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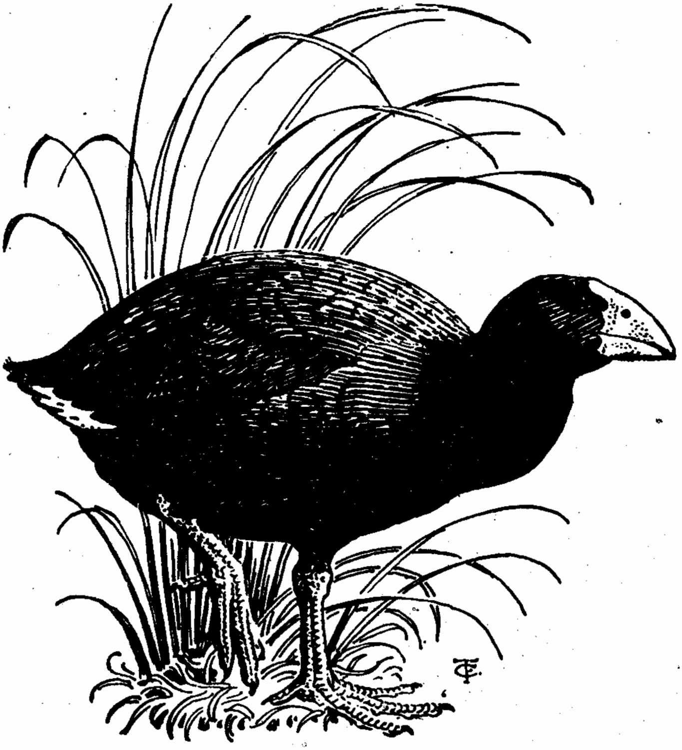
Journal of the Ornithological Society of New Zealand



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VOCALISATIONS OF *Procellaria* PETRELS

By JOHN WARHAM

ABSTRACT

The vocal repertoires of Grey, White-chinned, Parkinson's and Westland Petrels are compared with the aid of sonagrams. All species have some very loud calls built from short, staccato notes, often given at very high rates to produce rattles, cackles and brays. These appear to advertise the bird's availability as a partner and/or possession of a territory, but some also seem to serve as threats. Other calls composed of longer notes are produced both when breathing in and when breathing out – as with *Puffinus* and *Calonectris* shearwaters. The recorded repertoire of the Grey Petrel is the smallest, that of the Westland Petrel the most extensive. There are indications that in some species there are sexual differences in their calls, but experimental verification is needed to confirm this.

INTRODUCTION

The Black or Parkinson's Petrel and the Westland Black Petrel *(Procellaria parkinsoni* and *P. westlandica)* are New Zealand endemics, the White-chinned Petrel or Shoemaker *(P. aequinoctialis)* and the Grey Petrel or Pediunker *(P. cinerea)* have circumpolar distributions, breeding on subantarctic or antarctic islands. *P. cinerea* and *P. westlandica* nest in winter; the others are summer breeders. All disperse northwards or eastwards after breeding. All lay their eggs in burrows.

Grey Petrels and Shoemakers often share breeding stations, but, despite nesting in opposite seasons, the chicks of the one species have not all fledged before breeders of the other arrive. The two endemic species may also have once bred sympatrically in the South Island, and their nesting cycles also overlap.

Brief references to the calls of these various petrels are found in the literature, e.g. in Serventy *et al.* (1971), but only Brooke (1986) deals specifically with this topic. He studied vocalisations of *P. cinerea* and *P. aequinoctialis* at Marion Island.

The birds all tend to be most vocal during the 2-3 hours after sunset, following the evening's influx. Calling declines during the middle of the night and develops again towards dawn as birds begin departing. The volume

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of sound in early morning may exceed that of the previous evening. The calls show a great deal of individual variation in acoustic structure, timing and length of 'song' from bird to bird, but analysis showed that such idiosyncrasies were constant features in the songs of particular birds.

METHODS

Recordings were made on Grundig TK6 and Uher Report L machines and analysed on a Kay 6061B Sona-graph. Sonagrams produced here were made using the narrow band filter to emphasise frequency structure. Because the main calls tend to be built from trains of notes, often repeated for many seconds, it is impracticable to figure complete songs: instead, typical portions are shown. Recordings were taken at night from birds on the surface and underground. All were singing normally, not in response to 'playback'. Their sexes were unknown.

Tapes of Grey and White-chinned Petrels were made at Antipodes Island during the University of Canterbury's Expedition there in January to March 1969. The Grey Petrels were recorded soon after their return in February and before egg laying, whereas the White-chinned Petrels were engaged in late incubation and early chick rearing. Westland Petrels were taped around egg laying in May 1967 and 1976 and during the chick-rearing stage in September 1972, and Parkinson's Petrels at Great Barrier Island in February 1972 by C. R. Veitch and in early March 1981.

In common with many other petrels, *Procellaria* species produce sounds both on intake and expulsion of breath. In favourable circumstances one can see the accompanying muscle contractions, confirming the link between sound and breathing. Otherwise the conjunction can often be deduced by the lower amplitude and more gasping 'noisy' sounds of inspiration, well shown in Figure 5A [Compare (x) and (y)].

Brooke (1986) studied his birds over about 5 of the 6-8 months that the birds are ashore. The present account, based mainly on quite short visits to the colonies, can only be regarded as provisional.

GREY PETREL

In its external morphology this bird is markedly different from other *Procellaria*. Its plumage is grey and white (not blackish-brown), and its beak has grey-green side plates and horn-coloured nails, whereas its congeners have bills with white or cream plates and variably blackish tips.

At Antipodes Island these birds were very vocal, calling from within or at entrances to burrows, from the surface of the ground, and when perched on rocks or tussocks (Warham & Bell 1979). Two main vocalisations were identified: 1. The *Moan*, and 2. The *Bleat*.

The Moan: Drawn-out moaning sound, heard from single birds or from pairs, were audible only at close range. Figure 1A shows an instance where the call consisted of three notes, the first (a) made on intake of breath, the last (c) on expiration, and with a very brief central note (b). Each note began on a rising pitch and ended on a falling one. The disposition of the frequency bands, the energy distribution within them, and the amount of frequency modulation varied from bird to bird. For example, in Figure 1A the lowest band was weak, much of the energy being in the third band at about 1 kHz. Most birds used calls of a lower pitch than in this example, e.g. those of Figure 2. The general effect was of a shearwater-style crooning. These *Moans* often preceded the more often heard vocalisation, *the Bleat*.

The Bleat: See Figure 2. This usually consisted of one to three low-pitched wheezy *Moans*, the last being inhalatory, one or two short notes of intermediate length (L) and then *The Bleat* proper. This was loud, far-carrying and based on very short notes c. 0.4 s long (M), separated by even shorter silences of c. 0.05 s. Like those of the intermediate notes, it carried strong frequency bands. After seven to nine of these pulse-like notes the pattern changed to one of double pulses (N), creating the impression to the human ear that two birds were involved. Analysis at half speed shows the transition more clearly – Figure 2C.

The whole of the *Bleat* sequence of such a call lasted 5-19 s (mean 9.4 s; n = 37), and I was hard put to believe that the bird could sing for so long without taking a breath. Presumably the inhalatory phrase fills the lungs and air sacs and perhaps the switch to the double note marks a change to taking small breaths between each. That is, in Figure 2C, (a) was exhalatory and (b) inhalatory. A prominent feature of this type of call was the explosive way in which the birds launched into the *Bleat* – as though trying to expel every breath of air from their lungs.

With some birds the preliminary phrases of the *Bleat* were quite complex. Figure 1B shows an example where three inhalatory sounds (e) and a succession of short notes preceded the *Bleat* proper.

At Antipodes Island the first birds to arrive for their winter breeding used the *Bleat* persistently, and as their numbers increased, their braying came to dominate the night-time bird chorus. These early arrivals were presumably established breeders and probably most were males. They were tame, even bold, after dark and could be watched at close quarters if cautiously approached. Those perched on rocks and on tussock crowns swung their heads from side to side, mouths wide agape, 'hosing' their songs across wide reaches of the breeding terrain.

Brooke (1986) described this call and figured a sonagram similar to my Figure 2B. He called it a 'rattle cry', but in New Zealand birds this is not hard enough for a rattle and Hutton's (1865) likeness to 'the bleat of a lamb' is very nicely descriptive. Elliott (1957) did not refer to any call of this kind and did not recognise it when tapes were played to him, but Grey Petrels were and are uncommon birds on Tristan da Cunha, their nests widely scattered, and so he probably missed hearing this vocalisation.

Brooke heard the *Bleat* almost entirely from burrows, even though he was on Marion Island throughout the prelaying period, whereas at Antipodes Island those singing in the open probably outnumbered those singing from below ground, at least before egg-laying started. Part of the difference may have been due to the species' greater abundance at Antipodes Island. The

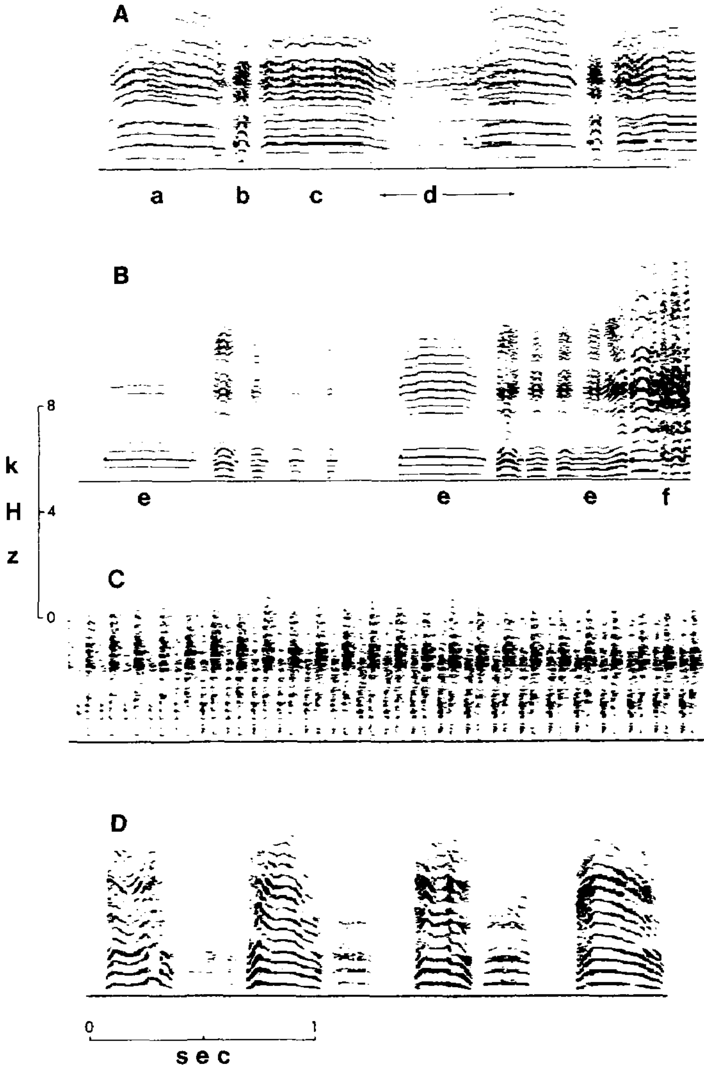

FIGURE 1 — A. GREY PETREL: introductory 'moans' preceding the 'bleat'; (a) inspiratory. (c) expiratory; (b) a short connecting note; (d) a call from another bird in the background.

B. GREY PETREL: a more complex prelude to a 'bleat' with 3 inhalatory 'moans' (e) and other short (expiratory?) notes leading to a 'bleat' beginning at (f).

C. PARKINSON'S PETREL: part of 'clack' sequence from a bird on the ground. The notes come in doublets with the sound spread widely across the frequencies.

D. PARKINSON'S PETREL: part of an alarm call of a grounded bird that used loud, high-pitched expiratory notes and quieter, low-pitched inspiratory ones.

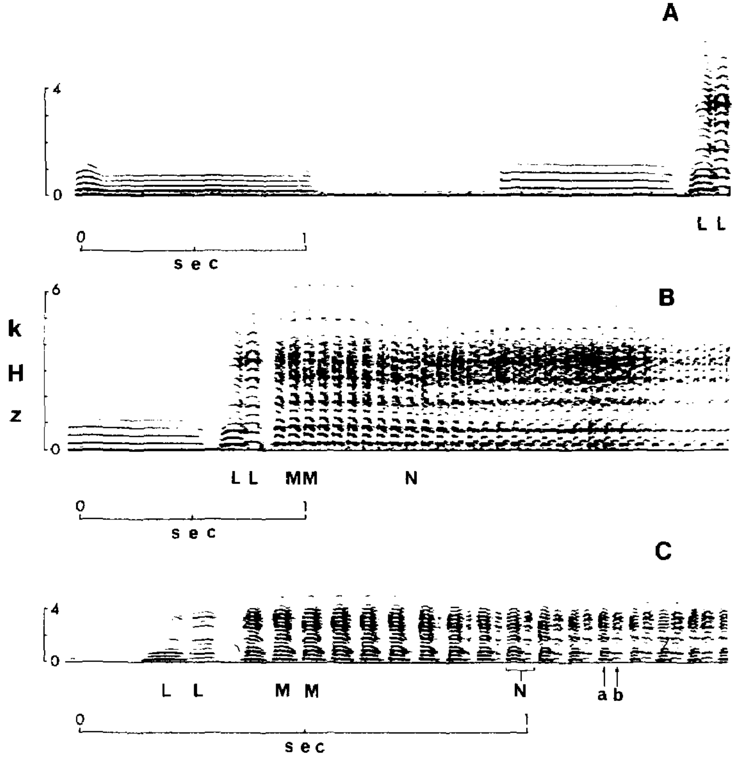

FIGURE 2 — GREY PETREL: A & B, two introductory, low-pitched 'moans' leading to the 'bleat'. Two short notes (L,L) of intermediate length preceded the fusillade of very short notes of the 'bleat proper(M, M). Just before (N) these notes began to develop into 2 distinct pulses. C, part of the sounds of B played at half speed to show the transition from single to double notes (a) and (b).

habit of singing in the open has apparently been discontinued at Marion Island because of cat predation. There are no cats at Antipodes Island.

Apart from these two types of call, Grey Petrels appeared to have rather limited repertoires, and even when handled they were usually silent (Warham 1969). In contrast to other *Procellaria*, they did not incorporate bill clicks into their vocal inventories, their beaks during the *Bleat* being held fully open. The tongue, however, could well have a role in sound production then. Some short 'quacking' calls were occasionally noted from birds disturbed in burrows but the usual response to close footfalls was a burst of bleating. Grey Petrels were otherwise silent by day, and although many alighted before dark and earlier than the Shoemakers, the Shoemakers were the first to start calling. Murphy (1936, p.649) suggested that the whaler's name 'Pediunker' for the Grey Petrel might be descriptive of its call, but I heard nothing like that.

No Grey Petrel was heard calling on the wing and there appear to be no records of aerial singing by this species.

SHOEMAKER

Although many were rearing chicks during our stay on Antipodes Island, there was still much calling both from the surface and from within burrows. 'Hosepiping' from raised perches, as described for *P. cinerea*, was not seen.

The repertoire was rather limited. However, my work was done mainly near Reef Point, where Shoemakers had only scattered nests: had I worked where their concentrations were greater, e.g. round the summit of Mt Galloway, I might have heard a greater range of sounds.

The vocal repertory included 1. The *Clack* or *Rattle* call, and 2. *Groans* and *Squealing* cries.

The Clack or **Rattle:** This was the dominant sound, heard from the surface and from under ground. Both sexes used it, sometimes in duets. Each call was composed of a succession of staccato notes or pulses and lasted from about 11 s (range 2 to 34 s; n = 10). Figure 3A shows an analysis of a typical such call from a bird in the open.

As that figure shows, this *Rattle* was built up from two types of notes, both of very short duration, c. 0.03 s, spread widely over the frequencies and very precisely timed in respect of one another. Most of the sound energy was in note (b). Note (a) had the form of a click. That is, the trace runs at right angles to the baseline, giving a mark on the graph like that resulting from the tap of a ruler on a desk. The bolder trace looks similar but is not precisely perpendicular and shows much amplitude modulation. These 'doublet' notes were timed at rates of 5-10/s – about the same as reported by Brooke (1986) for Marion Island birds.

Brooke heard Shoemakers, unlike the Grey Petrels, giving the *Rattle* from the surface as well as from their burrows, as they also did at Antipodes Island.

Figure 3B and C depicts calls from partners at a nest on the ground in a small cave. Their *Rattles* sounded rather different, the one in Figure 3C being of a lower pitch and having a slower delivery of the individual pulsed notes. These came in triplets. Its partner (Figure 3B) produced more by way of a fusillade of notes. I sexed neither bird, but from its more aggressive and vociferous nature I suspect that the sounds of Figure 3B were from the male.

Figure 3D shows part of Figure 3C but with the tape slowed to show more detail. Each triplet consisted of two clicks immediately followed by the strongest component, an abrupt and remarkably rapid downwards slur. Calls figured by Brooke (1986, Fig.1) seem similar. One possible interpretation is that the double click came from bill snaps whereas the third note was produced in the vocal apparatus. Although the Shoemakers were reasonably tame I saw no such bill snapping because singers stopped abruptly in a torch beam. As they commonly rattle their beaks in threat, for example, when defending themselves against skuas, such sounds might be expected to be incorporated into vocalisations, but Imber (pers. comm.) saw them calling with wide open and vibrating beaks, which were not snapped shut.

Another noticeable feature of the *Rattle* was that both pitch and rate of delivery of the notes could be varied. As I crawled into the cave, whichever bird was on the nest would start calling, rattling quietly at first, but as I edged closer the pitch, loudness and sometimes the rate of delivery of the notes increased. Such increases are shown in Figure 3B and C, the latter from the sounds given when I reached out to inspect the egg.

Groans and Squealing Cries: The *Rattle* of the presumed male of the cave-nesting pair was often preceded by harsh *Groans* or squawks, as in the first two notes of Figure 3B. Similar notes were sometimes given during or at the end of a *Rattle* sequence, as in Figure 4A of a Shoemaker recorded by the late G. R. Williams at the Auckland Islands.

Notes of this type seem similar to those of the 'wheezy' call analysed by Brooke (1986), which he heard from birds of either sex in burrows. But at Marion Island that call was used repeatedly, whereas I heard it only as single notes, not in sustained use. Brooke's 'wheezy' call may have been that described by Matthews (1929, p. 574) of a bird resting between bouts of burrowing – "It also made a harsher note, holding the beak upwards and vibrating it rapidly."

A call of a different kind was a high-pitched squeaking or squealing, three examples of which – all from the male (?) bird responsible for the call of Figure 3B – are shown in Figure 4, B to D. In Figure 4B, the two *Squeals* before the *Rattle* were given simultaneously with a more asthmatic note with much 'white noise', as also at the end of Figure 4A. In Figure 4C, the acoustic pattern at the start is quite different and, as in Figure 4B, reached quite high frequencies. The sonagram of Figure 4A also shows how a simple *Rattle* (first four notes) may be elaborated into complex squealing sounds (notes five to seven).

The call of Figure 4D was not associated with a *Rattle* but was from the same bird as before, now brooding a new-born chick. As I cautiously edged this from beneath the parent for weighing, the adult gave a succession of drawn-out, piercing, frequency-modulated *Squeals*, possibly the same sort of call that Murphy (1936, p. 642) described as high-trilling notes of piercing quality. All the calls of Figure 4B to D were in response to my intrusions.

Like Brooke, I heard no Shoemaker call on the wing.

PARKINSON'S PETREL

This bird breeds in burrows in heavy rainforest and its calls, like those of other *Procellaria*, tend to be loud and far-carrying. The habitat makes callers much harder to observe than the previous species, which nest more in the open.

The calls of Parkinson's Petrels are the least known of any *Procellaria*, but can be categorised as 1. *Clack*, 2. *Throaty Squawk*, and 3. *Aerial Calls*.

The Clack: This call, which I heard from birds on or below ground, seems to be that most often used and most often mentioned in the literature (e.g. Sibson 1974). It consists of strings of staccato pulsed notes, which may be preceded by low, wheezy (inhalatory?) syllables. Figure 1C is from a bird recorded by C. R. Veitch. Here the notes came in doublets, at a rate of c.9/s and extended across a wide range of frequencies. These sounds are

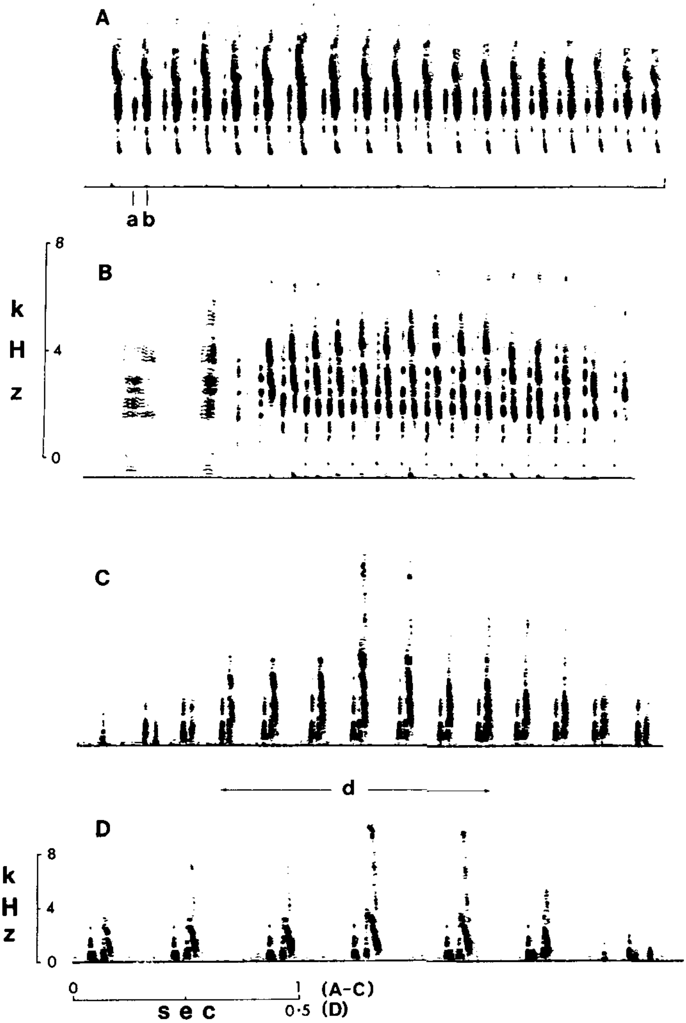

FIGURE 3 — 'Rattle' calls of SHOEMAKERS

A: from a bird on the surface showing the 'doublet' structure of the notes, composed of a faint note (a) and a strong one (b).

B: 'rattle' of bird 'Red' on nest in cave. There was a groaning prefix followed by 'rattle' notes of increasing and then decreasing pitch and amplitude as the microphone was pushed near to and withdrawn from the bird.

C: call of bird 'Yellow' — partner to 'Red'. Again pitch rose as bird was approached.

D: part (d) of call C above analysed at half speed to show that the sounds apparently consisted of 2 taps and a strong, extremely rapid downwards glissando through the frequencies.

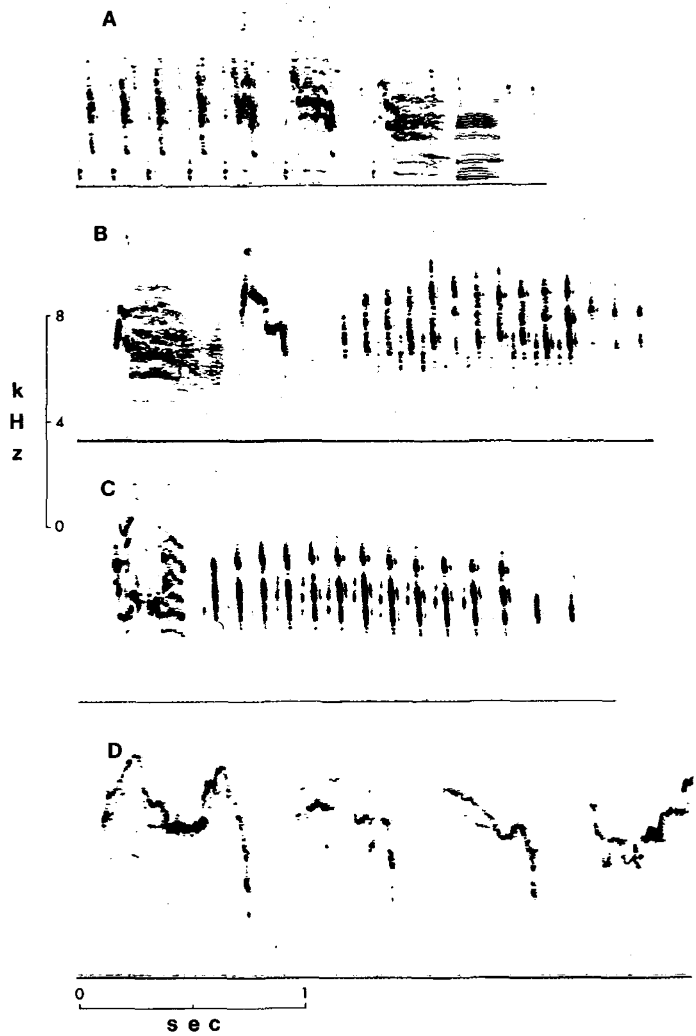

FIGURE 4 — SHOEMAKER

A: 'Rattle' from bird at the Auckland Islands that changed first to 2 high-pitched 'squeals' and then to lower-pitched squawks.

