

Burrow competition between Chatham petrels and broad-billed prions: the effectiveness of burrow blockading as a management strategy

Phillipa Gardner¹ and Kerry-Jayne Wilson²

¹ 'Thistledown', Coutts Island Road, RD, Christchurch, New Zealand

² Ecology and Entomology Group, PO Box 84, Lincoln University, New Zealand

ABSTRACT

The Chatham petrel (*Pterodroma axillaris*) is an endangered seabird endemic to the Chatham Islands, New Zealand. The breeding range is now restricted to Rangatira Island. Burrow competition between Chatham petrels and broad-billed prions (*Pachyptila vittata*), has a negative effect on Chatham petrel productivity. Burrow blockading is a management strategy developed by the Department of Conservation in response to burrow competition. Chatham petrel burrows are blockaded (by a gate set over the entrance) between July and October each year to prevent broad-billed prions from breeding in them. Blockades are removed shortly before Chatham petrels return to commence breeding. To determine the effectiveness of burrow blockading, Chatham petrel burrows were monitored daily over two consecutive breeding seasons (November 1995 to May 1996 and November 1996 to June 1997) to record the frequency and result(s) of broad-billed prion interference.

This study found burrow blockading to be ineffective in deterring broad-billed prions from interfering with Chatham petrel breeding burrows, but effective in ensuring burrows are available to returning Chatham petrels. Levels of interference over both seasons were high, with 87.3% of all known Chatham petrel breeding burrows affected. Broad-billed prions are likely to be responsible for 68.9% of known Chatham petrel breeding failures. Although broad-billed prions are known to oust, injure and kill Chatham petrel chicks, the majority of interferences (78.8%) caused no physical harm. Broad-billed prions caused at least four adult Chatham petrels to desert during incubation. Most broad-billed prions (where sex was confirmed) that interfered with Chatham petrel burrows were male (64%) and had no recorded prior association with the burrow.

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1. Introduction

Broad-billed prions (*Pachyptila vittata*) have a negative impact on Chatham petrel (*Pterodroma axillaris*) productivity resulting from burrow competition. Broad-billed prions are only absent from Rangatira island (Chatham Islands, New Zealand) for approximately 5–6 weeks (between January and February), when they leave to moult. From February to July (non-breeding season), they use burrows when on land. Their return in February coincides with the hatching of Chatham petrel chicks. Interference by broad-billed prions during the chick-rearing period is often detrimental to chick survival, as broad-billed prions are known to oust, injure and kill Chatham petrel chicks of all ages. Broad-billed prions are also known to cause incubating Chatham petrels to desert (pers. obs.; G.A. Taylor, pers. comm.). Burrow competition between the species, while perhaps a naturally occurring phenomenon, may not have been as intense in the past as it is today. Increased burrow competition on Rangatira Island may be a symptom of wider issues concerning loss of breeding habitats, the introduction of mammalian predators and habitat change in the Chathams archipelago. The Chatham petrel as a species is particularly vulnerable to this competition as the only known population breeds on Rangatira Island.

To address and alleviate the problem of inter-specific burrow competition, broad-billed prions were excluded from Chatham petrel burrows. The use of baffles, such as those used by Wingate (1977) with Bermuda petrels (*Pterodroma cabow*) to exclude white-tailed tropic birds (*Phaethon lepturus*), was not possible as broad-billed prions are very similar in size to Chatham petrels, and to exclude one would be to exclude the other. Therefore, the Department of Conservation developed the management strategy of burrow blockading in 1994, whereby broad-billed prions are denied access to Chatham petrel burrows during the first half of the prion breeding season (July–October). The blockades (gates constructed of wire and plastic garden mesh (Fig. 1a,b p. 39)) are placed across the entrances of all known Chatham petrel burrows in July. They are removed (late October to early November) before Chatham petrels return to the island to reoccupy their burrows and commence courtship. Artificial burrows with nova pipe tunnels prevent broad-billed prions digging past a blockade.

This strategy not only ensures the availability of the burrows to returning Chatham petrels but attempts to break any bond a broad-billed prion may have for a particular Chatham petrel breeding burrow. By preventing broad-billed prions from breeding in Chatham petrel burrows it was hoped that the birds would have no reason to return and interfere with burrows during the Chatham petrel breeding season (Late November to June).

2. Objectives

- To determine the effectiveness of burrow blockading in deterring broad-billed prions from interfering with Chatham petrel burrows.
- To establish how often broad-billed prions evict or kill Chatham petrel eggs or chicks in occupied burrows.

