Detection of sooty shearwater chicks (*Puffinus griseus*) by response to sound

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ABSTRACT

To assess a technique for detecting chicks of sooty shearwater (*Puffinus griseus*), their cheeping and movement responses to noise and vibration at their burrow entrance were monitored. Test burrows were selected on Putauhinu, Taukihepa, and Whenua Hou Islands, off Rakiura (Stewart Island), in the 1998/99 breeding season. Overall response rate was too low to allow the method to reliably measure absolute burrow occupancy or breeding success. Chick responses varied between nights at the same island and between years. Large variation occurred between two islands even within the same year. This variability in chick behaviour makes the method unreliable even as a relative index of burrow occupancy and breeding success between colonies and in different years. Chick cheeping and movement was heard within several burrows where a burrowscope had failed to detect a chick. The burrowscope remains the most reliable method of detecting chicks. Further study is required to measure burrowscope accuracy in breeding colonies with different burrow density, complexity and architecture.

Keywords: sooty shearwaters, *Puffinus griseus*, muttonbirds, titi, burrow occupancy, breeding success.

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1. Introduction

Study of breeding success of the smaller Procellariiforms is made difficult by their building nests within burrows (Warham 1996). We sought a cheap, quick and reliable method to detect sooty shearwater chicks (*Puffinus griseus*, tītī, muttonbird) within breeding burrows in colonies around Rakiura (Stewart Island), southern New Zealand.

The long-term research project, '*Kia Mau Te Tītī Mo Ake Tōnu Atu*' ('Keep the tītī forever'), seeks a cheap and reliable method for the community itself to maintain sooty shearwater population dynamics (Moller et al. 1999). A successful method was needed to assess sustainability of the traditional harvest of tītī by Rakiura Maori (Moller 1996, Taiepa et al. 1997; Moller et al. 2000). We needed to identify burrows with chicks to establish inspection hatches over nests, for radio-tracking to measure harvest selectivity (Hunter et al. 2000a), and to estimate breeding success for demographic prediction of harvest impacts (Hunter et al. 2000b).

Traditional methods of determining burrow occupancy using smell and sign at the burrow entrance are too inaccurate or variable for scientific monitoring (Hamilton 1998). Toothpick 'barricades' can monitor whether or not a burrow has been visited sometime since the last time the barricade was erected (Hamilton 1998), but this method does not confirm that a chick is present because adults often visit burrows which do not have eggs or chicks. Also, visits by adults are very infrequent near the end of the breeding season, and other species (other seabirds, rabbits, rats and mustelids) can knock down the barricades. Inspection of burrows with a 'burrowscope' (miniature video camera on the end of a tube inserted into the burrow) demands use of trained personnel and is laborious, expensive and inaccurate (Hamilton et al. 1998, Lyver et al. 1998, Hamilton 2000).

Measures of vocalisation responses to noise outside sooty shearwater burrows in 1993 rejected the method for accurate determination of burrow occupancy (Hamilton 1993). Overall the response rate of both adults and chicks to play-back of audio-taped recordings of sooty shearwater calls, hand-claps and 'war-whoops' was too low to make the method much use (Hamilton 1993). However, on Putauhinu Island in late March and early April of 1998 we noted a very high response rate of chicks at dusk to our noise outside burrows. The chicks moved to near the burrow entrance and cheeped loudly, often for over a minute. We did not immediately quantify the proportion of chicks responding in this way, but the method seemed sufficiently promising to initiate the study described here; in the following (1998/99) breeding season, we systematically tested the repeatability of the method for detecting chicks from their responses to sound at the burrow entrance.

We aimed to measure the proportion of chicks that responded to auditory stimulation and vibration of the ground outside the burrow on three islands. This was to assess whether that proportion varied (i) between stages of the season, (ii) between islands at the same stage of the season, and (iii) according to whether the chick had just been fed. If the response was variable, the method would be unreliable as a measure of relative burrow occupancy. Similarly, if recent feeding affected the probability of detecting the chick that was then selected for monitoring or banding, results might be biased by inclusion of chicks with either higher, or lower quality parents (those that fed their chicks more, or less frequently, respectively). The latter problem could affect subsequent measures of recruitment rate and harvest selectivity. Our overall aim was to evaluate whether a cheeping response by chicks could be reliably used to assess burrow occupancy and breeding success.

