



Field trials for the eradication of House Mice from South Georgia
Fieldwork Report March-April 2012 – RSPB/GSGSSI

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Published by the RSPB Conservation Science Department

RSPB Research Report No 48



Published by the Royal Society for the Protection of Birds,

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ISBN 978-1-905601-35-6

Recommended citation:

Cuthbert, R.J., Black, A., Rexer-Huber, K., Parker, G. and Sommer, E. (2012). Field trials for the eradication of House Mice from South Georgia. RSPB Research Report No. 48. Royal Society for the Protection of Birds, Sandy, Bedfordshire, UK. ISBN 978-1-905601-35-6

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Executive Summary

Fieldwork on South Georgia was undertaken during March and early April 2012 in support of the next stage of the rodent eradication programme that is being planned for 2013 by the South Georgia Heritage Trust (SGHT). Fieldwork took place on the Nuñez Peninsula and on Cape Rosa, which are the only two areas of South Georgia known to hold populations of House Mice *Mus musculus*. The main objective of the fieldwork was to evaluate the effectiveness of the proposed baiting strategy for eradicating mice, as well as gathering information on the density, distribution and ecology of house mice to further aid the eradication planning.

The key findings of the study were:

- Mice occurred at low densities, estimated to be around 2 mice/hectare in vegetated areas of tussac habitat, although higher densities of approximately 9 mice/hectare were recorded along a narrow shoreline fringe in some areas.
- Snap-trapping lines indicated that mice were present at similar levels in all vegetated habitats, with the exception of the coastal fringe (high numbers) and in tussac habitats that are heavily disturbed by seals where mice were found in low numbers. No mice were captured in higher altitude fell-field habitats including areas where this habitat was burrowed by diving petrels.
- Trapping indices from snap-trapping lines and baiting grids had mice capture rates of 3.4% and 1.7%, respectively. These rates of capture were markedly lower than found in an earlier study on the Nuñez Peninsula: comparison of the “bay mouth site” in Shallop Cove (same area as Grid 4 of our study) indicated capture rates of 23.3% in 1978 versus capture rate of 5.3% at this site in 2012.
- Mice on South Georgia were breeding during March, with 58% of mature females either pregnant or lactating. A higher proportion of mice on the Nuñez Peninsula were immature individuals in comparison to Cape Rosa (33% and 4% respectively) suggesting an earlier onset and/or more successful breeding at Nuñez.
- Limited numbers of mice could be caught and ear-tagged prior to bait spreading, however, data from four mice indicated relatively large movements of between 75-178m.
- Four study grids (two at each site) were baited with non-toxic bait pellets at application rates of 8 kg/ha or 4 kg/ha. Of the 38 mice captured after baiting, 37 had consumed bait pellets, as revealed by the presence of florescent pyridine dye, giving an overall uptake rate of 97%. Evidence for relatively large movements of mice in the trapping grids makes it plausible that the single mouse negative for bait had moved in to the grid from outside

the baited area, although the possibility that it was a resident mouse that did not consume bait cannot be excluded.

- Rates of bait depletion on the trapping grids indicated an average rate of bait consumption of 0.079 ± 0.014 kg/hectare/day during the 7 days after bait spreading. Based on the upper 95% confidence limit of this rate, bait should be depleted to around 6.8 kg/ha and 2.8 kg/ha after ten days for initial baiting rates of 8 kg/ha and 4 kg/ha, respectively, excluding climatic or other events that may remove bait.
- Heavy snowfalls occurred in March that covered bait pellets for up to four days and appeared to limit the activity of mice.

Based on these results we conclude for the proposed eradication operation that:

- The proposed bait application rate of 8 kg/ha in vegetated areas appears to be more than adequate for the densities of mice encountered in vegetated areas of our study and a lower bait application rate could be considered, such as the 4 kg/ha tested at two sites.
- Mice were not captured in higher altitude areas of fell-field habitat and are either absent or occur in very low numbers in these areas. Consequently, a lower bait application rate is justified for upland fell-field habitats in comparison to vegetated areas.
- High densities of mice occurred in a narrow coastal fringe and special treatment of the shoreline (as will occur if helicopters spread bait around the perimeter of the baiting zones) should be undertaken to ensure complete coverage of these higher density areas.
- Mice were breeding during March on South Georgia and consequently it is possible that young mice may emerge from nests some time after the initial bait drop. However, given the bait depletion rates observed in this study it is likely that significant quantities of bait will be remaining on the ground ten or more days after the bait application.
- If a second application of bait is planned then it is likely that its main benefit would be to limit gaps in coverage rather than replacing bait that has been consumed. Consequently a lower baiting rate could be considered for a second drop.
- While the results of this study have increased our knowledge of mice on South Georgia necessary caution should be applied due to the low numbers of mice captured, the absence of 100% bait uptake by mice on the trapping grids, and an indication that in some years mice appear to be present in higher numbers than found during 2012.