3. Method

To test the effectiveness of burrow blockading as a technique for reducing broad-billed prion interference, Chatham petrel breeding burrows were divided into those which were blockaded and those that were not blockaded. The status of these burrows was recorded each time monitoring occurred: eg. egg abandoned, cracked or removed from the nest bowl; chick ousted from the burrow, injured or dead; and the presence of a broad-billed prion. If a broad-billed prion was present, the time was recorded, the bird banded (1995/96) and then removed from the burrow. If present in the burrow during the day, the bird was placed into an empty burrow nearby so that it was not preyed upon by skuas (*Catharacta lonnbergi*). Those found at night were taken varying distances from the burrow (1995/96 10 m, 1996/97 up to 100 m) and released. From 9 March 1997, birds that repeatedly interfered with Chatham petrel burrows were occasionally blockaded into empty burrows nearby if they were injuring a Chatham petrel chick. The blockades were removed the following day, no more than 12 hours after being erected.

From 4 April 1997 broad-billed prions found in Chatham petrel burrows were killed. They were dissected to determine sex and general measurements were taken. Further information regarding general methods is available in Gardner, this volume.

4. Results

4.1 EFFECTIVENESS OF BURROW BLOCKADING

The study burrows, which included all known Chatham petrel breeding burrows (1995/96 n = 38, 1996/97 n = 44), were divided into those which were blockaded and those that were not blockaded. In 1995/96 there was one study burrow and in 1996/97 two study burrows where broad-billed prion interference was suspected but not verified. These burrows have not been included in the analysis of the effectiveness of burrow blockading.

TABLE 1. NUMBER (n) OF BLOCKADED AND NON-BLOCKADED CHATHAM PETREL BREEDING BURROWS IN WHICH THERE WAS INTERFERENCE BY BROAD-BILLED PRIONS (1995/96 AND 1996/97).

	BLOCKADED BURROWS (n)	INTERFERENCE	NON-BLOCKADED BURROWS (n)	INTERFERENCE	FISHER EXACT TEST TWO-TAILED, P VALUE *
1995/96	23	87%	14	92.9%	p = 0.99
1996/97	34	85.3%	8	87.5%	p = 1
Combined	57	86%	22	91%	p = 0.72

* Comparison of percent interfered, between blockaded and non-blockaded burrows

During both seasons, breeding burrows were monitored to establish if broad-billed prion interference was more frequent in, and involved a higher number of, non-blockaded burrows than blockaded (Table 1). In both years there were fewer non-blockaded burrows (see discussion for further details), and no significant difference in interference level between blockaded and non-blockaded burrows (Table 1).

Natural versus artificial burrows

There was no significant difference in the proportions of natural and artificial burrows interfered with (1995/96 $p = 0.16$, 1996/97 $p = 0.46$ Fisher Exact test, two-tailed). There was also no significant difference when data from both years was combined ($p = 0.13$).

We also investigated any difference in the number of interferences per burrow between the three types of burrows (box, dome, and natural). There was no significant difference ($p = 0.47$ Kruskal-Wallis Test) although a pattern appeared to be evident that was consistent over both seasons. Box burrows received 5.1 ± 1.0 interferences per burrow, as opposed to 4.7 ± 0.8 per dome burrow and 3.3 ± 1.3 per natural. With both types of artificial burrows combined (box + dome), artificial burrows received 4.9 ± 0.7 interferences per burrow v. 3.3 ± 1.3 interferences per natural burrow. There was no significant difference ($p = 0.3$ Kruskal-Wallis Test).

4.2 FREQUENCY OF BROAD-BILLED PRION INTERFERENCE

During the 1995/96 season there were 142 recorded broad-billed prion interferences in Chatham petrel burrows (Table 2). Only three blockaded burrows and one non-blockaded burrow received no known interference. The 1996/97 season also revealed high broad-billed prion interference, with 231 recorded offences (Table 2). During this breeding season, five blockaded burrows and one non-blockaded burrow received no known interference. Blockaded and non-blockaded burrows in both years received high levels of interference (Table 1).

TABLE 2. TYPES AND NUMBER OF KNOWN BROAD-BILLED PRION INTERFERENCES IN CHATHAM PETREL (CP) BREEDING BURROWS 1995/96 AND 1996/97.

