) lower storey, comprising saplings and tree ferns, (4) middle layer and (5) canopy. In addition, three horizontal zones were recognised: (a) an inner zone, on or close to the trunks of trees or the stems of tree ferns and saplings, (b) a middle zone, of branches, and (c) an outer zone, of twigs and leaves. No

such division was possible for ground and undergrowth vertical zones. Finally, each bird was classified according to its foraging method: (1) flycatching, where birds caught insects and other invertebrates by hovering or swooping, (2) gleaning, where they sought invertebrates by moving up and down stems, probing and stripping bark, dead leaves and other vegetation, and (3) foliage searching, where they took invertebrates by flying and picking insects off foliage. A fourth category could be included for nectarivorous birds, but as I usually could not differentiate them from foliage-searching insectivorous birds, I grouped these two categories. I did not see birds eating fruit.

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

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

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

RESULTS

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

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

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

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

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

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

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

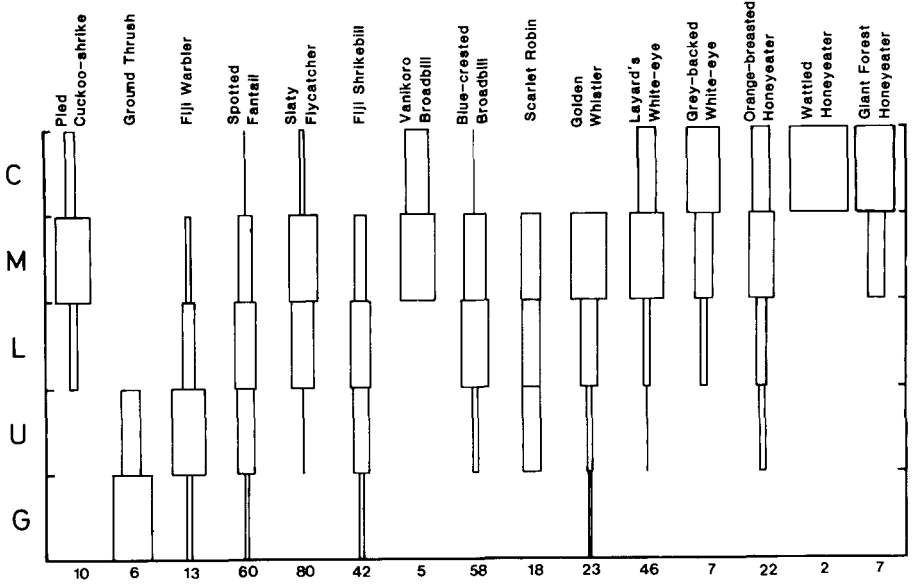


FIGURE 1 — Vertical feeding zones of Fijian rainforest passerines at Wailoku, Viti Levu. C = Canopy M = Middle zone L = Lower zone U = Undergrowth G = Ground. Numbers represent sample size

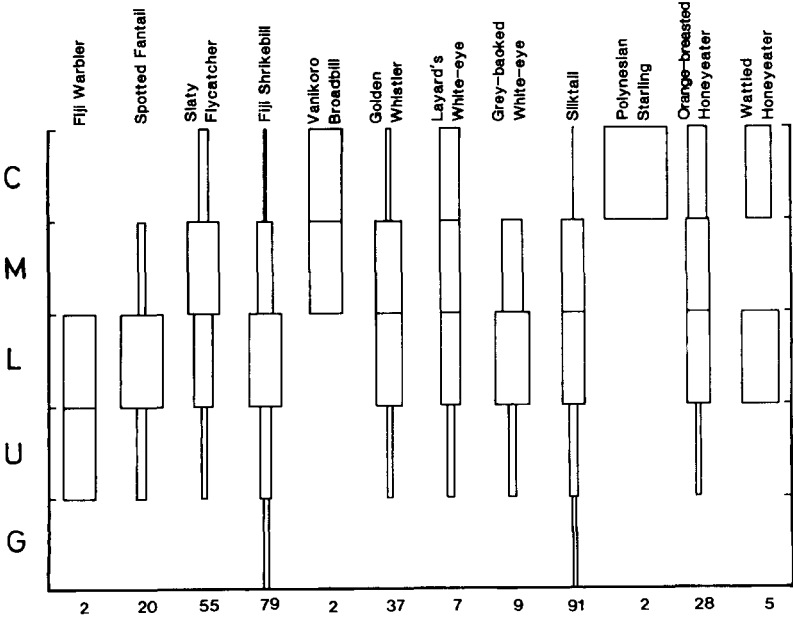


FIGURE 2 — Vertical feeding zones of Fijian rainforest passerines at Kubulau, Vanua Levu. Key as for Fig. 1. Numbers represent sample size.