2. Study area

The study areas were on two of the Titi Islands (Muttonbird Islands) off the southwest corner of Rakiura (Stewart Island), southern New Zealand: Taukihepa (Big South Cape Island) and Putauhinu, and also on Whenua Hou (Codfish Island) off the northwest of Rakiura. A map showing the location of the study areas is given by Lyver (2000).

3. Methods

3.1 STIMULUS TO CHICKS AND THEIR RESPONSE

Tests were done from dusk until one hour after dark at a total of 174, 492, and 1234 holes on Taukihepa, Putauhinu, and Whenua Hou, respectively, during the 1998/99 breeding season (Table 1). Scratching the ground at the entrance of burrows, which was intended to mimic the adult's extraction of leaf material from the burrow entrance, was done by observers using a small hand rake (four parallel tines arranged 25 mm apart). Three strokes of the rake were made within 15 cm of the burrow entrance over 4–5 seconds. The observer then listened for 30 seconds and scored whether a chick called or moved forward to the entrance, or whether no response was detected. The observers walked as quietly and lightly as possible between holes to minimise disturbance.

3.2 CHICK OCCUPANCY

'Occupied' holes were defined as ones where burrowscoping (15–20 March 1999) and/or inspection hatches placed over nesting chambers confirmed the presence of at least one chick in any of the burrows leading from that hole. 'Unoccupied' holes were those where the burrowscope was able to explore the complete length of the burrows leading from the hole but no chick was seen. 'Unresolved' holes were ones where no chick was found but obstructions prevented the full length of the burrows being explored.

TABLE 1. PERCENTAGE OF HOLES WHERE A CHEEPING OR MOVEMENT RESPONSE BY A CHICK WAS DETECTED IN MARCH AND APRIL 1999 ON THREE TITI ISLANDS. NUMBER OF HOLES TESTED IS GIVEN IN BRACKETS.

	OCCUPIED HOLES	UNOCCUPIED HOLES*	ALL BURROWS ON TRANSECT†
Whenua Hou			
17 March	14.3% (21)	12.5% (8)	12.7% (150)
20 March	8.3% (12)	0 (7)	7.0% (86)
23 March	21.1% (19)	0 (11)	10.1% (139)
26 March	11.1% (18)	0 (11)	6.7% (210)
14 April	16.7% (30)	0 (13)	13.8% (188)
17 April	11.5% (26)	10.0% (20)	9.2% (239)
20 April	14.3% (28)	0 (13)	6.3% (222)
All nights	14.2% (155)	3.6% (83)	9.3% (1234)
Putauhinu			
20 March	2% (50)	4.5% (22)	4.7% (85)
24 March	4.2% (48)	5% (20)	3.8% (80)
28 March	4.3% (46)	4.5% (22)	3.8% (79)
2 April	1.9% (52)	9.1% (22)	3.5% (85)
7 April	0 (52)	0 (21)	1.2% (85)
12 April	13.6% (22)	10.0% (10)	10.3% (39)
15 April	4.3% (23)	0 (10)	2.6% (39)
All nights	3.4% (293)	4.7% (127)	3.9% (492)
Taukihepa			
18, 19 March	8.3% (13)	4.8% (42)	5.7% (174)

* Excludes unresolved holes where no chick was found but the entire length of the burrow could not be explored because the burrowscope became jammed or could not extend around a corner or over a root or rock.

† Includes occupied and unoccupied burrows, and those with occupancy unresolved.

