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SHORT NOTE

Canopy and above canopy movements of birds on Whatupuke Island, New Zealand

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Flight heights are not generally recorded in studies of New Zealand birds or during monitoring programmes, but this behaviour has received recent attention due to concerns about the impact and risk of wind turbines to birds (Powlesland 2009). Counts of kukupa (*Hemiphaga novaeseelandiae*) in the forest canopy have also been undertaken at Trounson Kauri Park to monitor changes in forest use by this species with management (Gillies *et al.* 2003). Clearly, understanding the movements of birds both through and above the canopy will be needed to assess how they respond to changes in management practices or, as in the case of wind farms, the placement of barriers to flight movements. The objective of our study was to define the patterns of movements of a variety of native birds within and above the canopy.

We conducted our study on Whatupuke I (also known as Mauiroto I) in the Marotere (or Chickens) Is group between 18-22 Nov 2004, while undertaking other kiore (*Rattus exulans*) post-eradication monitoring (Towns & Parrish 2005). The island is 102 ha in area, and we camped at 20 m altitude beside a ground level water collection roof (2668614E, 6588470N), and 15 m from a seep where birds were likely to come to drink (Fig. 1). This site faced south and was at the bottom of a 234 m valley. The forest within 10 m^2 had been cleared and it was through the 10x10 m gap in the canopy that we noted substantial movements of a number of bird species.

To assess movements of birds, observations were conducted with 2 people standing on the eastern side of the water collection roof looking up to the north-west while the third person wrote the records as they were called out. All birds crossing the gap were scored to species, time, height, and direction of exit. Height was scored as either: (1) within the canopy (3 - 5 m), (2) above the canopy to 40 m, or (3) well above canopy (>40 - 230 m). Straight flights were defined by the direction of exit. Birds that looped within the zone of coverage were assigned the direction they left the coverage zone and looping was noted.

Counts of birds moving through the canopy were conducted on all 4 days. A total of 17 observation bouts were made, with each bout varying from 15 to 32 minutes in length. Sixteen observation bouts were equally divided between the early morning (0800 - 1015), late morning (1015 - 1230), afternoon (1315 - 1700) and evening (1730 – 2030; all times are New Zealand summer time). The direction of the wind was southerly at all times except during the 1st observation bout on 18 Nov, when the wind blew from the south-east. Winds were relatively calm throughout the study with speeds varying from 0 to 1.0 m/sec. Only on 18 Nov did winds peak at 2.5 m/sec. Temperatures were relatively mild and ranged from 15.1 to 20.5 C during the observation bouts. Sunrise was at 0550 and sunset at 2020, and the southerly aspect of the valley and height of the

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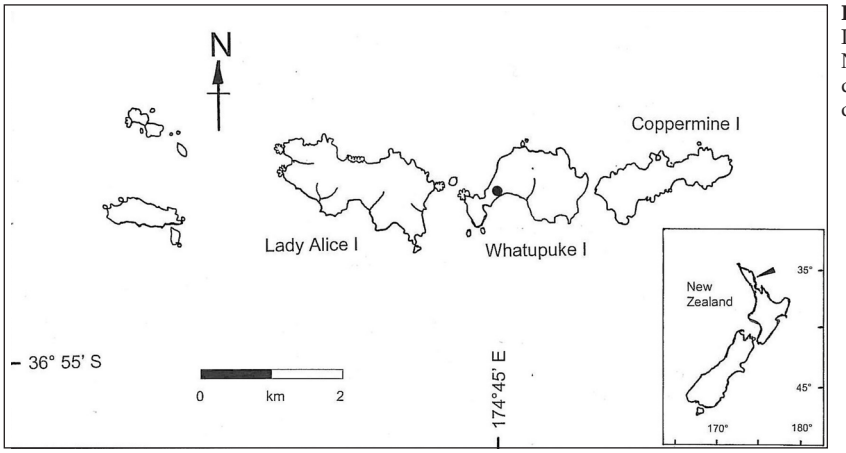

Fig. 1. Location of Whatupuke I, in the Marotere Is group, Northland, New Zealand. Black dot indicates site at of counts of canopy birds.

Table 1. Species recorded flying through and above the canopy. Values are the number of birds observed moving in each of 3 height categories.

Species	Within canopy	Above canopy to 40 m	Well above canopy >40-230 m	Detections (%)
Australasian harrier	-		5	0.4
Kaka	-	5	23	2.1
Pied shag	-	75	16	6.9
Black-backed gull	-	11	8	1.4
Kingfisher	-	5	2	0.5
Welcome swallow	-	20	4	1.8
Red-crowned parakeet	22	54	21	7.4
Kukupa	8	98	18	9.4
Bellbird	92	183	28	23.1
Tui	52	391	159	45.8
Australasian gannet	-	1	-	0.1
North Island saddleback	1	6	-	0.5
Blackbird	1	2	-	0.2
Fantail	1	-	-	0.1
Grey warbler	1	-	-	0.1

island (234 m) meant that our observation area was primarily in shade until 0900.

A total of 15 species (n = 1313 records) were observed crossing the gap during 483 min of observations (Table 1). Nine species were primarily terrestrial and forest-dwelling birds, including North I kaka (*Nestor meridionalis septentrionalis*), red-crowned parakeet (*Cyanoramphus novaezelandiae*), bellbird (*Anthornis melanura*), tui (*Prosthemadera novaeseelandiae*), kukupa, grey warbler (*Greygone igata*), fantail (*Rhipidura fuliginosa*), North I saddleback (*Philesturnus carunculatus rufusater*), and blackbird (*Turdus merula*). Three species were mixed-habitat birds, and included New Zealand kingfisher (*Halcyon sancta*), welcome swallow (*Hirundo tahitica*) and Australasian harrier (*Circus approximans*). We also observed 3 species of seabirds flying across the opening: Australasian gannet (*Morus serrator*) pied shag (*Phalacrocorax varius*) and black-backed gull (*Larus dominicanus*) (Table 1).