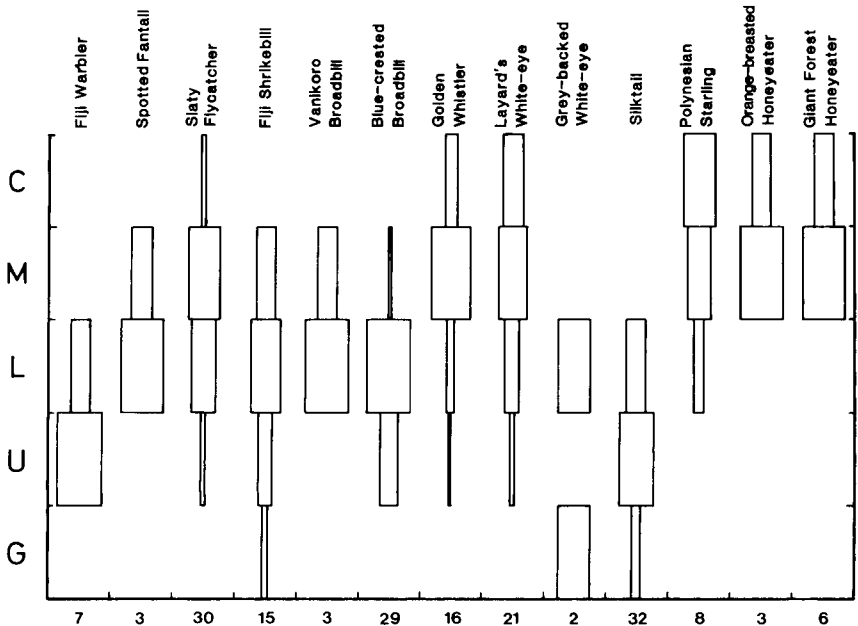


FIGURE 3 — Vertical feeding zones of Fijian rainforest passerines at Tutu, Taveuni. Key as for Fig. 1. Numbers represent sample size

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

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

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

* Flowers borne on trunk

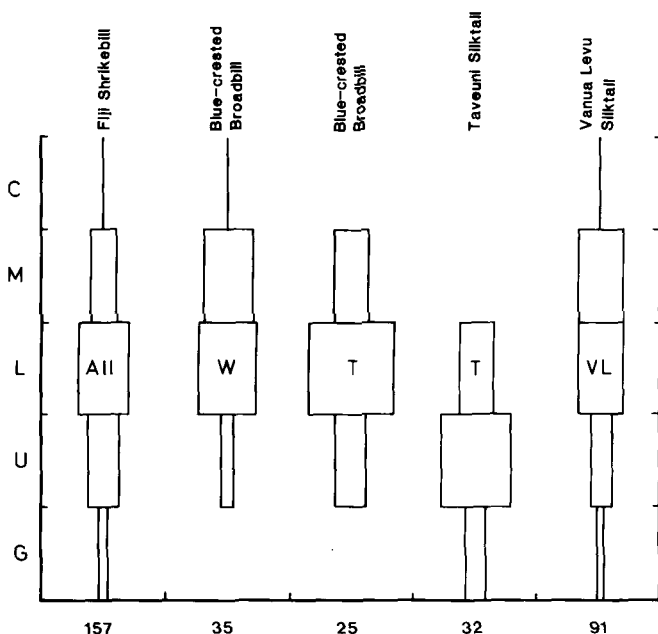


FIGURE 4 — Vertical feeding zones of Fiji Shrikebill, Blue-crested Broadbill and Silktail. Numbers represent sample size. W = Wailoku, Viti Levu, T = Tutu, Taveuni, VL = Kubulau, Vanua Levu

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

Horizontal zonation

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

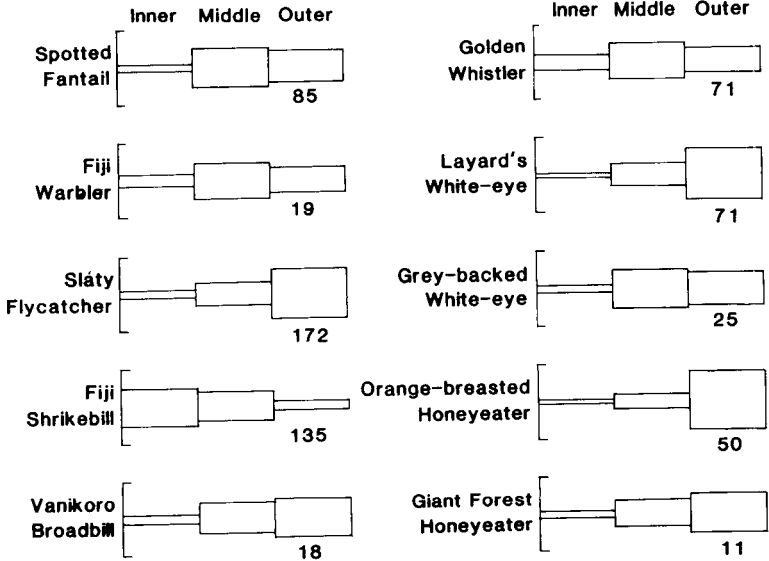


FIGURE 5 — The horizontal feeding zones of 10 Fijian rainforest passerines. Numbers represent sample size