B: High-pitched 'squeals' of bird 'Red' followed by a 'rattle' call. The complex first note has much 'white-noise' and was given simultaneously with the 'purer' note of the 'squeal'.

C: Another variant of the 'squeal' from the same bird as in B.

D: Extended and penetrating 'squeals' of bird 'Red' in response to close approach when guarding its small chick.

not unlike the double pulses of the Shoemakers of Figure 3. The weaker of the two notes could perhaps have been given during inhalation, cf. Figure 1D. The *Clack* calls timed lasted 7-10 s.

Throaty Squawks: At times high-pitched, these sounds were made by grounded birds during what appeared to be territorial disputes and by birds being handled. Figure 1D is an analysis of such a call, with loud exhalatory and quieter inhalatory notes.

Aerial Calls: Parkinson's Petrels seem to call only rarely on the wing and Imber (1985) thought that they were silent then. However, at Great Barrier Island, where, as he points out *(in litt.)*, the species is more abundant than on Little Barrier, I heard several birds calling in flight during an overnight camp on top of Mt Hobson on 3 March 1981. These calls were so regular that I could follow the courses of individual birds as they circled over a limited area of the forest. The flight calls were a series of *Clacks*, usually with a low moaning introduction, but were of shorter duration than the *Clack* sequences heard from grounded birds at that date.

WESTLAND BLACK PETREL

Westland Black Petrels also nest and display under an almost closed forest canopy. They are noisy birds. In the prelaying period the chorus tended to fade 2-3 hours after dusk, although some calling was heard throughout the night, the chorus renewed before dawn. I found many calling from burrows from which no calls had been heard the previous evening. During the September visit around hatching time, and under a clear sky with the moon in its second quarter, there was no real chorus and all the birds heard were under ground.

The main categories of vocalisations identified were 1. *The Quack*, 2. *The Jackass Call*, 3. *Moaning Calls*, 4. *Alarm Calls*, and 5. *Aerial Calls*.

The Quack: This was a succession of usually duck-like notes, evidently used by both sexes (if duettists were of opposite sex), and given from burrows, from the forest floor and the air.

The individual *Quack* notes were uttered at rather regular rates, but which varied from bird to bird. A complete vocalisation averaged 13 s (n = 28, range 5-45 s). Two to four notes were sounded per second. The note length sometimes varied in the course of a song but usually lasted about 0.15 s, occasionally as long as 0.35 s.

The *Quacks* were simple cries produced on expiration, showing as arcs on the sonagrams – Figure 5A. There were numerous frequency bands and usually an inhalatory note or sigh of low-frequency 'white-noise'. In the example of Figure 5A (a section from a longer call), not every *Quack* (Y) was prefaced by an audible inspiration (X). The acoustic structure of each note could change during a vocalisation and might also vary considerably from bird to bird: with some the frequency bands were close together, but with others the sound energy was disposed quite differently, often with more 'noise'. Nor were the notes evenly spaced: several birds gave them as doublets and some very high-pitched sequences seemed to be but rather extreme variations of this call.

During duets I could easily identify each caller because one tended to have a higher-pitched and clearer voice. Figure 6, X to Z, shows a complete sequence from two Westland Petrels in their burrow. The first and loudest had a high-pitched voice and introduced each *Quack* (b) with a loud inhalatory note (a). The second bird joined in for part of the time. Its voice (c) was quieter, of lower pitch and of distinctive acoustic pattern, and this bird appeared to time its notes to those of its partner.

The Jackass Call; After the *Quack*, this was the call most often heard on the breeding grounds. It was quite unmistakable and usually developed as the climax to a bout of *Quack* songs. Figure 5B shows a typical analysis. A bird, singing on the surface, gave voice to a series of *Quacks* (y) interspersed with inhalatory notes (x) and then speeded up its delivery (z) as it switched to producing a fusillade of pulse-like notes. This second series sounded very like the hysterical song of Kookaburra *(Dacelo gigas)* – hence *Jackass Call.*

The call consisted of very brief notes, each lasting about 0.05 s, given at 8-12/s, broken by slightly longer silences. Such calls were timed to run from 2 s to 56 s (mean 14 s, n = 17). Some lasted much longer. One bird called for 104 s before my tape ran out. Presumably such birds took air in during the c. 0.06 s silent intervals between notes. During these long calls the repetition rate might be reduced or increased, evidently in response to the reactions of other birds.

The acoustic pattern of the notes included a lot of 'noise', extended over a wide frequency range, and often showed banding at lower frequencies, as in Figure 5B. Note also that the distribution of energy in the notes of the *Jackass Call* was similar to that of the preceding *Quack Call.*

This *Jackass Call* was given by single birds and during duets, but whereas both duettists used the *Quack* sequences, I heard only one make the *Jackass Call.* When this began the other bird either continued its *Quacks* or fell silent. The call was not heard from flying birds. It may have been the "ecstatic cackle" referred to by Jackson (1958).

Moaning Calls: I occasionally heard low pitched, drawn-out, throaty crooning cries from pairs of unknown status in burrows. These sounded like the *sotto voce* songs of shearwaters such as *Puffinus griseus*, but were of low amplitude and audible only at close quarters. Some such calls, sounding rather like a pigeon's *coo*, with both birds calling simultaneously, were quite low-pitched. Figure 5C was made from a recording of at least two birds singing in a burrow: their voices seldom rose above 1 kHz.

Alarm Calls: Like Shoemakers, Westland Petrels often yell out when their burrows are invaded. They use cries of very varied acoustical structure, even in successive calls by the same bird. Some examples (Figure 5) show that these may range from strident squawks of mainly 'white noise' (Figure 5D) to high-pitched screams (Figures 5E and F).

Aerial Calls: During their inwards flight at dusk, a few Westland Petrels called from the air and some did that as they flew out in the morning. Both Jackson (1958) and Baker & Coleman (1977) noted this, and Jackson thought that cries from the air were answered by birds near him on the ground. The vocalisation used was usually a short *Quack*, sometimes a deeper and repeated but quite brief croaking. I got no satisfactory recordings of these calls.

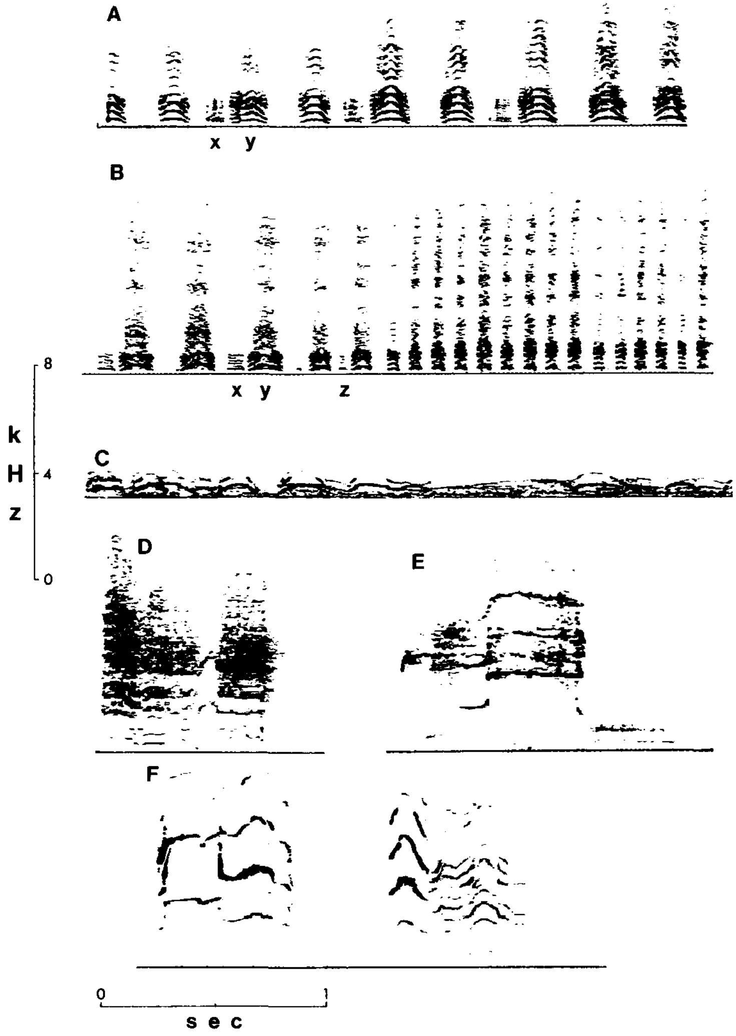

FIGURE 5 —WESTLAND PETREL

A: Part of the 'quack' of a bird singing from the ground showing low-pitched, low-amplitude inhalatory notes (x) and loud, higher pitched exhalatory one (y).

B: Part of a typical 'jackass' call developing as a climax to a 'quack' call, with inhalatory and exhalatory notes (x) and (y). Two notes of intermediate length and structure (z) linked the 'quack' to the 'jackass' call that followed.

C: Low moaning calls from 2 birds in a burrow singing simultaneously. Their voices were very low-pitched and the details unclear due to overlap and background noise.

D: A loud 'squawk' of mainly 'white noise' in response to a hand reached into a burrow.

E: Another fear or threat response from a bird in a nest different from that of D above.

F: Two strident screams from a lone bird: note that the structures of the two successive notes were quite different.

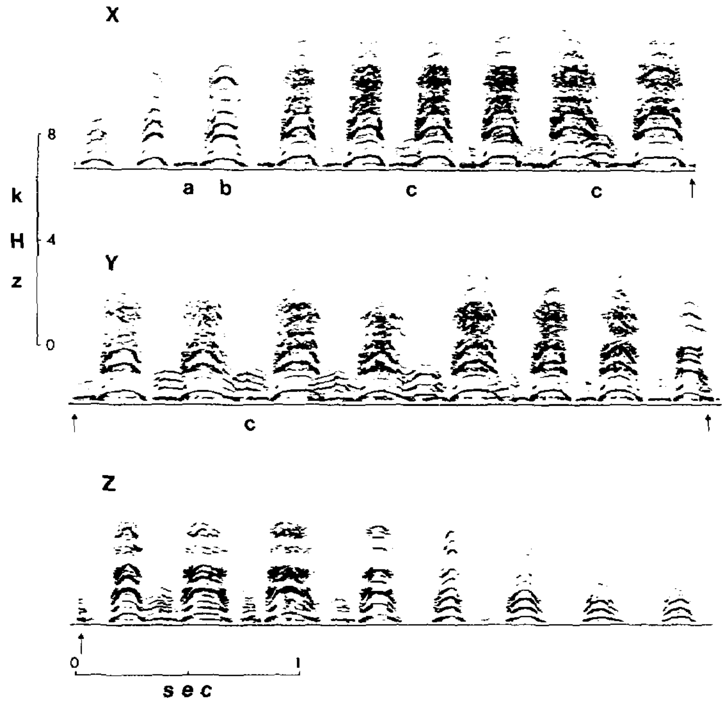

FIGURE 6 — WESTLAND PETREL

X-Z, a complete duet from 2 birds calling from the surface. Read from top to bottom, left to right: arrows mark points of overlap of the graphs. The inhalatory notes of the louder singer show a strong frequency band close to the baseline, e.g. at (a), and these notes tend to mask the quieter and rather low-pitched calls of the second bird such as (c). Both started singing quietly, their voices rose to a crescendo and then died down as first one and then the other bird fell silent. The quieter bird seems to have timed its calls against those of its partner.

DISCUSSION

Even though the present data are incomplete, the calls of these four species seem to share some common features. All use loud cries composed of rapidly repeated staccato notes, each spread widely across the frequencies cf. Figures 1C, 2B and 5B. The *Bleat* of the Grey Petrel is rather similar acoustically to the *Jackass* of the Westland species and both not unlike the *Clack* of Parkinson's Petrel – cf. Figures 1C, 2B and 5B. The Shoemaker *Rattle* notes are of the same general character but lack clear frequency bands. Also all four birds use some kind of low-pitched inhalatory notes, as in Figures 1B, 1D, 2A and 3B.

Whereas such similarities support the idea of their belonging to the same genus, some of the differences support the current practice of regarding all as distinct species. For example, calls of the Westland Petrel show little detailed resemblance to those of the Shoemaker and provide no evidence for the Westland being merely a winter-breeding race of the Shoemaker. Nor does the vocal evidence suggest a very close link between Westland and Parkinson's Petrels.

Other petrels use calls consisting of very short notes strung together – the short-legged *Oceanodroma* storm petrels, for example – but their calls do not range widely across the frequency band as do those of *Procellaria.*

Low introductory wheezing or moaning calls – cf. Figures 2A, 5C and 6 [note (c)] – show similarities to common calls of *Puffinus* shearwaters, whose songs also have inhalatory and exhalatory components, and *Procellaria* is often regarded as a genus of large shearwaters. Calls on intake or expulsion of breath are heard, however, not only from shearwaters like *P. puffinus, P. carneipes* and *P. griseus* (Lockley 1942, Warham 1958 and pers. obs.), but also from more distant relatives like albatrosses such as *Diomedea exulans* and *D. nigripes* (Matthews 1929, pers. obs.).

Perhaps the hard *Rattle* notes of the Shoemaker have the most unusual acoustic patterning, the frequency of their main note falling extremely rapidly, a feature also of the modulated screams of Figure 4D. Such rapid frequency change is not unique to this bird because the frenzied pipings of prion chicks like *Pachytpila turtur* include similarly abrupt switches in pitch.

Grey Petrels appear to differ from the rest in lacking an extensive repertoire. Neither I nor Brooke (1986) heard any calls other than the *Bleat* and its introductory moans. Further study may well reveal that other calls are used. Similarly, that neither he nor I heard Grey Petrels or Shoemakers calling in flight over land does not mean that they do not do so in the appropriate circumstances. J. A. Bartle (pers. comm.) points out that Shoemakers are very vocal when scavenging behind fishing vessels.

The functions of the various calls were not worked out but Brooke (1986), from field experiments using playback to birds of known sex, suggested some functions of calls in *P. aequinoctialis* and *P. cinerea.* He concluded that the role of the *Rattle* of the Shoemaker, which when given from the surface was mainly used by males, was to indicate the caller's availability as a mate. The Antipodes birds singing in this way certainly appeared to be advertising themselves or their possession of a burrow, although with the cave birds, the call also appeared to form part of their threat response. Brooke considered that the *Bleat* of the Grey Petrel, which he nearly always heard from the burrow, served to warn off intruders. In contrast the behaviour of these birds at Antipodes Island at the very start of the breeding season in singing lustily from raised perches suggests that they too were advertising their availability as partners or as owners of a burrow. The same call might, of course, also function to repel unwanted visitors. The loud *Clacks* of Parkinson's Petrel and the *Quacks* of the Westland birds also seemed designed to draw attention to themselves.

Jackson (1958) believed that he could tell the sexes of Westland Petrels from their voices and found that males (sexed during copulation) used the ecstastic cackle. My recordings of duets, in which one bird had a lower-pitched voice and with only one of the two using the *Jackass* call, also suggested a sexual difference. This has been confirmed by V. Bretagnolle (pers. comm.), who recorded birds of known sex: he found that the *Jackass* call was used by the males whereas there were sexual differences to the *Quack* of this species. The marked (and constant) difference in the *Rattles* of the cave Shoemakers also raised the possibility of a sexual difference. On the other hand, Brooke analysed *Rattles* of sexed birds and could detect no sexual dimorphism here. He concluded that the considerable variation alone enabled partners to recognise each other's calls.

Clearly there is room for much more examination of these repertoires in general and the role of sexual differences in particular. It seems that all the shearwaters in the genera *Calonectris* and *Puffinus* so far studied in detail have sexually dimorphic voices. Such a facility would seem of great value to nocturnally active birds nesting in burrows, especially when doing so under cover of rainforest.

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SHORT NOTE

Soft-plumaged Petrels *(Pterodroma mollis)* in New Zealand waters

During 1987 I made the following observations of Soft-plumaged Petrels *(Pterodroma mollis)* in New Zealand waters.

On 6 September, a bird approached the stern and briefly followed in the wake of the MV *Fijian*, which was on passage from Onehunga to Suva. The ship was in the Tasman Sea at 36° 18′ S, 173° 38′ E, about 15 nautical miles (nm) NW of Kaipara Harbour North Head (sea temperature 13.7 °C). Despite a wide distribution in the Southern Ocean, the Soft-plumaged Petrel is not often reported in Australasian waters, apparently seldom penetrating far into the Tasman Sea (Harper 1973, Nakamura 1982), and is only rarely reported as a beach-wreck in New Zealand (Powlesland 1987). A strong SW air flow predominated over the Tasman Sea during 4 and 5 September 1987, which probably resulted in the bird being driven northwards out of its usual range.

On 16 December, when SRV *Totorore* was at 44° S, 177° W, about 50 nm SSW of Chatham Island (sea temperature 15.4 °C), Gerry Clark and I observed a Soft-plumaged Petrel close behind the yacht. Two more birds were seen soon after dawn the next day, when *Totorore* was at 45° S, 177° W. It is probable that these records refer to birds from a population now suspected to be breeding at the Antipodes Islands (Imber 1983).

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A SOUTH ISLAND PUZZLE – WHERE HAVE ALL THE DABCHICKS GONE?

By B. D. HEATHER

Buller (1888) said of the New Zealand Dabchick *(Podiceps rufopectus)*: "It is very abundant in all the freshwater lakes and lagoons of the South Island." Yet now it is apparently extinct in the South Island.

During the 1970s and 1980s, likely Dabchick habitat in the South Island has received a great deal of attention; resident birds, and even stragglers, are not likely to have been missed. The intensive coverage made during 1969-1979 for the *Atlas of Bird Distribution* (Bull *et al.* 1985) yielded no records of Dabchick, although Hoary-headed Grebes *(P. poliocephalus)* and Australian Little Grebes *(Tachybaptus novaehollandiae)* were found. That the coverage of South Island freshwater lakes and lagoons was thorough is shown by the South Island maps of, for example, Southern Crested Grebe *(P. cristatus australis)*, New Zealand Scaup *(Aythya novaeseelandiae)*, Grey Duck *(Anas superciliosa)* and Australasian Bittern *(Botaurus stellaris poiciloptilus)*.

Since 1979, various surveys and inquiries have kept likely Dabchick habitat under scrutiny, for example, searches for Hoary-headed and Little Grebes, for Cattle Egrets *(Bubulcus ibis)* and for Chestnut-breasted Shelducks *(Tadorna tadornoides)* and investigations into the status of the Southern Crested Grebe (Sagar 1981, Sagar & O'Donnell 1982).With the annual autumn movement of Dabchicks to lakes and ponds in the southern North Island, a spill-over to the northern South Island was expected, and so the most likely places there have been watched – Lakes Grassmere and Elterwater in Marlborough, St Anne's Lagoon in North Canterbury, and the oxidation ponds in Nelson, Blenheim and Christchurch.

On 17 June 1987, W. F. Cash, H. A. Robertson, T. J. Taylor and I saw a Dabchick at Lake Elterwater, Marlborough. It was in adult plumage and trying to keep company with a rather reluctant Hoary-headed Grebe, which was probably resident. Seeing a Dabchick in the South Island was such an unusual event that it was reported to the OSNZ Rare Birds Committee. The bird was probably a straggler from the southern North Island, where many gather for the winter months on coastal lakes and on sewage oxidation ponds in Wairarapa, Manawatu and west Wellington (Stidolph & Heather 1978).

The decline of the Dabchick in the South Island has been vaguely ascribed to "the advance of settlement" (Oliver 1955: 92), whereas in the North Island the Dabchick has, since the 1940s, gained from "settlement" by the widespread construction of farm dams and ponds, where many breed, and of sewage oxidation ponds, where many winter. Was the Dadchick "very abundant" in historical times, as Buller said? What is the history of its decline? I have examined the literature available to me, together with other sources, dividing it into the periods before and after 1940, when OSNZ began to publish its members' reports.

NOTORNIS 35: 185-191 (1988)

Before 1940

1. Two Dabchicks, from Taieri and Waimate, were taken to Britain by the Antarctic expedition under Sir James Ross, which visited New Zealand in 1840 (Oliver 1930). The Taieri bird, at least, was collected by Percy Earl (Fleming 1982).

2. Potts (1869), speaking presumably of Canterbury, said that the Dabchick was ". . . far from uncommon, and is to be met with on lakes, lagoons, and deep creeks that run still and swift, unlike the noisy torrents in which the Mountain [Blue] Duck delights". I am puzzled by "far from uncommon" but, provided that Potts was speaking from personal experience, the Dabchick seems to have been well distributed in Canterbury.

3. Travers (1871): "Amongst the birds which frequent the inland lakes of the Middle [= South] Island are two species of Grebe, namely, the *Podiceps cristatus*, or Crested Grebe, and the *Podiceps minor*, or Dab-chick."

4. Hutton (1871): "Both islands".

5. Travers (1872) included the Dabchick in his list of the "principal aquatic birds" at Lake Guyon, Nelson Province. However, although he then discussed the other principal species, he did not mention the Dabchick again.

6. Hamilton (1878), in his discussion of the birds of Okarito district, merely listed the Dabchick. His comment that the Crested Grebe was "tolerably plentiful on the lagoon and smaller lakes" may imply that the Dabchick was not.

7. Smith (1888): In the Lake Brunner district "Not uncommon on the lake . . . They frequent the bays on the north-west shore more than elsewhere, and are generally met with in pairs".

8. Buller (1888): "It is very abundant in all the freshwater lakes and lagoons of the South Island".

9. Handly (1895) did not include it in his comprehensive list of Marlborough birds.

10. Douglas (c. 1899), in his monograph on the birds of South Westland, described the 'small grebe': "It always was a comparatively rare bird and it is a very curious little being, quite tame in the presence of man".

11. Henry (1903), by his discussion of whether Dabchicks can fly, implied that they were commonplace to him during 10 years living at Te Anau.

12. Fulton (1908): "Our grebe and dabchick, expert divers, remain in fair numbers on some of the lakes in Nelson and Otago".

13. Philpott (1914): "Mr. Jules Tapper reports the little grebe as not uncommon on Lake Hauroko, and it probably frequents all the lakes and lagoons between Hauroko and the west coast." This seems to be a sweeping statement based only on a single secondhand report. However, Park (1921) did not mention dabchicks, saying that "the crested grebe . . . is common on Lake Hauroko", during his extensive survey of eastern Fiordland.

14. Stead (1927): "The two grebes found in New Zealand were at one time common on the lakes of Canterbury. The . . . Dabchick . . . has, so far as I know, entirely disappeared from our district [Canterbury], though it is still to be found in other provinces."

15. Oliver (1930): "Generally distributed throughout the North and South Islands, not uncommon but easily overlooked . . . According to Stead it has disappeared from Canterbury."

16. Moncrieff (1938) merely listed it for Nelson Province.

17. Studholme (1940) said that Dabchicks were not seen in the Waimate-Ki Wainono district of Canterbury after the 1880s (R. J. Pierce, pers. comm.).

18. K. Morrison (pers. comm.) has found no mention of Dabchick in Fiordland in Richard Henry's annual reports and letters, in A. Reischek's lists of Fiordland birds, or in E. H. Wilmot's journal. Raymond Murrell, an explorer-naturalist who was born in Manapouri in 1900, told K. Morrison (pers. comm.) that "the dabchick was becoming rare on Lake Manapouri by 1920".

In seeking a clear picture of South Island distribution from this record, one is pursuing shadows. Buller's assessment seems to have been exaggerated. The Dabchick may have been widely spread in the mid-19th century but its numbers seem to have been low, even in Fiordland and on the West Coast, where records persisted longest. Buller's statement, which may have been based on Potts's comment, perhaps clouded the judgment of later writers, who *expected* the Dabchick to be "not uncommon" in their districts.

What, then, is the record of specimens in New Zealand museums from before 1940?

1. *Southland Museum and Art Gallery:* Five skins (three mounted), together with no information. An early register shows one entry, October 1915, for a Dabchick donated by Robert Gibb, a Southland collector. (L. Williams, pers. comm.)

2. *Otago Museum:* Study skin and cranium, locality Bluff, no date. Two mounted specimens, locality Mataura, no date. (J. T. Darby, pers. comm.)

3. *Canterbury Museum:* One skin marked c.1886, ? Canterbury, ex School of Fine Art, Ilam. One skin, female, 24.5.20, Lake Ellesmere, collected E. H. Greenfield, per. L. A. Shand. Subfossil material from Lake Grassmere and Pyramid Valley. Most of the collection is of North Island origin, from O'Connor, Stead and Pycroft. (R. N. Holdaway, pers. comm.)

4. *National Museum, Wellington:* No South Island material.

5. *Auckland Institute and Museum:* One skin, locality Otago, collected W. Smyth. The museum bought various bird skins from W. Smyth, Dunedin, in 1886-1888. (B. J. Gill, pers. comm.)

Thus the record in New Zealand museums adds little to the picture, giving shadowy records from Canterbury, Otago and Southland.

Storer (1987), in examining museum collections in Australia, Canada, England and the United States, found 14 more "South Island" specimens. As usual, labels are frustratingly uninformative.

1. *American Museum of Natural History (New York):* One "Canterbury"; one "Glenmark"; one "Kakapo Creek, Ti Anau, Jan 1875"; one "Otago 1894".

2. *Museum of Comparative Zoology, Harvard University (Cambridge, MA, USA):* Two "Christchurch, Dr J. Haast".