SEASON	TYPE OF INTERFERENCE					
	DEATH OF AN EGG	INJURY TO A CHICK	DEATH OF A CHICK	CHICK OUSTED CAUSING DEATH	BROAD-BILLED PRION FOUND IN A CP BURROW	TOTAL INTERFERENCES
1995/96	1	22	13	1	105	142
1996/97	3	29	8	3	188	231
Total	4	51	21	4	293	373

In 1995/96 there were 3.7 interferences per burrow compared to 5.2 interferences per burrow during the 1996/97 season but this can probably be attributed to more intense monitoring in the latter year.

The level of broad-billed prion interference varied from night to night, and appeared to relate directly to the number of broad-billed prions that were on land (although this was not tested). Interference in Chatham petrel burrows fluctuated on a daily basis (Figs. 2 & 3). Colony attendance by broad-billed prions may follow weather patterns, but this was not analysed during the study (see discussion for details).

All broad-billed prion interferences recorded were categorized depending on impact on Chatham petrel breeding success (Table 2). The greatest proportion of interferences recorded (78.8%), caused no measurable harm. Chicks were injured in 13.7% of interferences, death was the result after chicks were ousted in 1.1% of cases, and in 5.4% of interferences chicks were killed in their burrows. During this study we did not attempt to determine the impact broad-billed prion interference had on egg survival.

Broad-billed prions found in Chatham petrel burrows were banded to determine the likelihood of the same individuals returning to the burrow in consecutive years (including those previously excluded). During 1995/96, 80 broad-billed

Figure 2. Number of broad-billed prion interferences in Chatham petrel breeding burrows per night (21/2/96-13/5/96).

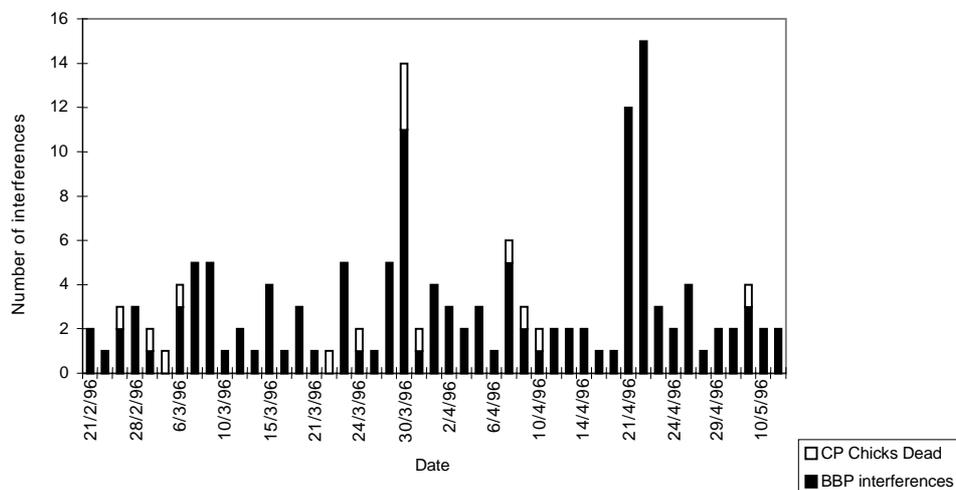
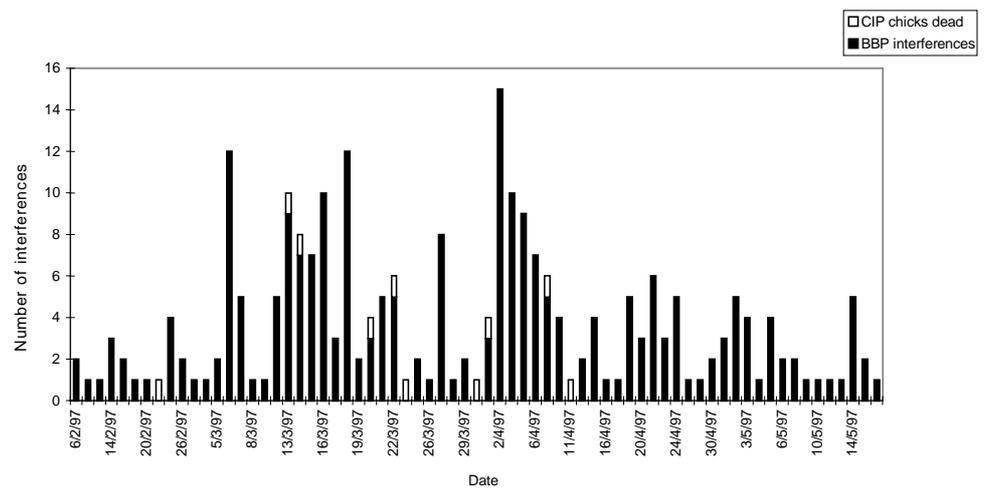