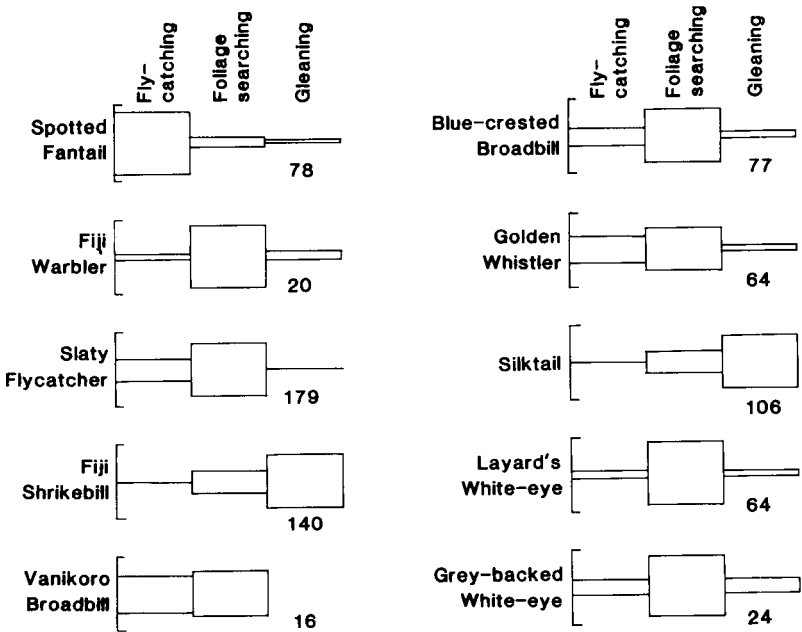


FIGURE 6 — The foraging strategy of 10 Fijian rainforest passerines. f = Flycatching, f/s = Foliage/searching, g = Gleaning. (See text for more details.) Numbers represent sample size

Foraging methods

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

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

Mist-netting

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

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

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

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

Species	No. Individuals	No. Recaptures	Total Captures
Island Thrush	25	14	39
Fiji Warbler	15	3	18
Scarlet Robin	7	3	10
Spotted Fantail	16	3	19
Blue-crested Broadbill	23	8	31
Slaty Flycatcher	11	2	13
Fiji Shrikebill	55	12	68
Black-faced Shrikebill	4	1	5
Silktail	11	4	15
Golden Whistler	22	2	24
Grey-backed White-eye	6		6
Layard's White-eye	5		5
Orange-breasted Honeyeater	23	2	25
Wattled Honeyeater	13	1	14
Red-headed parrotfinch	8	1	9

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

Comparison of observations and mist-netting

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

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

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

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

*includes Nadarivatu

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

The Giant Forest Honeyeater was recorded only at Wailoku and Taveuni, where it foraged only in the canopy and middle zones. The Wattled Honeyeater was found at Wailoku and Kubulau foraging in the canopy, but it also descended to the lower zones and featured in the mist-net samples. Both Wattled and Orange-breasted Honeyeaters were found also in the open

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

DISCUSSION

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

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

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

On Taveuni, the Silktail was also a gleaner (53%) occupying the inner zone (75%), although frequently gleaning on vines. It mainly occupied the undergrowth (56%), thus reducing competition with the Shrikebill, which used the lower storey (47%) and the middle zone (27%) and foraged less in the inner zone (44%). On Vanua Levu, although the Blue-crested Broadbill was absent at Kubulau, the smaller Silktail subspecies fed higher up in the lower storey (36%) and the middle zone (36%), compared with 49% and 33% respectively, for the Fiji Shrikebill. The Silktail occupied similar feeding

zones – inner (49%) and middle (29%) – to those of the Shrikebill (41% and 41%, respectively). Both fed mainly by gleaning (Silktaill 73% and Shrikebill 66%). The overlap probably means that the larger Fiji Shrikebill (29.2 g, n = 74) displaces the smaller Vanua Levu Silktaill (11.3 g, n = 5), which could be one of the factors contributing to the rarity of the Silktaill on Vanua Levu, as suggested by Heather (1977).

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

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