3. *Cambridge Museum (Cambridge University, England):* One "Otago, Nov 1902".

4. *Merseyside County Museums, Liverpool:* One "Canterbury 1873", one "Port Cooper, F. Strange".

5. *British Museum (Nat. Hist.), Tring:* One "Christchurch, mouth Waimakariri River, Aug 1878"; one "? Otago (Otago University Mus.) 1896"; one "Waimate, Antarctic Expedition"; one "Port Cooper"; one "Port Cooper, Capt. Stokes RN".

Thus we have 10 from Canterbury, 3 from Otago, and one from Te Anau. Port Cooper was the former name of Lyttelton Harbour, more likely to have been a collector's point of despatch than a collecting site. The *Acheron*, under Captain Stokes, was surveying the New Zealand coast in 1847-1851 (Oliver 1955: 20).

In the 1870s, Haast was sending overseas collections of all sorts, including many moa skeletons from the Glenmark swamp in North Canterbury, on exchange to build up the collections in the new Canterbury Museum. These included many exchanges with Agassiz at the Museum of Comparative Zoology at Cambridge, USA (e.g. pages 604, 626, 678 in H.F. von Haast, 1948). Most of the "Canterbury" specimens from the 1870s were probably from Haast, not necessarily collected in Canterbury, although Potts did some collecting for Haast in Canterbury and on the West Coast in this period.

Thus the overseas record is no less shadowy than the rest but seems to confirm the impression of a small presence of Dabchicks in Canterbury, Otago and Fiordland.

After 1940

The record consists of 14-15 sightings reported in *Notornis* and several unconfirmed records from Fiordland in 1947 and 1949. Two 1956 skins from the West Coast are in museums.

1. K. R. Sutherland, in Department of Lands & Survey file 13/1/10/1, Invercargill, "Report on shooting trip to the Hankinson-Lake Sutherland area, June 2nd to July 1st", reported: "One little grebe was seen on Lake Sutherland; also large numbers of Black Teal, Brown Duck and a few Black Swan" (K. Morrison, pers. comm.). This was in 1947, not 1948 as stated in Poole (1951).

2. Poole (1951): In the Caswell/George Sounds to Lake Te Anau area, members of the New Zealand-America Fiordland Expedition reported several Dabchicks in 1949 – two with a young, probably at Three Duck Lake, one at the head of George Sound, one at Lake Alice, and one at Lake Thomson.

3. In addition for Fiordland, K. Morrison (pers. comm.) says that the wapiti hunting reports for 1947-1982 contain no reference to Dabchicks, other than Sutherland's above, that P. Dorizac, Fiordland National Park ranger 1954-1964, did not mention them in his notes on many extensive tramps, and that he himself has not seen them during 1972-1987.

4. Coker & Imboden (1980) did not record Dabchicks in the 1977-78 surveys of South Westland and listed Dabchick as a species that has always been uncommon there.

The following are the reports published in *Notornis.*

1. Lake Kanieri, January 1940. One pair with two young; three other birds, perhaps full-grown young (R. B. Sibson). Otago Harbour, 8/6/40, one picked up dead, covered with oil (F. G. G. Peake, Otago Museum) (*Reports & Bulletins* 1953: 6).

2. Lake Fergus, Eglinton Valley, 12/1/41. A pair with a small riding youngster (R. B. Sibson – *Reports & Bulletins* 1953: 37).

3. Lake Brunner, reported rare. Kanieri, one pair seen. Lake Wahapo, two pairs. Lake Mapourika and Lake Wombat, reported. Nov. 1941 (C. A. Fleming – *Reports & Bulletins* 1953: 81).

4. Lake Kanieri, 6/2/50, one pair (L. W. McCaskill). Lake Wombat, 9/10/49, two (R. H. D. Stidolph). Titri, Otago, 13/8/49, one (K. J. Wyness-Mitchell). (*Notornis* 1951, 4: 39)

5. Tomahawk Lagoon, Dunedin, 19/8/51, one, also seen three previous days by others (L. E. Walker). (*Notornis* 1952, 4: 176)

6. Eglinton Valley, 18/1/52, two (Dunedin Naturalist's Field Club). John O'Groats Valley, Fiordland, Feb. 1953, two seen (J. A. Mackintosh). (*Notornis* 1954, 5: 213)

7. Queenstown district: "Rare. Perhaps seen on Lake Dispute two years ago." (Soper & Jardine 1957). However, Soper (1972: 84) stated that he had yet to see a Dabchick in the South Island.

8. Hurunui, 8/12/62, three in old channel, under road bridge (J. R. Jackson). Lake McGregor, Oct 1962, one (B. D. Bell). Lake Mapourika, Sep 1956, L. Angas found two men poaching dabchick (J. R. Jackson). Lake Gunn, March 1964, one (M. McIntyre). (*Notornis* 1972, 19 Supp.: 9)

9. Lambert (1970) reported a possible sighting of one on Lake Thomson in November 1966.

Most of these sightings were by experienced field ornithologists and cannot be discounted; secondhand reports are less convincing. H. R. McKenzie, in his travels of the South Island, did not see Dabchick and so did not mention them in his guide to birdwatching places (McKenzie 1972), except to suggest that "little Lake Wombat can at times show what is thought to be the only party of Dabchick on the West Coast." Presumably in view of the reports of the 1940s and 1950s, Oliver (1955) changed his South Island distribution to ". . . mainly on the western side as far south as Lake Hauroko, near Foveaux Strait. Least common in Canterbury and East Otago, from where it has no doubt almost disappeared from all localities."

The two 1956 museum specimens are as follows:

1. Canterbury Museum, a "subadult", 10/5/56, Hunt's Beach, Jacobs River, South Westland, collected F. Wilson.

2. National Museum, Wellington, a male, West Coast, South Island, NZ Wildlife Service, June 1956. The plumage of its chin and chest suggests a first-year bird (pers. obs.).

It is conceivable that these two birds were stragglers from the normal autumn dispersal in the southern North Island, but they could have been from Fiordland.

An egg in the Otago Museum with "Dabchick Te Anau" pencilled on it is not a Dabchick egg, its measurements (39.5 x 28.4 mm) falling squarely into the range for Hoary-headed Grebe. It is accompanied by an Australian Little Grebe egg, and both were received with the Green collection in 1950, the origin being almost certainly an Australian dealer.

CONCLUSIONS

1. As a picture of events, the published and museum record is singularly vague and inconclusive.

2. In the mid-19th century, the Dabchick was apparently widespread in the South Island, though nowhere common. Most South Island museum skins were collected in the North Island, and the general accounts are vague, even evasive, as to distribution and numbers. We have little evidence of their presence in Nelson north of Lake Guyon, which in effect is in northern *Canterbury, and none for Marlborough.*

3. In the second half of the 19th century a sharp decline apparently occurred, especially in Canterbury.

4. In the first half of the 20th century, small numbers persisted in Fiordland and on several West Coast lakes. None were left by the mid-1960s.

5. With the prominent autumn movement of Dabchicks in the southern North Island each year, one would expect birds to reach the northern South Island regularly, and yet the one bird of June 1987 is the first recorded. Suitable breeding and wintering places exist; perhaps the Dabchick, now quite numerous in the central and southern North Island, will reoccupy the South Island, or perhaps the closely related Hoary-headed Grebe will occupy the Dabchick habitat instead.

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SHORT NOTES

Breeding of Great Spotted Kiwis in captivity

Before 1985, Great Spotted Kiwis *(Apteryx haastii)* had laid in captivity at the National Wildlife Centre, Mount Bruce, Wairarapa, and at the Otorohanga Zoological Society's aviary, but none of the eggs had hatched successfully. When I arrived in December 1984, the National Wildlife Centre had one pair of Great Spotted Kiwis. Both birds were from the Greymouth area, being of unknown age and victims of gin-trap injuries. The female arrived at the Centre in June 1974 suffering from an injured toe, which healed. The male arrived in 1983. He had two toes missing from his left foot, although this did not appear to handicap his movements.

These two birds were put together in June 1983 in a pen of about 200 m^2 of forest consisting of tawa *(Beilschmiedia tawa)*, kamahi *(Weinmannia racemosa)* and tree-fern *(Cyathea dealbata* and *Dicksonia squarrosa)*. The pen was on flat ground and included three artificial burrows. The kiwis were given a diet of 200 g per bird per night of a mixture of water-soaked rolled oats, wheatgerm, multivitamin/mineral supplements, and minced ox heart. In addition, they often ate natural food they found in the enclosure.

During each of the two subsequent breeding seasons they produced an egg but broke it. Their first egg was laid in November 1983, and the two birds were seen together during the day in the nest burrow before the was broken after two weeks. The second egg was laid in October 1984, but it was punctured by a claw. I believe that these breakages occurred because the birds had been disturbed during the day to check the egg's progress. Similarly, a pair of North Island Brown Kiwis *(A. australis mantelli)* at the Centre broke their egg when disturbed.

From September 1985, the Great Spotted Kiwis were not disturbed by day; the contents of their burrows were checked only at night, and only when both birds were out. During November the kiwis prepared a nest in a previously unused burrow, in which I had put bits of *Dicksonia squarrosa* fronds, by forming a bowl in the soil and flattening the fern fronds. They also began eating more of the supplied food. Some time between 22 December and 4 January an egg (white with green gloss) was laid. The male incubated by day, but seemed to be out foraging alone at night. To distinguish between the two birds at night, by day I put reflective tape on the female's leg band. After this disturbance she spent each day in the nest burrow with the male. I could then confirm that, after an hour of darkness, the male was the bird out foraging.

To get more detailed information, I set up in front of the burrow entrance a video nest monitor with a passive infrared movement detector and date/time inset. Thus, whenever a kiwi moved near the burrow, it was recorded on tape for up to 1 minute. I found that the female left the nest at dusk and fed for an hour or two. She then returned to the nest, where there would be much snorting and grunting for 20-50 minutes, before the male left. These sounds were also heard throughout the breeding season whenever the pair came together while foraging, when they would also touch and rub each other with their bills.

Whenever the kiwis left the nest they tossed sticks back at the entrance, but without covering or camouflaging the entrance. The female was inside the nest burrow usually for 4 hours every night. I did not look into the burrow when a bird was inside and so do not know whether the female covered the egg with her body. When the female left the nest, the male usually returned to the nest within 10 minutes. The male then incubated for the rest of the night, and the female returned to the burrow at about dawn.

The egg was removed on 23 February because a nocturnal house was being built beside the kiwi pen and the kiwis would probably break or abandon the egg. The egg was put in a still-air incubator at 34.5 °C and 80-90% humidity. The egg was beginning to pip, but it progressed little for 8 days.

Then on 2 March the chick became very active, pecking the shell at a different site and pushing with its feet. However, the chick was oriented incorrectly. Its feet were positioned wrongly and so it hatched feet first, through the smaller end. The incubation period had been a minimum of 57 and a maximum of 71 days. The chick's legs were splayed, but this was remedied by tying them together and sitting the chick in a cradle for about 10 days. During this time it was hand fed and had its legs exercised every few hours. After this setback, the chick progressed well and became nocturnal at 6 weeks of age.

In August 1986, the pair was moved to an enclosure of about 2000 m^2, consisting of half tawa, kamahi and tree-fern forest and half grass, and containing two artificial burrows. The birds soon dug two burrows into a bank. They ate little of the supplied food, presumably finding enough naturally. By October, they had built a nest of dry grass in a roost box. On 20 October, I could hear grunting and snorting from the box all morning, and that evening a newly laid egg was present. The next night the egg was being incubated and I did not check it again until it was removed. The pair's nesting behaviour was the same as in the previous season, although the female roosted in a natural burrow by day.

The egg was removed on 30 December. Its shell was thin and had cracked on the bottom. Although extra calcium had been added to the supplied food, a thin-shelled egg was laid, presumably because the female preferred to eat natural food. The chick hatched within 24 hours of pipping on 1 January 1987, 73 days after the egg was laid. It was a healthy, normal chick.

I had not heard before of female kiwis helping to care for eggs during incubation. Unfortunately, I could not tell whether the female Great Spotted Kiwi actually *incubated* the egg or not. I could not catch her in 1985 to see whether she had a brood patch because she roosted in a very long burrow. In 1986, A. Sturmer and A. Grant (pers. comm.) saw a female Stewart Island Brown Kiwi *(A. australis lawryi)* in a nest in southern Stewart Island and M. Potter (pers. comm.) saw female North Island Brown Kiwis *(A. a. mantelli)* in nests at Tangiteroria, near Whangarei. These observations show that female kiwis may have some part in egg care. We still do not know, however, whether the female incubates the egg.

The incubation period of the Great Spotted Kiwi does not seem to differ much from that of the North Island Brown Kiwi. B. Rowe (pers. comm.) found that the incubation period of the North Island Brown Kiwi was on average 71 days but may be as long as 91 days.

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Female kiwis incubating

On 27 November 1986 at about 1700, we heard a male Stewart Island Brown Kiwi *(Apteryx australis lawryi)* calling in the podocarp-kamahi forest along the banks of the Robertson River, southern Stewart Island (grid ref. 21136 53275). We watched it from about 10 metres away as it foraged among ferns, after which it disappeared into the base of an old stump. Under the stump we found a small burrow and, by torch light, saw two birds inside, one sitting on an egg. Neither bird seemed disturbed or distressed by the presence of the other or by our activity at the burrow entrance. On the basis of size, bill shape and bill length, we determined that they were male and female. The female, larger and with a longer and more curved bill, was sitting on the egg.

We visited the nest three more times during our 2 week stay in the area. A male bird was incubating the egg on two of these visits and what seemed to be a female on the third. Without having the two birds together to compare their size and without taking measurements we cannot definitely say that this bird was a female, although it seemed much larger and had a longer bill than the bird seen on the other two visits.

On 20 January 1987, Ralph Powlesland, Department of Conservation, found the egg abandoned in the burrow. From its smell and the discharge of fluid, the egg may have been abandoned for 2-3 weeks. The egg contained a fully formed embryo, probably 1 or 2 days from hatching. The preserved embryo was examined by Jim Jolly and Brian Reid, Department of Conservation, who considered it close to hatching.

The incubation period of the Stewart Island Brown Kiwi is not known, but that of the North Island Brown Kiwi *(A. a. mantelli)* is 71-84 days (Robson 1947; Reid & Williams 1975; Reid & Rowe 1978, unpub. report of Otorohanga Zoological Society).

From the probable length of the incubation period and the likely number of days it had been abandoned before being retrieved, the egg was probably laid about mid to late October. Therefore in November the female would have been sitting on the egg about 4-6 weeks after it was laid.

Two kiwis in a burrow containing an egg and the female sitting on the egg are unusual. Information on the North Island Brown Kiwi suggests that the female leaves the egg within 24 hours of laying it and that the male does all the incubation (Buller 1888; Reid & Rowe 1978; M. Potter, pers. comm.). However, Robson (1947) found that the female may sit on the egg for up to three days after laying it but that the male did the rest of the incubation.

On 8 December 1986 we found a second kiwi nest, in a narrow burrow in fairly open manuka scrub, 1-2 m high. At the time, a male kiwi was incubating the egg, but when we visited the nest late in the afternoon the next day, a larger bird with a longer bill, presumably therefore a female, was sitting on the egg. This nest was also inspected in January 1987 by Ralph Powlesland and found to be empty. If the egg had successfully hatched, the female, in December, would have been sitting on the egg at least four weeks after it was laid (assuming an incubation period of 71-84 days and a hatching date of about 15 January).

Our observations suggest that the female Stewart Island Brown Kiwi covers or incubates the egg while the male is foraging. Observations in September 1957 by Soper (1976) suggested that the female Stewart Island Brown Kiwi has a share in parental care. On four consecutive nights he saw a female emerge from a burrow that contained a chick less than a week old. Detailed observations are now needed on the breeding behaviour of the Stewart Island Brown Kiwi to find out the extent of female involvement in incubation and parental care.

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Spur-winged Plover longevity record

On 2.3.87 I last saw a Spur-winged Plover *(Vanellus miles novaehollandiae)* which I had banded BR/YA at Akers Road, Otatara, near Invercargill, on 8.9.71. I believe that this bird, a male, was at least 20 months old when banded. Its mate in 1971 was a banded female OY/AG. OY/AG's previous mate, also a banded bird, had been killed on the road by a vehicle on 1.11.70. On 15.11.70 I saw OY/AG in coition with a "new" male which had noticeably stiff legs and knobby knees. I saw her again with this bird on 18.5.71, 18.6.71, 16.7.71 and 8.9.71, when the nest was found and the male trapped and banded. A male Spur-winged Plover is known to have attempted coition at 10 months of age (Barlow *et al.* 1972), and so BR/YA was probably at least that age on 15.11.70.

In early July 1985, Southland Acclimatisation Society field officer Mark Sutton reported seeing a banded Spur-winged Plover at Akers Road, and on 13.7.85 I found the bird and had good views of the leg-bands through a 20x telescope. The red and yellow bands were easily picked up, but the blue band had only a small fleck of paint left in one place.These were aluminium bands which had been anodised, enamelled and baked. The monel (M) band was bright and shiny. It had been electroplated as an aid to visibility. On 13.7.85 I saw BR/YA copulating with an unbanded female and later found their nest about 300 m from BR/YA's 1971 nest and banding site.

I next saw BR/YA on 18.6.86, when he had moved 2 km to soccer grounds at Sandy Point, on a strip of land between the road and the Oreti River. Only the yellow band was easily identified. The "blue" band was pale dull metal with no visible paint left, and the red band was mostly pale and dull with small flecks of red paint in places in the engraved numbers on the band. The electroplated monel band was still bright, and could sometimes be seen without telescope or binoculars when caught by the sun.

Between June 1986 and February 1987, I saw the bird on almost every one of my fortnightly visits to the area. He was one of a flock of 9-17 Spur-winged Plovers which regularly fed, loafed and preened on the soccer grounds and a tidal spit across the river. At least five of the birds had deformed feet or legs, a known effect of living in an area with a high sheep population (Barlow 1978a). Throughout the 1986/87 breeding season I saw no territorial behaviour or signs of breeding in this area. Harriers *(Circus approximans)* were frequently present and allowed to pass by without the aggressive attacks usually made by breeding Spur-winged Plovers. It would be easy to assume that these Spur-winged Plovers were non-breeding geriatrics. However, in the 1965/69 study, it was found that breeding Spur-winged Plovers sometimes join loose flocks when off-duty from a nest or brood, and at least one Spur-winged Plover bred right to the time of its (apparently natural) death (Barlow *et al.* 1972).

On 18.6.86, BR/YA was still knobby-kneed and stiff-legged, but there was little apparent change until 14.2.87 when the field note reads: "Very stiff, walking jerkily, normal flight, untidy landing." On 2.3.87 he was on the soccer ground among a flock of 17. "Shuffled reluctantly away from circling motor mower. All other birds flew. One stiff leg stretched out straight to the side, like peg-leg. Joint seems quite fixed." I returned on 4.3.87. No Spur-winged Plovers were on the soccer ground but 12 were loafing on the tidal flats across the river, too far away for bands to be visible. I searched the rough grass on the perimeters of the soccer ground to no avail.

On 17.3.87, 12 were on the soccer field, including 4 with deformed feet, but BR/YA was not among them, and a further search of the perimeters and down to the river did not reward me. The bird was not seen on further fortnightly visits from April to July. It is assumed dead on or about 2.3.87, at a certain age of at least 16 years 4 months (Sep 1971 minus 10 months = Nov 1970 hatch date), but a probable age of at least 17 years 2 months (Nov 1970 minus 10 months = Jan 1970 hatch date).

BR/YA was the last known survivor of the 400+ Spur-winged Plovers that were individually colour-banded in the 1965/71 study of the species in Southland.

The previous longevity record for a Spur-winged Plover was 12 years 1 month (Barlow 1978b).

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KIWIS AND DOG PREDATION: OBSERVATIONS IN WAITANGI STATE FOREST

By MICHAEL TABORSKY

ABSTRACT

A wild dog was found to kill 13 out of 23 kiwis marked with transmitters. The whole population may have lost 500 out of 900 birds, although this estimate may be conservative. The population will probably need 10-20 years and a rigorous protection scheme to recover to previous densities.

KIWI STUDY

The reproductive behaviour of the North Island Brown Kiwi *(Apteryx australis mantelli)* was studied during the breeding periods between 1985 and 1987 by M. Taborsky and B. Hudde in Waitangi State Forest, a commercial pine forest near Kerikeri, Northland.

The kiwis in Waitangi Forest are important for three reasons:

1. They form the largest known and counted population of *Apteryx australis*, estimated at 800-1000 birds (Colbourne & Kleinpaste 1984; Kayes & Rasch, unpublished NZ Forest Service report 1985).
2. They have been studied since 1978. The 147 birds banded so far have provided long-term and large-scale information on the social structure of the species for the first time.
3. They constitute an apparently stable population in a commercial pine forest. Their habitat requirements are of great interest and have important implications for the management of kiwis elsewhere.

In June and July 1987, 24 birds were tagged with radio transmitters so that their spacing and reproductive activities could be studied. These birds covered an area of about 500 ha. In the main study area (approx. 80 ha) nearly all the resident kiwis had transmitters on in August 1987.

A dead kiwi, the biggest female ever caught and banded in this population, was found on 24 August 1987. Obviously it had been killed by a dog on 21-22 August.

Telemetry checks and carcass inspection

Birds with transmitters were recaptured every 2-5 weeks to check their breeding status, weight and general condition and to check the straps holding the transmitters. When dog predation became evident, the frequency of checks was increased and birds were located by their transmitter signals as often as possible (i.e. largely each day and night). Whenever a carcass was found its position in the forest was noted, together with such factors as whether the body was buried, its posture, the nearby vegetation, and closeness to roads or nests. The surroundings were searched for traces and footprints. Each body was thoroughly searched for marks (e.g. bruises, dents, defeathered areas, scars, fractures) and four carcasses were sent to C. R. Veitch (Department of Conservation, Auckland) for autopsy.

NOTORNIS 35: 197-202 (1988)

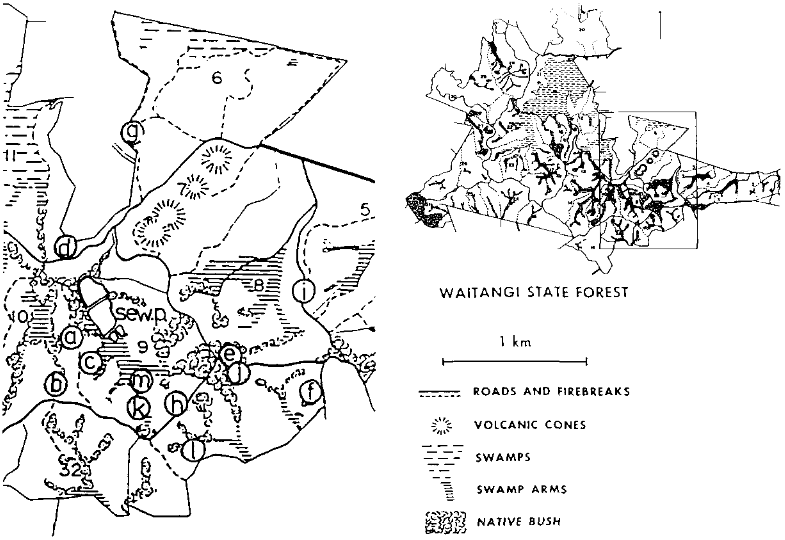

FIGURE 1 — Map showing where dead kiwis with transmitters were found (encircled letters a to m). See text for dates of kills. Exact dates and so sequence of birds, c to h, were uncertain. Numbers refer to forest compartments. The top right-hand corner shows the position of the study area rectangle that is enlarged on the left. sew.p. = sewerage oxidation ponds.

Dead birds found

From 21 August to 27 September 13 birds were killed of the 23 which had transmitters when the predation started. Carcass inspection, dog footprints and autopsies revealed that a dog was responsible for all deaths. Most bodies had defeathered areas, bruises (sometimes all over the body), dents in the skin and blood in the beak. The autopsy of a carcass with hardly any signs on the surface revealed that liver and lungs had haemorrhaged and been ruptured when a dog had squeezed the bird. Toothmarks in the shape of a dog mouth were found under the skin. Only one kiwi had minor open injuries (two little wounds on its foot). Ten of the 13 birds were found partly covered or completely buried under leaf litter and soil.

The letters against dates show when the birds were killed. In some, the date of death could only be roughly estimated because the interval between when the kiwi was found dead and when it had last been checked was too long.

AUGUST/SEPTEMBER

21	22	23	24	25	26	27	28	29	30	/	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
a			b										c		de	f	g	h								i

17	18	19	20	21	22	23	24	25	26	27	28	29	30
j							k	l		m			

Kiwis were killed in all forest compartments (6, 8, 9, 10, 11) in which birds had transmitters, ranging from the southern to the northern edge of the forest (Figure 1).

Rogan Colbourne from the Dept. of Conservation, Wellington, searched through the forest for kiwis with Tess, a dog trained to find live kiwis. He found two carcasses in compartments 14 and 16, and forestry workers found four carcasses in compartment 7 and one on the road in compartment 8. I found one carcass of an unbanded bird in compartment 8, and I was told that possum trappers found two more carcasses, although I could not find out in which compartments.

This adds up to 10 dead kiwis without transmitters. I investigated 4 of them, and their condition suggested that they had been killed within the same period of time as the birds with transmitters.