Other fieldwork was conducted during the research expedition and the following results were found:

- Kerguelen Petrels *Lugensa brevirostris* were found occupying burrows, calling and displaying at Shallop Cove, Nuñez Peninsula. This discovery increases the number of bird species breeding on South Georgia to 30 and extends the breeding range of this species by more than 2,500 kilometres.
- Counts of breeding Wandering Albatross *Diomedea exulans* at Prion Island on the 29 March 2012 indicated 26 hatched chicks from the 28 birds that were recorded incubating during January.
- A bait palatability trial was undertaken on the 2-3 April 2012 at the Barff Peninsula to investigate if Reindeer *Rangifer tarandus* were likely to consume bait pellets. Observations were made of two animals that were seen feeding near but were not observed eating pellets. Heavy snowfall on the night of the 3 April precluded any further observation and these results are not conclusive.
- Monitoring of 46 rodent monitoring wax tags on the coastal fringe and in inland tussock areas of the Greene Peninsula was undertaken on the 2-3 April 2012. These checks revealed no evidence of rat activity during this month, more than one year after baiting of this area.

Acknowledgements

The project was funded by the UK Government's Darwin Initiative Programme under grant 18-017 "Developing knowledge to eradicate house mice from UK OT islands", which is administered and managed by the Royal Society for the Protection of Birds. Further support for the project was provided by GSGSSI in the form of camping and fieldwork equipment following a grant from the UK Government's Overseas Territories Environment Programme (OTEP). Our thanks go to St John Payne GSGSSI Fisheries Officer and to the Master and crew of the FPV *Pharos SG* for the logistical support they provided in landing and picking us up from fieldwork sites, and for daily communications while in the field. Thanks to the British Antarctic Survey staff at King Edward Point for further support with equipment, making us welcome on base and for boat transport to the Green and Barff Peninsulas. Thanks to Nigel Butcher, Tracy Winn and James Millett at the RSPB for assistance in ordering and sending equipment, to South Atlantic Trading for shipping of gear, to Tony Martin of SGHT for ordering and arranging couriership of bait, to Derek Brown, Nick Torr, Sally Poncet, Darren Christie and Tony Martin for providing helpful comments on the fieldwork plans, and to Martin Collins for accommodation in Port Stanley and logistical support.

Background

In 2010 the South Georgia Heritage Trust (SGHT) embarked on an ambitious programme of work to eradicate invasive rodents from South Georgia, with an aerial application of rodenticide bait pellets spread on the Thatcher, Greene and Mercer Peninsulas. The objective of this baiting operation was to test the effectiveness of the baiting strategy at eradicating Brown Rats *Rattus norvegicus* prior to undertaking the eradication of rats from the whole of South Georgia in 2013 and 2014. Rats have been present on South Georgia since around 1800 (Matthews 1931) and have had a very detrimental impact on a wide range of bird species. On South Georgia rats are active predators of eggs and chicks of burrowing petrels including Common Diving Petrels *Pelecanoides urinatrix exsul*, South Georgia Diving Petrels *Pelecanoides georgicus*, Antarctic Prions *Pachyptila desolata* and Blue Petrels *Halobaena caerulea*, as well as predators of the endemic ground-nesting South Georgia Pipit *Anthus antarcticus* and Yellow-billed Pintail *Anas georgica georgiana* (Pye & Bonner 1980; Prince & Poncet 1996; Poncet 2000). As a result of their impact burrowing petrels and South Georgian Pipits are absent or only occur at very low numbers in areas where rats are present.

As well as eradicating rats from South Georgia the SGHT also plan to eradicate House Mice *Mus musculus* from the island. Mice are only known to occur at Cape Rosa and the Nuñez Peninsula on the south coast of South Georgia and the species' presence on the island was only discovered in 1976 (Bonner and Leader-Williams 1977). It is likely that they became established in the 19th Century during whaling and sealing operations on the island (Berry *et al.* 1979). The impact of mice on the wildlife of South Georgia is likely to be less than that imposed by rats, as at both Nuñez and Rosa good populations of burrowing petrels and South Georgia Pipits exist (Cook *et al.* 2010). While this is the case it is likely that mice will be impacting on invertebrates and plant communities as these are likely to be the principal food source of mice in these areas (Smith *et al.* 2002; Jones *et al.* 2003; Russell 2012). It is also possible that mice on South Georgia may be predated chicks of burrowing petrels and ground nesting passerines, as has been found for mice at Gough Island and Marion Island (Cuthbert and Hilton 2004; Wanless *et al.* 2007; Jones and Ryan 2010) and more recently at Steeple Jason in the Falklands (Bolton and Stanbury 2011). The common factor linking these islands is the presence of mice as the sole introduced species of mammal, and it is hypothesised that mice may have a greater impact when they are present on their own (Wanless *et al.* 2007); as is the case for Cape Rosa and the Nuñez Peninsula. While it is not yet apparent if mice are having a major detrimental impact on South Georgia their eradication from the island will nonetheless be an important step towards restoring the natural ecology of the island and these areas will be targeted during Phase II of the restoration programme.

