SHORT COMMUNICATION

Use of burrow entrance flaps to minimise interference to Chatham petrel *(Pterodroma axillaris)* chicks by broad-billed prions *(Pachyptila vittata)*

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Abstract: The Chatham petrel *(Pterodroma axillaris)* is an endangered species, restricted to. a single population on South East Island, Chatham Islands. The key threat to breeding success is loss of chicks as a result of interference by broad-billed prions *(Pachyptila vittata)* prospecting for burrows for their oncoming breeding season. The effectiveness in decreasing interference using an artificial burrow entrance flap was investigated. The flap exploits behavioural differences between the species. Chatham petrels have a high incentive to push through a flap due to. their investment in their burrow and chick, while prospecting prions are influenced by ease of access when searching for potential burrows. This trial found 90% of Chatham petrels entered their burrows through the artificial flap. Flaps acted as barriers to. broad-billed prions, where 22% entered the burrow through the flap *(P* < 0.01) compared to. the control burrows. Artificial burrow flaps have the potential to provide a low cost, low labour strategy for protecting the known breeding population of Chatham petrels.

Keywords: broad-billed prion; burrow competition; burrow entrance flap; Chatham petrel.

Introduction

The Chatham petrel *(Pterodroma axillaris)* is an endangered marine bird endemic to the Chatham Islands, New Zealand. It is now restricted to. a single breeding population on South East (Rangatira) Island, Chatham Islands. The total population is estimated at 500 to 1000 individuals (Kennedy, 1994). The key threat to breeding success arises from interference to. chicks by broad-billed prions *(Pachyptila vittata)* (Kennedy, 1994; Gardner and Wilson, 1999). While burrow competition between the two species is likely to have occurred in the past, it has probably been exacerbated by intense burrow competition due to a reduction in suitable habitat for both species (Sullivan, 2000).

During the non-breeding season broad-billed prions spend much of the night prospecting to establish ownership of burrows for the oncoming breeding season (Was, 2000). This coincides with the Chatham petrel chick-rearing period (mid February to. June). Chatham petrel chicks are left unattended by the adults who. generally visit the chick once every 2-3 nights. Broad-billed prions will evict or kill the chick to. claim ownership of the burrow (West, 1994; Gardner and Wilson, 1999). Gardner and Wilson (1999) found that without active management 55% of Chatham petrel breeding attempts failed and they attributed 70% of these failures to. interference by broad-billed prions.

To prevent broad-billed prions injuring Chatham petrel chicks and forming an association with Chatham petrel burrows during the breeding season, Department of Conservation staff check the known Chatham petrel burrows up to six times a night. All broad-billed prions found within the burrow are culled. The fledging rate has improved since this high intensity management regime was established in 1997, increasing to 78% in 1999 (Bancroft, 1999). This management regime is not without costs - it disturbs Chatham petrels, is labour intensive, provides only short-term relief, and involves killing a protected native species. Alternative methods are needed to. manage this population with minimal intervention.

The impacts of burrow competition in seabirds of different sizes have been reduced in the past by artificially reducing the size of the burrow entrance, excluding the larger competitors (Wingate, 1977; Ramos *et. al.,* 1997). Reducing the size of the entrance is not an option in this situation as broad-billed prions and Chatham petrels are both approximately 200 g (Marchant and Higgins, 1990). Behavioural differences between the two species could be exploited, due to the different stages of their annual life cycles.

Our research trialed artificial burrow entrance flaps attached to the entrance of Chatham petrel burrows, to investigate their effectiveness at determining broad-billed prions from entering burrows. The flap is attached after hatching, when presumably the adult has a high incentive to push through the flap. Prospecting broad-billed prions may be influenced by the conspicuousness of a burrow entrance or ease of access when searching for potential burrows. Gardner and Wilson (1999) suggest that larger, easily accessible burrows may be invaded by broad-billed prions more frequently than burrows with smaller or less conspicuous entrances. If so, they are likely to be deterred from entering burrows by burrow entrance flaps.