The buried carcasses had all been covered in a similar way, and none of them was opened up or torn apart. The footprints found near some of the carcasses were all of the same size (9.5 cm for the hind foot). Dog droppings of one type and size were found in different parts of the forest, and these faeces often contained possum remains and sometimes kiwi feathers. These facts indicated that a single dog was responsible for the killings.

The killing dog

On 30 September a female German Shepherd was shot in compartment 9. She had a collar but was not registered, and the long claws suggested that she had not been on hard surfaces for some time, i.e. was probably living in the forest. Her stomach was empty. The owner of the dog was not found.

Due to new captures the number of birds with transmitters was subsequently increased from 10 to 18. All survived at least until 31 October, when the study finished and the last transmitters were removed. Dog baits laid by the Department of Conservation were not taken after the dog was shot. From these facts I conclude that the destroyed dog was responsible for all reported killings.

The damage to the population

The dog killed 56.5% of kiwis with transmitters (13 out of 23), and there is no reason to believe that birds with transmitters were at greater risk than those without. The course of events would even suggest that these birds were partly protected by our presence and activities, which may have deterred the dog from staying in this area. Most of the transmitter birds living outside our main study area were killed (7 of 9), whereas only 6 of the 14 birds inside were killed. Of these six of the main study area, five were killed after all the peripheral ones had been. The dog was most likely hunting at night, and at the same time we were working in our main study area on most nights.

If we assume the proportion of killed transmitter birds to be representative for the total losses, which is the only estimate available to date and might even be conservative (see above), the dog may have killed about 500 out of the estimated 900 birds. Rogan Colbourne, in a report to the Department of Conservation in 1987, gave a similar figure.

Several lines of evidence support the conclusion that the proportion of killed kiwis was very large. In all parts of the forest that were searched, dead kiwis, dog faeces with possum remains and kiwi feathers, dog footprints, or possum carcasses were found. The carcasses of the 10 kiwis without transmitters turned up despite the remote chance of finding such birds. We estimated the calling activity of kiwis on an arbitrary scale each night during our whole study and noted a major drop in the average calling rates after the reported incident. The trained kiwi dog, Tess, did not find a single live kiwi in any parts of the forest which were searched through, although she found two dead ones. Her lack of success in Waitangi may be another hint that kiwi numbers had been greatly reduced. Finally, we also know that some individual birds without transmitters disappeared during the time the tagged kiwis were killed.

Could a single dog really do so much damage? People working trained kiwi dogs at night know it is very easy indeed for a dog to spot and catch a kiwi. The birds are noisy when going through the bush and their smell is very strong and distinctive. When a kiwi calls, a dog can easily pick up the direction from more than 100 m away. With a kiwi density as high as it was in Waitangi Forest a dog could perhaps catch 10-15 kiwis a night, and the killing persisted for at least 6 weeks.

There is evidence that predation on kiwis has happened before. In an area of 18 ha on the south-east end of compartment 9, six banded birds disappeared between the study seasons of 1986 and 1987 (i.e. between October 1986 and May 1987). From our knowledge of the stability of kiwi home ranges it is most unlikely that all these birds left the area on their own account. Yet by 1987, the whole area was inhabited by only one previously uncaught bird.

The studies of McLennan (in press) and Potter (pers. comm.), as well as our study, revealed that kiwis have a very low reproductive rate. According to our preliminary calculations the population in Waitangi will take at least 8-10 years, probably 10-20 years, to recover to its previous size. This estimate is based on the reproductive rate found in Waitangi Forest and on the likely number of reproductive birds left. It assumes that no further predation on adult kiwis will occur.

CONCLUSIONS AND DISCUSSION

This is the first account of very severe predation on kiwis. Within weeks or a few months a single dog reduced one of the largest kiwi populations, probably by half. Why could this happen?

The responsibility for the forest was recently transferred from the New Zealand Forest Service to Timberlands, a division of the recently established Forest Corporation. While the former management tried to keep the forest free of dogs and cats, under new administration the forest is no longer closed for dogs.

This change in management policy is probably not the sole cause for the events. Even with a restrictive programme the presence of a dog in the forest may have escaped notice for quite a while: we did not encounter the dog at all, even though three of us were working in the forest for at least 6 hours every day and night, especially at dark when the dog was probably hunting. It was merely by chance that our telemetry study was in progress when this predation occurred. Otherwise, few or no dead kiwis would have been found, and the authorities would not have been alarmed.

This is a most important problem for the future. Another predatory incident like the one reported here could easily wipe out the Waitangi kiwis or reduce them to a number that could not recover. If this kiwi population is regarded as being important enough to be saved, certain steps can be taken immediately:

1. The forest has to be strictly closed for dogs. Any dog may accidentally encounter a kiwi and is very likely to kill it. Kiwis are vulnerable even to a "gentle" capture by a dog. Once a dog's interest has been aroused it may continue to take kiwis whenever it can.
2. The forest should be searched regularly for signs of feral dogs (e.g. footprints in muddy places, dog droppings) and bait laid. The intervals should be at least monthly because a dog might, within a month, reduce the population to a stage from which it cannot recover.
3. Pigs have recently been released in the forest, presumably for hunting. They are believed to be a danger to kiwi eggs, chicks, and adults hiding in their daytime shelters or breeding. These pigs should be controlled immediately, before their population can expand throughout the forest. Obviously poison must be used and not pig dogs, which would be an enormous threat to kiwis.

As the kiwi population is probably vulnerable at its present low state, other measures are worth consideration:

4. Burning and bulldozing after clearfelling are a great threat to kiwis and so should be avoided. In contrast to what Colbourne & Kleinpaste (1983) suggested our study has revealed that kiwis not only move into but even nest in clearfelled areas.
5. Cats are probably killing chicks (e.g. one of 4 chicks in 1987 may have been lost to a cat; it disappeared after a feral cat was seen close to its nest). The frequent sightings of cats in 1987 as opposed to previous years suggest that cats are increasing and should be controlled.
6. Activities of the public in the forest should be supervised more rigorously. People have stayed overnight in the forest with an unleashed dog, even though they have been well informed about kiwis being killed there by a dog.

Future research in Waitangi Forest is needed to improve our knowledge on the real extent of the damage and whether and how the population will recover.

Scientifically, this predatory incident may be viewed as a giant experiment providing unique opportunities for research on basic biology and population dynamics of kiwis (research recommendations were given elsewhere). The disappearance of kiwis from other populated parts of New

Zealand during the last decades underlines the general importance of the issue to the protection and management of kiwis.

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SHORT NOTE

Birds taking insects from car radiators

Our note describing how House Sparrows *(Passer domesticus)* search for insects on car radiators in Lower Hutt, New Zealand, Illinois, USA, and England (Flux & Thompson 1986 *Notornis* 33: 190-191) stimulated four most informative responses.

Mrs Jean Potter reported sparrows visiting car radiators at Moorhouse Avenue, Christchurch, between August and December 1985. Mr R. C. Baker had watched a male sparrow making four or five visits to his Mazda 323 before transferring its attention to several adjacent cars parked at Lake Rotoiti, Nelson Lakes National Park, in the summer of 1982-83. Mr Dick Veitch saw sparrows searching cars at the terminal building, Auckland Domestic Airport; and at a Give Way sign at the main highway junction east of Te Puke, where most cars have to pause, "The sparrow was disappearing into the fronts of these briefly stopped cars". Finally, Dr Peter Harper had seen sparrows at bus radiators at least three times in Canterbury, and on 15 January 1987 watched a pair of Greenfinches *(Carduelis chloris)* gathering insects, including two white butterflies, from the radiator of his MG Montego parked on the Arthur's Pass road.

These reports establish that the habit is widespread in cities in both the North and South Islands; that some birds learned the trick in places as isolated as St Arnaud, Lake Rotoiti; and that another species, the Greenfinch, also shows similar initiative. We are very grateful to these respondents for their observations.

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THE DISTRIBUTION OF BULLER'S SHEARWATER (*Puffinus bulleri*) IN NEW ZEALAND COASTAL WATERS AND IN THE TASMAN SEA

By J. A. F. JENKINS

ABSTRACT

Records gathered since 1960 in the coastal waters of New Zealand and in the Tasman Sea are plotted. They show the September return of Buller's Shearwaters from migration; their distribution through the austral summer; and their almost total withdrawal from the region by the end of May. Their present wider distribution is shown, apparently related to the increasing numbers of breeding birds at the Poor Knights Islands.

INTRODUCTION

Harper (1983) recorded the known history of Buller's Shearwater at the Poor Knights, their only known breeding islands. However, little has been written on their distribution at sea in the South-west Pacific, other than my records, largely in New Zealand coastal waters (Jenkins 1974). Since 1974 the total population has increased markedly (Harper 1983), and so it is useful to update the pattern of coastal distribution and show how the birds have spread into the Tasman Sea. More people have been keeping records in the region since 1974, giving much better coverage. This paper is based on all the observations I have been able to find, including my own records made before 1974.

The charts (Fig. 1-12) show the highest count of Buller's Shearwaters seen at one time in any area of one degree of latitude by one degree of longitude. The charts also show areas visited where none were seen (open circles) and areas not visited (blank).

DISTRIBUTION AT SEA

Buller's Shearwaters arrive back in New Zealand waters early in September. First sightings were 12 Sep 1961 (Edgar 1962), 19 Sep 1962, 11 Sep 1967, 2 Sep 1969, 3 Sep 1974, 13 Sep 1976, 13 Sep 1978, 10 Sep 1982, 14 Sep 1984, 15 Sep 1986, and 3 Sep 1987. Although these are the dates the birds were first seen at sea, not necessarily the dates of arrival, the spread of dates – 18 days – is small. On Aorangi, Poor Knights, in 1981, the first birds were seen ashore on 10 September, and birds were all over the island by 18 September (Harper 1983). In 1987, the first few single birds were seen at East Cape on 3 September, but many thousands were about the Poor Knights by 9 September. It appears that the birds are usually back in New Zealand waters by the middle of September and can be expected during the first week.

The first influx appears to be directed toward the breeding islands, although weather-affected migrants probably arrive anywhere from East Cape

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to north of North Cape. Birds have been seen as far west as 163E by 15 September, possibly non-breeders without attachment to the Poor Knights.

An apparent arrival of migrating birds was seen on 11 September 1967 (Jenkins 1974) some 160 nautical miles north of the Poor Knights at 32S 175E. Here "... for over two hours we passed through a continuous stream of Buller's Shearwaters spread out in the typical shearwater migration pattern, in ones and twos and in small groups of about five birds. They were seen out to the limit of visibility on both sides of the vessel's track and were all heading south. At least several thousand birds must have passed during the afternoon".

Since then many passages have been made through this area at the same time of the year, enabling three further series of sightings. In 1974, I saw a few birds there and to the north. Actual observations were one bird at 23S 176W on 1 September, two at 28S 179W on 2 September, and ten at 32S 176E on 3 September. All birds were flying directly towards the Poor Knights at an estimated speed of about 25 knots. The second series of sightings was made on 13 September 1978 when, in areas 33S 177E and 33S 176E, I saw a few small parties of 4-12 birds. They were all on a course of about 225° (directly for the Poor Knights) and were making an estimated 20 knots. The third series was made a few days later, 16 September. The wind was strong to gale west to west-south-west throughout the day:
0730 34.9S 175.1E – 200+ spread out with no specific direction of flight.
0800 34.7S 175.2E – 300+ flying, without much purpose, to the north.
0900 34.5S 175.2E – 200+ making slowly to the north, with more and more birds coming in from the east. Small flocks of 3-30 birds were seen throughout the day, the last sighting being of four birds at 1630 in 32.4S 175.5E. These migrating birds were seemingly being forced to the north by the strong head winds they were encountering.

These sighting show that, during the migration, few birds were north of 32S. This probably indicates that the main migration path approaches New Zealand from the east.

In October, numbers increased about the North Island, though this increase is masked in Figure 2, which shows the highest numbers seen together rather than the total number of birds in the one degree area. Distribution appears less wide than in September owing, no doubt, to the attachment of breeding birds to the Poor Knights. Probably all the breeding birds are back in coastal waters during October because Harper (1983) said that in 1975 and 1981 copulation was prevalent in the colonies on the evening of 26 October. Birds have spread down the west coast of the North Island, but very few are on the east coast south of Hawke Bay. Birds were seen 25-28 October 1986 in west longitude out from East Cape (Fig. 2). They were largely rafted and were probably migrants held up by the adverse winds – the wind was between WSW and WNW and 30-40 knots. Outside coastal waters, no birds were seen south of 38S, again suggesting that the birds to the north were returning migrants. The small parties of up to seven birds seen north of New Zealand from 32S to 33S 175E on 2 October 1977 were all flying to the south, toward Poor Knights, and were thought to be returning migrants.