3.3 SAMPLING DESIGN

The most detailed sampling was on Whenua Hou, at three study plots (A, B, C) in the Alphonse area (the exact location and detail of the study burrows is described by Hamilton et al. 1996). Four surveys were done at three-day intervals starting from 17 March 1999, this was followed by a three-week break before three more surveys were done at three-day intervals from 14 April. Occupied holes were targeted each night, but other randomly selected holes were also tested by walking down lines traversing the study plots. These randomly selected holes were at least 5 m apart to reduce the possibility that chicks from more than one test burrow would hear the stimulus and respond at once (we could only detect the chick response within the closest burrow, and the chick might have lost interest if it had heard the signal from several neighbouring burrows and learnt that the noise was not made by their returning parent). Toothpick barricades were erected on all study burrows each day before dusk. They consisted of 4–5 toothpicks erected in a row 10–15 cm inside the burrow entrance. We scored whether or not the barricade had been knocked down by the time we scratched at the entrance (knocked down indicated that a parent had entered to feed the chick in the preceding hour before we tested the chick's cheeping response).

On Putauhinu Island, chick responses were also surveyed on four fixed transects during seven nights at 3–5 day intervals between 20 March and 15 April 1999. Transects each had 20–23 entrances (originally 20 holes were marked in 1997, but additional holes appearing in the transect were added in the next two seasons). All holes on each transect were tested for cheeping responses for the first five survey nights, but only about half of the holes were scored during the last two nights.

At Boat Harbour, Taukihepa, chick cheeping responses were also scored on four marked transects and 58 randomly selected holes on 18 and 19 March 1999. Transects were 2 m wide and encompassed the first 20 burrow entrances encountered. Holes were selected at random, as the nearest hole to every fifth pace when walking in straight lines spread throughout 14 grid squares covering the 'Manu Maaka Horomanupatu' (the Bull whānau birding territory).

4. Results

4.1 VARIATION IN RESPONSE RATE BETWEEN NIGHTS

Testing for differences in the proportion of holes from which a cheeping response was elicited on different nights is problematical because expected cell frequencies in contingency tables were often less than 5. Therefore we spot-checked a null hypothesis for no difference between nights by testing the most extreme pairs of outliers (highest v. lowest proportion responding) within each island using Fisher's Exact Tests. There was no evidence that the proportion of all burrows giving a cheeping response varied between the two nights surveyed at Taukihepa ($P = 0.34$), but differences occurred between nights at Whenua Hou ($P = 0.027$) and Putauhinu ($P = 0.034$).

There was no sign of a systematic change in the frequency of responses as the season progressed at Whenua Hou or Putauhinu (Table 1).

4.2 VARIATION IN RESPONSE RATE OF RECENTLY VISITED CHICKS

On Whenua Hou, 21.1% of occupied holes that had their barricade knocked down by the time of our test gave a cheeping or movement response, compared to 13.1% of occupied holes with erect barricades. However, this difference was not significant ($P = 0.47$). There were strong differences in the proportion of barricades knocked down each night ($\chi^2 = 23.2$, 5 d.f., $P < 0.001$).

4.3 VARIATION IN RESPONSE RATE BETWEEN SITES

Chick responses were heard at 9.3%, 3.9%, and 5.7% of the occupied holes at Whenua Hou, Putauhinu, and Taukihepa, respectively (Table 1). After pooling for all nights on each island, Fisher's Exact Test accepted a null hypothesis of equal response rate between Taukihepa and each of the other two islands for all holes, and just for occupied holes ($P > 0.35$). However, the four times higher response rate on Whenua Hou than on Putauhinu was highly significant for all holes pooled, and those confirmed to be occupied ($P < 0.001$).

4.4 DETECTION OF OCCUPANCY FROM CHICK RESPONSES

A chick response was sometimes heard at burrows that were considered not to have a chick (as determined by burrowscope inspection). This averaged 3.6% of tests at 'Unoccupied' burrows on Whenua Hou, and 4.7% of those at Putauhinu (Table 1). Indeed, there was little difference in the overall proportion of tests leading to a response between 'occupied' and 'unoccupied' burrows at Putauhinu. In contrast, there was a much lower response rate at 'unoccupied' cf. 'occupied' burrows at Whenua Hou.

Repeated visits to the same occupied burrows led to 55.2% and 33.7% of them having at least one chick response elicited by the end of the study at Whenua Hou and Putauhinu, respectively.