Figure 3. Broad-billed prion interferences in Chatham petrel breeding burrows per night (6/2/96-26/5/96).



prions were banded in Chatham petrel breeding burrows. Of these birds, 23.75% (n = 19) were seen again in the 1996/97 season and 76.25% (n = 61) were not observed. Of the 19 prions that were seen again, 94.7% (n = 18) were found in the same burrow in which they were banded. Two of the 19 returned prions also visited another Chatham petrel burrow nearby (within 6 m). Broad-billed prions (n = 54) were also banded in 1996/97. As a result of a management decision, banding of broad-billed prions in Chatham petrel burrows ceased after 4 April 1997.

Between 4 April 1997 and 26 May 1997, any broad-billed prion found in a Chatham petrel burrow was killed and dissected to determine sex. Of the birds killed 64% were male, 27% were female and the sex of 9% was unknown. The highest proportion of broad-billed prions killed were unbanded birds (67%), followed by those banded during the 1996/97 season (17%), and those banded in 1995/96 (16%).

4.3 EFFECT OF INTERFERENCE ON CHATHAM PETREL PRODUCTIVITY

Over the two seasons it was possible to identify the extent to which broad-billed prions impacted on Chatham petrel productivity. Of 38 burrows in 1995/96, 56% of breeding attempts failed (i.e. either eggs failed or chicks died). Of these failures, 57% can be attributed to broad-billed prion interference. The causes of a further six failures (14.3%) strongly suggested broad-billed prion involvement (broad-billed prion feathers and faeces in the burrow entrance and chamber). The cause of failure remains unknown in the remaining 28.6%. It is therefore possible that broad-billed prions were responsible for at least 71% of Chatham petrel breeding failures in the 1995/96 season. The results were only marginally better for the following season. Of 44 breeding burrows, 54.5% failed (eggs failed or chicks died). Of these failures, 45.8% can be directly attributed to broad-billed prion interference, 20.8% of failures were likely to have been caused by broad-billed prion interference and in 33.3% the cause of failure was unknown. In the 1996/97 breeding season broad-billed prions possibly caused 66.6% of Chatham petrel breeding failures (Table. 3)

TABLE 3. CHATHAM PETREL BREEDING FAILURES AND NUMBER OF FAILURES ATTRIBUTED TO BROAD-BILLED PRIONS (BBPs).

	NUMBER OF BREEDING BURROWS	NUMBER OF BREEDING FAILURES	NUMBER OF FAILURES CAUSED BY BBPs	NUMBER OF FAILURES POSSIBLY CAUSED BY BBPs	NUMBER OF FAILURES, CAUSE UNKNOWN
95/96	38	21	12	3	6
96/97	44	24	11	5	8
Total	82	45	23	8	14

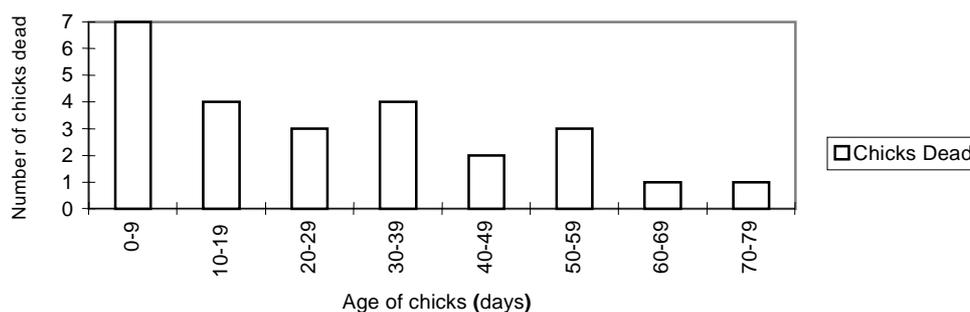
By analysing the breeding phase at which failures occurred, it was possible to identify when a breeding attempt was most likely to fail due to broad-billed prion interference. During 1995/96, 18% of breeding attempts failed during incubation and 37% failed during chick rearing. In 1996/97, 29.5% failed at incubation and 25% failed as chicks. The reduced number of chick failures in the latter season was probably the result of the management decision to kill broad-billed prions found in Chatham petrel burrows. The reason for the increase in failures during incubation in 1996/97 is unclear. It was difficult to determine the cause of egg failure, but there were 4 burrows where broad-billed prions were known to have been responsible for causing adult Chatham petrels to desert their eggs.