The eradication of rodents from islands has become an important field of conservation management and in the last decades has been lead by work in New Zealand (Howald *et al.* 2007). Typically large islands are cleared by spreading bait pellets containing brodifacoum or other anti-coagulant toxin from helicopters flying along GPS guided flight-lines to ensure no gaps in coverage (e.g. Golding 2010). By 2007 a total of at least 318 islands had been cleared of rats (*Rattus* spp.) with a reported success rate of 92.4% (Howald *et al.* 2007). In comparison to rats, mice have been eradicated from far fewer islands and with a lower rate of success (30 islands as of 2007 and a success rate of 77%; Howald *et al.* 2007), and the area from which mice have been successfully eradicated is smaller (3,800 Rangitoto-Motutapu islands versus 11,300 ha Campbell Island; McClelland and Tyree 2002; N. Torr *pers. com*). The reasons behind this lower rate of success are unknown, however in comparison to rats mice range over smaller areas (RJC unpublished data; Russell 2012), are less likely to cache and consume large quantities of bait upon first encountering it, and require a higher dosage of toxin to cause mortality (Cuthbert *et al.* 2011a): all of these factors on their own or in combination could be responsible for the lower rates of success.

In order to treat the Cape Rosa and Nuñez Peninsula the SGHT, following advice and discussion with New Zealand's Department of Conservation Island Eradication Advisory Group (IEAG), has proposed two bait drops (spaced a minimum of 10 days apart) using identical bait applications rates set at 8 kg/ha in vegetated areas, 3 kg/ha in non-vegetated areas and an additional coastal swath at 3 kg/ha. These application rates are higher than that used on the Thatcher, Greene and Mercer Peninsulas where rats were the target species. The higher application rate for mice has been set in order to attempt to overcome the lower success rate of mice eradications.

To provide further confidence that this baiting strategy is likely to be effective at eradicating mice from South Georgia and other islands the Royal Society for the Protection of Birds (RSPB) is managing a grant from the UK Government's Darwin Initiative entitled "*Developing knowledge to eradicate house mice from UK OT islands*". This project is working at three UK Overseas Territories: Tristan da Cunha (Gough Island), Falkland Islands (Steeple Jason Island) and South Georgia, which all contain islands or peninsulas where plans are being made to eradicate invasive House Mice. As part of the project fieldwork was planned for South Georgia during the austral summer of 2012 in order to undertake baiting trials for mice and provide more knowledge on the distribution and ecology of mice in these areas. Baiting trials have been undertaken at a number of islands prior to going ahead with the eradication operation, including at Campbell Island (P. McClelland *pers. com.*), Gough Island (Wanless *et al.* 2008; Cuthbert *et al.* 2011b), and Henderson Island (Cuthbert *et al.* 2012).

Goal and Objectives

The goal of the fieldwork on South Georgia was to:

Evaluate the effectiveness of the proposed SGHT baiting strategy in order to achieve the eradication of House Mice on South Georgia

Specific objectives of the mouse work included:

1. Assess the proportion of mice consuming bait under different baiting regimes over 4 separate bait uptake trials,
2. Determine population density of mice on the two peninsulas,
3. Assess the distribution and relative abundance of mice within key habitats,
4. Collect mouse tissue, plant, bird and invertebrate samples for stable isotopes,
5. Collect reference DNA samples of mice populations from both peninsulas.

As well as undertaking the objectives described above the project also aimed to:

6. Undertake any observations and monitoring that further knowledge of the avifauna of South Georgia and that can support the work of GSGSSI and the SGHT.

The latter objectives included counts of breeding Wandering Albatrosses *Diomedea exulans*, observations of Kerguelen Petrels *Pterodroma brevirostris*, checking for rat sign on the Greene Peninsula and a visit to the Barff Peninsula for a Reindeer bait palatability trial *Rangifer tarandus*. These results and the methods involved are detailed separately in Outputs 2-5.

