SHORT COMMUNICATION

Differences in habitat selection between Chatham petrels *(Pterodroma axillaris)* and broad-billed prions *(Pachyptila vittata):* implications for management of burrow competition

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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, New Zealand. The key threat to Chatham petrel breeding success is interference with chicks by broad-billed prions *(Pachyptila vittata)* prospecting for burrows for their oncoming breeding season. This burrow competition has resulted from alteration to breeding habitat by humans throughout the Chatham Islands. Understanding habitat preferences may enable managers to manipulate habitat to reduce burrow competition and will be essential in order to translocate Chatham petrels to a proposed second colony. Habitat characteristics surrounding both Chatham petrel and broad-billed prion burrows were quantified and selection ratios compared. Both Chatham petrels and broad-billed prions selected habitat factors associated with mature forest. Chatham petrels avoided a large number of habitat characteristics, which suggests they were habitat specific, and their preferred habitat is now limited. Broad-billed prions used a wide range of habitat characteristics, which suggests they are not habitat specific. This study recommends that selection values be used when deciding on the best location to establish a second Chatham petrel colony.

Keywords: broad-billed prion; burrow competition; Chatham petrel; habitat selection; *Pachyptila vittata; Pterodroma axillaris.*

Introduction

The Chatham petrel *(Pterodroma axillaris)* is an endangered seabird endemic to the Chatham Islands, New Zealand. The species is now restricted to a single breeding population on South East (Rangatira) Island, Chatham Islands. Chatham petrels were originally distributed throughout the Chatham archipelago (West, 1994). While never abundant, numbers are unlikely to have been as small as the current population (West, 1994), which is estimated to be less than 1000 individuals (Kennedy, 1994). The immediate threat to breeding success of Chatham petrels is chick interference by prospecting broad-billed prions *(Pachyptila vittata)* which compete for Chatham petrel burrows (Kennedy, 1994; Gardner and Wilson, 1999). Broad-billed prions kill or oust chicks when taking over Chatham petrel burrows.

The native broad-billed prion is abundant on South East Island with numbers estimated to be 300 000 pairs (West and Nilsson, 1994).

High levels of intra- and inter-specific competition for burrows may be a result of human induced alteration of breeding habitat limiting appropriate sites for nests and confining populations to a few, usually predator free, islands. Although Chatham petrels and broad-billed prions currently burrow in relatively similar habitat, traditionally they presumably partitioned available habitat to reduce burrow competition, and the two species would have selected different habitat characteristics. However, there have been major habitat changes-to South East Island, with grazing of stock occurring for about 100 years (Nilsson *et al.,* 1994; West and Nilsson, 1994). A considerable proportion of the forest on the lowland terraces was converted to pasture, while the remaining tract of forest was severely damaged by overgrazing and

fire (West and Nilsson, 1994). Stock were removed by 1961 after the island was created a reserve in the 1950s but by then the island had reduced forest cover and altered forest composition (Richie, 1970). Thus, burrow competition has probably been exacerbated by a reduction in suitable habitat for both species. Because habitat generalist species are more likely to adapt to modified or sub-optimal habitat than specialist species, broad-billed prions are likely to have the advantage over Chatham petrels.

Overlap in nest-site requirements between species should result in inter-specific competition (Whittam and Siegal-Causay, 1981; Ramos *et al.,* 1997). To avoid competition, clear separation of site preferences should have evolved (Burger and Gochfield, 1988). This would result in the selection of particular physical features of a habitat (e.g., Ramos *et al.,* 1997). Physical aspects of habitat and nest-site selection by either Chatham petrels or broad-billed prions have not been quantified. The aim of this study was to quantify the habitat features that they may be selecting to determine whether habitat selection could be manipulated to manage burrow competition. If the known Chatham petrel population is aggregated within particular habitat types, it may be possible to manage the habitat to support higher densities of Chatham petrel burrows. If broad-billed prions select areas with particular features, habitat could be managed to reduce the attractiveness of habitat surrounding Chatham petrel burrows so that interference decreases. An improved understanding of the optimal habitat for both Chatham petrels and broad-billed prions could assist in selection or alteration of habitat elsewhere in the Chatham Islands when establishing a second Chatham petrel population.