Chatham petrel chicks are particularly vulnerable to broad-billed prion interference when very young but are also susceptible until fledging. Death rate declined with age (Fig. 4), probably because larger chicks were better able to survive an injury.

Although Chatham petrel chicks died throughout the chick period there was a noticeable rise in deaths during the latter half of March in both years (Fig. 5).

In an effort to develop a more effective system for monitoring burrows at night, times of interferences were recorded during 1996/97. Most interferences occurred from 0200–0500, with another smaller peak from 2200–0000 (Fig. 6).

Figure 4. Age of Chatham petrel chicks at death, 1995/96 and 1996/97.



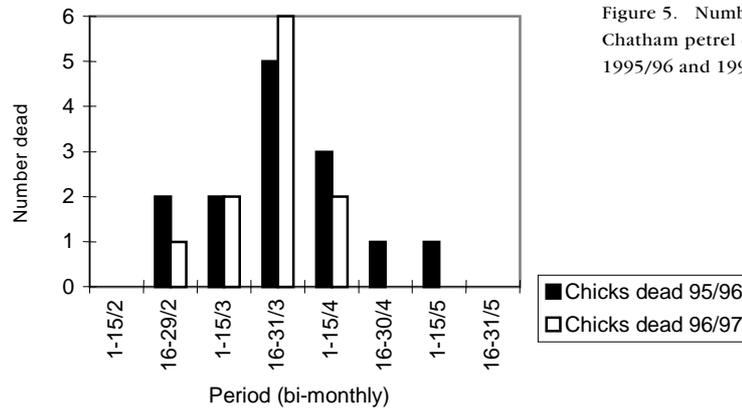
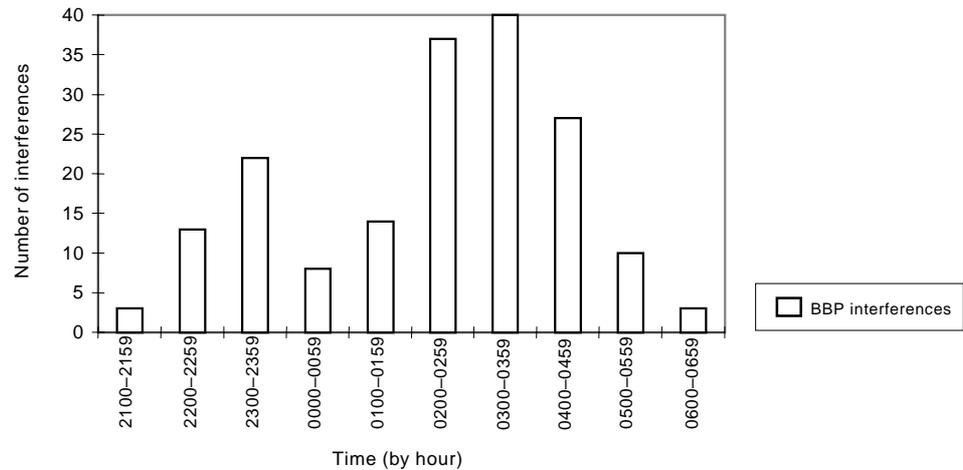


Figure 5. Number and period of Chatham petrel chick deaths, 1995/96 and 1996/97.

Figure 6. Times of broad-billed prion (BBP) interferences in Chatham petrel burrows 1996/97.



5. Discussion

Burrow blockading

Data collected from the two breeding seasons show that burrow blockading was not effective in deterring broad-billed prions from interfering in Chatham petrel breeding burrows between February and July (broad-billed prion non-breeding season). There are probably a combination of factors that explain why this is the case. Some of these have been identified and will be discussed, but further study is needed to better understand petrel dynamics on the island.

Burrow blockading could lower broad-billed prion interference in two ways. First, by denying broad-billed prions the opportunity to breed in Chatham petrel burrows (by blockading the burrows in July each year), the burrows would be available to Chatham petrels returning in November to commence breeding. The success of blockading during this period seemed intuitively obvious and was not tested in this study. Second, as broad-billed prions have not had access to blockaded burrows, no bonds to these burrows will have formed, thereby deterring broad-billed prions from interfering with these burrows after they return in February from moulting.