Study sites

The main fieldwork was undertaken at Cape Rosa and on the Nuñez Peninsula, the two areas of South Georgia where mice are known to occur (Figure 1). Landings were made at a small sheltered beach in King Haakon Bay on Cape Rosa and at Shallop Cove on the Nuñez Peninsula. Camp sites were established in areas of relatively sheltered ground 100-200 m behind the beach landing sites. Depots of food and equipment were left above the upper tide line of the beaches at both sites. Most fieldwork was undertaken in areas of tussac (dominated by Tussac Grass *Parodiochloa flabellata*) where we predicted mice were most likely to be occurring, but further trapping was undertaken along the beaches and in areas utilised by seals, as well as at higher altitude sites where low vegetation and rock and scree dominated. At the Nuñez Peninsula fieldwork occurred in areas close to the camp site at Shallop Cove and at Holmestrand Bay, which was reached after crossing the neck of the peninsula in around a one

hour walk from the camp. Additional work on South Georgia was undertaken at Prion Island, and at the Greene and Barff Peninsulas .

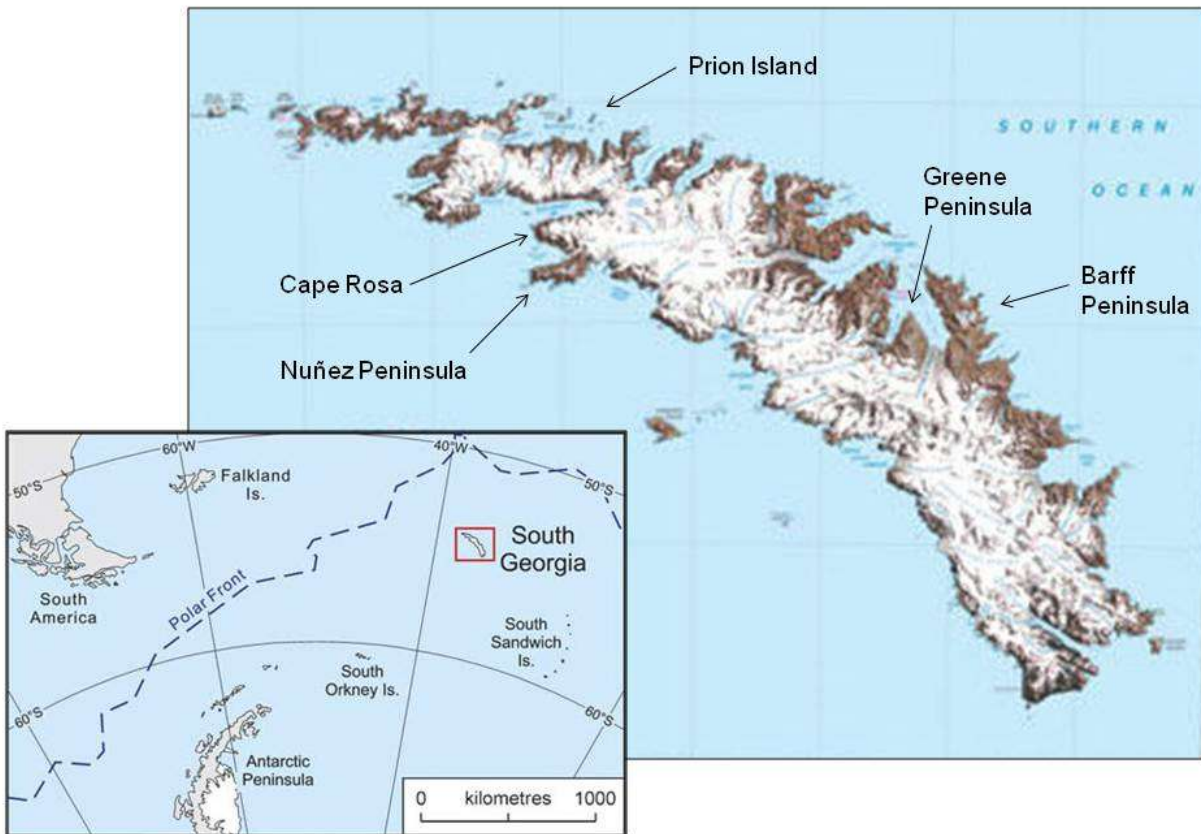


Figure 1 Map of South Georgia indicating the location of the island within the Southern Ocean, the location of the two main study sites at Cape Rosa and the Nuñez Peninsula, and additional fieldwork sites at Prion Island and the Greene and Barff Peninsulas.