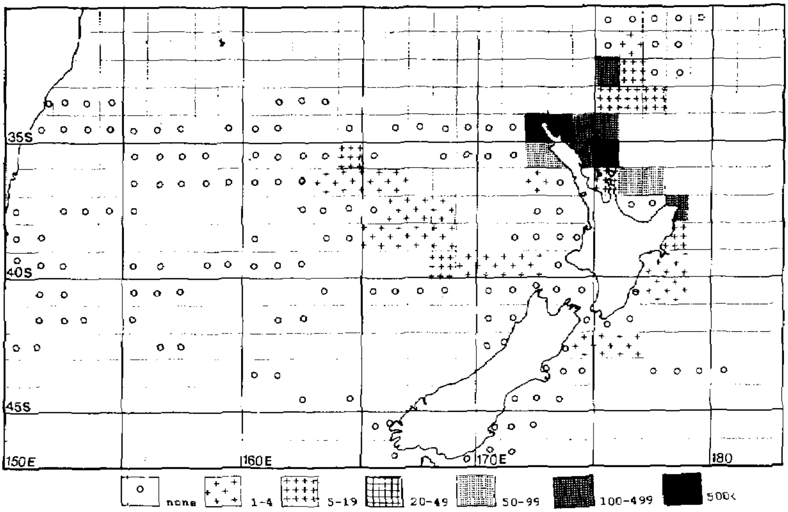

FIGURE 1 — September

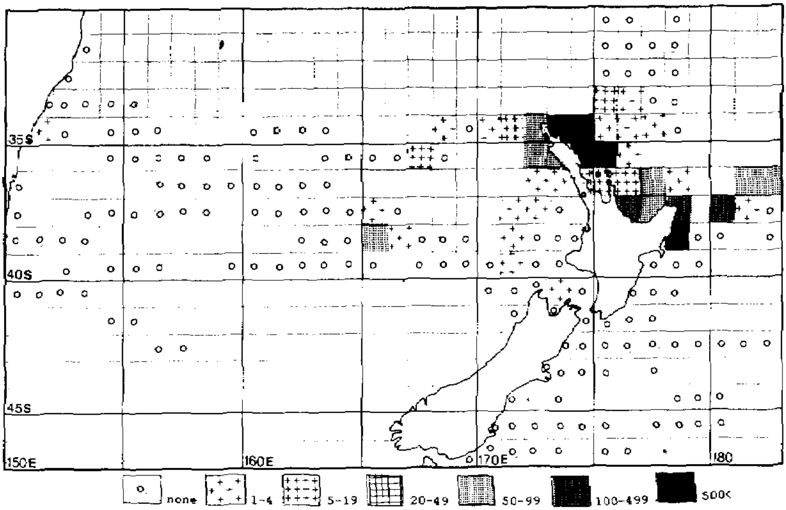

FIGURE 2 — October

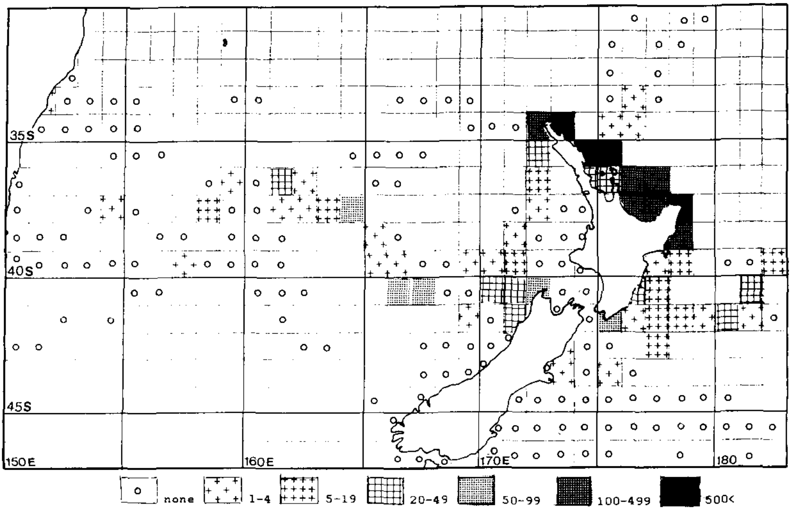

FIGURE 3 — November

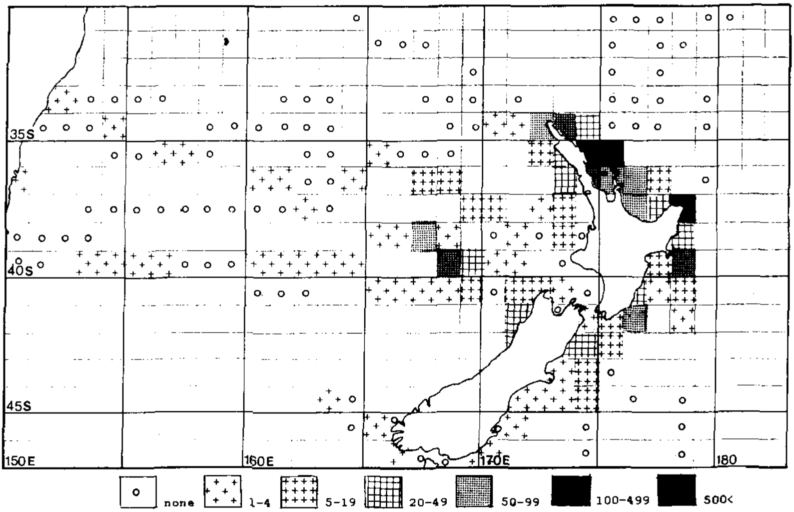

FIGURE 4 — December

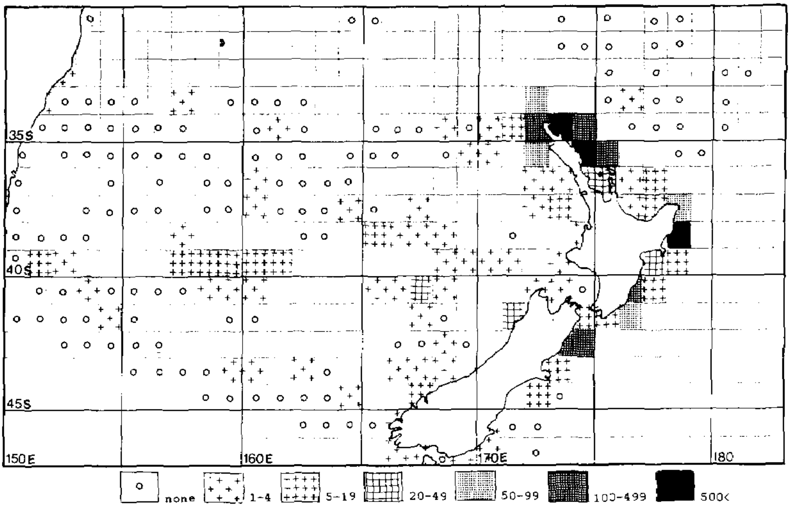

FIGURE 5 — January

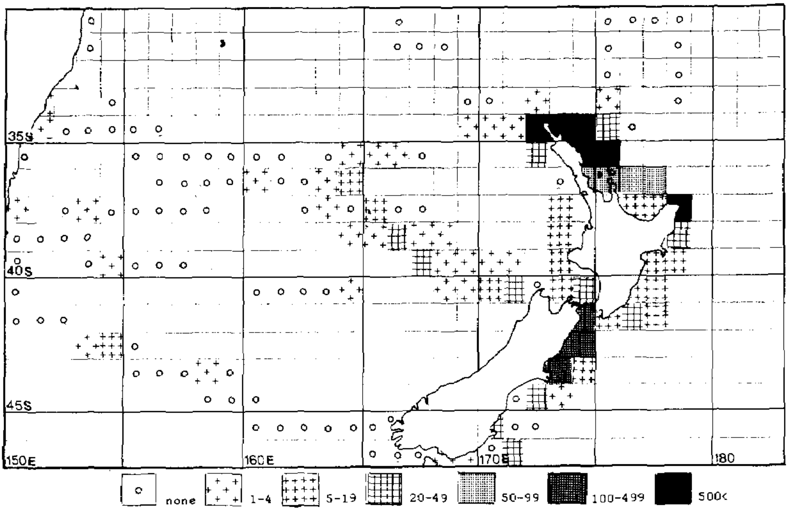

FIGURE 6 — February

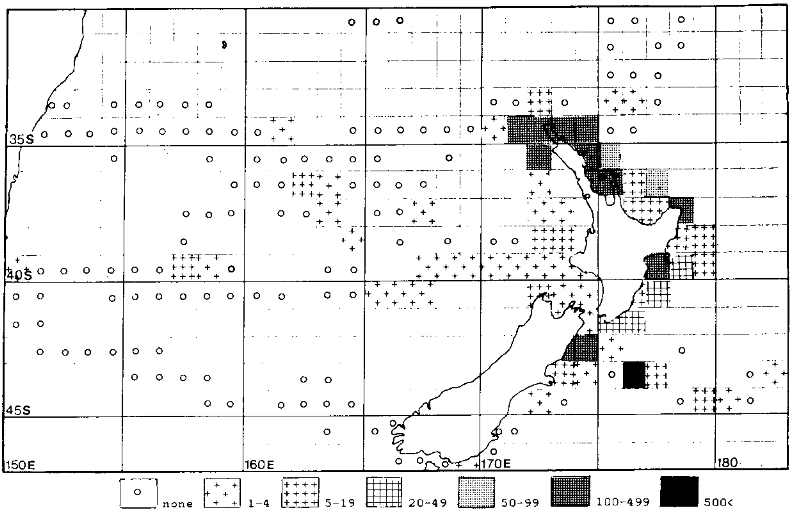

FIGURE 7 — March

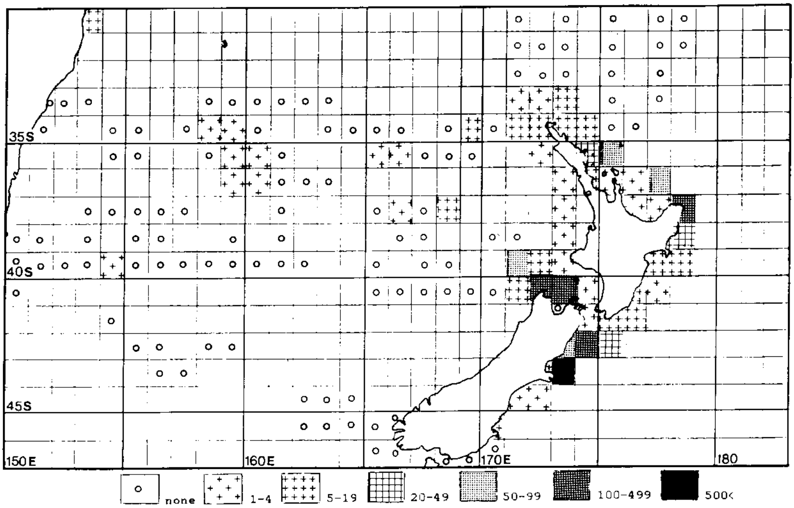

FIGURE 8 — April

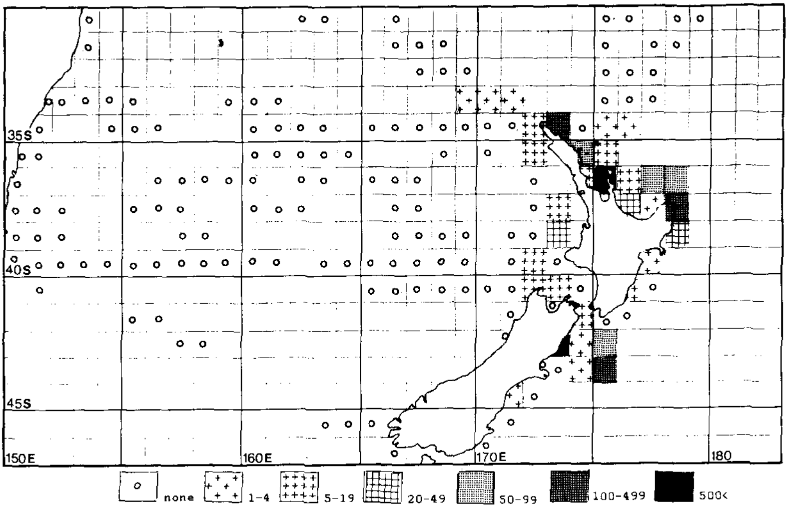

FIGURE 9 — May

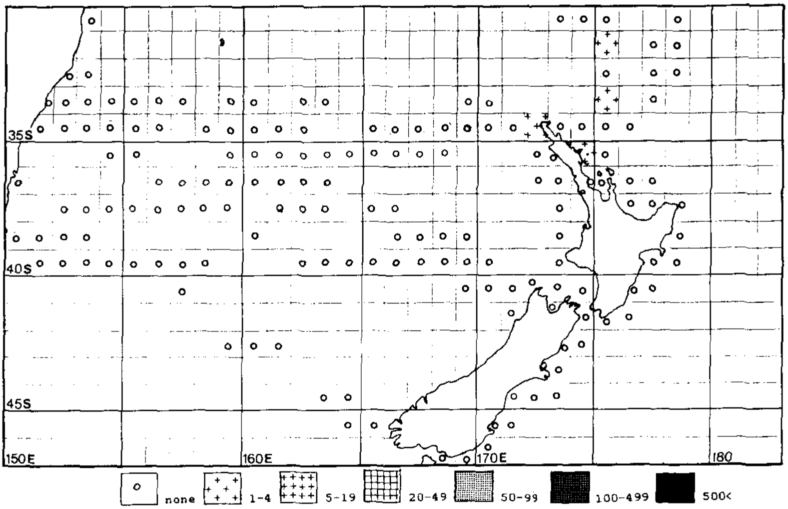

FIGURE 10 — June

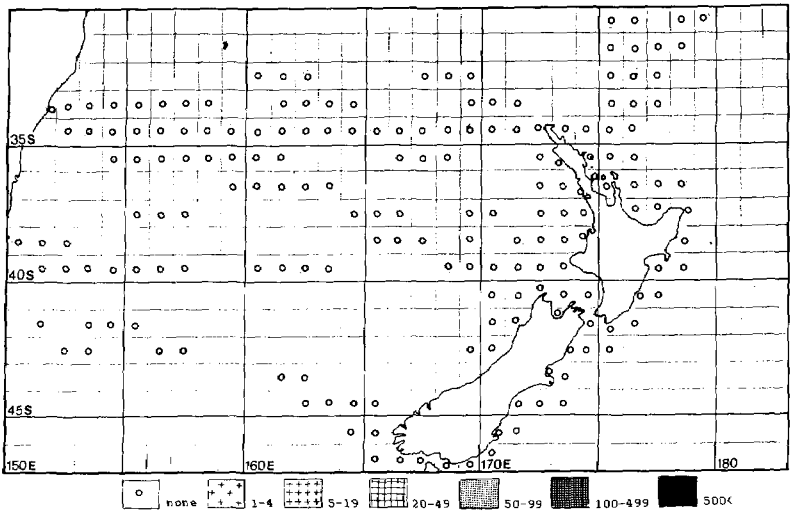

FIGURE 11 — July

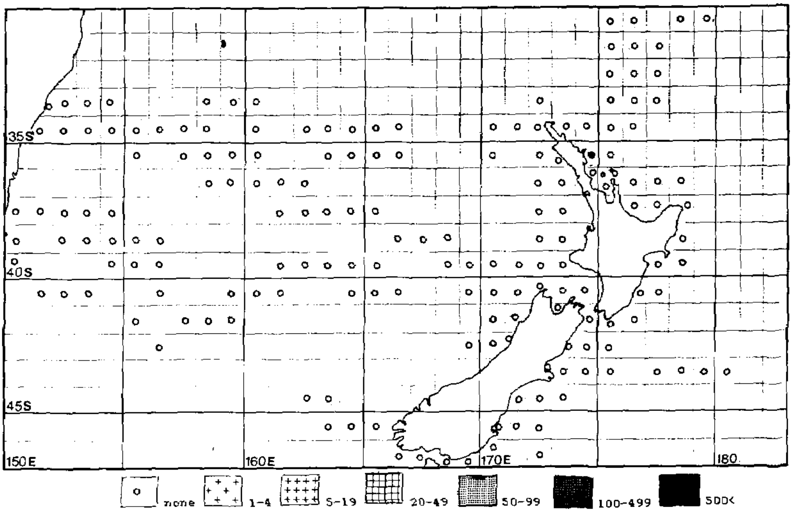

FIGURE 12 — August

According to Harper (1983), the prelaying exodus has ended a few days after 26 October. In November, therefore, large numbers are at sea. Most seem to remain between Three Kings and East Cape, favoured feeding grounds that offer the sheltered waters preferred (Jenkins 1974). Many thousands have regularly been recorded close to the Poor Knights in early November (Fig. 3). Returning non-breeders might account for the slightly wider distribution in the Tasman Sea and in coastal waters south of Cook Strait. By the end of November, and for the rest of the summer, only the odd straggler is seen beyond the continental shelf to the north of New Zealand.

In December, even though half the breeding population and many non-breeders are ashore by day, most eggs being laid 26-30 November (Harper 1983), there seems to be little reduction in the numbers seen at sea. The distribution expands greatly during this month (Table 1), across the Tasman Sea into Australian coastal waters, south to Foveaux Strait, and out to the Chatham Islands. This expanded distribution could indicate that non-breeding birds are still arriving in the region, but it is more likely to be related to the departure of unemployed birds, which start to leave the breeding islands in late December.

The January pattern (Fig. 5) is similar to that of December with little obvious difference in either numbers or distribution.

Table 1 shows that, in February, birds have been recorded in approximately the same percentage of sea areas visited as in December and January. However, it is obvious from Figure 6 that considerable changes occur in February. The numbers and distribution fall in the Tasman Sea and rise on the New Zealand coast, especially to the north of the country and about the eastern approaches to Cook Strait. Harper (1983) recorded 23 flocks of between 179 and 315 birds off Banks Peninsula on 19 February 1982. During frequent voyages between Wellington and Lyttleton and between Banks Peninsula and Cape Palliser, I made many such observations, seeing rafts of up to 600 birds. M. J. Imber (pers. comm.) has regularly seen Buller's Shearwaters in Pitt Strait, Chatham Islands, during February.

In March (Fig.7) there is a noticeable decrease in the numbers recorded about the breeding islands and to the north of New Zealand. In the Tasman Sea both numbers and distribution are much reduced and the birds seem to have withdrawn from the southern Tasman.

The chart for April (Fig. 8) shows fewer birds in mid-Tasman and south of Banks Peninsula, and a further reduction in the numbers around the breeding islands and the north of the North Island. Sizable flocks are still on the east coast between Banks Peninsula and East Cape. On 9 April 1984, I saw rafts of Buller's Shearwaters from 1230 h at 43.3S 173.3E to 1345 h at 43.0S 173.6E. During this time I recorded 10 rafts of 50-400 birds. After 1345, although birds were seen, there were no more than three together. From the time that the ship had left Lyttleton until 1345, we passed more than 40 squid boats, all lying to sea anchors, rigged for and obviously awaiting darkness to resume fishing. It appears that the shearwaters and the squid are attracted to the area by the same food source, just as the many albatross species and Westland Black Petrels *(Procellaria westlandica)* are attracted by the squid.

In May (Fig. 9), numbers seem to increase about the breeding islands. Certainly, larger flocks have been recorded between Auckland and North Cape in May than in April. On 17 May 1979, in a strong SSW wind, large rafts were sheltering in the lee of Little Barrier Island, the largest containing no fewer than 2000 birds. Harper (1983) suggested that the young leave their islands during May, which probably accounts for the larger numbers seen. Elsewhere in May, apart from a few birds to the west of Cape Reinga, there is an almost total withdrawal from the Tasman Sea. There are still birds about East Cape and some flocks in the eastern approaches to Cook Strait. There are no records of birds south of Banks Peninsula after the end of April and few to the north of New Zealand. However, Cheshire (1974) and Jenkins (1980) saw a few birds in Tongan and Fijian waters at this time and, in addition, there are May records of one bird between Tonga and the Kermadec Islands and two birds south of Samoa at 14S 172W on 8 May 1975. Many voyages between New Zealand and Samoa have produced only these few sightings of fewer than 10 birds in total.

TABLE 1 — The number of one degree areas visited each month and the percentage of areas in which Buller's Shearwaters were seen

Month	Number of areas visited	Areas in which Buller's Shearwaters were seen	
		Number	%
Jan	223	91	41
Feb	165	74	45
Mar	193	68	35
Apr	169	57	34
May	174	33	19
Jun	162	4	3
Jul	179	0	0
Aug	178	0	0
Sep	191	44	23
Oct	200	40	20
Nov	210	59	28
Dec	186	87	47

In the New Zealand region there are no further June sightings other than the four given in Jenkins (1974). These were made in 1959 (1 bird), 1962 (1 bird), 1963 (2 birds), and 1969 (4 birds). It seems odd that there have been no further sightings since 1969, even though the population is known to have been increasing continuously.

For the region under discussion there are no August records. However, an important sighting, obviously of returning migrants, was made on 31 August 1978, when 15 birds were seen at 32S 175W (Chapman 1981). These birds could easily have been at the Poor Knights by 1 or 2 September.

The small circles in Figures 10-12 show that there was no reduction in effort during June, July, and August, when the birds were away on migration.

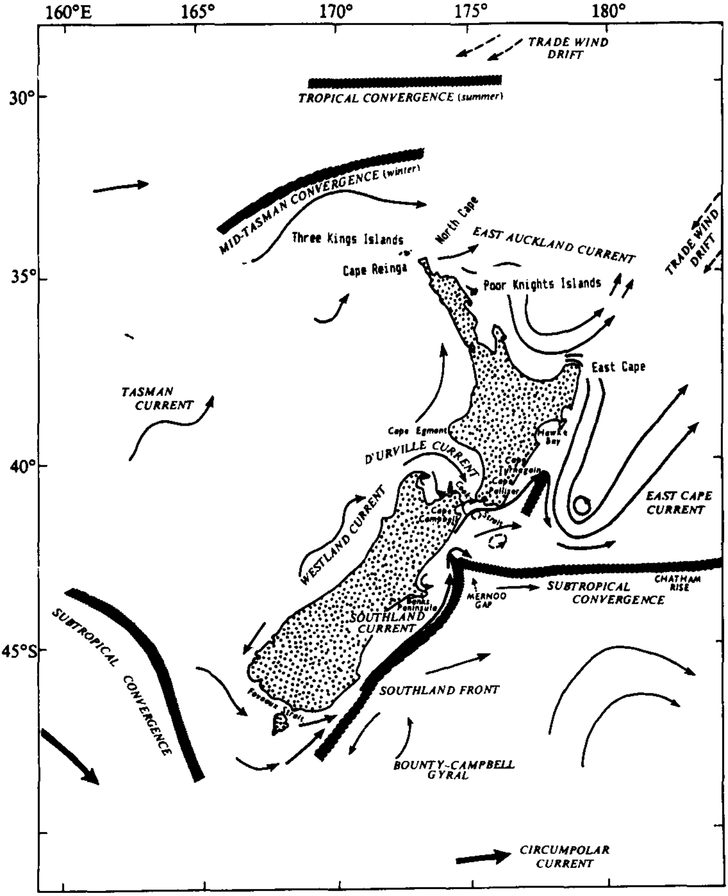

FIGURE 13 — Ocean currents around New Zealand, as shown by Heath (1975)

DISCUSSION

Comparing these observations with the ocean current chart of Heath (1975) (Fig. 13), we see that Buller's Shearwaters appear to spend the austral summer in subtropical waters. The few records south of the subtropical convergence are probably of birds feeding in the convergence zone. Although there are few records, probably some birds feed out towards the Chatham Islands, north of or in the convergence, from November until they leave on migration. By keeping close to the east coast of the South Island the birds are able to remain in the comparatively warmer water of the Southland Current down to and through Foveaux Strait. The birds range far more widely in the south Tasman Sea than they do in comparable latitudes to the east of New Zealand, where the convergence is further north. The birds spread throughout the Tasman Sea and eastward to the Chatham Islands are probably non-breeders. If so, the waters closer to the Poor Knights provide feeding grounds for the breeding birds. The morning flight of birds from the Poor Knights toward the North Cape/Cape Reinga area (Jenkins 1974) probably consists largely of breeding birds feeding close to the breeding islands.

In my 1974 paper I said that I had not seen a return flight, later in the day, from the north of New Zealand toward the Poor Knights. From this I suggested that ". . . there could be many birds that over-fly the North Island and return direct to the Poor Knights from the west coast." Since 1974 I have many records from the area of birds moving south in the late afternoon and early evening – obviously birds returning to the breeding colonies. I have no proof that any birds return to their islands by flying across the North Island, and any reference I have made to this happening should be discounted.

Once the southerly migration is completed, few Buller's Shearwaters are seen north of the continental shelf and almost none north of 33S. This northern limit of distribution may be related to a scarcity of acceptable food to the north of the shelf. The Wedge-tailed Shearwater *(Puffinus pacificus)*, which is close taxonomically to Buller's Shearwater, feeds regularly in the austral summer down to about 100 n.miles north and north-east of New Zealand (Jenkins 1979). It seems that the same barrier which keeps the Wedge-tailed Shearwater to the north keeps the Buller's Shearwater to the south and so ensures their separation during the breeding season. However, in Australian coastal waters, Wedge-tailed and Buller's Shearwarters are recorded in the same sea areas throughout the austral summer. Hindwood (1955) reported that the first sighting of Buller's Shearwater for Australia was on 31 October 1954. Holmes (1975) showed that they had been seen offshore from October to April and recorded a beach-washed specimen in early June. Our records show that, in Australian coastal waters, we have seen small numbers fron October to April (Fig. 2-8). It appears that Australian Wedge-tailed Shearwaters occupy the same waters as does Buller's Shearwater, whereas the Wedge-tailed Shearwaters from the Pacific Islands to the north of New Zealand do not. This may be a further difference between these two populations of Wedge-tails (Jenkins 1979) rather than having anything to do with the preference of Buller's Shearwaters for a particular sea area.

Bartle (1968) said that the burrows of Buller's Shearwater on Aorangi Island had increased from almost nil in 1925, when wild pigs were present, to about 100 000 in 1964, 28 years after the pigs had been exterminated. This trend has continued and Bartle (pers. comm.) has suggested that the burrows on Aorangi doubled between 1964 and 1980. This increase is reflected in the larger numbers seen in the Tasman Sea (Fig. 1-9) than the mere 20 birds seen over a long period of Tasman crossings before 1974 (Jenkins 1974).

ACKNOWLEDGEMENTS

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SHORT NOTE

The Hakawai

Colin Miskelly's paper on "The identity of the Hakawai" (*Notornis* 34(2): 95-116) makes most a convincing case for the Stewart Island Snipe. It is particularly satisfying to be able to rescue from mythology all those traditional stories of a fabulous bird that cries in the night but is never seen.

There must be many references to Hakawai or Hokioi in old writings, but one I came across may be of interest. The diary of Frederick Tuckett, surveyor for the New Zealand Company (published in T. M. Hocken's *Contribution to the Early History of New Zealand*, 1898), described his explorations in Southland in 1844. He made the following comment as an aside to his entry for Friday 24 May:

> All the people frequenting this coast [of Foveaux Strait] believe in the existance of an extraordinary bird, or phantom, which they can never see, but only hear rushing past them with the rapidity of a falling rocket, and making a terrible rushing sound. The Maories declare that it is a bird possessing many joints in its wings. The whalers call them *break-sea-devils*, after the name of an island where this phenomenon is of most frequent occurrence.

It is not clear which is the island referred to, for there are at least three named Breaksea. That in the mouth of Breaksea Sound, Fiordland, is perhaps least likely, but either the group off Shelter Point to the east of Stewart Island, or the small islet south of Green Island, off Ruapuke Island, could have held Hakawai, Break-sea Devils – or Stewart Island Snipe. But clearly the sound of the mysterious bird was well known in the Foveaux Strait region in 1844.

ROSS GALBREATH, *Naike, RD2, Huntly*

The extract from Frederick Tuckett's diary was also sent to me by Dr Atholl Anderson (Anthology Department, University of Otago). Jenkin (1970) discussed the "mysterious *hakuwai* bird", and wrote (p. 157) that "a similar strange bird, called by the whalers the Breaksea Devil, was said to be heard on Breaksea Island". I considered the record too vague for inclusion in my hakawai paper but now that the source and context of the information are known, Breaksea Island can be added to the list of island where snipe/hakawai occurred. Tuckett was probably referring to Rukawahakura and/or Wharepuiataha Islands (47°07′ S, 168° 13′ E), south of Port Adventure, where muttonbirds *(Puffinus griseus)* are still harvested annually. The other "Breaksea Islands" in the Foveaux Strait region (46° 48′ S, 168° 34′ E) are unlikely to have had a snipe population as they are tiny, although less than 2 km from Green I., which did have snipe.

Rukawahakura and Wharepuiataha Is have had ship rat *(Rattus rattus)* for many years and have a depauperate bird fauna (Beattie 1954: 38). It is interesting that Tuckett's mention of "break-sea-deveils" was made towards the end of the muttonbird season (24 May) – it is possible that the sound was heard on "Breaksea Island" in April or May 1844.

I am interested to hear of any other reports of hakawai or related phenomena found by readers.

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EFFECT OF TOPOGRAPHY ON SEASONAL DISTRIBUTION OF FOREST BIRDS IN THE OHIKANUI, LOWER BULLER AND INANGAHUA VALLEYS, NORTH WESTLAND

By P. R. WILSON, R. H. TAYLOR and B. W. THOMAS

ABSTRACT

Birds were counted in the montane Ohikanui Valley and nearby at the mouth of the Buller Gorge in all four seasons of the year. Counts from these areas are compared with those from three sites previously studied in the much larger and broader Inangahua Valley in the same region. The effect of topographic temperature inversion on the deep and glaciated Ohikanui Valley is reflected in the pattern of vegetation and also in the altitudinal and spatial distribution of the birds. Large differences between the seasonal patterns of occurrence of some species of birds in the Ohikanui and Inangahua Valleys are demonstrated. Reasons for these differences are examined, such as seasonal migration in and out of the Ohikanui Valley for species such as Tui *(Prosthemadera novaeseelandiae)*, Bellbird *(Anthornis melanura)*, and Silvereye *(Zosterops lateralis)* and altitudinal movement by species such as Rifleman *(Acanthisitta chloris)* and Grey Warbler *(Gerygone igata)*.

The study emphasises the importance of warm, floristically rich, lowland forest for the winter maintenance of honeyeater populations which breed in the montane valleys.

INTRODUCTION

This study of the seasonal distribution of birds in a large forested montane valley was undertaken to test the hypothesis that lowland forest provides essential resources for birds inhabiting higher-altitude forests for much of the year (Falla 1939, 1955; Taylor 1977). The Ohikanui Valley was chosen because the forest-type mapping (NZ Forest Service 1974) showed that the floor and terraces of the central part of the valley contained significant amounts of podocarp/beech forest of the "P.B.1" type (Naylor 1955, Masters *et al.* 1957), a forest type found to be a favoured bird habitat in the neighbouring Inangahua Valley (Dawson *et al.* 1978). In fact, although for 18 km the altitude of the valley floor is between 30 and 300 m a.s.l., lowland floristic elements are rare. Topographic inversion of temperature has created a climate where the forest composition of the valley floor resembles that of montane slopes elsewhere in the region. Although the lack of type P.B.1 forests was unexpected, the study proceeded as the valley was clearly an excellent area for studying the habitat preferences and seasonal movements of birds. It also provided an opportunity to compare the results from the glaciated montane Ohikanui Valley with those from the much larger, broader Inangahua Valley approximately 15 km to the east (Fig. 1).

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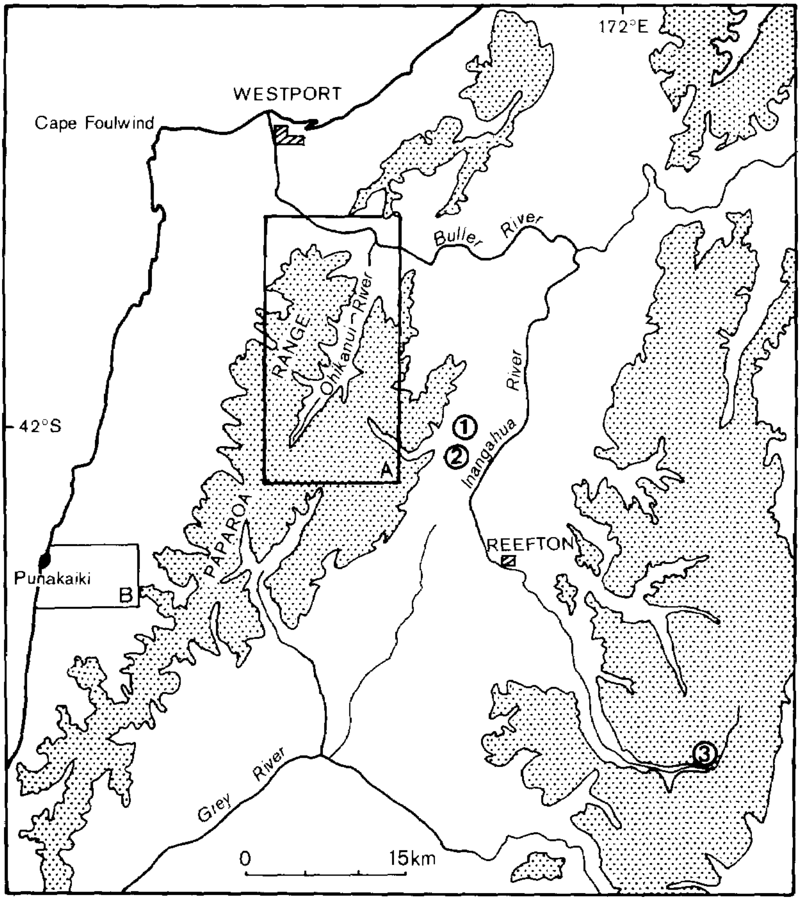

FIGURE 1 — The Ohikanui Valley, Paparoa Range, in relation to previous bird-count study areas in the Inangahua Valley (Dawson *et al.* 1978) and in the Western Paparoas (Onley 1980). Study areas: Ohikanui A. Western Paparoa B. Inangahua Valley (1) Fletcher Creek, (2) Te Wharau, (3) Rahu Saddle. Land over 600 m a.s.l. is shown stippled.

THE OHIKANUI VALLEY

The glaciated U-shaped Ohikanui Valley is 27 km long and drains the northern end of the Paparoa Range (Fig. 2). It joins the Buller River only 6 km before the Buller leaves its gorge to flow a further 13 km across its floodplain to the sea (Fig. 1). The Paparoa Range is formed from a large horst of hard pre-Tertiary rocks, mainly granite and gneiss, which has been carved by glaciation to form knife-edged ridges and deep cirques (Fig. 3). The mountains are mainly over 1200 m with the highest, Mt Uriah, at 1532 m.

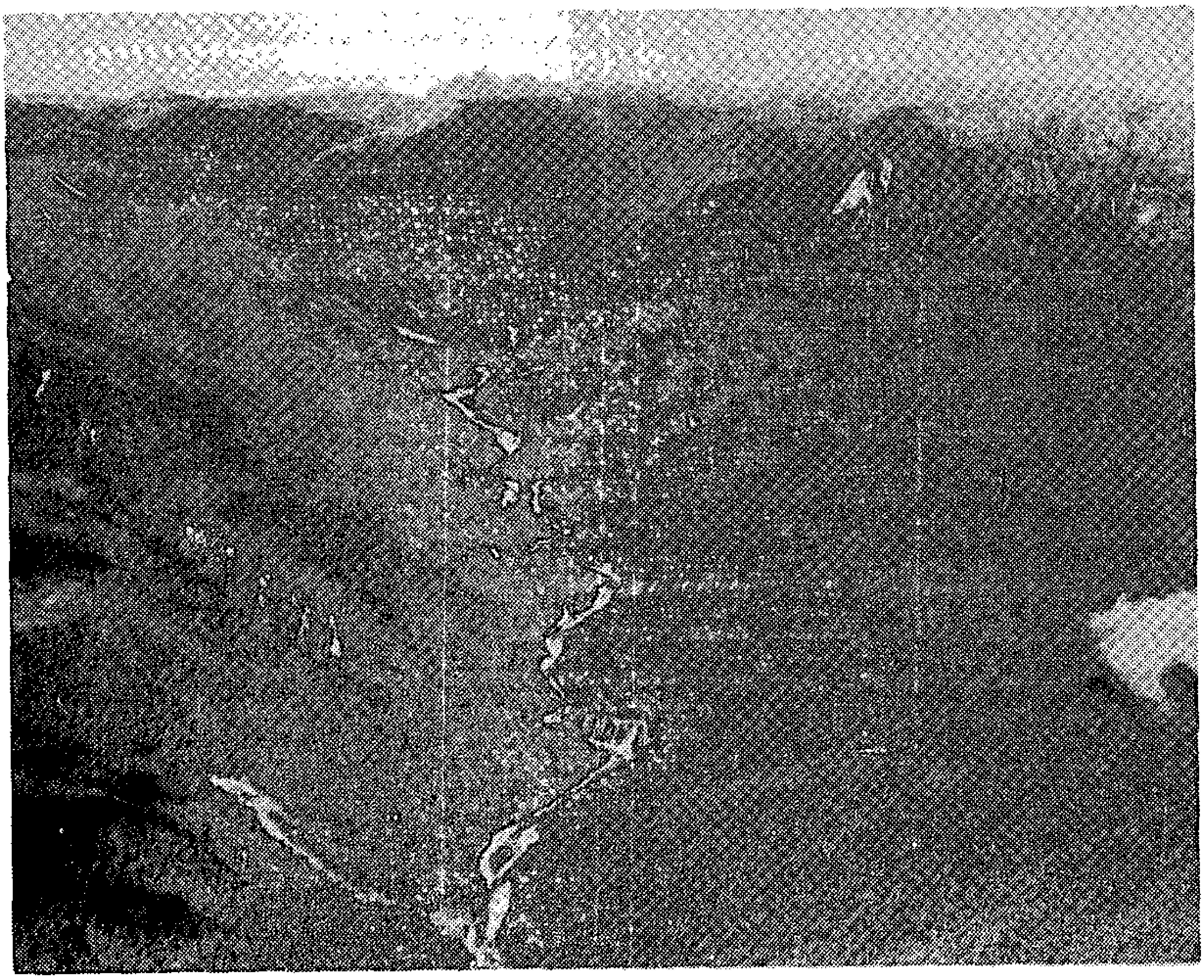

FIGURE 2 — Aerial view of the Ohikanui Valley looking upstream into the heart of the Paparoa Range from a point above the Buckland Creek/Ohikanui River confluence

Photo: Lloyd Homer, NZ Geological Survey

The geology of the Ohikanui River catchment, particularly the south-western portion, consists of undifferentiated schist, gneiss, diorite and granite gneiss, all locally intermingled. Most of the northern and eastern catchment is white muscovite granite. To the west of the mouth of the river a small area of black biotite quartz diorite outcrops (Nathan 1978).

