WINTER COLONY ATTENDANCE BY ADULT SOUTHERN GIANT PETRELS *MACRONECTES GIGANTEUS*: IMPLICATIONS FOR RODENT ERADICATIONS

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Received 11 July, accepted 09 September 2021

ABSTRACT

RYAN, P.G. & OPPEL, S. 2022. Winter colony attendance by adult Southern Giant Petrels *Macronectes giganteus*: implications for rodent eradications. *Marine Ornithology* 50: 1–4.

Southern Giant Petrels *Macronectes giganteus* are partial migrants, but the proportion of adult males and females that visit the colony on Gough Island during winter is poorly defined. A better understanding of winter colony attendance is important to predict the possible impact of non-target mortality during restoration efforts involving poison baiting to eradicate introduced mammals. We repeatedly checked the individual identity of all giant petrels attending the largest breeding colony on Gough Island for rings during April–May 2021. Although the maximum number of individually identifiable ringed adults in a single check was 202, overall, 353 ringed adults were recorded, including almost 90% of the individuals that bred in 2020. Males were more likely to be present than females, but the ratio of males to females decreased from the end of April (3.24:1) to the latter half of May (1.25:1). Many birds were paired with their previous breeding partners by the end of May, despite egg laying not starting until late August. Our observations indicate that most adult Southern Giant Petrels are present at their breeding colonies on Gough Island three to four months before breeding, and are thus potentially susceptible to non-target poisoning during mammal eradication operations.

Key words: non-breeding behavior, sex roles, pair bonds, Gough Island

INTRODUCTION

Giant petrels *Macronectes* spp. are opportunistic predatory and scavenging seabirds that breed at islands in the Southern Ocean south to the coast of Antarctica (Marchant & Higgins 1990, Brooke 2004). At their breeding islands, they target a range of seabird prey and scavenge in seal colonies, but they also feed at sea, taking crustaceans, fish, squid, and other seabirds (Marchant & Higgins 1990, Gonzaléz-Solís *et al*. 2000). Their opportunistic diet, and in particular their scavenging behaviour on land, makes them vulnerable to non-target poisoning during island restoration operations that rely on the use of poison bait to eradicate introduced mammals. Both species of giant petrels were poisoned during the rodent eradication at South Georgia (Martin & Richardson 2017) and during the multi-faceted effort to rid Macquarie Island of rabbits and rodents (Springer & Carmichael 2012). Mortality was negligible at South Georgia (< 10 carcasses found; Martin & Richardson 2017), but at least 760 giant petrels, mainly Northern Giant Petrels *M. halli*, died during baiting at Macquarie Island, despite efforts to reduce the availability of carcasses and baiting in winter to minimise the risk to summer-breeding species such as giant petrels (Springer & Carmichael 2012). Fortunately, this mortality had no long-term impact on the island's Northern Giant Petrel population (Alderman *et al*. 2019).

Gough Island (40°S, 10°W) is the northernmost breeding colony of Southern Giant Petrels *Macronectes giganteus* (Johnstone *et al*. 1976), although giant petrels bred on the main island of Tristan da Cunha (37°S, 12°W) until the island was colonised by people in the 19th century (Wace & Holdgate 1976). House Mice *Mus musculus* were introduced accidentally to Gough Island during visits to exploit seals in the late 1700s or early 1800s (Ryan 2007). The severe impact of mice on breeding seabirds at Gough Island (e.g., Wanless *et al*. 2007, Dilley *et al*. 2015, Caravaggi *et al*. 2019, Jones *et al*. 2021) has prompted an effort to eradicate mice from the island (www.goughisland.com). The operational plan for the Gough Island Restoration Programme calls for poison baiting in winter, in part to reduce the risk to non-target species such as giant petrels and Brown Skuas *Stercorarius antarcticus* (McClelland 2019). However, the proportion of giant petrels attending colonies during winter, and their composition in terms of age and sex, is unclear.