Field team

The field team consisted of five personnel: Richard Cuthbert (RSPB), Erica Sommer (RSPB), Andy Black (GSGSSI), Kalinka Rexer-Huber (GSGSSI) and Graham Parker (GSGSSI), and were supported by St John Payne (GSGSSI Fisheries Officer) and the Master and crew of the GSGSSI's fisheries patrol vessel the *Pharos SG*.



Figure 2 South Georgia 2012 mice research team on a rare warm day (from left to right: Kalinka Rexer-Huber, Richard Cuthbert, Erica Sommer, Graham Parker and Andy Black).

Timing of fieldwork

The team arrived at King Edward Point, South Georgia on 3rd March 2012 and were landed ashore at Cape Rosa on the 4th March. Eleven days were spent ashore at Cape Rosa before being picked up and transferred to the Nuñez Peninsula on 15th March, where fieldwork was undertaken for 14 days before being picked up on the 28th March. A further seven days were spent in and around King Edward Point which included visits to Prion Island and the Greene and Barff Peninsulas. A full time-table of the fieldwork is detailed in Appendix 1.

Output 1 Mice research on Cape Rosa and the Nuñez Peninsula

Fieldwork methods

Study sites

At both Cape Rosa and the Nuñez Peninsula we selected two sites to form the main study areas, with four trapping grids in total. These trapping grids ranged from 6 – 9 ha in area. The four trapping grids were selected to be representative of the vegetated coastal fringe of Cape Rosa and Nuñez, as well as being sufficiently large to encompass the trapping grid (200 x 200 m) and baiting area (300 x 300 m). All four grids encompassed a range of habitats including: burrowed and unburrowed tussock, areas of low lying vegetation (a mixture of *Acaena*, grasses and moss), tussock containing breeding populations of Gentoo Penguin *Pygoscelis papua*, Antarctic Fur Seals *Arctocephalus gazella* and Southern Elephant Seals *Mirounga leonine*, shoreline habitats, and areas of rock and scree (fell-field). Tussock, burrowed or unburrowed by breeding petrels, was the main habitat within the grids, as this is the major vegetation type and we predicted most mice would be occurring in these areas. The four trapping grids are indicated in Figures 3-5. Further sampling of mice was undertaken through snap-trapping lines that were spread out over both peninsulas and encompassed a wide range of habitat types.



Figure 3 The main study sites at Cape Rosa with Grid 1 located in the area of tussock in the foreground and Grid 2 located just beyond the sun lit area of tussock behind the landing bay.



Figure 4 The landing beach on the Shallop Cove side of the Nuñez Peninsula with Grid 3 located on the vegetated hill side in the centre of the image.



Figure 5 Bordering Grid 4 on the Nuñez Peninsula and Graham with a rare mouse.

Bait trials

In order to test if all mice can be exposed to toxic bait pellets we undertook bait uptake trials at both sites, whereby non-toxic bait (manufactured by Bell Laboratories, Madison, Wisconsin, USA, and with the same formulation as toxic bait) containing the bio-marker pyridine was spread at set densities and mice were then caught 1-4 days after spreading in order to evaluate if they had or had not consumed pellets. Four trials were run in total, with two trials undertaken at Cape Rosa and two at Nuñez Peninsula (Figures 6 and 7). Bait was spread at the proposed baiting rate of 8 kg/ha in the first trial at each site, however due to the very low numbers of mice encountered the second trial at both sites was run with a baiting rate of 4 kg/ha. The first three trials (two on Rosa and one on Nuñez) each covered 9.0 ha area (300 x 300 m) with a core central area of 3.7-4.2 ha (*ca.* 200 x 200 m) where trapping was undertaken, and a buffer area 50 m in width on all sides. The fourth trial at Nuñez was conducted over a smaller area (5.2 ha) with dimensions of *ca.* 400 x 140 m and a central core area of 3.2 ha. The boundary area of Grid 4 was again 50 m but this was only placed on three sides as the fourth side core area was the shoreline. Live trapping of mice was undertaken at Grid 1 and Grid 2 (on Rosa) and Grid 3 (at Nuñez), however due to the very low number of mice captured live-trapping this was only continued for one night on Grid 2 and was not undertaken on Grid 4 (Nuñez). Aluminium Sherman traps (HB Sherman, Florida, USA), plastic "Trip Traps" (Proctor Bros Ltd, Caerphilly, UK) and metal multi-catch traps (Proctor Bros Ltd, Caerphilly, UK) were used for live-trapping, all baited with a mixture of peanut butter and oats. All live traps were provided with a mix of dry grass and polyester stuffing, in order to provide insulation to mice trapped overnight and reduce the risk of any deaths. Live-traps were set out on a 20 x 20 m grid with 121 traps distributed over the 200 x 200 m core central area and were run for three consecutive nights. Prior to release mice captured in live-traps were sexed and fitted with an individually numbered ear-tag (Vet Tech Solutions, UK) in each ear.