The Ohikanui Valley floor is characterised by a high glacial aggradation terrace and lower degradation terraces; it has a complete forest cover and no grassy flats. The altitude at which tall forest is replaced by stunted forest merging to alpine scrub varies considerably within the Ohikanui catchment. Aspect, geomorphology and the effect of cold air drainage are more important than geology in determining the upper limit of tall forest, which varies from 800 to 1200 m a.s.l.

The Ohikanui area has on average over 2540 mm of rain and more than 200 raindays per annum. It was described by Garnier (1958) – along with much of Fiordland, the West Coast of the South Island and North-west Nelson – as having a cool superhumid climate with a low mean annual range of temperature. The whole Ohikanui catchment has been less modified than many other forested areas of New Zealand. No timber has been extracted; at the time of our survey, red deer *(Cervus elaphus)*, goats *(Capra hircus)*

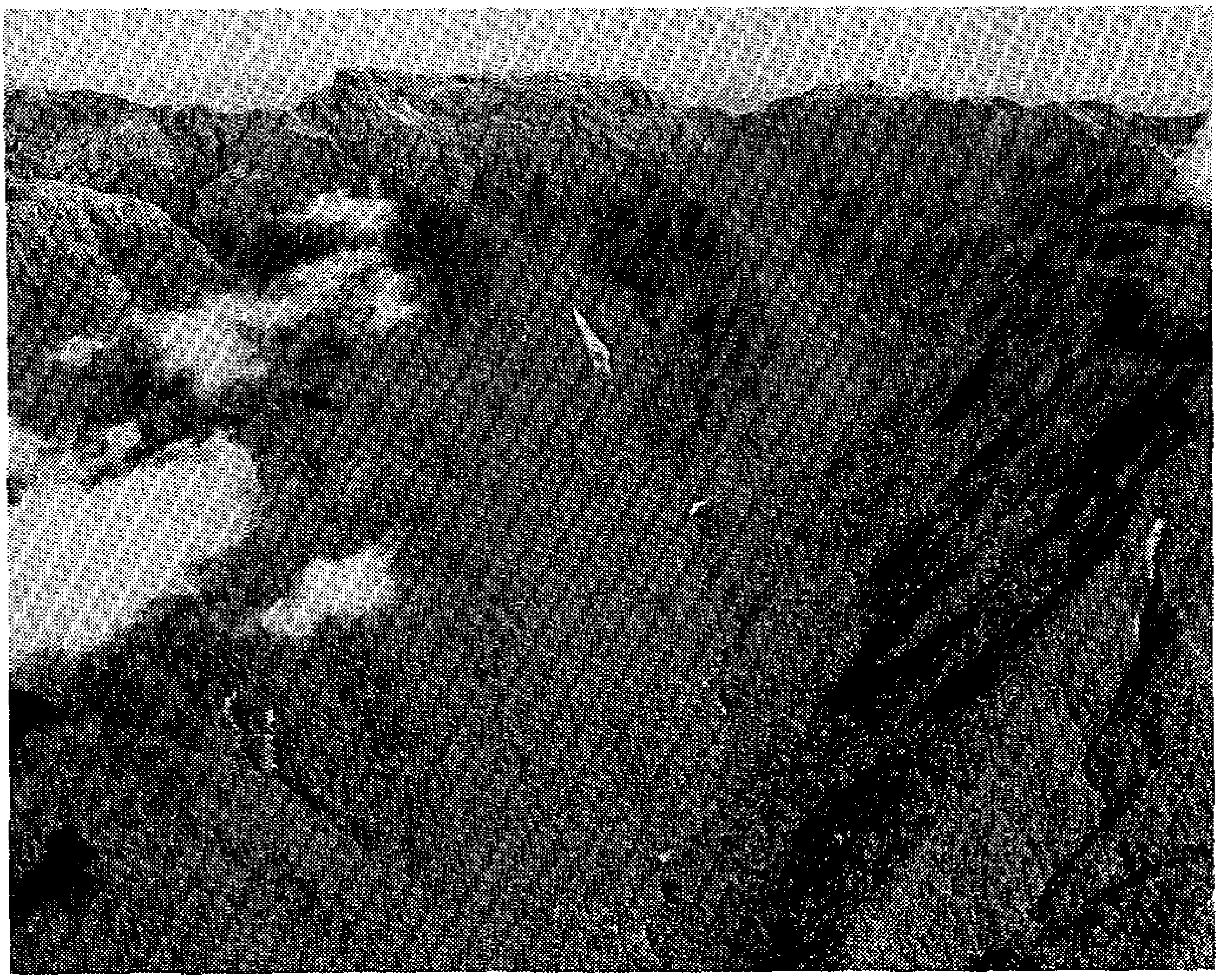

FIGURE 3 — Aerial view of Buckland Creek, a major tributary of the Ohikanui River, showing glacial features and exposed granite tops
Photo: Lloyd Homer, NZ Geological Survey

and rodents *(Rattus* spp. and *Mus musculus)* were scarce throughout most of the area, and possums *(Trichosurus vulpecula)* were in moderate numbers. Stoats *(Mustela erminea)* were present throughout.

FIELD SITES AND METHODS

Field work

The birds of the Ohikanui Valley were studied between June 1975 and December 1977. During this period, four major and three minor field trips to the area involved up to nine ornithologists for a total of 213 man-days. A total of 1920 standard 5- minute bird counts, as described by Dawson & Bull (1975), was made to assess the relative abundance of the various species in different habitats. All bird counts were carried out by observers drawn from a pool of six experienced bird-counters. Numerous incidental observations were also recorded on birds and other wildlife. The base camp was 11 km up the Ohikanui, 1 km below Bartrum Stream (Fig. 4).

As the aim was to compare seasonal and altitudinal changes in bird distribution, study areas and bird-count lines (Fig. 4) were sited to sample valley floor habitats at varying distances up-river from the coastal plain and to sample different altitudinal zones within the Ohikanui Valley. In siting bird-count lines, we attempted to cover the range of vegetation types and land forms in the valley. Each line comprised 10 bird-count stations about

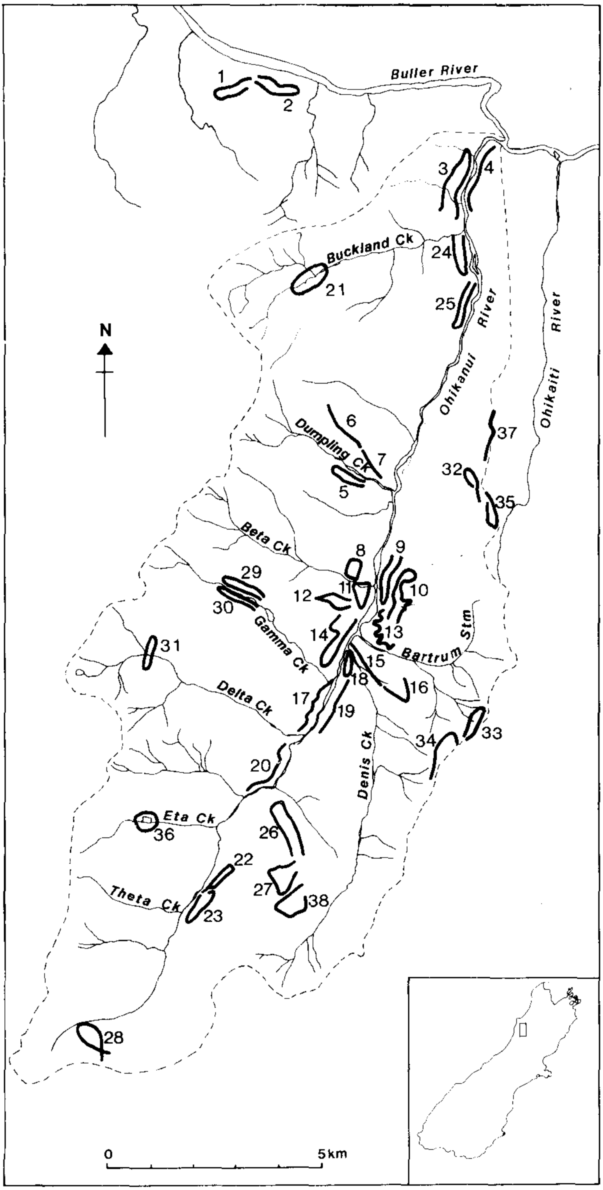

FIGURE 4 — The bird-counting lines (numbered) in the Ohikanui River catchment (dotted line) and at the mouth of the Buller Gorge (lines 1 and 2)

200 m apart. Each line was defined on field maps, but the individual stations were not permanently marked.

In June 1975, birds were counted by five observers on 15 lines (6-20). Each line was counted twice, usually by two different observers who made ten 5-minute counts at each. With one minor variation, these same lines were counted similarly in December 1975, September 1976 and March 1977. Because of a misunderstanding, line 5 was counted instead of line 8 in September 1976. However, as the two lines are at similar altitudes and have comparable bird habitats, this variation should not have affected the overall results. Another four lines were counted similarly in September 1976, and in March, June and December 1977: two at the mouth of the Buller Gorge (1 and 2) and two near the mouth of the Ohikanui (3 and 4). Consequently, birds were counted during four seasons (winter, spring, summer and autumn), on each of 19 lines over a 2.5 year period; no season was replicated at any site.

In March 1977 two additional lines (24 and 25) were counted twice in the lower Ohikanui Valley about 4 km up from the Buller confluence. Helicopters were used in September 1976 and March 1977 to gain access to some of the more remote areas of the Ohikanui catchment, and ten 5-minute bird counts were made at each (lines 26-34 in September 1976; 21-23 and 35-38 in March 1977). These lines were not revisited.

Study areas

"Buller" (lines 1 & 2): Tall emergent northern rata* over a dense canopy of mahoe, pigeonwood, toro, and kamahi, with much supplejack, kiekie, epiphytic ferns, and climbing ratas. This forest has been selectively logged in the past, probably to remove large podocarps (rimu, kahikatea) (G. N. Park and G. Y. Walls, pers. comm.; pers. obs.).

"Lower Ohikanui" (lines 3 & 4): The effect of temperature inversion continues the entire length of the Ohikanui Valley, and it is only here, within the lowermost 2 km at the confluence with the Buller River, that matai and kahikatea occur in the canopy and lowland species such as mahoe, *Coprosma australis, C. robusta,* supplejack, *Coriaria arborea, Cordyline banksii* and kowhai are present on the valley floor and terraces. There is much rimu, with yellow-silver pine, mountain toatoa and mountain beech at the mouth.

"Central Ohikanui" (lines 5-20): The majority of seasonally repeated bird-counting sites were in the central portion of the Ohikanui Valley (Fig. 2 & 4). Nine forest types were recognised in this area. They were distributed altitudinally as in Fig. 5, and they are described as follows.

1. Tall forest on the lowest terraces with a canopy of silver beech, red beech and occasional rimu. There is a dense understorey of horopito and crown fern, and bush rice grass and moss are abundant on the ground.

2. Tall red beech forest on fans and the base of the main slope. More open beneath with some horopito and crown fern, and less moss than the terrace forests.

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* Common and scientific names of plants in the text and glossary (Appendix 1) follow Allan (1961), Moore & Edgar (1970) and recent changes listed in Edgar & Connor (1983).

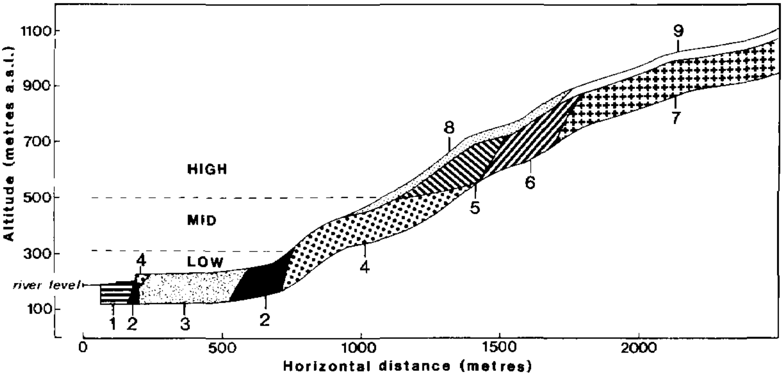

FIGURE 5 — Typical altitudinal profile of the central Ohikanui River valley near count lines 15 and 16 (after G.N. Park, unpublished). The relationships of "low", "mid" and "high" altitudinal bird counting zones to the valley profile and broad vegetation categories (numbered and described in the text) are indicated.

3. Forest on the upper terraces with a fairly open canopy of rimu, cedar and Hall's totara; a subcanopy of yellow-silver pine and mountain beech; and an understorey of mountain toatoa, Westland quintinia, *Myrsine divaricata*, and other species. The ground is very mossy and poorly drained. In some places where this forest is stunted, yellow-silver pine is dominant.

4. Hard beech/silver beech/Hall's totara forest on the main slopes to about 500 m a.s.l., and on the tread of upper terrace, with a dense understorey of Westland quintinia, kamahi and much crown fern.

5. Forest on the middle slopes at about 500-700 m a.s.l. in which silver beech dominates, with some hard beech, red beech and Hall's totara. Some Westland quintinia, kamahi and crown fern, but less than lower down. Mosses increase with altitude.

6. Above 700 m, to about 850 m a.s.l., silver beech dominates, with occasional kamahi, southern rata and Westland quintinia. The understorey is mostly silver beech and the ground is very mossy.

7. Above 850 m to the timberline, silver beech and mountain beech dominate with *Archeria traversil* and *Dracophyllum traversii* common in the understorey, and much moss is on the ground and trees.

8. On ridges of the valley sides between 400 and 900 m a.s.l., low forest of yellow-silver pine/mountain beech/southern rata is common.

9. On ridges between 900 m and the bushline, a low forest of bog pine, yellow-silver pine, and mountain beech is characteristic.

Lower valley terraces and fan slopes south of Buckland Creek (lines 24 & 25): Broadly similar to forest types 1 and 2 of the Central Ohikanui.

Remote areas (lines 21,26-38): High-altitude sites fall mainly in forest types 7-9 as described for the Central Ohikanui.

Upper Valley (lines 22 & 23): Similar in composition to valley bottom forests of the Central Ohikanui.

Analysis

Bird counts from Buller (lines 1 & 2), Lower Ohikanui (lines 3 & 4) and Central Ohikanui (lines 5-20) were analysed and compared. In the Central Ohikanui, the bird-count stations of the 15 counting lines which were repeated during four seasons were analysed according to which altitudinal zone they fell in, as follows: low (0-315 m a.s.l.), mid (316-500 m a.s.l.) and high (501-999 + m a.s.l.). The counting sites in "Lower Ohikanui" and "Buller" were all classed as low altitude.

Bird counts from the present study are compared with those from three areas studied in the Inangahua Valley (Dawson *et al.* 1978). The Inangahua Valley areas (Fig. 1) were Fletcher Creek (230 m a.s.l.), a remnant of the forest type once common on alluvial flats and terraces; Te Wharau (300-420 m a.s.l.), representing the main hill-country forest type; and Rahu Saddle (820-1070 m a.s.l.), a high-altitude "protection forest".

Data from the "low" altitude zone of Central Ohikanui are compared with data from Fletcher Creek; data from the "mid" altitude zone of Central Ohikanui are compared with data from Te Wharau and data from the "high" altitude zone of Central Ohikanui are compared with data from Rahu Saddle.

Ohikanui birds were counted in March, June, September and December, whereas Inangahua birds were counted in April, June, August, October, December and February. To compare the results of the two studies, we took the mean number of each species of bird counted in February and April in each of the Inangahua study areas to represent March, and took the mean of the August and October counts to represent September. The seasonal trends of most species studied at Inangahua and Ohikanui suggest that this procedure was valid.

Data for the more frequently recorded species were analysed by both non-parametric analysis (Kruskal-Wallis) and analysis of variance on transformed data. The transformation used was $\sqrt{x} + \sqrt{x+1}$, which Snedecor & Cochran (1967) reported to be slightly better at stabilising variances for low counts than a simple square-root transformation. This transformation was sometimes still inadequate, but as the conclusions were all corroborated by the Kruskal-Wallis test, we considered the results to be valid. All mean values presented in the paper are back-transformed.

Data from remote sites, and for infrequently recorded birds, were categorised into present/absent and analysed as contingency tables by the chi-square test.

To compare the frequently recorded species from remote sites with those in Central Ohikanui and in Lower Ohikanui, we used the Kruskal-Wallis test. The data did not allow seasonal effect to be separated from annual effect. In making these comparisons we have assumed that the patterns observed relate to altitude and season and are not caused by major differences between years.

All statistical differences stated to be significant are at the 1% probability level or less. We chose this level of significance, rather than the usual 5%

level, to increase confidence in differences detected because the study design was not completely balanced. For example, the seasonal counts did not all fall in the same year and the bird-count stations were not fixed exactly.

RESULTS

Broad habitat preferences

As was to be expected, bird species were not distributed evenly throughout the Ohikanui Valley, and most displayed obvious habitat preferences. Two aspects of these preferences are illustrated in Fig. 6, which is based on yearly averages of counts at seasonally repeated sites.

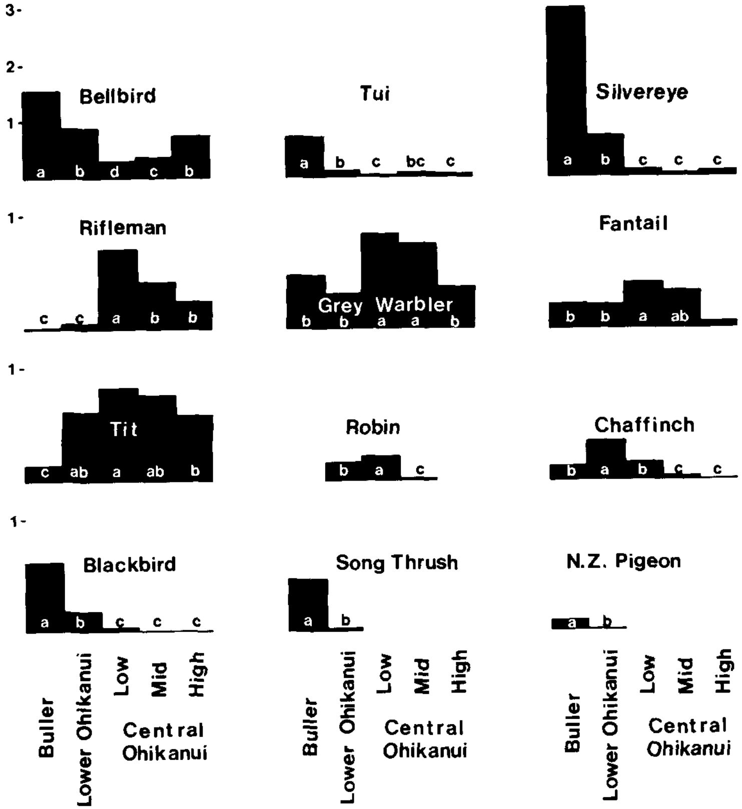

FIGURE 6 — The mean number of each species counted in 5 minutes in low-altitude forest at Buller (n = 160 counts), Lower Ohikanui (n = 160), and in each of the low, mid and high altitudinal zones in the Central Ohikanui (n = 705 low atlitude; 295 mid; 250 high) averaged over the whole year. Note differing scales. Means with the same letter do not differ significantly ($P<0.01$).

The figure shows the effect of distance up-river from the coastal plain for low-altitude forest and the effect of increasing altitude in the Central Ohikanui. Bellbirds, Tuis, Silvereyes, Blackbirds, Song Thrushes, and New Zealand Pigeons were most common at Buller, less so in Lower Ohikanui, and least common in Central Ohikanui. The converse was true for Riflemen, Fantails, Tits and Robins, which increased in abundance with distance up the valley. The preferences of certain species for the three altitudinal zones up the sides of the valley in Central Ohikanui are also illustrated. Numbers of Riflemen, Grey Warblers, Fantails, Tits, Robins and Chaffinches decreased significantly with increasing altitude. Blackbirds, Shining Cuckoos and Wekas (Table 1) had a similar trend. In contrast, Bellbirds and Redpolls (Table 1) showed a significant preference for the higher-altitude zones.

Lines counted over four seasons

The average 5-minute counts for the 12 most common forest birds from the Ohikanui and Buller study areas are given by altitudinal zone and season in Fig 7. Less frequently encountered species are listed in Tables 1-3. Each species is discussed below, and its seasonal and altitudinal habitat preferences in the montane Ohikanui Valley are compared with those found in the Inangahua Valley. It is well known that many birds vary in conspicuousness seasonally (Dawson 1981). As most birds counted are located by sound rather than sight, a greater proportion of the population is indexed by counts during their song period. Where known, seasonal changes in conspicuousness have been considered in the interpretation of our counts.

Bellbird *(Anthornis melanura):* Bellbirds were few in the Central Ohikanui at all times of the year. On average, low-altitude counts were one-fifth of those at Fletcher Creek, and mid-altitude counts one-sixth of those at Te Wharau; only high-altitude counts compared in magnitude with those from Rahu Saddle, though with an entirely different seasonal pattern (Fig. 7A). Bellbirds in the Central Ohikanui clearly favoured the high altitude zone, and significantly more were found there than at mid or low altitude in all seasons except September.

The Lower Ohikanui area exhibited a marked and significant reduction in the number of Bellbirds in June, as in all three altitudinal zones of the Central Ohikanui. The increase in numbers counted between June and September was much more marked in the Lower Ohikanui than in the Central Ohikanui; numbers fell in the Lower Ohikanui between September and December while they rose (significantly in low and high altitudes) in the same period at all altitudes in the Central Ohikanui.

Large numbers of Bellbirds were found in Buller during June. The whole pattern of seasonal abundance demonstrated at Buller, with its lowest count in December, is virtually the converse of that for all Central Ohikanui Valley sites. The Buller area, with its more diverse and warmer forest type, could have been acting as wintering-over quarters for many Bellbirds coming out of the Ohikanui. The significant decrease in numbers of Bellbirds at Buller from June to December, and the corresponding significant increase between June and September in the Lower Ohikanui, followed by a decline there in December (though not significant), is entirely consistent with a return

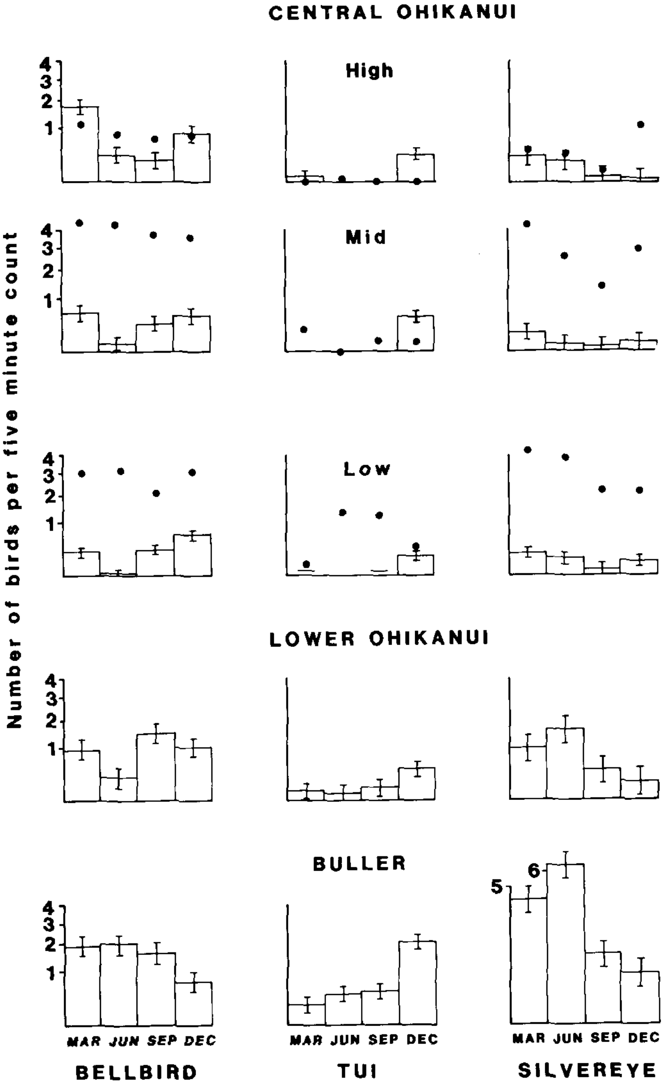

FIGURE 7A — Seasonal and altitudinal distribution of 12 species of birds indexed by standard 5-minute counts in and near the Ohikanui Valley. Seasonally repeated lines for each area were: "Central Ohikanui", lines 6-20 inclusive; "Lower Ohikanui", 3 & 4; "Buller", 1 & 2 (Fig. 4). For the "Central Ohikanui", "high", "mid" and "low" indicate counts from above 500 m a.s.l., 316-500 m a.s.l. and 315 m a.s.l. and below, respectively. Both "Lower Ohikanui" and "Buller" are low-altitude areas. Histograms show mean values (with their 99% confidence limits) from the Ohikanui study. Values too small to plot are indicated by a horizontal bar. Black dots show means from the Inangahua Valley study areas (see analysis section).

flow of Bellbirds through forests at the mouth of the Ohikanui en route to summer quarters higher up the valley.