Methods

Study site

This work was conducted on South East Island, Chatham Islands, New Zealand. This island has a vegetation cover of regenerating forest (45% of the island area) and areas of introduced grasses, pohuehue *(Muehienbeckia australis),* bracken *(Pteridium escuientum)* ake ake *(Oiearia traversii),* scrub and herbfield (Nilsson *et al.,* 1994). Habitat characteristics from all of these areas were measured between 17 February and 1 April 1999.

Measuring habitat characteristics

Because of the disproportionate number of Chatham petrel burrows to broad-billed prion burrows, habitat characteristics for each species were measured differently.To measure Chatham petrel habitat, a 3 m radius circular quadrat was placed around each Chatham petrel burrow using the entrance as the centre. When measuring broadbilled prion habitat, we used random four-digit numbers to place quadrats throughout the island, after West and Nilsson (1994). Habitat availability was calculated using data from both sets of quadrats.

For each quadrat, 14 characteristics were measured (Table 1). A total of 124 quadrats were measured: 44 around Chatham petrel (27 breeding and 17 non-breeding)burrows, and 80 random quadrats.

Determining habitat selection

Selection describes the use of a resource by an animal in proportion to resource availability (Manly *et al.,* 1993).

Table 1. Habitat characteristics measured within each 3 m radius quadrat on South East Island, Chatham Islands.

	Habitat characteristic	Definition
I	number of broad-billed prion burrows	burrows with entrances ≈ 130 x 70 mm (West and Nilsson, 1994)
2	dominant species	tree species with the predominant number of stems in quadrat
3	aspect (º)	compass direction of slope
4	soil compaction	hard: a person can walk without collapsing burrows; medium: requires boards to prevent burrow collapse; soft: burrows collapse even with boards (West and Nilsson, 1994)
5	slope (º)	estimated angle of ground at centre of quadrat
6	canopy cover (%)	estimated cover of vegetation within the quadrat> 6 m (±5%)
7	understory cover (%)	estimated cover of vegetation 0.5-6 m (±5%)
8	vegetation height (m)	estimated maximum height of vegetation (±l m)
9	number of logs	> 50 mm diameter at widest width
10	number of stems	all stems> I m tall
11	diameter of stems	% < 50mm; % 51-100 mm; % > 100 mm
12	take-off tree (T.O.T) species	tree that seabirds climb to launch themselves from canopy: > 50 mm DBH with scratch marks on trunk; ≈ vegetation height, and nearest to centre of quadrat
13	T.O.T diameter (mm)	DBH
14	T.O.T lean (º)	±5º

Table 2. Summary of habitat characteristics selected or avoided by Chatham petrels, South East Island, Chatham Islands.

Habitat characteristic	Selected	Avoided
dominant species	-	ake ake
aspect	north-east	-
soil compaction	-	-
slope(°)	-	-
canopy cover (%)	21-40	-
understory cover (%)	-	61-80
vegetation height (m)	11-20	-
no. logs (3 m radius quadrat)	2	-
no. stems/m^2	-	0
		≥3
stems < 50 mm (%)	-	81-100
stems 51-100 mm (%)	21-30	0-10
stems> 100 mm (%)	-	0-10
take-off tree (T.O.T) species	karamu	whitey-wood
T.O.T diameter breast height (mm)	-	-
T.O.T lean (°)	16-30	0-5

Table 3. Summary of habitat characteristics selected or avoided by broad-billed prions, South East Island, Chatham Islands.