Methods

Study site

Chatham petrel observations took place in the Kokopu Creek catchment on South East Island, where the majority of the known Chatham petrel burrows are situated. The broad-billed prion trials used the artificial broad-billed prion burrows set up by Was (1999) in Woolshed Bush. These sites are vegetatively similar and have been described in detail in Sullivan (2000). The trials were kept separate due to the possibility of inducing increased interference to Chatham petrel chicks by broad-billed prions that had been discouraged from entering their own burrows by the flaps.

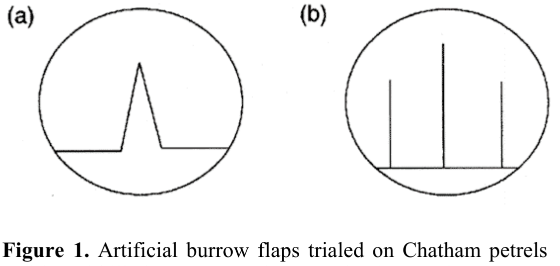

Figure 1. Artificial burrow flaps trialed on Chatham petrels and broad-billed prions, South East Island, 15 February - 12 April 1999. a. 'Neoprene' flap made with 2 mm neoprene with an inverted T cut; b. 'Tyre' flap made with 1 mm thick bike inner tube cut into four 25 mm strips.

Burrow entrance flap design

Two designs were fitted to a 30 mm length of 110 mm Marley drainflo novapipe using a 90-114 mm hose clasp. The 'neoprene' flap was made from 2 mm neoprene, with an inverted T cut, 70 mm x 70 mm in length, aligned with the botttom of the novapipe (Figure la).The 'tyre' flap was made with 1 mm thick mountain bike inner tube, cut into four 25 mm strips. The two inner cuts were 80 mm and the two outer cuts were 70 mm (Figure 1b). The trials took place on South East Island from 15 February to 12 April 1999.

Chatham petrel burrow flap trial

To measure the response of Chatham petrels to the burrow entrance flaps, 21 artificial burrows from the total of 54 known breeding burrows with chicks were selected. A simultaneous Department of Conservation trial on alternative burrow protection methods reduced the number of available burrows and meant that burrows could not be selected randomly. However, treatments were randomly allocated to the 21 study burrows (control:n = 12, 'neoprene': n = 16, 'tyre': n = 15).

A 3 m circular quadrat was marked out around the burrow entrance. Each observer watched one urrow per night, for three to five hours beginning at dusk. Behaviour was observed through a night-vision scope (Zenit NVI00 and Apple Nightspy) approximately 5 m from the burrow entrance.

A pre-treatment phase was completed on 10 petrels using a digital timer to determine the mean time a petrel from 1 m away took to enter its burrow. The mean number of attempts taken by each bird to enter was recorded. The term 'attempt' was defined as when a petrel looked into the burrow entrance when within approximately 0.05 m. These values helped us determine the extent to which the Chatham petrels were disturbed by the flap during the treatment stage.

During the treatment phase, burrows were observed for three visits by the same Chatham petrel to determine the extent of habituation. This gave an indication of whether their tolerance changed with increased familiarity to the flaps. Observations ceased after five nights if the bird did not visit the burrow during the observation period. The members of the pair were distinguished by a coloured paint stripe on the head that allowed identification without the birds being handled. The lid of the artificial burrow was raised to identify the Chatham petrel 20 minutes after the adult had entered to allow time for the chick to be fed undisturbed. The bird was identified using low intensity torch light. If the petrel appeared to be distressed and refused to enter the burrow after approximately 7 minutes, twice the typical time determined from the pre-treatment phase, the flap was gently pulled away using an attached string. The flaps were only in place while observers were present.

Observations on a control burrow occurred simultaneously with a treatment burrow. The data were analysed using analysis of variance and Fisher's least significant difference tests in SYSTAT.

Broad-billed prion burrow flap trial

To measure the effectiveness of flaps in preventing broad-billed prions from entering burrows, 47 artificial broad-billed prion burrows were used. These burrows were used and described by Was (1999).