5. Discussion

5.1 VARIATION IN CHICK RESPONSES

Significant variation in response rate between nights on the same island suggests that some external variables influence chick behaviour. There was evidence of night-to-night variation in the proportion of chicks that had been visited (and presumably fed) by their parents by the time we tested their response to noise and vibration. However, there is no evidence to reject the null hypothesis of equal response rates for individual chicks that had been visited compared to ones not visited. Feeding is accompanied by load cheeping, so neighbouring unfed chicks may also be stimulated to expect the return of their own parent. If so, high frequency of feeding in the neighbourhood could have elevated response rates of all chicks on a given night. We had insufficient nights of barricade data in this study to test this hypothesis that chick responses correlate with frequency of feeding.

No formal counts were made in 1998, but cheeping could be heard from many of the holes in mid- to late-March. A cheep and/or rapid movement to the entrance could be triggered by scratching at the burrow entrance in over half the holes tested at that time (H. Moller, pers. obs.), a ten-fold higher rate than observed there in 1999 (Table 1).

5.2 POTENTIAL BIAS WITH FED CHICKS

There was no firm evidence to reject a null-hypothesis that chicks that had been fed were more likely to respond to the noise and/or vibration of observers at the burrow entrance. Detection of occupied burrows by this method is therefore unlikely to be seriously biased with respect to provisioning frequency and size or weight. Nevertheless the low sample size led to low power for our test for different responses for chicks recently visited by an adult or not. More checks for bias would be advisable if the acoustic detection method is used as the main or regular method of detecting occupied burrows for behavioural study or extraction of chicks for banding.

5.3 UTILITY OF CHICK RESPONSES FOR DETERMINING OCCUPANCY

It was hoped that chick responses to sound would have allowed rapid measures of burrow occupancy. The overall response rate at occupied holes was far too low to for the method to be a reliable measure of absolute occupancy levels. Indeed, 3–6 visits to score cheeping responses still only detected 34% and 55% of the chicks we knew to be present from burrowscoping or inspection hatches on Putauhinu and Whenua Hou, respectively. Hamilton (1998) found that only 29–33% of chicks responded to auditory stimuli at two mainland sooty shearwater colonies. The method can only give a crude minimum occupancy, even if tests are repeated several times throughout the season, at least in years of overall low response rate like 1999.

Four-fold differences in chick responses were detected between occupied burrows at Whenua Hou and Putauhinu in 1999. This negates the use of the cheeping response as a relative index of differences in burrow occupancy between places, even at the same time of season or in the same year.

Cheeping responses are probably best used in conjunction with other methods for detecting chicks. This study found chicks apparently living in burrows where no chick was seen with the burrowscope, even where the operators believed they had been able to prospect the entire burrow length leading from that entrance. There was a relatively poor correspondence between burrowscope and cheeping response data at Puatuhinu Island and relatively good correspondence at Whenua Hou. Burrow density is much lower, and burrows are shorter and less interconnected at Whenua Hou than at Putauhinu (Charleton 2002; H. Moller, unpubl. obs.). Perhaps (i) there were fewer burrowscoping errors at Whenua Hou, or (ii) chicks cheeping from nearby burrows at Putauhinu misled the observers in this study, and/or (iii) increased interconnection of burrows allowed chicks nesting in nearby burrows to move to the entrance of the burrow being tested by the observer at Putauhinu.

Automatic monitors of traffic in and out of burrows are expensive, impracticable for surveying widely spaced burrows, and prone to error (Moller et al. 2003). Occupied and unoccupied burrows are visited by non-breeders, so barricades and automatic exit/entry monitors are inadequate on their own for estimating chick occupancy and breeding success. Smell and sign at burrow entrances are variable indicators of burrow contents (Hamilton 1998) but are used successfully by some muttonbirders to target burrows with chicks present. For all its practical difficulties and inaccuracies, burrowscoping therefore remains the most reliable method of measuring occupancy, chick density and breeding success for scientific studies (Hamilton 2000). However, this study highlights the need for a follow-up study of the burrowscope's accuracy and the way it may vary between breeding colonies with different burrow density, complexity and architecture.

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