The Southern Giant Petrel is a partial migrant (Marchant & Higgins 1990). Newly fledged juveniles disperse at sea, only returning to their colonies once they are three to four years of age (Conroy 1972). However, some adults remain around their breeding sites year-round, even at the southern limit of their breeding range in Antarctica (Mougin 1968). Geolocator tracking data for adult giant petrels breeding at Bird Island, South Georgia, indicate that male Southern Giant Petrels tend to remain closer to their breeding colony during winter than male Northern Giant Petrels, whereas females of both species disperse to an intermediate extent (Gonzaléz-Solís *et al*. 2008). However, these conclusions were based on modest sample sizes (11–15 males and females of each species), and even some male Southern Giant Petrels dispersed far from South Georgia, visiting the Falkland/Malvinas Islands and the Patagonian Shelf edge north to around 35°S (Gonzaléz-Solís *et al*. 2008). In preparation for the planned mouse eradication on Gough Island, winter counts of giant petrels were made at Low Hump, the largest breeding colony on the island. Both of these counts reported over 300 giant petrels: 328 on 29 May 2019 and 311 on 28 June 2019, indicating that a substantial proportion of adults winter on

the island, given a subsequent colony size of 233 breeding pairs in September 2019 (RSPB Centre for Conservation Science, unpubl. data). However, no attempt was made to determine the status of the birds present on the island during winter.

A better understanding of the ages and sexes of birds attending colonies in winter is needed to assess the possible demographic consequences of any non-target mortality caused by attempts to eradicate introduced mammals. We repeatedly identified all individually-marked giant petrels attending the Low Hump breeding colony on Gough Island during April–May 2021 to estimate the proportion of breeding males and females potentially at risk from poisoning during the mouse eradication attempt in June–August 2021.

STUDY AREA AND METHODS

Southern Giant Petrels breeding on the southwestern slopes of Low Hump, Gough Island (40.34°S, 9.94°W), have been studied annually since 2010 (Cooper & Parker 2012). Breeding adults are ringed with individual metal rings (right leg) and field-readable plastic rings (left leg), although rapid wear of the latter rings, especially on males, can render some rings hard to read (Cooper & Parker 2012). A few birds require the replacement of their plastic rings almost every year. Nests are marked with numbered poles at the start of egg laying in early September and are checked regularly through incubation to identify both partners at each nest. The fate of each nest is then followed, and chicks are ringed with a metal ring (left leg) prior to fledging in late February–March.

In most years, the colony has been confined to the border between fern bush and wet heath vegetation at around 350–400 m elevation, but since 2019, smaller numbers of pairs have started breeding higher on the ridge at around 450 m. In 2020, the colony was too large to easily monitor all nests (240 pairs), so only 176 nests in selected portions of the colony were numbered where most adults were ringed. However, nests in other areas were checked for ringed birds, with 357 plastic-ringed adults recorded in total (302 breeding at monitored nests, and 55 either loafing or breeding at other nests). We checked all giant petrels in the Low Hump colony to identify individuals using their unique ring numbers 10 times in April–May 2021 (Table 1). The total number of birds present was estimated on all visits, and we also checked birds for the presence of wing moult. Colony checks lasted roughly 2–4 h, depending on the number of birds. On one visit (24 May) the upper colony was checked twice, both on the way to and from the main colony area, to assess turnover of marked individuals within a few hours.

Pairs of birds that appeared to be holding a breeding site were recorded as being together. Giant petrels are the most sexually dimorphic of the Procellariiformes, with females having distinctly smaller bills than males (Marchant & Higgins 1990, Cooper & Parker 2012), which is particularly apparent when a pair is together. We were thus able to confidently sex almost all birds, either from observations during this study, or from observations during previous breeding seasons; only two newly-recruited birds were not sexed. We calculated the cumulative number of ringed adults recorded during successive visits, and the ratio of males to females during visits in late April (n = 1), early May (01–10 May, n = 1), mid-May (11–20 May, n = 4), and late May (21–30 May, n = 4). To estimate the sex ratio for mid- and late May, we used the cumulative number of birds of each sex across all four visits.

RESULTS

The estimated number of giant petrels present in the Low Hump colony during early winter ranged 80–325 birds, with numbers generally increasing from April through May (Table 1). However, time of day also seemed to play a role, with more birds typically present in the colony during the afternoon than in the morning (Table 1). Across all visits, 55%–70% of birds were identified

TABLE 1
Estimates of the numbers of Southern Giant Petrels *Macronectes giganteus* attending the Low Hump breeding colony on Gough Island in April–May 2021, and the number of birds identified from their field-readable plastic rings