A pre-treatment phase of 20 days established the natural visitation rates to burrows. For the treatment phase, 20 burrows had a flap attached (10 of each design) with 27 burrows as control burrows. To monitor movement into the burrow and therefore the effectiveness of the flap, a 'fence' made of sticks was placed inside the entrance and if displaced it indicated the burrow had been entered. This technique is often used for monitoring petrel burrows (e.g., Bartle, 1968), as it avoids unnecessary disturbance. It did not prevent broad-billed prions from entering the burrows. The fences were checked and if necessary replaced at approximately 0100 to 0200 hrs and again after dawn. Any unbanded broad-billed prion found within a burrow was banded. The bird was returned to the burrow via the tunnel rather than via the burrow lid as this is considered less stressful (Gardner and Wilson, 1999), unless a flap was attached, in which case it was returned via the burrow lid to avoid induced habituation. The treatments were randomly allocated and swapped every 12 days as some burrows were already occupied. This meant that those birds would have greater incentive to push through and would have a faster rate of habituation to the flaps than broad-billed prions prospecting at Chatham petrel burrows.

Birds found within the burrows were categorised as 'occupiers' or 'prospectors'. Occupiers were broad-billed prions that had been found in that burrow two or more times. Data from Was (1999) gave the occupancy history for individual burrows for four years. The frequency with which broad-billed prions entered treatment and control burrows was compared and data were analysed using analysis of variance on SYSTAT.

Results

Chatham petrel trial

During several preliminary trials using variations on the basic flap design, we established that it was important the opening of the flap aligned with the bottom of the novapipe. This lets the bird push through the flap and allows movement of plant material and soil in and out of the entrance. These preliminary trials are described in detail in Sullivan (2000) and are not described further here.

Both burrow entrance flap designs significantly increased the time it took for Chatham petrels to enter their burrows (Fisher's LSD test: $P < 0.01$) compared to the control burrows. The flap did not cause the number of attempts to differ significantly (one-way ANOVA, $F_3 = 1.69$, $P = 0.18$), and 90% of Chatham petrels went through the flap compared to 100% through the control burrows (Table 1). We were not able to test whether the three petrels that did not enter would have entered in subsequent visits. The response of Chatham petrels to the neoprene and tyre designs were not significantly different (Fisher's LSD test: $P = 0.81$).

Natural behaviour of a Chatham petrel around its burrow entrance without the flap attached was highly variable. Time to enter the control burrows ranged from 11 seconds to 5.20 minutes, and the number of attempts to enter ranged from 1 to 12.

Broad-billed prion trial

There was a highly significant decrease in the frequency at which broad-billed prions entered treatment versus control burrows (One-way ANOYA, $F_3 = 24.27$, $P < 0.01$), with a reduction of 80% for the neoprene design and 73% for the tyre design (Table 2).

For the neoprene flap trial, the majority of broad-billed prions found in the burrows were occupiers. Within

Table 1. Response of Chatham petrels to burrow entrance flaps.

	Mean time (min) [1]	Mean number of attempts [2]	% of burrows entered	n
Control burrows	0.52	3	100	12
Flap designs				
'neoprene'	2.05**	4 NS	88	16
'tyre'	2.21 **	2 NS	93	15

[1] Time taken, from 1 m from burrow entrance, to enter burrow.
[2] Number of times bird looked into entrance from within 0.05 m.
[3] 'Neoprene' design made with 2 mm neoprene with an inverted 'T' cut (Figure la). Tyre' design made with 1 mm bike tyre inner tube, cut into four 25mm wide strips (Figure 1b).
Significance: NS = $P > 0.05$; * = $P < 0.05$; ** = $P < 0.01$.

Table 2. Effect of burrow entrance flaps on the frequency burrows were entered by broad-billed prions.

