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VOCALISATIONS OF *Procellaria* PETRELS

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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

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

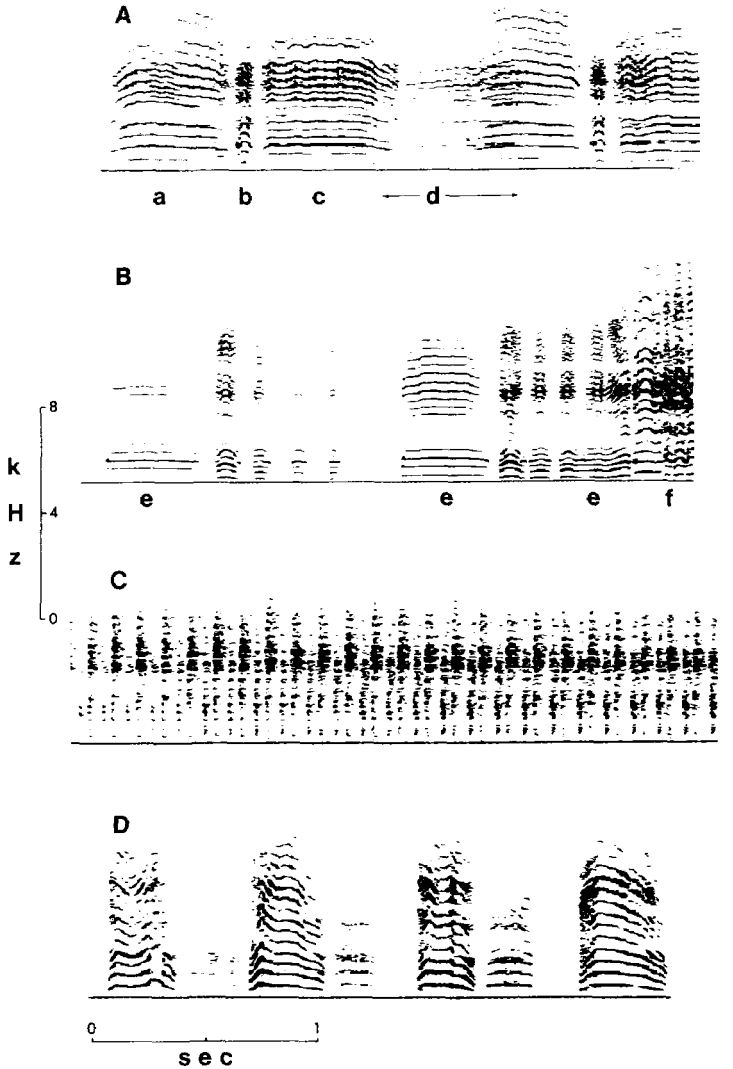

FIGURE 1 — A. GREY PETREL: introductory 'moans' preceding the 'bleat'; (a) inspiratory. (c) expiratory; (b) a short connecting note; (d) a call from another bird in the background.
B. GREY PETREL: a more complex prelude to a 'bleat' with 3 inhalatory 'moans' (e) and other short (expiratory?) notes leading 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.

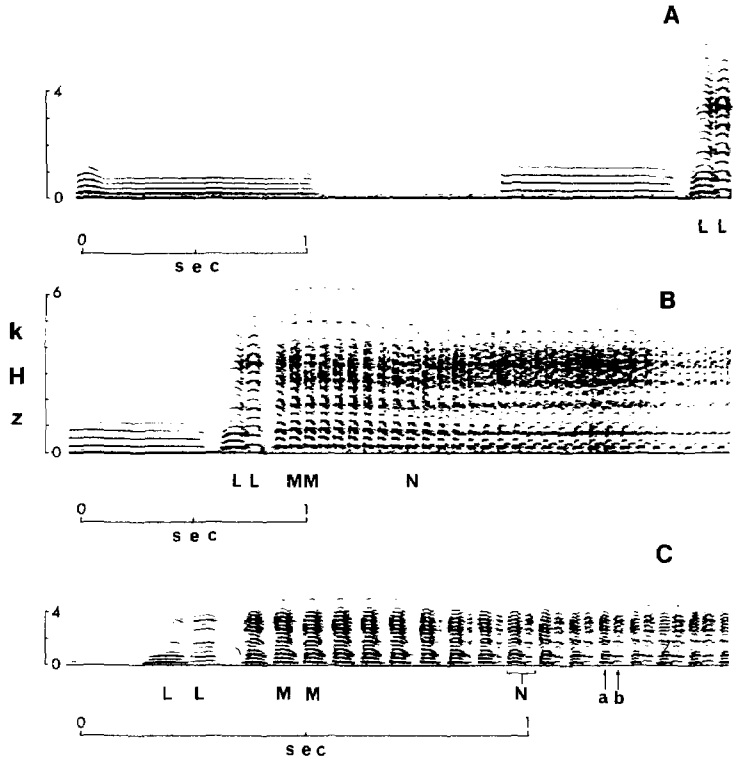

FIGURE 2 — GREY PETREL: A & B, two introductory, low-pitched 'moans' leading to the 'bleat'. Two short notes (L,L) of intermediate length preceded the fusillade of very short notes of the 'bleat proper(M, M). Just before (N) these notes began to develop into 2 distinct pulses. C, part of the sounds of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