Date	Time[a]	Number of birds present[b]			Number of plastic-ringed birds	
		Upper	Main	Total	No. resights[c]	Cumulative (2020 br)[d]
25 April	10h00	40	86	126	89	89 (86)
10 May	15h00	58	104	162	103	156 (144)
11 May	10h00	20	60	80	43	171 (156)
14 May	12h00	30	80	110	75	198 (179)
17 May	14h00	110	200	310	185	280 (256)
19 May	14h00	110	180	290	164	314 (284)
24 May	12h00	100	160	260	185	334 (303)
27 May	14h00	115	210	325	202	345 (312)
28 May	12h00	95	160	255	155	350 (317)
29 May	14h00	125	190	315	187	353 (319)

[a] Approximately at the mid-point of each survey.
[b] The total number of birds recorded per visit in the Low Hump breeding colony, including those recorded in the upper and main colony areas.
[c] The number of identified plastic-ringed birds seen in each survey.
[d] Cumulative number of all ringed individuals recorded in the colony (cumulative number of birds recorded in the colony during the 2020 breeding season).

from their field-readable plastic rings. The remaining birds were either unringed (typically 20%–25% of birds), had metal rings only (recent recruits to the colony that had been ringed as chicks since 2010, or birds ringed as adults, together comprising 5%–10% of birds), or were plastic-ringed individuals that could not be identified (5%–10% of birds). Birds holding nest sites were readily approached, whereas some birds that were 'floating' (either resting or interacting with other birds) flew off before the ring could be read. No birds were seen in active wing moult.

Even without disturbance from observers, there was regular movement of birds arriving at and departing from the colony, especially on windy days. This resulted in some turnover of ringed birds during each survey. For example, on 24 May, 55 ringed birds were identified in the upper colony on the first check and 59 on the second check, 3.5 h later. Of these, only 44 were seen on both checks, indicating at least 20% turnover. A few birds were also recorded in both the upper and main colonies on the same day, indicating local movements that would have required take-off and landing elsewhere.

Colony attendance varied considerably among individuals (Fig. 1); only one male was recorded on all 10 visits. Males tended to be recorded more often (mode = 5, average ± SD = 4.6 ± 1.7) than females (mode = 3, average ± SD = 3.5 ± 1.6), although these estimates are conservative given that up to 10% of plastic-ringed birds could not be identified on each visit. There were more males than females in the colony on each check. However, the ratio of males to females decreased markedly from late April (3.24 males per female, n = 89 birds) through early May (2.64, n = 102) to mid-May (1.25, n = 283) and late May (1.25, n = 329).

Although the maximum number of ringed birds identified in a single visit was 202 birds (on 27 May), the total number of plastic-ringed birds identified was 353 (Table 1). Of these, 319 (90.3%) were recorded in the colony in 2020, mostly as breeders (94%, n = 301), with the remainder loafing. This amounts to 89.4% of the 357 plastic-ringed birds recorded in the colony in 2020. Overall, 78% of birds were noted as paired with another bird at least once. Where a bird was recorded as paired at least twice, it was with the same partner in 92% of cases. Of these 'established' pairs, 52 were with the same bird they bred with in 2020. Twelve pairs involved a bird that bred in 2020 with a partner that was not recorded breeding in 2020 (but in several cases the partner in 2021 was recorded as loafing in the colony in 2020, and may well have been the mate, as not all mates were identified in 2020, especially at nests outside the core study area). Only four pairs indicated birds having acquired new partners, despite the presence of their 2020 partners in the colony in 2021 (two of these pairs involved first-time breeders in 2020), and one pair comprised two birds, neither of which was recorded in 2020.

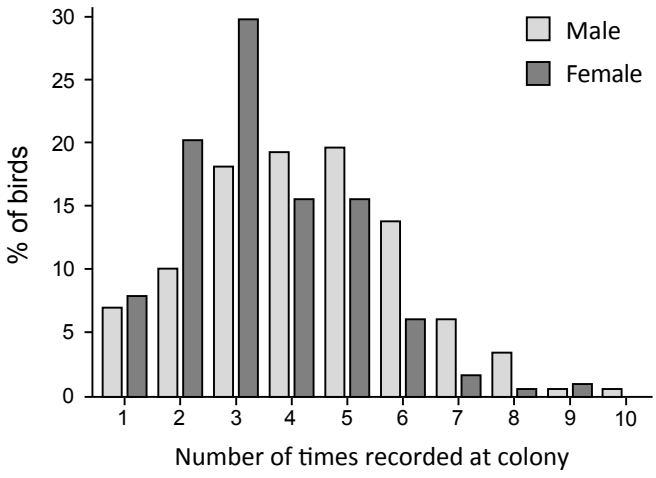

Fig. 1. The proportion of male (n = 195) and female (n = 160) Southern Giant Petrels *Macronectes giganteus* recorded one to 10 times at the Low Hump breeding colony on Gough Island during 10 colony checks in April–May 2021.