Habitat characteristic	Selected	Avoided
dominant species	matipo	ake ake
	mixed	karamu
		grass
		flax
aspect	north-east	-
	south-east	-
soil compaction	soft	-
slope (°)	11-40	-
canopy cover (%) understory	61-80	-
cover (%) vegetation height	21-40	-
(m)	11-20	-
no. logs (3 m radius quadrat)	1	-
	2	
	>3	
no. stems/m^2		≥3
stems < 50 mm (%)	41-60	20
stems 51-100 mm (%)	11-40	-
stems> 100 mm (%) take-off	11-30	-
tree (T.O.T) species	ake ake	none
	karamu	
	ngaio	
	ribbonwood	
	whitey-wood	
	matipo	
T.O.T diameter breast height (mm)	201-600	-
T.O.T lean (°)	≥16	-

To quantify habitat selection, the percentage use of a habitat characteristic is divided by the availability of that characteristic to calculate a selection ratio. Selection ratios for each habitat category of each variable were used to quantify habitat selection for both Chatham petrels and broad-billed prions using the equation:

$$W_i = O_i / \pi_i$$

where:

O_i = the proportion of used quadrats with habitat characteristics of category i

π_i = the proportion of available habitat characteristics of category i (adapted from Manly *et al.,* 1993).

Because of the small number of Chatham petrel burrows, 'used' (O_i) resources were measured at an individual level, whereas 'available' (P_i) resources were considered at a population level (Design II; Manly *et al.,* 1993). For broad-billed prions, both sets of measurements were made at a population level (Design I; Manly *et al.,* 1993). Overall, the mean density of broad-billed prion burrows was 0.31/m^2. Based on this measurement, a burrow density of > 0.18/m^2 (i.e., > 5 burrows/3 m^2) was considered 'used' habitat (Oi), and a density of < 5 burrows/ 3 m^2 was considered available habitat (P_i). Standard errors (SE) were determined for the selection ratios using the equation:

$$SE = Wj \times \text{square root}(1/n_i - 1/n_t + 1/r_i - 1/r_t)$$

where:

n_i = number of used quadrats containing type i

n_t = total number of quadrats

r_i = number of available quadrats containing type i

r_t = total number of available quadrats.

To determine whether selection occurred for any of the habitat characteristics, we used the equation W_i = +/- Z x SE to calculate 95% confidence intervals. These were then used to determine whether the selection ratio was significant at the $P < 0.05$ level. Ratios with both lower and upper confidence intervals < 1 indicated negative selection, and those with both confidence intervals> I indicated positive selection. Values for which the lower confidence limit was < I and the upper confidence limit> I indicated that the habitat characteristic was used in proportion to its availability (i.e., no selection).

Results

Chatham petrel burrow density was linked significantly to several habitat characteristics (Table 2). Chatham petrels selected areas with a vegetation height of 11-20 m, canopy cover of 21-40%, northeastern aspects, and forest which contained 21-30% stems of 51-100 mm diameter at breast height (DBH). They selected sites near karamu *(Coprosma chathamica)* take-off trees of 16-30° lean, and areas where two logs per quadrat were present. Chatham petrels avoided sites at which ake ake predominated, where understory was 61-80%, and vegetation height was 0-5 m. They avoided areas where there were no stems as well as areas where the greatest proportion of stems were < 50 mm DBH, and 0-10% of stems were> 50 mm DBH. They also avoided areas with

whitey-wood *(Melicytus chathamica)* take-off trees and take-off trees with a lean of 0-5°.

Broad-billed prions selected a large number of habitat characteristics (Table 3). They selected mixed forest or areas in which matipo *(Myrsine chathamica)* dominated, where canopy cover was 61-80% and understory cover was 21-40%. They selected areas in which 41-60% of the stems were < 50 mm, 11-40% of stems were 50-99 mm and 11-30% and more than 40% of stems were> 100 mm DBH. They also selected areas where the take-off trees were predominantly ribbonwood *(Plagianthus regius),* ake ake, matipo, karamu, ngaio *(Myoporum laetum)* and whitey-wood that had a DBH of 50-200 mm and a lean of > 16°. They also selected eastern aspects with slopes of 11-40°, soft soils, and logs in the vicinity of the burrow. Broad-billed prions only avoided sites that were predominantly grass, karamu or flax *(Phormium tenax),* and areas with no take-off trees.