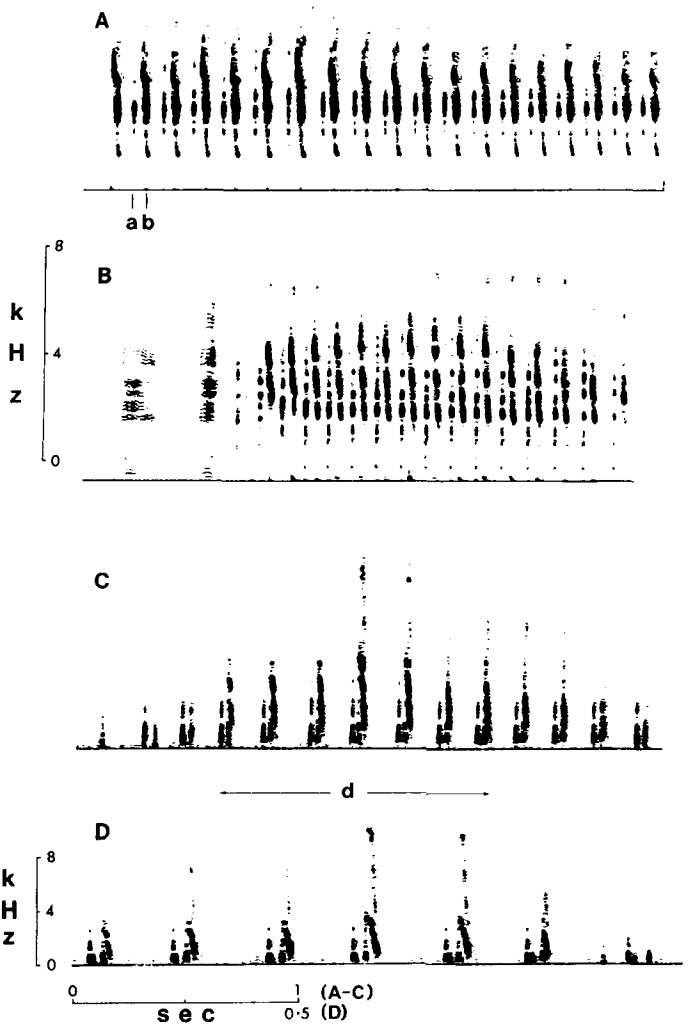

FIGURE 3 — 'Rattle' calls of SHOEMAKERS

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.

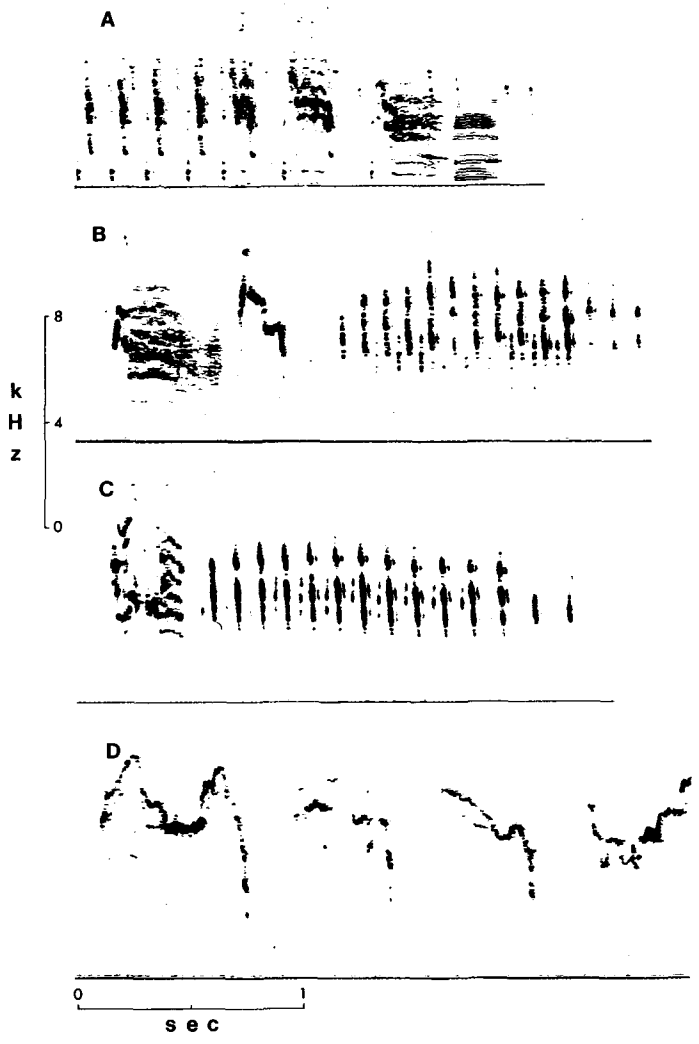

FIGURE 4 — SHOEMAKER
A: 'Rattle' from bird at the Auckland Islands that changed first to 2 high-pitched 'squeals' and then to lower-pitched squawks.
B: High-pitched 'squeals' of bird 'Red' followed by a 'rattle' call. The complex first note has much 'white-noise' and was given simultaneously with the '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.