	Burrows entered (% decrease cf. control)	Occupiers (%)[1]	Prospectors (%)[2]	Unknown (%)[3]
Control burrows	271	30	7.8	62.2
flap designs[4]				
'neoprene'	11 (80%)	63.6	18.2	18.2
'tyre'	35 (73%)	37.1	8.6	54.3

[1] ≥2 recorded visits in one burrow by same bird over 4 seasons (data also from Was, 2000).
[2] Broad-billed prion found in burrow in which it has never previously been recorded.
[3] Burrow had been entered but no broad-billed prion found.
[4] As described in Table 1.

the control burrows and those with the tyre flap attached, the majority *of* the birds that entered were not found in the burrows, thus the status of these birds was unknown.

Discussion

Response of Chatham petrels to entrance flaps

Behavioural differences between two species of seabird are not known to have been used to minimise the effects of burrow competition. Our research shows that manipulating behavioural differences has the potential to be an effective management tool for alleviating burrow competition.

Burrow entrance flaps do not prevent adult Chatham petrels from entering their own burrows. Chatham petrels were affected by the flap, as shown by the increased time it took to enter the burrow. However, this does not appear to be detrimental as the number of attempts to enter the burrow did not change, and the majority of Chatham petrels still entered. Of the 19 Chatham petrels trialled, three did not enter through the flap. Of these, one Chatham petrel pulled off the flap, which was not secured properly, and entered, and one Chatham petrel refused to enter despite previously entering the burrow through the flap. Due to time and permit restrictions, we were not able to test whether these Chatham petrels would have refused to enter with subsequent visits or if tolerance to the flap would increase. In a subsequent trial using Pycroft's petrel *(P. pycrofti)* outlined in Wilson (2000), the flaps had no detrimental effect and 25 out of 26 chicks fledged successfully.

Currently, the Department of Conservation's management strategy is to attach the flap after the egg has hatched and remove it before the Chatham petrel chicks first leave the burrow. However, the stage in the breeding cycle at which the flap is attached may have a significant influence on subsequent behaviour by Chatham petrels. Nest-site tenacity is generally high in Procellariiformes (Thibault, 1994). Petrels tend to return to the same nest during successive breeding seasons, the nest providing a focal point for partners to meet (Warham, 1990). The following questions need to be answered. Would the incentive to push through the flap lessen if the flap was attached before the breeding season? If the flap had been on for the majority of the previous season, would the Chatham petrel recognise its own burrow the following season if the flaps were not attached until after incubation? Severe disturbances to nest sites may cause shifts to new nest sites. Such shifts could result in the break-up of pairs and consequently lower reproductive success (Morse and Kress, 1984; Warham, 1990). Long-term trials are important to ensure that the flap does not disrupt mate and burrow fidelity, and cause burrow swapping in succeeding seasons. Ideally, the flap should be in place all year round to prevent problems in burrow recognition, minimising the likelihood of induced burrow. shifts.

Chicks of many petrel species leave the burrow at night some time before fledging to exercise and orientate with their surroundings (Harper, 1976; Warham, 1990). The timing of this behaviour varies with species. For example, fairy prion chicks first leave the burrow about 52 hours before departure (Harper 1976), and black petrel chicks 10 nights prior to fledging (Imber 1987). Incidental observations suggest Chatham petrel fledglings start leaving the burrow at approximately IS days prior to fledging (P. Gardner, Lincoln University, N.Z., *pers. comm.).* The flap may prevent the chick leaving, disrupting exploratory behaviour, or prevent the chick from returning to the chamber, causing it to leave the burrow prematurely.

Burrow entrance flaps may change burrow microclimate, reducing airflow, increasing humidity, temperature, ammonia and carbon dioxide levels, which could have detrimental impacts on chick respiration and growth. However, many petrel species have deep chambers and petrels often block their entrances with leaf material while the adult is in occupancy (Warham, 1990), consequently airflow may be naturally limited. Chatham petrels cover their entrances with leaf material when they leave, but we have not observed them blocking the entrances while in the burrow.