It was not possible to leave 50% of known Chatham petrel breeding burrows without blockades in either study year, so sample sizes of blockaded and non-blockaded burrows differ. In 1995/96, we had no control over which burrows were blockaded, as blockading occurred in July 1995 and this study began in November 1995. When deciding which burrows to leave without blockades for the 1996/97 season, we considered several issues. Some members of the Chatham Petrel Recovery Group had expressed concern at the apparently high rate of burrow turnover and consequent loss of breeding pairs able to be monitored. The Chatham Petrel Recovery Plan aims to ensure burrow and pair stability wherever possible. Given the difficulty in finding burrows, it may not have been possible to secure results from non-blockaded burrows. To confirm results from these burrows, Chatham petrels would have had to have been located after they had possibly been excluded from their burrows by breeding broad-billed prions. If the perceived risk of burrow loss came to fruition, it would not only have been detrimental to the species and the monitoring programme, but may have increased the risk of even smaller sample sizes for this study. Further, the results from 1995/96 suggested that Chatham petrel productivity was low, perhaps not even maintaining the population (Taylor 1997). Taking these concerns into account, all known Chatham petrel burrows were blockaded in July 1996. With new burrows found during November–December 1996, there were some non-blockaded burrows in the 1996/97 sample.

There had been an assumption that Chatham petrel breeding attempts were failing because broad-billed prions with a bond to a particular Chatham petrel burrow (having been in occupation of the burrow previously) were returning to the burrows and ousting or killing Chatham petrel adults and chicks; the conflict between the species pertaining to burrow ownership. In response to this assumption, the Department of Conservation had banded and later killed broad-billed prions found in Chatham petrel breeding burrows. This study has shown that a small proportion (less than 25%) of the broad-billed prions visiting Chatham petrel burrows had a prior bond with the burrow they visited. Most of the banded broad-billed prions were not found again in the burrow they were banded in, even though they may, in the most extreme cases, have had six months to bond with the burrow before the blockade was erected. The majority of interferences were from individuals that may have had no known prior history with the burrow at which they were found. The reason why we see no significant difference in interference between blockaded and non-blockaded burrows could be because it is not bonded birds who are predominantly responsible for interference.

Most interfering broad-billed prions are unlikely to be established breeders. As only about one third of a 'robust' petrel population is breeding at any one time (M.J. Imber, pers. comm.), one could assume that most breeding broad-billed prions have a burrow to return to after moulting and, therefore, should have no reason to interfere with Chatham petrel burrows. However, it is possible that if a limiting factor for broad-billed prions on Rangatira Island is burrows and burrowing space, a few established breeders may lose claim to their burrows. This is supported by observations of inter-specific competition for burrows (pers. obs.; Was, pers. comm.). Presumably many non-breeding and pre-breeding broad-billed prions return to the island between February and July

(non-breeding season) as well as established breeders. Most of these birds will be participating in pair establishment or reaffirmation, prospecting for breeding burrows or renovating one they already own. Therefore, it is perhaps likely that most broad-billed prions found in Chatham petrel burrows will be of 'no fixed abode' and prospecting for a burrow. This has been supported in this study by the number of broad-billed prions banded in Chatham petrel burrows over the two years and the number of unbanded birds killed in 1997. It is further supported by the findings of Was & Wilson from broad-billed prion study burrows on the island.

Observations using night vision scopes showed that broad-billed prions not only spend considerable time prospecting but also actively and aggressively defend burrows. They evict white-faced storm petrel (*Pelagodroma marina*) adults and chicks from their burrows (pers. obs.) in order to renovate the burrow so that they may occupy it themselves. The enlarging of such a small burrow by a broad-billed prion appears to require considerable digging and is unlikely, in Gardner's opinion, to be in preference to finding an existing suitably sized burrow. Prospecting broad-billed prions are known to travel distances of up to 60 m (Was, pers. comm.) and appear to have a preference for obvious burrow entrances (pers. obs.). Having observed this behaviour, we can understand the appeal of Chatham petrel burrows, as not only are their burrow mouths cleared and open from the frequent comings and goings of feeding adults, but the nova pipe used in stabilising the tunnels and excluding broad-billed prions makes a slightly larger and more obvious entrance than would naturally occur. Nova pipe tunnels may attract prospecting broad-billed prions, although rates of interference between artificial and natural burrows did not differ significantly.