DISCUSSION

Our results show that almost all breeding adult Southern Giant Petrels in the Gough Island population are present in early winter. Each colony check continued to add new birds, and further checks would likely have increased the proportion of 2020 breeders over 90%, although the rate at which new birds were added at the end of May had fallen to < five birds per visit (Table 1). Many males were present at the colony by the end of April, and both sexes were present in almost equal numbers by mid-May. Given egg laying at Gough Island is in early September (Johnston *et al*. 1976), this is three to four months before the start of the breeding season. At Signy Island in the maritime Antarctic, Conroy (1972) recorded that Southern Giant Petrels return to the colony in July, with activity increasing through August and September. Egg laying at Signy Island occurs from early to mid-November (Conroy 1972), substantially later than at Gough Island, so the timing of colony return relative to the breeding season is similar at both sites. Conroy (1972) highlighted this early return to the colony, noting that it coincided with pupping by Weddell Seals *Leptonychotes weddellii*. However, at Gough Island, there is no obvious increase in local food availability during April–May.

Conroy (1972) did not report the sex of the birds attending the colony in July–August, merely noting that most birds were paired by the end of September, usually with the same mate from the previous year's breeding attempt (although both sexes would associate with other birds if their mate was absent). Our observations indicate that males return to the colony first, as is typical of many Procellariiformes. However, at Gough Island, females were almost as likely to be present in the colony as males from mid-May onwards. During the breeding season, adult females typically spend more time foraging at sea than males (Granroth-Wilding & Phillips 2019), but our results suggest that if this pattern persists in winter, it does not result in a markedly greater amount of time spent away from the colony.

All adults completed moulting their flight feathers by the time they returned to the colony (Conroy 1972, this study), a pattern that raises the question: why do giant petrels start to moult while breeding if they complete their moult three to four months before the next breeding season? However, there appears to be considerable variation in the timing of adult moult among colonies. Hunter (1984) found that male Southern Giant Petrels at South Georgia started primary moult during egg laying, and then suspended moult during the main chick rearing period, whereas females typically started to moult only after chick hatching. By comparison, successful breeders at Signy Island started moult in February, after the end of the brood-guard phase (Conroy 1972). The timing of moult at Gough is not well known, but no breeding birds have been observed to moult during the first half of incubation (PGR pers. obs). Given

that adult giant petrels at Gough Island are not migratory, and are therefore exposed to resource fluctuations around their breeding colony, it is plausible that the energetically demanding activities of breeding and moult are constrained to the same season in which there is abundant food supply (Bridge 2006). Further observations on the timing of moult in this species are needed.

It would be interesting to monitor colony attendance at Gough Island through late summer. Assuming birds are moulting at this time, they might well spend more time at sea. Failed breeders start to moult 4–6 weeks earlier than successful breeders at Signy Island (Conroy 1972), and Gonzaléz-Solís *et al*. (2008) found that failed breeders disperse much more widely than wintering adults. However, our main result indicates that winter baiting for a mouse eradication at Gough Island is likely to expose a high proportion of breeding adults to the risk of non-target poisoning. This finding has implications for planned eradication attempts at other giant petrel breeding sites such as Marion Island, where winter baiting is proposed, in part, to reduce non-target mortality (Parkes 2014). Our results also imply that colony attendance by adult giant petrels in the breeding season following an eradication attempt should provide a direct measure of mortality during the eradication.

ACKNOWLEDGEMENTS

We thank Amy King, Vonica Perold, Dylan Seaton, and Kim Stevens for assistance in the field; and Chris Jones, Alexis Osborne, Michelle Risi, Vonica Perold, Kim Stevens, and Roelf Daling who recorded breeding birds in 2020. This study forms part of the Gough Island Restoration Programme and was conducted with the support of Tristan's Conservation Department. We appreciate comments by Donna Patterson and John Cooper on an earlier draft of the manuscript.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Peter G. Ryan: Conceptualization, Investigation, Data analysis, Writing (original draft). Steffen Oppel: Investigation, Data analysis, Writing (review & editing).

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