After live-trapping was completed bait was spread at the target baiting densities of 4 or 8 kg/ha. To mimic an aerial baiting operation, bait was hand broadcast on a 20 x 20 m grid preset on a handheld GPS. Bait was spread over the whole of the grid covering both the core central trapping grid and the outer buffer area. At each waypoint, a fixed volume of bait (corresponding to the required bait application rate) was scooped into a measuring jug and spread in all directions within an 8-12 m radius of the point. At the end of each baiting session the total mass of bait broadcast was weighed in order to calculate the actual bait application rate versus the targeted bait rate. To monitor the persistence of bait within the trapping grids a single bait pellet was placed alongside each of the trap stations within the grid and their presence/absence was recorded over the period of trapping (with the exception of days of heavy snowfall that buried the bait).

Following baiting the sites were trapped with a mix of live-traps (as detailed in the previous section) and Victor Easy Set snap-traps (Victorpest, Lititz, Pennsylvania, USA) and Snap-E mouse traps (Kness Manufacturing Company Inc, Albia, Iowa, USA), with two traps (one live-trap and one-kill trap) located at each 20 m interval. Kill-trapping for mice began 24 hours after baiting at Sites 1, 2 and 3 but was delayed until 48 hours after baiting at Site 4 due to heavy snowfall in the first 24 hours after baiting this site. Mice caught in live traps were euthanised and after capture all dead mice were labelled and placed in individual re-sealable plastic bags. The mouth parts, anus, intestines and hind and fore feet of all mice were then examined with an ultraviolet light to determine if pyridine dye from the bait was present or absent.