In contrast, Bellbirds in the Inangahua Valley preferred hill country forests and only rarely exhibited statistically significant variation in apparent numbers in any of the four areas counted throughout the year. The small changes observed there can probably be explained by seasonal conspicuousness.

Tui *(Prosthemadera novaeseelandiae):* Only during December were Tuis distributed throughout the altitudinal range in the Central Ohikanui. Almost none was detected during the months of June or September (Fig. 7A), although a very few were counted in March, almost all at high altitude. Tuis are generally common, noisy and hence conspicuous during winter in low-altitude mixed beech/podocarp forest (Dawson *et al.* 1978; pers. obs.). A feature of the Central Ohikanui was that no Tuis were found in the beech/podocarp forests during winter (at any altitude) and those that did migrate into the valley for summer were significantly more common at mid altitude than at low or high altitude. This was the converse of Tui distribution found in beech and beech/podocarp forests in the Inangahua Valley (Fig. 7A). Similarly, there was no winter peak in numbers of Tuis in either the Lower Ohikanui or the Buller study areas (Fig. 7A). In fact, although on an annual basis significantly more were counted in Lower Ohikanui, and particularly Buller, than in the Central Ohikanui, the seasonal pattern of a significant increase in December is the same in all areas (2% level, Lower Ohikanui) and altitudes.

Although Tuis were fairly numerous at Buller during the winter (0.5 per count), over three times as many were counted there during December. By comparison, numbers at Fletcher Creek had halved from winter to December. Clearly, Buller is not a prime wintering area for Tuis but does attract them in large numbers in summer, presumably from overwintering areas not sampled during this study.

Silvereye *(Zosterops lateralis):* Silvereyes displayed a significant preference for high and low altitudes in the Central Ohikanui and were found there at all altitudes and in all seasons. Like Bellbirds, they were surprisingly few at lower altitudes in Central Ohikanui compared with their numbers at Lower Ohikanui and Buller, and in the Inangahua Valley (Fig. 7A).

Kikkawa (1962) suggested that some Silvereyes leave the montane forests in winter. Figure 7A tends to support this suggestion. A significant decrease in Silvereyes counted occurred at low and high altitudes in the Central Ohikanui from March to September, but increases were recorded in June in the Lower Ohikanui (not significant) and Buller forests (significant), before numbers dropped there also in September (significant at both Buller and Lower Ohikanui). The very large number of Silvereyes recorded in the Buller area in March and June may reflect the result of breeding followed by possible migration down from the montane environment to a richer winter food supply, such as the abundant autumn-flowering *Metrosideros fulgens* in these forests.

South Island Rifleman *(Acanthisitta chloris chloris)*: The distribution of the Rifleman in the Ohikanui is perhaps the best illustration of the effect of temperature inversion on habitat in such a montane valley. In the Central Ohikanui they were more common in low-altitude forests than at mid or high altitudes (Fig. 7B), which is the converse of the pattern recorded in

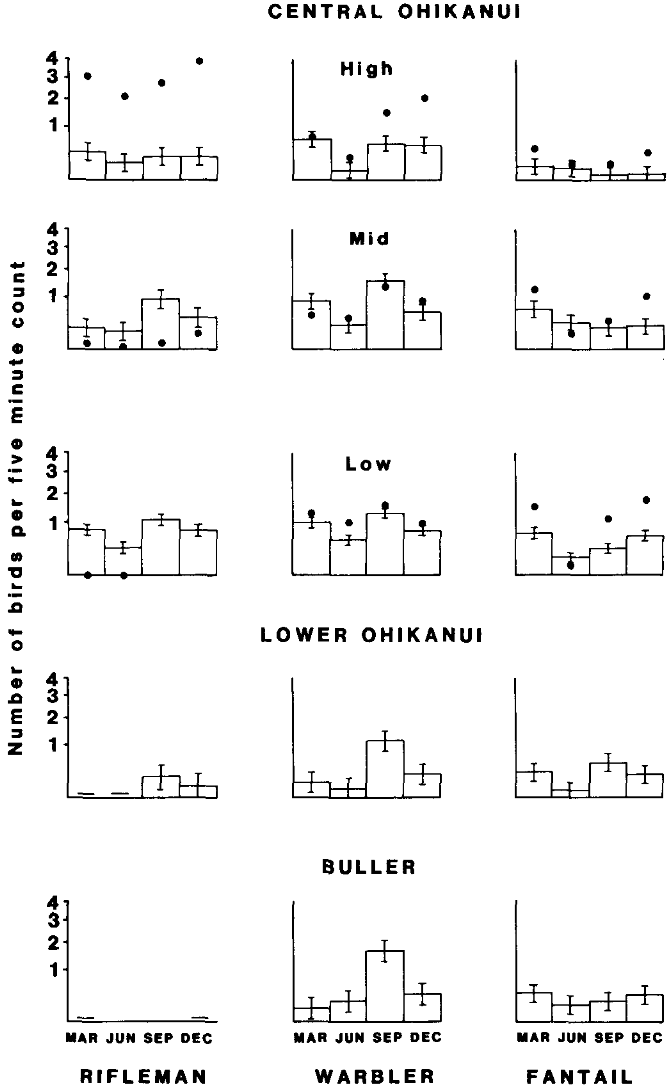

FIGURE 7B — Seasonal and altitudinal distribution of 12 species of birds indexed by standard 5-minute counts (continued) the Inangahua Valley (Dawson *et al.* 1978). However, although some Riflemen were counted at all altitudes in the Ohikanui, nowhere were their numbers as high as those recorded at Rahu Saddle, where over twice as many Riflemen as anywhere else were counted in any season (Fig 7B). At Rahu Saddle, Rifleman numbers rose from a low in winter to a peak in summer and remained high in autumn. The closest approximation to this pattern is illustrated by the low-altitude Central Ohikanui counts, but without a peak in December. The mid-altitude counts are less similar, with a pronounced peak in September, while Rifleman numbers at high altitudes were relatively constant throughout the year.

Our data suggest that, in the Ohikanui, some birds may move down to breed in September. Significantly more Riflemen were counted in September than in June in the mid- and low-altitude Central Ohikanui and the Lower Ohikanui. This pattern was not repeated at high altitude.

Grey Warbler *(Gerygone igata):* Grey Warblers were spread throughout the altitudinal range in the Central Ohikanui, being a little more numerous at low and mid altitudes than at high altitudes (Fig. 7B). Numbers of warblers counted seasonally at low and mid altitudes in the Central Ohikanui correspond very closely to those at Fletcher Creek and Te Wharau in the Inangahua Valley. In all these areas the numbers counted between June and September increased by 2-3 times because of increased conspicuousness, warblers being most vocal from August until October.

The number of Grey Warblers counted in the Lower Ohikanui and Buller in September was significantly larger than in March and June. In March, significantly more warblers were recorded at all altitudes in the Central Ohikanui than in either Lower Ohikanui or Buller. A possible explanation is that some birds move down the valley to breed in September but that breeding is more successful further up the valley.

South Island Fantail *(Rhipidura fuliginosa fuliginosa):* Significantly more Fantails preferred low- and mid-altitude forests in both the Ohikanui and Inangahua studies. The seasonal pattern recorded in the Ohikanui was similar to, but less accentuated than, that in the Inangahua (Fig. 7B).

Yellow-breasted Tit *(Petroica macrocephala macrocephala):* The altitudinal and seasonal distributions and the numbers of Tits counted were very similar in both the Central Ohikanui and Inangahua Valley (Fig. 7C). This pattern is mainly due to seasonal conspicuousness, but the comparatively high numbers counted in the low-altitude area of Central Ohikanui in June suggest that some Tits may migrate there in winter.

The significant reduction from September to December in the numbers of Tits counted in the Lower Ohikanui and at Buller is inconsistent with the seasonal pattern recorded in the Central Ohikanui and at all study sites in the Inangahua Valley. Either some Tits in the Lower Ohikanui and Buller areas move higher up the valley sides in December or, more likely, they breed much earlier in these low-altitude areas and territorial singing finishes sooner.

South Island Robin *(Petroica australis australis):* In the Central Ohikanui, Robins were most abundant at low altitudes where, in fact, they were in almost identical numbers and exhibited the same seasonal pattern as Robins at Fletcher Creek. A few Robins were recorded at mid altitude, as at Te Wharau, but none was recorded in the high-altitude counting zone in the

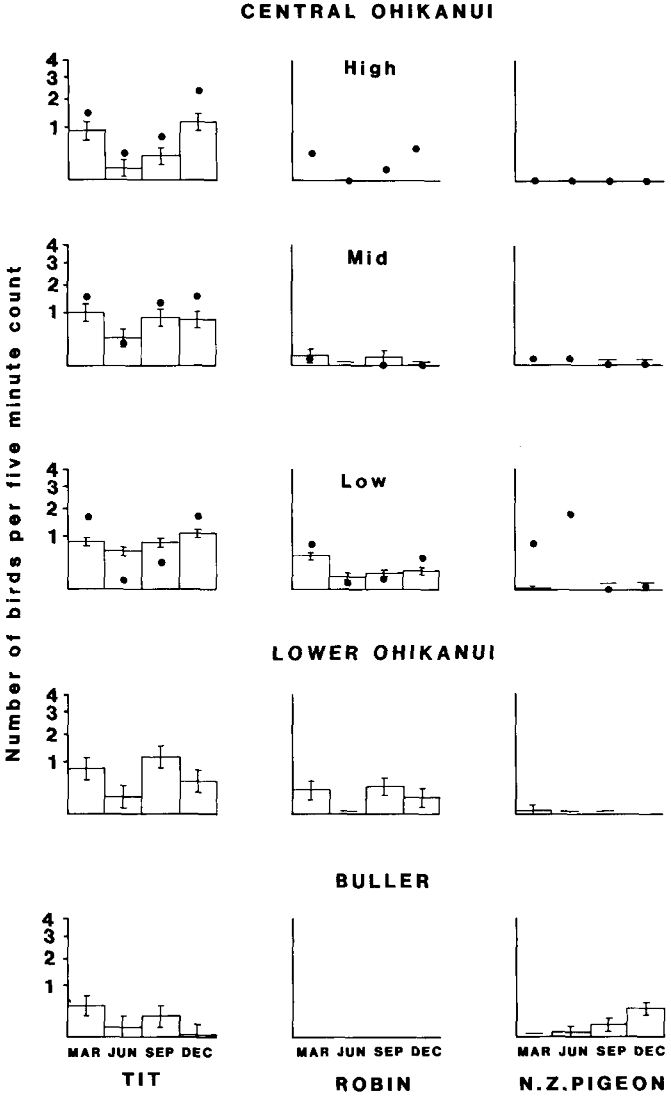

FIGURE 7C — Seasonal and altitudinal distribution of 12 species of birds indexed by standard 5-minute counts (continued)

Central Ohikanui, whereas at Rahu Saddle they were quite common (Fig. 7C). On average, similar numbers of Robins were recorded in Lower Ohikanui as in the low-altitude zone of Central Ohikanui. None was recorded at Buller, however.

New Zealand Pigeon *(Hemiphaga novaeseelandiae):* Very few New Zealand Pigeons were counted in the Ohikanui (Fig. 7C). They were absent in June, except for a few in the Lower Ohikanui; they were rarely recorded at other times of the year and then only at low and mid altitudes. By comparison, their numbers peaked in June at Fletcher Creek in the Inangahua Valley (Fig. 7C). In fact, the seasonal use of the Buller forest by pigeons is the converse of that recorded at Fletcher Creek. Pigeons were present in very low numbers at Fletcher Creek during counts in August, October and December, whereas there were peak numbers at Buller during the September and December counts.

Chaffinch *(Fringilla coelebs):* Significantly more Chaffinches were recorded in low-altitude forest than in mid- and high-altitude forests in the Ohikanui Valley. During September and December fewer were in the mid- and high-altitude zones of the Central Ohikanui than in the hill and protection forests of the Inangahua. During March surprisingly few were recorded in Central Ohikanui, the Lower Ohikanui, or Buller, compared with other times of year. This and the large differences between Buller and Lower Ohikanui in June, September and December (Fig. 7D) are best explained by seasonal migrations out of the valley in autumn and winter.

Blackbird *(Turdus merula):* Blackbirds were evenly spread throughout the altitudinal range in both the Central Ohikanui and Inangahua study areas. The seasonal pattern of change in the number of Blackbirds recorded throughout the year was identical in both the Ohikanui and Inangahua Valleys. At all times of year significantly more Blackbirds were recorded at Buller than in the Ohikanui study areas, probably because of their preference for more modified habitats. The highest numbers were recorded at Lower Ohikanui and Buller in December (Fig. 7D), when Blackbirds were still in full song and there were large numbers of fledged young.

Song Thrush *(Turdus philomelos):* Song Thrushes were rare in the Central Ohikanui. None was counted there in March, and only in December were they recorded at all altitudes (Fig. 7D). However, the counts were higher during September and December in the Lower Ohikanui, and were significantly higher at Buller, particularly in spring and summer.

Brown Creeper *(Finschia novaeseelandiae):* Brown Creepers were only rarely recorded during bird counts in the Central Ohikanui but were significantly more common at high altitudes (Tables 1 & 4). They were recorded only once at Lower Ohikanui and never at Buller. In the Inangahua Valley, Brown Creepers were recorded only at high-altitude Rahu Saddle.

Lines counted in one season only

September 1976: The bird-counting team was positioned in nine remote areas of high-altitude forest (counting lines 26-31, 33 and 34, Fig. 4). The results from these nine lines (Table 4) were compared with the September high-altitude counts from the Central Ohikanui counting area. Very few differences were detected. Brown Creepers and Rifleman were significantly more common in the remote counts. Tuis and Robins were recorded in low numbers, whereas they were not recorded during the Central Ohikanui high-altitude counts. Of the introduced birds, only the Chaffinch was significantly more common in the remote counts. Otherwise, for all other species, the

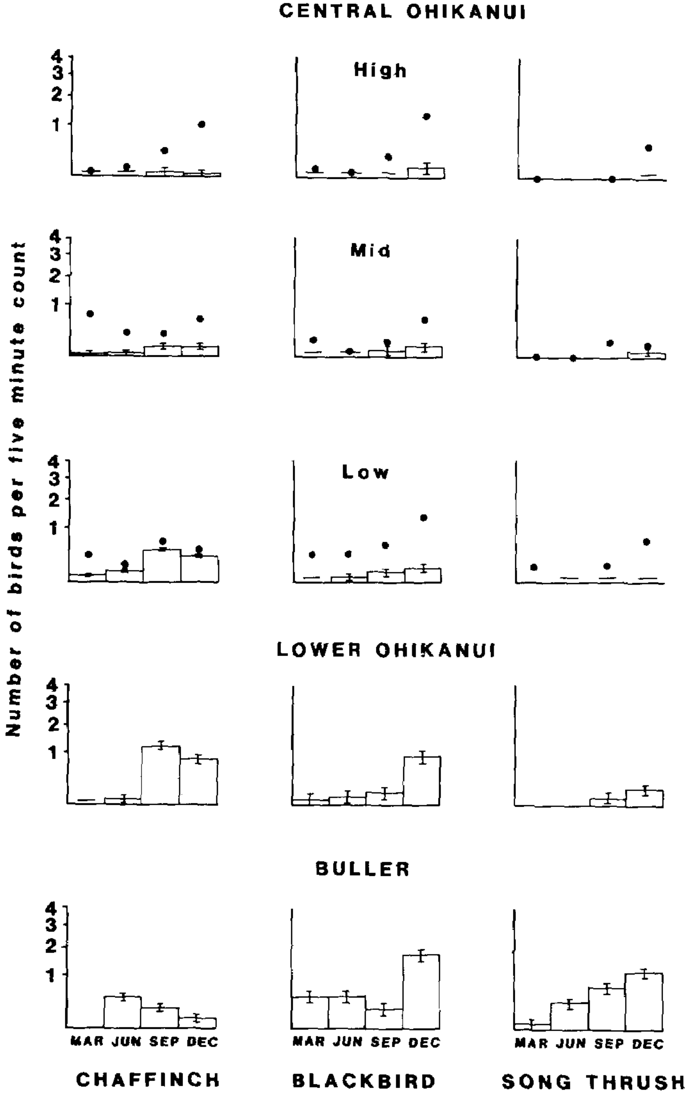

FIGURE 7D — Seasonal and altitudinal distribution of 12 species of birds indexed by standard 5-minute counts (continued)

TABLE 1 — Species in the "Central Ohikanui" area not included in Fig. 7. Percentage of 5-minute counts in which each species is represented

	Altitude	Mar 1977	Jun 1975	Sep 1976	Dec 1975	Significance of chi-squared
Number of observations	high	67	62	59	62	*** P<0.001
	middle	69	69	78	77	** P<0.01
	low	184	179	173	171	
SPECIES:						
Brown Creeper	high	5	0	0	7	***
	middle	0	0	0	3	
	low	0	1	1	1	
Parakeet	high	9	3	5	13	n.s.
	middle	7	13	8	9	
	low	12	3	12	11	
Kaka	high	2	0	0	5	n.s.
	middle	1	1	1	3	
	low	0	1	2	2	
Kea	high	0	0	2	0	n.s.
	middle	0	4	4	1	
	low	1	0	2	1	
Shining Cuckoo	high	0	0	0	5	***
	middle	0	0	0	8	
	low	0	0	0	11	
Pipit	high	0	0	2	3	***
	middle	0	0	0	0	
	low	0	0	0	0	
Weka	high	0	0	2	0	n.s.
	middle	3	0	1	1	
	Low	1	2	4	2	
Kingfisher	high	2	0	0	0	n.s.
	middle	0	0	1	0	
	low	1	0	0	0	
Redpoll	high	10	3	22	10	***
	middle	0	0	9	3	
	low	2	3	2	7	
Goldfinch	high	0	0	0	0	n.s.
	middle	0	3	0	0	
	low	0	1	1	0	
Greenfinch	high	0	3	0	0	n.s.
	middle	0	0	1	0	
	low	0	1	0	1	
Hedgesparrow	high	0	0	0	0	n.s.
	middle	0	0	0	0	
	low	0	0	1	0	

TABLE 2 — Species in the "Lower Ohikanui" area not included in Fig. 7. Percentage of 5-minute counts in which each species is represented

	Mar 1977	Jun 1977	Sep 1976	Dec 1977	Significance of chi-squared
Number of observations	40	40	40	40	** P<0.01
SPECIES:					
Brown Creeper	3	0	0	0	n.s.
Parakeet	0	5	5	13	n.s.
Kea	0	0	8	0	n.s.
Shining Cuckoo	0	0	0	10	**
Weka	0	3	3	0	n.s.
Kingfisher	3	0	5	10	n.s.
Redpoll	0	0	8	0	n.s.
Greenfinch	0	0	0	3	n.s.
Hedgesparrow	0	0	5	0	n.s.

TABLE 3 — Species in the "Buller" area not included in Fig. 7. Percentage of 5-minute counts in which each species is represented

	Mar 1977	Jun 1977	Sep 1976	Dec 1977	Significance of chi-squared
Number of observations	40	40	40	40	*** P<0.001
SPECIES:					
Kea	0	0	0	3	n.s.
Shining Cuckoo	0	0	3	8	n.s.
Skylark	0	0	13	0	***
Weka	3	0	3	3	n.s.
Harrier	0	5	5	0	n.s.
Redpoll	5	3	5	3	n.s.
Goldfinch	3	0	0	0	n.s.
Hedgesparrow	0	0	3	0	n.s.

mean number counted in the remote sites compared remarkably well with the Central Ohikanui high-altitude zone.

March 1977: Five remote high-altitude lines (21, 35-38) were counted – three in alpine scrub and two predominantly in high-altitude forest (Table 4) – and the results were compared with those from the Central Ohikanui high-altitude zone.

Significantly fewer Bellbirds, Tits and Warblers were encountered in the remote sites. Robins and Pipits were also recorded in low numbers, whereas they were not found in the high-altitude zone in the Central Ohikanui. Conversely, Parakeets were not found in the remote sites, but were recorded in all altitudinal zones of Central Ohikanui. There were no significant differences for any other species counted.

Another two remote lines (22 and 23) in the upper reaches of the Ohikanui River between Eta and Theta Streams were counted in March 1977. Although these two sites were in the bottom of the Ohikanui Valley they fell on the boundary of the mid- and high-altitude zones. Significantly fewer Bellbirds and significantly more Riflemen, Robins and Warblers were counted on lines 22 and 23 (Table 4) than in the Central Ohikanui mid- and high-altitude zones. There were no other significant differences.

Two lines (24 and 25) in the Ohikanui Valley above Buckland Creek were also counted in March 1977 (Table 4) and compared with Lower Ohikanui lines 3 and 4. Bellbirds and Silvereyes were fewer above Buckland Creek

TABLE 4 — Lines counted in one season only, giving the percentage of 5-minute counts in which each species is represented and mean values per 5-minute count for frequently recorded species

	Lower Valley Lines 24, 25 Mar 1977		Upper Valley Lines 22, 23 Mar 1977		High altitude Lines 21,35-38 Mar 1977		High altitude Lines 26-34 Sep 1976	
Number of observations	40		20		70		180	
SPECIES:								
	%	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$
Bellbird	55	(0.45)	25	(0.11)	43	(0.36)	44	(0.35)
Tui	8	(0.01)	0	(0.00)	1	(0.00)	5	(0.01)
Silvereye	25	(0.26)	5	(0.02)	14	(0.06)	8	(0.03)
Rifleman	18	(0.08)	95	(2.56)	31	(0.25)	56	(0.81)
Grey Warbler	45	(0.29)	95	(1.56)	21	(0.07)	47	(0.40)
Fantail	33	(0.25)	40	(0.42)	17	(0.07)	16	(0.05)
Tit	70	(0.82)	75	(0.99)	40	(0.25)	55	(0.53)
Robin	40	(0.31)	70	(1.04)	9	(0.01)	8	(0.02)
NZ Pigeon	3	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)
Chaffinch	8	(0.01)	5	(0.00)	3	(0.00)	27	(0.17)
Blackbird	0	(0.00)	5	(0.00)	3	(0.00)	12	(0.03)
Song Thrush	0		0		0		3	
Brown Creeper	0		0		6		14	
Parakeet	3		15		0		1	
Kaka	0		0		0		1	
Kea	0		0		0		1	
Pipit	0		0		10		5	
Fernbird	0		0		1		1	
Weka	0		0		0		1	
Harrier	0		0		0		1	
Falcon	0		0		1		0	
Redpoll	0		0		0		18	
Hedgesparrow	0		0		0		3	

than at Lower Ohikanui (significant at 5% level). This is to be expected because the vegetation changes abruptly about Buckland Creek. Lines 24 and 25 sampled forests similar to other low-altitude sites in the Central Ohikanui area, whereas lines 3 and 4 were in warmer lowland forests at the mouth of the Ohikanui.

Nocturnal and infrequently recorded species

Great Spotted Kiwi or Roa *(Apteryx haastii):* Roas were common from the valley bottom to above the bushline in all parts of the Ohikanui except near the confluence of the Ohikanui and Buller Rivers. At all times of year, their tracks were frequently found in snow or soft mud and birds were heard calling. Nearly all calls heard were after dark but one bird was calling as early as 1415 h on 16 September 1976. Often three or four were heard at night from the one site, and on 12 March 1977, four pairs of Roa were calling in the hanging valley at Gamma Lake. No sign of kiwis was seen or heard at the Buller counting area, nor did any kiwis respond to tapes played in this area or along the Buller Gorge to the confluence of the Ohikaiti River in March 1977. On this visit a special effort was made to tape kiwi calls, and to attract kiwis by playing tapes of their local dialect at Buller, Lower Ohikanui and in many places from the valley bottom to above the bushline in Central Ohikanui. This exercise clearly indicated the wealth of calls in the Roa repertoire, which had almost convinced us that Little Spotted Kiwi *(A. owenii)* and South Island Brown Kiwi *(A. australis australis)* were also present. However, after closely observing several Roa clearly producing all the calls we heard at night, we concluded that Roas were common and were the only species present.

Morepork *(Ninox novaeseelandiae):* Moreporks were recorded at all altitudes. They were commonly heard at night throughout the valley, at the mouth of the Ohikanui, and in the Buller study area.

Blue Duck *(Hymenolaimus malacorhynchos):* Blue Ducks were recorded on the main Ohikanui River on each of the four visits. Only one was observed in June 1975, just above the Denis Creek confluence. In December 1975, one pair was found between Denis and Delta Creeks and another pair, with four ducklings (probably not more than 2 weeks old), 400 m below the Bartrum Stream confluence. In September 1976, single birds were seen on different days at the Bartrum Stream confluence and on a rock in the river just downstream from Denis Creek. In March 1977, a pair was twice observed flying upstream past the main camp and once at the Bartrum Stream confluence.