Heights of flight movements appeared to vary across species, but kaka was the only species to show a significantly greater number of movements in the > 40-230 m zone than in other zones ($\chi^2 = 11.6$,

Table 2. Frequency of movements (mean number of birds/minute) at Whatupuke I in relation to time of day.

	early morning		late morning		afternoon		evening	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Bellbird	0.48	0.24	0.69	0.16	1.00	0.35	0.72	0.87
Kukupa	0.23	0.09	0.38	0.28	0.46	0.30	0.18	0.16
Red-crowned parakeet	0.24	0.24	0.33	0.11	0.25	0.12	0.09	0.13
Tui	1.06	0.48	1.40	0.66	1.61	0.37	1.45	0.99
Pied shag	0.14	0.21	0.03	0.05	0.13	0.16	0.40	0.26
Welcome swallow	0.01	0.01	0.03	0.03	0.06	0.08	0.13	0.23
Kaka	0.05	0.04	0.08	0.11	0.03	0.05	0.10	0.08
Kingfisher	0.04	0.03	0.03	0.03	0.00	0.00	0.00	0.00

df = 1, $P < 0.001$). They were observed frequently at 150 m or more above the canopy and were probably moving between islands. Tui (n = 602), bellbird (n = 303) and kukupa (n = 124) movements comprised the bulk (78.7%) of the records (Table 1). Bellbirds and kukupa tended to move within or just above the canopy. In contrast, most tui movements were either above or well above the canopy (Table 1). Twelve tui were observed 200 m above the canopy.

The detection rate per count period averaged 2.73 birds/minute (se = 0.22, n = 17). There were differences in the detection rates between days and times of the day but no obvious pattern was evident (Table 2: ANOVA, $F_{1,15} = 0.271$, $P > 0.05$). Kingfisher (n = 7) movements were only recorded in the morning, and pied shag (n = 92) had peaks in the early morning and late afternoon when many birds left and returned to a roost and breeding site that was 100 m west of the count site.

There were significantly more movements by birds exiting the forest opening parallel with the slope (east or west), than either up and down the slope ($\chi^2 = 790$, *df* = 2, $P < 0.001$). The data was heavily influenced by the high proportion of the most common 5 species, so we investigated diurnal patterns and directions of movements in these species separately. Whether birds flew east or west was significantly dependent on time of day in both tui and bellbirds, but there was no significant effect of time of day on flight direction in pied shags, kukupa and red-crowned parakeets (Table 3).

The vast majority of records (96.3%) involved a straight flight through the census zone. However, 5 species turned at least 90 degrees in the observation zone. Pied shags turned 26 times as they maneuvered to return to the roost. Twenty tui, 5 bellbirds, 3 welcome swallows, 3 black-backed gulls, 1 kukupa, and 1 kaka changed direction while in flight.

Few other behaviours were seen while birds were in flight. The only calling birds in flight were 3 kaka at 1910 on 18 Nov 2004. Four chases were recorded; 2 between tui, 1 between bellbirds, and a tui chased a bellbird. Three kukupa and 2 tui gave dive and stall displays. A tui carried nest material and another food in their bills.

Despite the preliminary nature of our observations and their restriction to one site, we found differences between species in the frequency and behavior of birds flying through and above the canopy. Such differences could be important for assessing how different species may react to changes in the structure of the canopy through management, or in the probability of collisions with human-made barriers. Although forest and open habitat bird detection has been investigated using a number of methods and indices in New Zealand (Stidolph 1948; Dawson & Bull 1975; Gibb 2000a, 2000b), detection due to flight and within-canopy movement heights are not specifically recorded. Data collected during our counts suggests that many movements over dense forest would go unrecorded using standard survey techniques. For example, on 21 Nov 2004, AJB tried to detect movements just above the study site but from below the taraire (*Beilschmiedia taraire*) canopy. However, he only recorded sub-canopy movements of birds when the movements seen at the canopy gap remained about 2.5 birds/minute.

The function of canopy and above canopy movements require further study, but it is likely some of them involve birds moving between roosts and/or feeding sites. In Northland, dawn and dusk movements by starling (*Sturnus vulgaris*), house sparrows (*Passer domesticus*) and common myna (*Acridotheres tristis*) to offshore islands and mainland roost sites frequently occur at 40-250 m or more (Beauchamp, *unpubl. data*). The highest flying species detected in this study were birds that are known to be frequent native long-range dispersers.

Table 3. Assessment of movements of birds above the canopy in relation to direction and time of day.

Species	Direction of flight	Time of day				χ^2	*P*
		Early morning	Late morning	Afternoon	Evening		
Kukupa	East	13	19	11	4	7.11	NS
	West	5	9	18	3		
Bellbird	East	29	41	54	34	29.04	<0.001
	West	16	45	34	31		
Tui	East	56	99	82	35	27.57	<0.001
	West	50	84	62	88		
Red-crowned parakeet	East	9	18	10	4	0.1	NS
	West	10	18	9	4		
Pied shag	East	12	3	3	23	1.69	NS
	West	11	1	5	27		

These included tui, kukupa and kaka which are regular commuters between mainland and island sites in the northern Hauraki Gulf. Bellbirds and red-crowned parakeets that we recorded as flying at lower altitudes also probably disperse at higher altitudes.

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