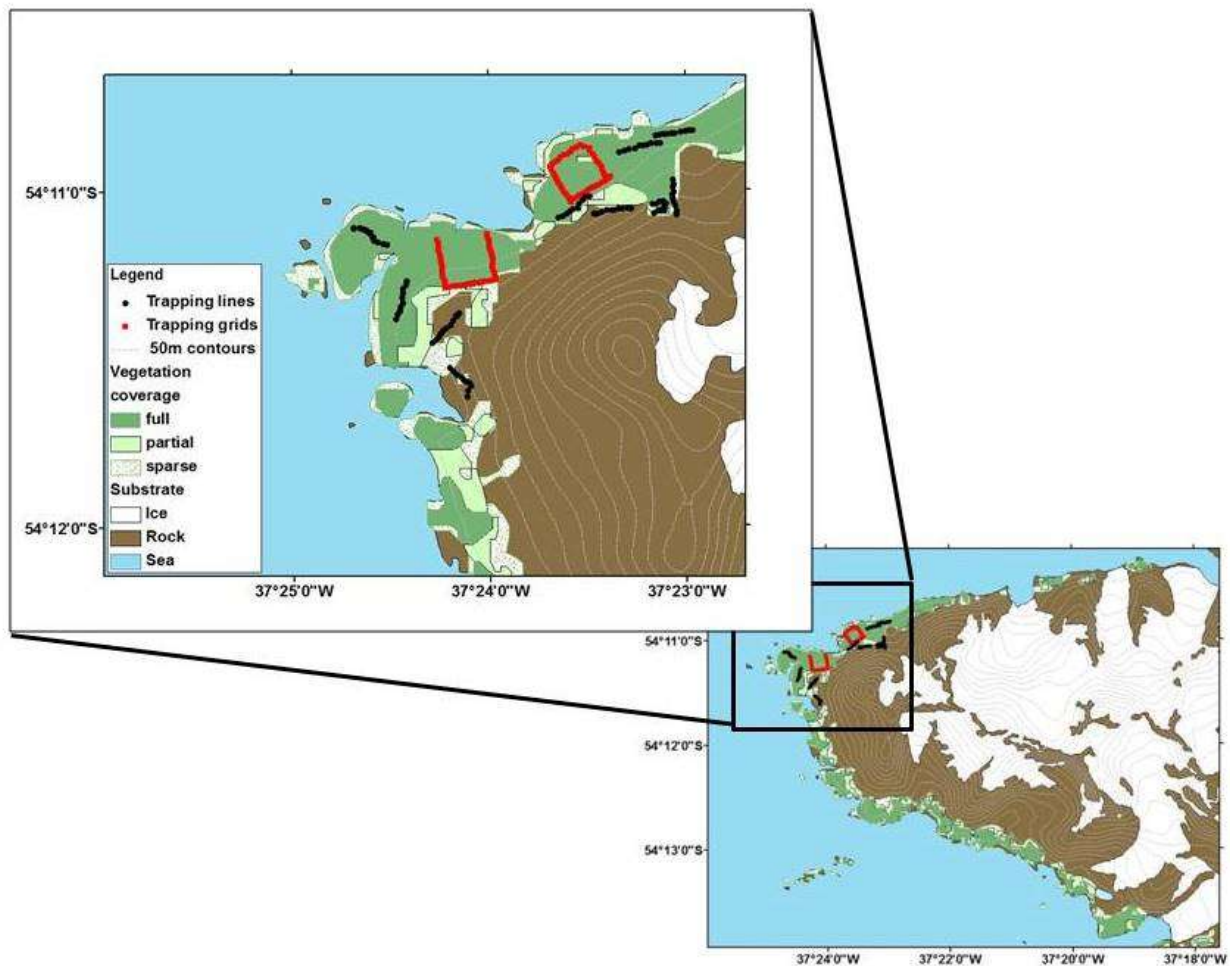


Figure 6 Map of Cape Rosa indicating the external boundaries of the trapping grids (red squares), snap-trapping lines (black lines), major habitat types.

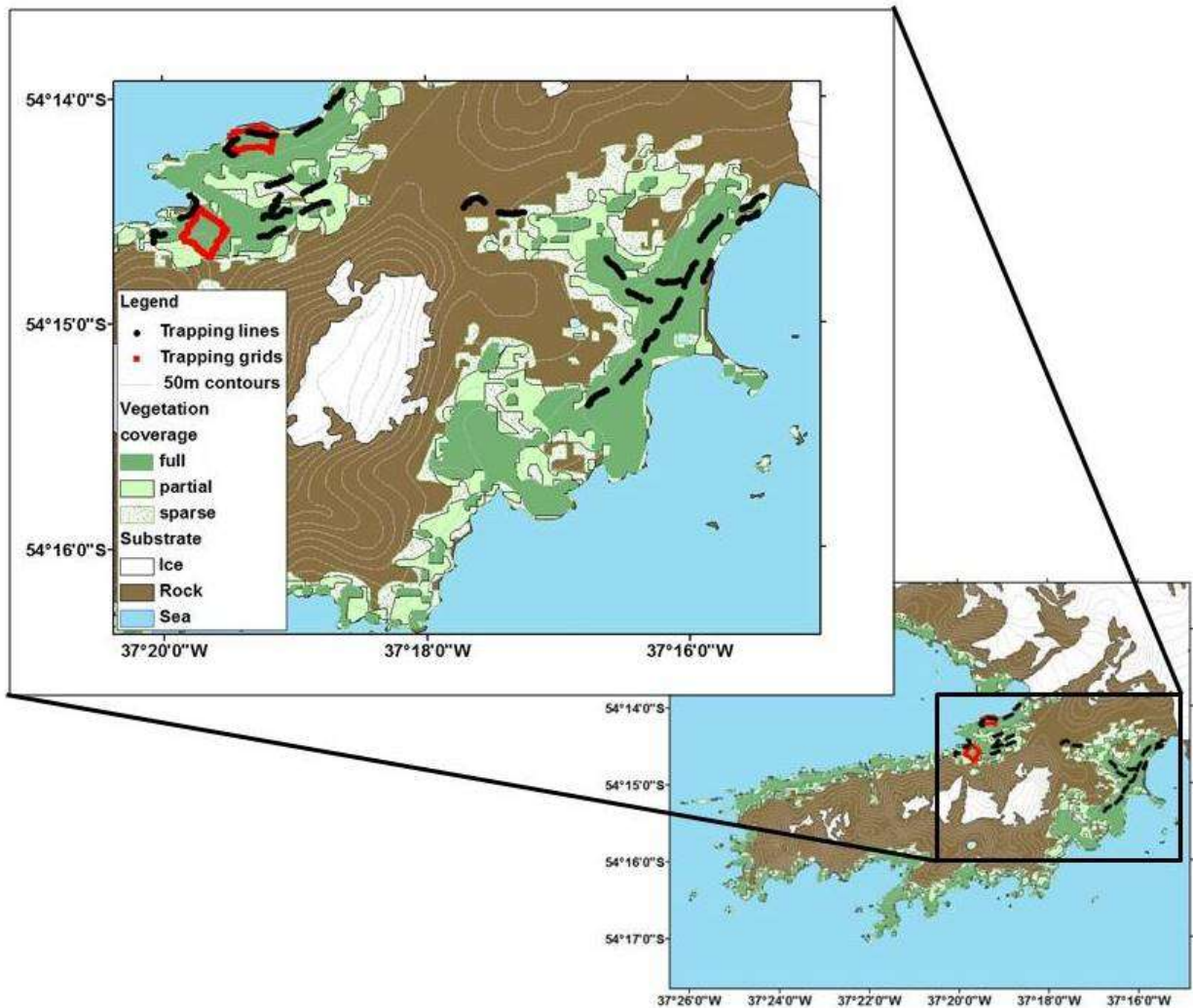


Figure 7 Map of Nuñez Peninsula indicating the external boundaries of the trapping grids (red squares), snap-trapping lines (black lines), major habitat types.