Yellow-crowned Parakeet *(Cyanoramphus auriceps):* Parakeets were recorded in small numbers at all altitudes in all seasons in both the Central Ohikanui and the Inangahua study areas. They were recorded in all seasons, except autumn, at Lower Ohikanui but never at Buller. Although most were heard and not seen, all were probably Yellow-crowned Parakeets.

South Island Kaka *(Nestor meridionalis meridionalis):* Small numbers were present in the Central Ohikanui throughout the year. They were not recorded at Lower Ohikanui or at Buller.

Kea *(Nestor notabilis):* A few were present throughout the year at Central Ohikanui. They were recorded only in September at Lower Ohikanui and only in December at Buller.

Shining Cuckoo *(Chrysococcyx lucidus):* Shining Cuckoos were recorded at all altitudes in Central Ohikanui in December, at Lower Ohikanui in December, and at Buller in September and December.

Long-tailed Cuckoo *(Eudynamys taitensis):* Long-tailed Cuckoos were not recorded during 5-minute bird counts in any of the Ohikanui study areas, but they were present in the Ohikanui Valley.

Pipit *(Anthus novaeseelandiae):* Pipits were recorded on the river bed and on open ground on some low fan deposits throughout the Ohikanui Valley, and also occasionally on the tops above the scrub zone.

South Island Fernbird *(Bowdleria punctata punctata):* At 1036 m a.s.l., Fernbirds were seen and heard on the tops between the Ohikanui and Ohikaiti Rivers in scattered scrub (up to 2 m high) of manuka, bog pine, yellow-silver pine, mountain toatoa and stunted mountain and silver beech. This appears to be the highest altitude at which the Fernbird has been recorded anywhere in New Zealand.

Western Weka *(Gallirallus australis australis):* Wekas were widespread but nowhere common in the Ohikanui Valley. Wekas were also present in low numbers at Buller.

Australasian Harrier *(Circus approximans):* The only Harrier recorded in the Ohikanui Valley was at count line 32 on the open tops east of Dumpling Creek. A few were present at Buller.

New Zealand Falcon *(Falco novaeseelandiae):* Falcons were rarely recorded in the Ohikanui. They were not encountered at Lower Ohikanui or at Buller.

New Zealand Kingfisher *(Halcyon sancta):* Kingfishers were recorded in low numbers in the Central Ohikanui during March and September and at Lower Ohikanui during December, March and September. They were not recorded at Buller.

Southern Black-backed Gull *(Larus dominicanus):* Black-backed Gulls were noted in September and December above the open tops in the Central Ohikanui. One was seen in the Ohikanui River bed in December, and single birds were recorded in June and December flying over the Buller study area. There is a breeding colony on the tops just west of the Buckland Peaks (Dennis 1981).

Black Shag *(Phalacrocorax carbo):* Single Black Shags were occasionally seen flying along the Ohikanui River in March, June and September.

Little Shag *(P. melanoleucos):* A Little Shag (pied phase) was seen in the Ohikanui River above the Delta Creek confluence in September 1976.

Other infrequently recorded species were Skylark *(Alauda arvensis)*, Redpoll *(Carduelis flammea)*, Goldfinch *(C. carduelis)*, Greenfinch *(C. chloris)* and Hedgesparrow *(Prunella modularis)* (see Tables 1-3).

GENERAL DISCUSSION AND CONCLUSIONS

The steep glaciated topography of the Northern Paparoa Range has a profound effect on the dispersion of many species of birds in the lower Buller and Ohikanui Valleys. Cold mountain air, draining down these long deep valleys, clearly influences the distribution of forest types and affects species richness in both plant and animal communities. In turn, these environmental factors affect the numbers and movement of birds, both altitudinally and seasonally.

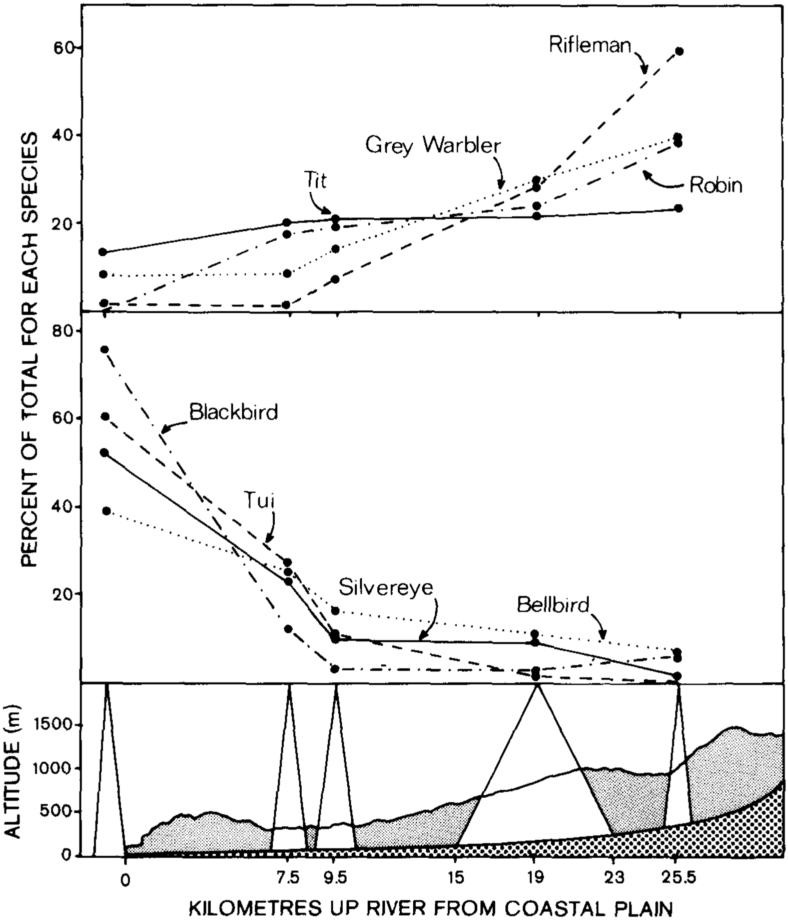

FIGURE 8 — Distribution of eight selected species of birds in valley bottom forests in March, in relation to the topographic position of 5 counting areas. The mouth of the Ohikanui Valley is 6 km up-river from the coastal plain.

Differences between counts in a complex of forest types, grading from modified warm forest at Buller through progressively less modified and colder forests to the headwaters of the Ohikanui (Fig. 6 & 8), illustrate the contrast between the habitat reqirements of the Tui, Bellbird and Silvereye (significantly more counted in more diverse, warm forest types) and the habitat requirements of some less mobile specialist insectivores, the Rifleman, Warbler, Robin and Tit (significantly more counted in less modified colder forests). Resources for nectar- and fruit-eating birds such as the Tui and Bellbird are severely reduced in the cold valley bottom. The variation in abundance of these two species at different distances into the valley in March (Fig. 8) reflects the effect on numbers of the rapid environmental changes that occur inside the mouth of the Ohikanui Valley.

Modification of natural habitat also affects the distribution of birds in the Ohikanui Valley (cf. Diamond & Veitch 1981). Blackbirds, which are very common in the modified forests of Buller, rapidly declined in numbers up the valley, reflecting their partly frugivorous food habits and their preference for modified habitat. Song Thrushes, Hedgesparrows and Harriers were also most abundant towards the edges of the forest, whereas Parakeets and Kaka and the native insectivores (Rifleman, Fantail, Tit, Robin and Brown Creeper) were most plentiful in the remoter, less modified forests.

The differences found between counts in remote sites and those in the high-altitude counting zone in the Central Ohikanui are not unexpected. The forests sampled at remote sites were on average at higher altitudes, and most were above the steep glaciated sides of the main valley and in forest with a more even canopy. Brown Creepers favour simple, even-canopy forests, apparently irrespective of altitude, as has been found elsewhere (pers. obs.; Clout & Gaze 1984). Robins tend not to favour steep land, but in the Ohikanui were found on the slopes above and below glacially truncated spurs.

Upper valley lines 22 and 23, which sampled beech forest in the bottom of the Ohikanui Valley, illustrate how spurious conclusions can be made if altitude alone is used to categorise the samples throughout the length of the valley. There, Bellbird numbers were much more like those recorded in low-altitude valley bottom sites affected by cold air drainage, than those in mid- or high-altitude sites in the Central Ohikanui. Robins and Rifleman also clearly preferred this cold valley bottom habitat in both the Upper and Central Ohikanui.

Overall, the Ohikanui remains a relatively unmodified montane valley habitat. In the less disturbed parts are good numbers of Roa, breeding pairs of Blue Duck, and low numbers of introduced bird species, together with few browsing mammals.

The hypothesis that "lowland" forest can provide essential resources for birds inhabiting higher-altitude forests for much of the year is supported by our results, provided that forest is warm, floristically rich, and has abundant flowers, fruit or invertebrates. However, this study has clearly demonstrated that not all low-altitude forest has these characteristics. Our results show that many Bellbirds and most Tuis migrate in winter from the Ohikanui Valley to other forests. For Bellbirds, the lowland forest type in the Buller study area appears to suit their winter requirements. Tuis in the Ohikanui and Lower Buller catchments apparently overwinter in forests not sampled in our study, but there is evidence to suggest that their winter habitat must contain nectar or honeydew (Gravatt 1970, Onley 1983, pers. obs.). From early September, numbers congregate in areas of flowering kowhai elsewhere in the Buller Gorge (pers. obs.).

The question remains of where the Tuis from montane valleys such as the Ohikanui and from hill forests such as Buller go during winter. In winter they probably favour species-rich, warm, lowland beech-podocarp forests, of a type rapidly becoming rare in central North Westland. It is likely that Tuis have progressively declined along with the decline in lowland forest on the coastal plain during the last 120 years and are now far fewer to disperse into their summer montane range.

During June 1982, Onley (1983) found an average of 1.5 Tuis per count in unlogged low-altitude podocarp-beech-hardwood forest near Karamea, and a very similar average of 1.3 Tuis per count was recorded at Fletcher Creek in the Inangahua Valley in June 1974. In another study of six lowland forest types of the Western Paparoas, Onley (1980) counted birds in November, December and January, and for Tuis there were averages of 0.41 (coastal), 0.79 (old Tertiary), 0.86 (karst), 1.1 (limestone talus), 0.62 (cutover) and 0.83 (cutover near road). Onley's figures for Tuis accord reasonably well with those found in the Ohikanui during December, with the exception of our Buller counts (2.2 Tuis per count). Onley reported, however, that in October before his counts began "Tuis were present in large numbers feeding on nectar in the coastal forest." This suggests that the lowland forests of the Western Paparoas, like those at Karamea, Fletcher Creek and elsewhere, are winter refuges for many Tuis which in summer migrate to and breed in montane areas such as the Ohikanui Valley. Montane forests are apparently suitable for rearing young, but they do not adequately provide the large amounts of nectar or fruit required by Tuis for the rest of the year (see Gravatt 1970).

Suitable wintering habitat for Tuis is not found only at low altitude. The abundant honeydew crop produced on red beech in the forests of the warm north-facing fan-slopes (460-610 m a.s.l.) of Mt Misery, Nelson Lakes National Park, supports twice as many Tuis in winter as in summer (unpublished results).

The results from the Ohikanui and Inangahua Valley studies provide compelling evidence for the seasonal movement of many species of birds, particularly long-distance movements of honeyeaters. Montane forests without attendant warm, floristically rich winter habitat will not by themselves satisfy the annual requirements of the birds. Banding and radio-telemetry studies are now urgently needed to determine more precisely the seasonal movements and habitat use of Tuis and Bellbirds. Managers of indigenous forests must recognise that their management decisions for individual forests affect not only the wildlife values of the particular forest, but also the welfare of wide-ranging species such as the Tui, Bellbird, Pigeon and Kaka, which use the forest resource of the whole region.

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APPENDIX 1

Glossary of plant names

Bog pine	*Halocarpus bidwillii*
Bush rice grass	*Microlaena avenacea*
Cedar	*Libocedrus bidwillii*
Crown fern	*Blechnum discolor*
Hall's totara	*Podocarpus hallii*
Hard beech	*Nothofagus truncata*
Horopito	*Pseudowintera colorata*
Kahikatea	*Dacrycarpus dacrydioides*
Kamahi	*Weinmannia racemosa*
Keikei	*Freycinetia bauriana var. banksii*
Kowhai	*Sophora microphylla*
Mahoe	*Melicytus ramiflorus*
Manuka	*Leptospermum scoparium*
Matai	*Prumnopitys ferruginea*
Mountain beech	*Nothofagus solandri var. cliffortioides*
Mountain toatoa	*Phyllocladus aspleniifolius var. alpinus*
Northern rata	*Metrosideros robusta*
Pigeonwood	*Hedycarya arborea*
Red beech	*Nothofagus fusca*
Rimu	*Dacrydium cupressinum*
Silver beech	*Nothofagus menziesii*
Southern rata	*Metrosideros umbellata*
Supplejack	*Ripogonum scandens*
Toro	*Myrsine salicina*
Westland quintinia	*Quintinia acutifolia*
Yellow-silver pine	*Lepidothamnus intermedius*

SHORT NOTES

Feeding behaviour of Bellbirds *(Anthornis melanura)* in a native and an introduced forest

From 17 August to 7 October 1986, I studied how the foraging habits of Bellbirds *(Anthornis melanura)* differed between native and pine forests in Hanmer Park (42°30′, 172°49′), North Canterbury. The native forests consisted of a mountain beech/red beech canopy with a mixed understorey of manuka, kanuka, and other endemic plants. The vertical and horizontal structure of these native forests differed greatly from that of the radiata and Corsican pine forests, which had denser canopies and less plant diversity. I recorded only those Bellbirds foraging activities which occurred in pine forest planted over 25 years ago. These pine forests were frequently dense enough to prevent undergrowth, although manuka did grow in some areas where sunlight penetrated the canopy.

During this study, I made 97 observations of Bellbirds foraging for insects or honeydew. Each observation included a record of area of activity (floor, trunk, branch, foliage), and pecking site (upper surface, lower surface, trunk, floor). With each observation, I included the method of feeding (a combination of hop, peck, fly, flutter), feeding height, and canopy height. I used the last two measurements to calculate relative feeding height: [feeding height/canopy height] ×100 = relative feeding height. No more than three observations were taken on any one bird; if taking a second or third observations, I left a 5min equilibrium time between observations.

From 53 observations of Bellbirds foraging in native forests and 44 observations of Bellbirds foraging in pine stands (three of which were on manuka bark), I found that the birds varied in relative feeding height as well as pecking site according to forest type (Fig. 1). In pines, Bellbirds fed on the ground and in the lower 60% of the forest more often than Bellbirds in native forests. The subcanopy (50%-70% relative height) was the favoured foraging area in native forest; over 37% of the birds I observed in native forests fed at this height range.

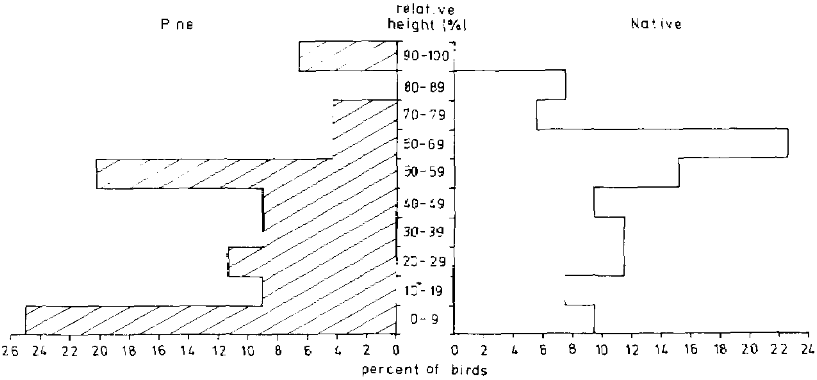

FIGURE 1. — Relative feeding height of Bellbirds in pine and native forests

Although the primary method of feeding was similar in both the pine and native forests, Bellbirds in the pines appeared more nervous and alert when feeding near the ground than did Bellbirds in native forest. In pine stands, Bellbirds probed the inner bark of manuka scrub (three observations), but more frequently they searched pine needles and pecked at branches.

The surfaces on which Bellbirds fed differed between forest types (Fig. 2). The birds fed on the ground twice as often in the pines (18%) as in the native forest (9%). In native forest 26% of the birds fed on insects and honeydew on the underside of branches and foliage, whereas in pines only 11% fed on the underside of branches and foliage. Bellbirds feeding on the upper surfaces of branches and foliage accounted for 19% of the observations in native forests and 50% in the exotic forests. In the native forests, 45% of the pecks occurred on tree trunks, whereas only 23% occurred on trunks in exotic forests.

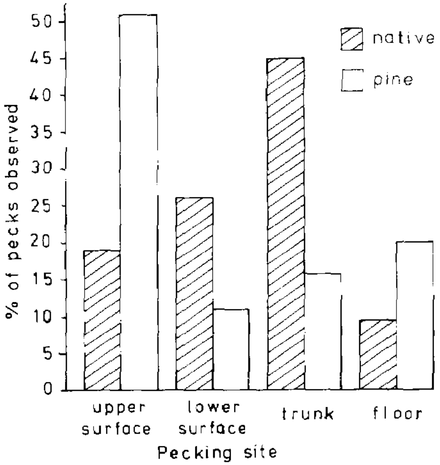

FIGURE 2. — Pecking sites of Bellbirds in native and pine forests

I thank Ian McLean for his advice and encouragement throughout the study and the Hanmer Forest Service for accommodation. I also thank the Sibley family for their hospitality and David Pearson for pre-study criticism.

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Nesting of White-Faced Herons at the Chatham Islands

White-faced Herons (*Ardea novaehollandiae*) usually nest in the tops of trees. In the Chatham Islands, however, where they have been known for over 100 years, they have been recorded nesting in rather different situations. Thus, Gordon (1979) reported a nest containing eggs and a chick in a cleft in a rocky bluff on the south-west coast of Chatham Island, over a kilometre from the nearest tree.

In December 1986 we came across two pairs of White-faced Herons breeding in such rocky situations, rather than atop trees, which we report here together with some observations on herons attempting to breed on South East Island.

RGC surveyed Motuhinahina Island on the western side of Te Whanga Lagoon on Chatham Island on 16 December. The island is a limestone outcrop rising some 3 metres above lagoon level, capped by 2 metre high scrub through which three trees emerge (one *Olearia traversii*, one *Hymenanthera chathamica* and one lower *Corynocarpus laevigatus*). Small limestone outcrops up to 1.5 metres high occur around the shore. A White-faced Heron nest containing three chicks was found on one outcrop. The nest of twigs was in a depression in the rock 1 metre above the lagoon and about a metre below nesting Red-billed Gulls (*Larus novaehollandiae*).

In mid-December a nest containing three pale blue eggs was found in a vertical fissure between two massive slabs of rock at the base of a c.50 metre cliff on the north coast of South East Island. On 28 December ADH inspected the site more fully and found two White-faced Heron chicks.

The fissure itself ran parellel to the coast some 10 metres inland and was about 30-40 cm in width. The nest — a characteristic shambles of twigs! — was on a small promontory within the fissure, about 4 metres above the sea, which was visible at the bottom over much of the c. 10 metre length of the fissure. The surrounding area, for about 100 metres in either direction, is devoid of vegetation and presents one of the bleakest stretches of coastline on the island.

On subsequent visits, up to 10 January, both chicks were still being attended by adults. Although we did not visit the nest after 10 January, ADH, from a vantage point at the top of the cliffs, saw adult herons make several visits to the site in early February. It seems likely, therefore, that a chick or chicks survived to fledging.

South East Island has often had two pairs of White-faced Herons during the summer over the past 10 years. Generally they are unsuccessful at breeding, although nests with young have been found in Thinornis Bay on the south-east coast. A major problem for White-faced Herons on the island appears to be breeding skuas (*Stercorarius skua lonnbergi*). Skua territories occupy virtually the whole coastline of the island and they react aggressively to intruding — or just nearby — herons from August to late December. A heron found with a broken wing by ADH in December 1984 had almost certainly been attacked by territorial skuas. At the same time a pair of herons attempting to build a nest in the top of a 3 metre *Olearia traversii* on the northern side of the island was repeatedly harried by breeding skuas and abandoned the attempt.

The stretch of coast on which this fissure nest occurred is one of the few coastal areas not actively patrolled by breeding skuas. In both 1984-85 and 1985-86 summers, a pair of herons was regularly seen along this coast and possibly nested high in cliffs below the summit of the island.

Robertson & Dennison (1979) conjectured that the occurrence of White-faced Herons on rocky shorelines might be explained by the absence of Reef Herons (*Egretta sacra*) in the Chathams or by "... limiting factors inland". On South East Island one such limiting factor is clearly the skua, whose effect seems to be to confine breeding attempts to those parts of the island not used by breeding skuas. On Chatham Island, skuas do not breed and are rarely encountered. It seems more likely there that often the herons do not find trees, as suggested by Gordon (1979), or the bush fragments they do find are untenable given the wind — perhaps the case on Motuhinahina, where they did not use the available trees. In more sheltered locations the herons may still nest in trees — as they do periodically in the fine shelter belts of *Macrocarpa* at Kaiwhata on the north-east corner of Chatham Island. Thus, we need not invoke the absence of Reef Herons at all, but see cleft nesting as a response to climate, harassment by skuas or simply lack of trees.

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Black Stilts nesting at Lake Ellesmere

Three Black Stilts (*Himantopus novaezelandiae*) constructed nests independently at Lake Ellesmere in spring 1986. Two were mated with Pied Stilts (*H. himantopus leucocephalus*). The third was two years old and was possibly unmated.

At Greenpark Sands on the shores of Lake Ellesmere on 23 September 1986, CO'D, Ken Hughey, Liz Jarman and Dick Hutchinson observed a Black Stilt feeding with Pied Stilts in a pond surrounding a small breeding colony of Pied Stilts. While we were watching, a Pied Stilt mounted and copulated with the Black Stilt. About 15 minutes later the Black Stilt moved to a small, grass-covered island, where it began arranging dry grasses at what appeared to be a nest.

There were 10 pairs of Pied Stilts in the colony. Their nests, which all had eggs, were on small hummocks of mud, covered with a salt-tolerant grass, *Agrostis stolonifera*, and surrounded by shallow water (100 mm). The colony was on the upper margin of the lake shore, close to farmland and nearly 2 km from open lake water.

The site was visited again on 25 September. The Black Stilt was roosting at the nest site, which was an empty scrape lined with dry grasses. A week later, on 2 October, CO'D, Ken Hughey, and Ron Nilsson visited the site and found the Black Stilt incubating four eggs. Two new Pied Stilt nests were also found and about 30 birds were at the colony. During two hours of observation, the Black Stilt incubated twice for 30 minutes, its pure pied mate incubating for the intervening hour. When Ron Nilsson visited the nest again on 9 October, the Black Stilt was not seen and all but one of the eggs had disappeared. During further checks over later weeks, the Black Stilt was not seen at the abandoned nest site.

Also in September, Teri Meis observed a second Black Stilt at Birdling's Flat, c.10 km further along the lake shore. This stilt was distinguished by its grey face and several white feathers about the vent. It was resident in a colony of about 100 Pied Stilts during late September and throughout October. Although no nest was found, Teri Meis, Peter McClelland, and Peter Reese saw the bird performing broken wing displays when they were near the colony in late October. On 20 November CO'D and Peter Dilks saw what appeared to be the same Black Stilt with four juveniles on the Greenpark Sands.

A third Black Stilt, a colour-banded two-year-old, was also resident on the lake in September and October 1986. On 21 October CO'D, Peter Dilks, and Kaye Stark observed it building a nest at Kaituna Lagoon. When first seen, the bird was collecting mud and vegetation from the edge of a pond. Later it was sitting or standing on a large mound, arranging the material around itself. However, this stilt was not seen on subsequent visits and probably did not breed; subadult stilts often build "play nests" (R. Nilsson, pers, comm.).

The Black Stilt has declined greatly in numbers and become in danger of extinction since the expansion of Pied Stilts in New Zealand earlier this century (Pierce 1984a). The present population comprises fewer than 100 birds, and breeding is confined to the Mackenzie Basin, where only 10 pairs nested in the summer of 1986-1987 (R. Nilsson, pers. comm.). Canterbury and Otago riverbeds supported large numbers of Black Stilts during the late 19th and early 20th centuries (Pierce 1984a). In lowland South Canterbury they persisted much longer than they did in North Canterbury, and breeding still occurred widely between 1920 and 1950. The last recorded nesting by a Black Stilt pair in lowland South Canterbury was on the Orari River in 1957 (Child 1959).

This nesting of Black Stilts at Lake Ellesmere seems to be the first in lowland Canterbury since 1979 and the first in North Canterbury since about 1905. There are two records of Black Stilts nesting with pied mates in lowland Canterbury since 1957, in the Hakataramea Valley (1971) and at Wainono Lagoon (1979) (Pierce 1984a). Whether the nesting at Ellesmere reflects some expansion in the range of Black Stilts as a result of management of breeding pairs in the Mackenzie Basin or was only a chance event is not known. Lake levels at Ellesmere were particularly suitable for stilts throughout 1986. Invertebrates were abundant in the thousands of hectares of shallow water. With up to 4000 stilts on the lake in autumn and winter 1986 and c. 1800 staying to breed, the Black Stilts may have lost the stimulus to return to the Mackenzie Basin. Black Stilts normally mate with other Black Stilts, but if none are available, they will mate with hybrids of pieds (Pierce 1984b). The colour-banded bird was originally raised by Pied Stilt foster parents, but the history of the other two is not known.

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