Our observations showed that broad-billed prions, when searching for a burrow, vocalised into suitably-sized entrances. When a broad-billed prion responded, the prospecting bird generally moved on and continued searching. Occasionally they entered the burrow but this appeared to be less common. When there was no response, they generally entered. Chatham petrel chicks are unlikely to respond to broad-billed prion calls and as broad-billed prions have been found in Chatham petrel burrows with the chick and adult, Chatham petrel adults may not respond to such calls either. Chatham petrel burrows could therefore attract prospecting broad-billed prions as they are the right size, the entrances are inviting and they appear empty. The only thing often stopping them from claiming the burrow is a Chatham petrel chick. Artificial Chatham petrel burrows may be more attractive to broad-billed prions than natural burrows because of the nova pipe tunnels. Many broad-billed prions that succeed in terminating a Chatham petrel breeding attempt carry out major renovations to the burrow, digging beyond the original chamber. Although there was no significant difference between interference in natural or artificial burrows, there appeared to be a pattern (box and dome burrows having more interference) over the two seasons. Less interference in natural burrows would support the theory of tunnel attractiveness.

Frequency and types of interference

The differences in number of interferences between the two seasons may be due to the following reasons. First, to manage the population in a manner in keeping with the aims of the Recovery Plan (to get as many Chatham petrel chicks to fledge as possible) the burrows were more intensively monitored

during 1996/97. Second, the burrows were monitored less frequently at night between April and May 1996 when we were not present on the island and interfering prions may not have been observed. Regardless of this inconsistency, broad-billed prion interference was high in both years.

The higher number of male broad-billed prions killed in 1997 is consistent with the generally accepted view that male petrels find burrows and attract females to them (Warham 1990).

Our results show that the majority of broad-billed prion interferences in Chatham petrel burrows cause no physical injury to Chatham petrel adults or chicks. West & Nilsson (1994) reported Chatham petrels fighting with broad-billed prions, presumably for burrows. In this study we made no such observations, but Gardner heard what she believed to be a fight between a Chatham petrel and broad-billed prion at a study burrow. By the time she arrived at the burrow, a rather bedraggled broad-billed prion was moving away from it and the Chatham petrel was entering. No injuries to Chatham petrel adults were observed during the study that indicated physical fighting between the two species.

The reason why most interferences cause no injury to Chatham petrel chicks could be that most of the interfering broad-billed prions have had no prior bond to the Chatham petrel burrow they entered and, therefore, no reason to rid the burrow of the chick immediately. This may change if the broad-billed prion repeatedly visits the burrow and attempts to claim ownership. During the study it was noted that many intruding broad-billed prions did not attack the chick on the first visit to the burrow (pers. obs.).

During 1996/97, the times of all broad-billed prion interferences were recorded. This was undertaken to establish when the majority of interferences occurred so that monitoring of the burrows could be more efficient and effective. The results showed that most of the interferences occurred between 0200 and 0500 each morning, but there was also a smaller peak between 2200 and 0000 (Fig. 6). The smaller peak corresponds with the arrival of broad-billed prions to the island. Many birds during the first half of the night appeared to spend time socialising and renovating burrows (pers. obs.). The large increase in interferences between 0200 and 0500 could be explained by the increased need to find a burrow by those broad-billed prions that remain on land. High levels of colony attendance appear to relate directly to high levels of interference (pers. obs.). The relationship between broad-billed prion colony attendance and weather is currently being investigated by Was and Wilson.

Effects of interference on Chatham petrel productivity

Broad-billed prion interference had a negative effect on Chatham petrel productivity. Prions were responsible for more than half the known breeding failures in 1996/97 and just under half in 1995/96. Most of these occurred during the chick-rearing period. Broad-billed prions were possibly responsible for up to two thirds of all breeding failures over the two years of this study. This probably would have been even higher if interfering birds had not been removed from Chatham petrel burrows.

Without internal infra-red burrow cameras, it was not possible to determine the level of broad-billed prion interference that resulted in the death of Chatham petrel eggs. In four study burrows broad-billed prions were responsible for Chatham petrels deserting during incubation. It is likely that these were not the only instances where this occurred.

In most cases, chicks suffered an injurious broad-billed prion attack before a further attack which caused death. Broad-billed prion attacks generally affected the eyes and heads of Chatham petrel chicks. In severe cases the skull was exposed. Chicks are very vulnerable to broad-billed prion attack in the first ten days of life, and are more likely to survive an attack the older they are. Once a chick becomes mobile it is probably able to defend itself to some degree. A response to an attack may be to leave the burrow in which case their chance of survival must be small until growth of feathers is complete. In all but one of the interferences that resulted in chicks being ousted from burrows, the chicks were at least half way through their development and quite mobile. Chicks can be killed by broad-billed prions right up until they fledge. The survival of five chicks that received injuries during the 1996/97 season may have been a result of their wounds being washed with disinfectant (savlon 1:10).