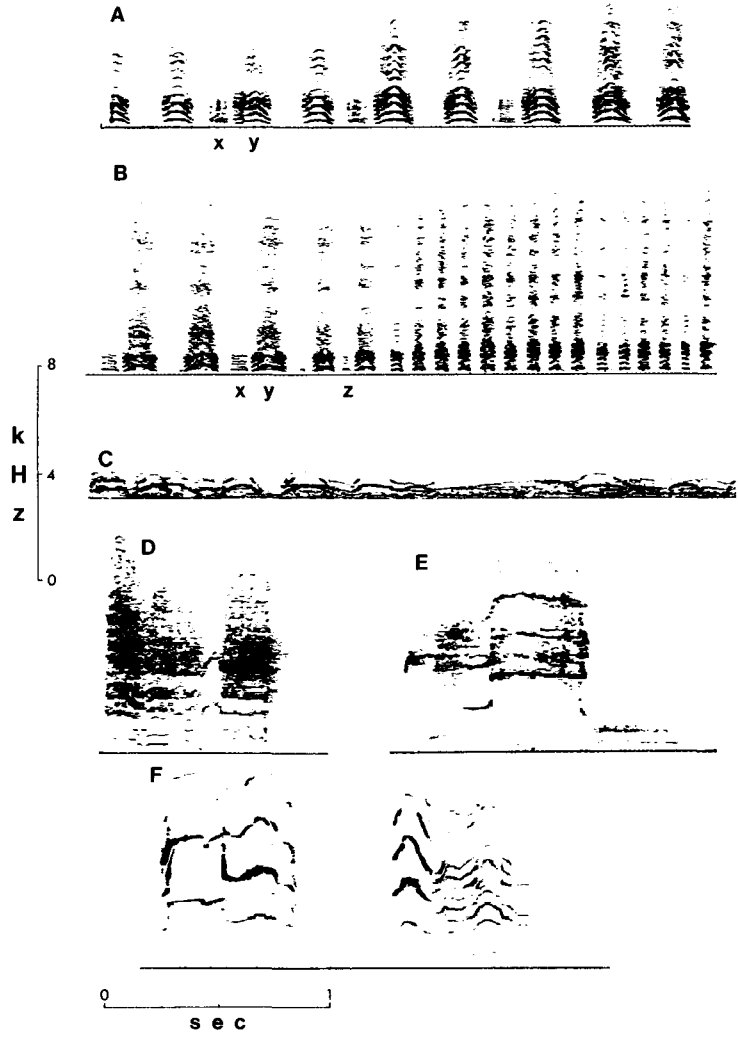

FIGURE 5 —WESTLAND PETREL

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.

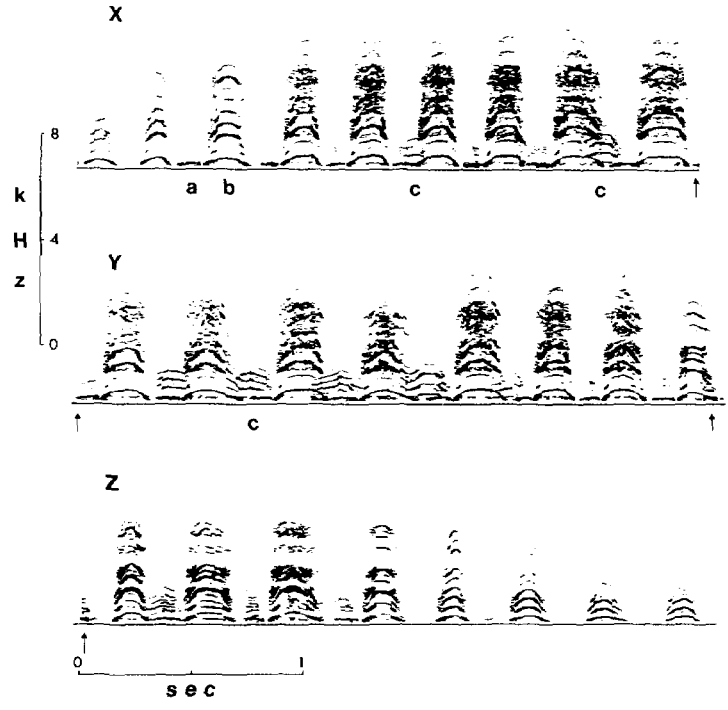

FIGURE 6 — WESTLAND PETREL
X-Z, a complete duet from 2 birds calling from the surface. Read from top to bottom, left to right: arrows mark points of overlap of the graphs. The inhalatory notes of the louder singer show a strong frequency band close to the baseline, e.g. at (a), and these notes tend to 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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