Discussion

Availability of suitable burrow sites may be important in limiting the expansion of seabird colonies and breeding success of individuals (Storey and Lien, 1985).As a result, there may be intense inter- and intra-specific competition for sites, with some individuals forced to nest in marginal sites and others unable to breed at all (Lack, 1968; Burger and Gochfield, 1988). Under such circumstances, species that are able to adapt are likely to oust others from particular habitat types (Lack, 1968).

Chatham petrel habitat selection was primarily influenced by forest type and structure, and the type of forest this species selected was indicative of mature forests. Their selection of karamu as take-off trees supports this view. Karamu was probably once a, but is currently only present as remnant trees (Wardle, 1991). Chatham petrels selected take-off trees with substantial lean as greater lean facilitates climbing. They avoided forests dominated by ake ake, and although it was probably an original species, it is now restricted to coastal fringes. Such areas may be unsuitable for petrel burrowing because of the exposure to extreme weather. Chatham petrels avoided areas with no stems, suggesting a need for some cover, for example, for aerial predator avoidance or shelter from adverse conditions (Spear and Anderson, 1989).

Like Chatham petrels, broad-billed prions preferred more mature forests of mixed size classes and avoided areas with high stem density. They required take-off trees but were more adaptable than Chatham petrels with respect to species and lean. Broad-billed prions were seen in both pohuehue and bracken, yet few burrows were found in these vegetation types and there was no preferential selection for this vegetative cover.

Topography and physical factors also influenced selection values. Chatham petrels selected a north-eastern aspect, while broad-billed prions selected an eastern aspect. While this study found that Chatham petrels did not select or avoid particular slopes, the selection values were positive for the steeper slopes, but because of the small sample size the values had large standard errors. Broad-billed prions also selected steeper slopes. Advantages of steep terrain over flatter ground may include rapid drainage, reduced burrow collapse and ease of excavation (Stokes and Boersma, 1991; Brandt *et al.,* 1995).

Burrow construction requires substantial excavation, and substrate stability and permeability will affect burrow quality and therefore influence burrow density (Stokes and Boersma, 1991). Many studies have shown burrowing seabirds prefer soft soils (e.g., Harris, 1974; Stokes and Boersma, 1991). While there was no correlation between soil compaction and Chatham petrel burrow density, broad-billed prions selected soft soils. These are a limited resource on South East Island due to regenerating forest, as soil becomes more compact as the number of stems increases.

The large number of variables avoided or selected by Chatham petrels suggests relatively high habitat specificity. Many of the features selected are now limited on South East Island. Mature forest was likely to have been more prominent on South East Island and throughout the Chatham Islands before farming began in the mid 1800s. Based on the small numbers of sub-fossil bones on Mangere Island, Chatham Islands (Tennyson and Millener, 1994), broad-billed prions were likely to have been less abundant on the Chatham Islands in the past. Mangere Island was predominantly forested but was cleared when farming began in 1892. Broad-billed prion numbers have since increased on Mangere Island (Tennyson and Millener, 1994). There is no information on the seabird communities on South East Island before farming, but broad-billed prions are likely to have followed the same trend given the similar farming history. Broad-billed prions selected most habitat characteristics, which suggests they are opportunistic and, with an expanding population, are fully utilising the available habitat range.

Understanding habitat selection of both species can assist future management. Modifying physical features to improve habitat quality may be useful in maximizing populations (Stokes and Boersma, 1991). When trying to reduce competition between a rare and an abundant species, it is important that habitat requirements are sufficiently understood to avoid disadvantaging the rare species with any changes (Feare *et al.,* 1997). With the relatively unmodified, old growth forest that Chatham petrels selected, few changes should or could be made. Due to the generalist behaviour of broad-billed prions and their high numbers, no differences in habitat selection

were identified that could disadvantage broad-billed prions and subsequently discourage them from the vicinity of Chatham petrel burrows.

The establishment of a second population of Chatham petrels is an essential long-term goal (Davis, 1999). Individual Chatham petrels probably still select burrow sites on the basis of habitat quality and as their preferred habitat is relatively specialised, it may limit colonisation and population growth.

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