A peak in chick deaths occurred in the latter half of March in both seasons. This peak could be the consequence of a cyclical pattern of broad-billed prion visitations to the island. Although broad-billed prions start returning to the island during the first week of February (as Chatham petrel chicks begin hatching), the number of birds appears to increase over March and April. Birds that return early to begin prospecting would have many empty burrows available to them and, therefore, interference in Chatham petrel burrows could be expected to be less than when prions had returned in greater numbers.

Broad-billed prions may impact on Chatham petrel productivity in ways other than those mentioned above. It is possible that the presence of broad-billed prions in and around Chatham petrel burrows may deter Chatham petrel adults from entering and feeding their chicks (Gardner, pers. obs.). Smell may also be a factor as broad-billed prions often defecate in and around Chatham petrel burrows. On four separate occasions, three Chatham petrel adults did not feed their chicks even though they had returned to the island and were observed within a few metres of their burrows. As the chicks were being weighed, it was possible to ascertain that they had not been fed. How detrimental this is to Chatham petrel chick development probably depends on how often it occurs.

This two-year study has shown that burrow blockading is not effective in deterring broad-billed prions from interfering with Chatham petrel burrows between February and July. It is successful in preventing broad-billed prions from breeding in Chatham petrel burrows, and the burrow is therefore available to returning Chatham petrels. Broad-billed prion interference appears to be very high, and most of the broad-billed prions found in Chatham petrel burrows apparently had no prior bond with the burrows. Of the broad-billed prions that were killed, almost two-thirds were male. Broad-billed prion interference is very detrimental to Chatham petrel breeding success.

6. Recommendations

The authors recommend the following:

- That Chatham petrel burrows be blockaded as soon as possible after a breeding attempt has failed, to reduce the time broad-billed prions have to bond with a burrow. Information on the time spent by Chatham petrels in burrows after a breeding attempt has failed will be necessary in order to ensure that burrows are not blockaded too early.
- Reduce the size, and change the shape, of artificial burrow entrances. Mike Bell (DOC, Chatham Area Office) has suggested a simple method for this. By cutting two slots into the entrance end of the nova pipe, each at 180 degrees, and squeezing the plastic into a more elliptical shape with wire, it would be possible to make a smaller and modified tunnel entrance without making the tunnel itself too small. This could be trialed on burrows other than Chatham petrel breeding burrows and, if successful, modifications could be made on Chatham petrel burrows currently in use.
- Alternatively, or in addition, a screen door system not unlike those seen in old green-grocer shops could be attached to the top of the nova pipe to hang down over the tunnel entrance. Each time the Chatham petrels enter or leave the burrow the screen would fall back into place, concealing the entrance. We imagine, given the vigorous way in which Chatham petrels remove fences, that the hanging straps would have to be weighted in some way to encourage them to return to the correct position. It is important that none of these screens dangerously restrict the air flow to the chamber.

Note. The above suggestions would not stop broad-billed prion interference, particularly not by those birds that already have a bond to a Chatham petrel burrow. However, by making the burrows less conspicuous they may reduce the level of interference by prospecting birds. Trials of these two methods are planned.

- To stop broad-billed prion interference a more permanent solution is needed. One such possibility is to install in Chatham petrel burrows doors that are triggered by Chatham petrels carrying transponders. The technology for such a system is available and, with modifications, a suitable door system could possibly be developed. This would provide a more permanent solution (it would only have to be active during the Chatham petrel breeding season) of stopping broad-billed prion interference. There are, of course, problems with such a solution. Not only would it be expensive to set up, but it would not be wise to depend entirely on an electronic system that has the potential to fail. The isolation of Rangatira and the frequently adverse weather conditions would make it difficult (but not impossible) to maintain such a system. On the other hand, the current level of monitoring of Chatham petrels is not sustainable and not ideal for the birds, and an automated system could reduce such human interference.
- Work towards the establishment of a second Chatham petrel colony should continue.

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Figure 1b. Artificial Chatham petrel burrow with stick and kawakawa leaf fence.
Photo: P. Knightbridge.



Figure 1a. Artificial Chatham petrel burrow with stick fence. Note blockade (made of wire and plastic garden mesh).
Photo: P. Gardner.