Response of broad-billed prions to entrance flaps

Attaching a burrow entrance flap to a burrow effectively deterred prospecting broad-billed prions from entering. Of the two flap designs, the neoprene design was the most effective.

Because the artificial prion burrows have been utilised by broad-billed prions for up to four seasons, a number of occupiers continued to enter the burrow through the flap. Like Chatham petrels, the longer a pair of broad-billed prions have bred together, the higher the chance of birds retaining their burrow despite disturbance, such as from the attachment of a flap. With current management no broad-billed prion establishes an association with a Chatham petrel burrow, therefore it is prospecting broad-billed prions that are the problem birds.

Conclusions

This research provides an alternative method for alleviating the effects of burrow competition between broad-billed prions and Chatham petrels. This would be at least or more effective as current management but would cause less disturbance to Chatham petrels. It would also be less labour intensive. With the reduced number of broad-billed prions likely to enter burrows the intensity of night patrols could be decreased and the number of native broad-billed prions culled reduced.

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References

Bancroft,F. 1999. *Department of Conservation, Chatham Islands, end of breeding season report* 1998 - 1999: *Chatham Island petrel* (Pterodroma axillaris). Department of Conservation, Chatham Islands, N .Z.

Bartle, J.A. 1968. Observations on the breeding habits Of Pycroft's petrel. *Notornis* 15: 70-99.

Gardner, P.K.; Wilson, K-J. 1999. *Chatham petrels* (Pterodroma axillaris) *studies - breeding biology and burrow blockading.* Science for Conservation 131. Department of Conservation, Wellington, N .Z.

Harper, P.C. 1976. Breeding biology of the fairy prion *(Pachyptila turtur)* at the Poor Knights Islands, New Zealand. *New Zealand Journal of Zoology* 3: 351-371.

Imber, M.J. 1987. Breeding ecology of the black petrel *(Procellaria parkinsoni). Notomis* 34: 19-39.

Kennedy, E. 1994. *Chatham petrel recovery plan.* Department of Conservation, Canterbury Conservancy. Christchurch, N.Z.

Marchant, S.; Higgins, PJ. 1990. *The handbook of Australian and New Zealand and Antarctic birds.* Volume 1a. Oxford University Press, Melbourne, Australia.

Morse, D.H.; Kress, S.W. 1984. The effect of burrow loss on mate choice in Leach's storm-petrel. *Auk 101:* 158-60.

Ramos, J.A; Monteiro, L.R; Encarnacion, S.; Moniz, Z. 1997. Characteristics and competition for nest cavities in burrowing Procellariiformes. *Condor* 99: 634-641.

Sullivan, W.J. 2000. *Differences in burrow site preferences between Chatham petrels* (Pterodroma axillaris) *and broad-billed prions* (Pachyptila vittata): *Investigating techniques to reduce the effects of burrow competition.* M.Sc. thesis. Lincoln University, Lincoln, N.Z.

Thibault, J.-C. 1994. Nest-site tenacity and mate fidelity in relation to breeding success in Cory's shearwater *Calonectris diomedea. Bird Study 41:* 25-28.

Warham, J. 1990. *The petrels: Their ecology and Breeding systems.* Academic Press, London. U.K.

Was, N.W. 1999. *Burrow occupancy and related behaviour of broad-billed prions* (Pachyptila vittata) *on Rangatira (South East) Island, Chatham Islands, New Zealand.* M.Appl. Sc. thesis. Lincoln University, Lincoln, N.Z.

West, J. 1994. Chatham Petrel *(Pterodroma axillaris)* an overview. *Notomis (Supplement)* 41: 19-26.

Wilson, K-J. 2000. Trial of burrow flaps to protect petrel chicks. *Conservation Advisory Notes No.* 313. Department of Conservation, Wellington, N.Z.

Wingate, D.B. 1977. Excluding competitors from Bermuda petrel nesting burrows. *In:* Temple, S.A. (Editor), *Proceedings of the symposium on management techniques for preserving endangered birds.* University of Wisconsin Press, Madison, Wisconsin, U.S.A.