Distribution and abundance

Kill-trapping of mice was undertaken on snap-trapping lines that were distributed within different areas of habitats at each study site. Snap-trapping lines consisted of 10 traps spaced 25-30m running on transect lines through different habitats. Each snap-trapping line was spaced >200 m from any neighbouring lines. These snap-trapping lines were distributed widely across both study sites (Figures 6 & 7) and were spread across a range of habitats types ranging from the shore-line to higher altitude scree and bare-rock 150-250 m above sea level.

Snap-trapping lines were run for three consecutive nights at all sites, with the exception of one line that was run for four nights. Kill traps, either Snap-E traps or Victor traps, were used on the transect lines. To reduce the risk of killing South Georgian Pipits or Yellow-billed Pintail chicks all kill traps were covered, either within the tunnels they were purchased with (Snap-E trap covers) or with a sheet of corrugated plastic signed board ("Coreflute") that was bent in to a U shape and pinned to the ground with metal pegs and/or weighed down with rocks. All kill traps were covered on snap-trapping lines as well as during snap-trapping of the baiting grids.

Mice ecology

All mice caught in the study, from both trapping grids and transect lines, were sexed and assigned to adult or immature status on the basis of external or internal testes for males, and perforate or imperforate vagina for females. All mice were weighed on an electronic balance (to the nearest 0.1 g) and measured (body and tail length to 1 mm on a stopped rule, hind foot length, ear length and head length to 0.1 mm with Vernier callipers). All perforate females were further examined to determine if they were pregnant or lactating, and the number of developing embryos and suckled teats was recorded.

Stable-isotope and genetic sampling

Samples for stable-isotope analysis were collected from all mice by collecting *ca* ¼ to ½ of the liver and removing a single rear leg (in order to sample fur, muscle and bone tissues). A sample of tail tissue (the distal 20-25 mm) was collected to provide a genetic sample from all mice. All samples were stored in 100% ethanol. Additional samples for stable isotope analysis were collected from the remains of burrowing petrels (feathers and muscle tissues) found at the sites (usually collected from territories of Subantarctic Skuas *Catharacta Antarctica lonnbergi*), from feathers shed by nesting Northern Giant Petrels *Macronectes halli* and from moulting Gentoo Penguins. Further isotope samples were taken by collecting invertebrates, and sampling seeds and leaves from the dominant plant species within the trapping grids. Stable isotope samples and reference genetic samples were collected from 68 mice in total, with 45 collected from the Nuñez Peninsula and 23 from Cape Rosa. Analysis of stable-isotope and genetic samples will be undertaken in due course in collaboration with other researchers, and the results of this side of the work are not presented in this report.

Results

Mouse bait trials

Live trapping of mice prior to baiting was undertaken during three of the four bait trials, with grids of 121 traps run for three nights and for Grid 1 (at Rosa) and Grid 3 (on Nuñez), and one night on Grid 2. Despite this trapping effort (traps were open 24 hours) very few mice were captured, with just one mouse caught at Grid 1 and three caught at Grid 3 (Table 1). Due to the low number of captures and time constraints on the fieldwork live-trapping was only undertaken for one night on Grid 2 (Rosa) and not at all on Grid 4 (Nuñez). Of the four mice caught in live-traps and ear-tagged, only two mice, both on Grid 3, were recaptured.

Table 1 Numbers of mice live-trapped and tagged, numbers recaptured, numbers kill-trapped and combined total number positive for bait and percentage positive for bait for each grid and over all four grids

| | Mice live-trapped and ear-tagged | Mice re- captured | Kill trapped | Bait positive | % positive |
|--------|-------------------------------------|----------------------|--------------|---------------|------------|
| Grid 1 | 1 | 0 | 16 | 15 | 0.94 |
| Grid 2 | 0 | - | 1 | 1 | 1.00 |
| Grid 3 | 3 | 2 | 5 | 5 | 1.00 |
| Grid 4 | - | - | 16 | 16 | 1.00 |
| Total | 4 | 2 | 38 | 37 | 0.97 |

Snap-trapping of mice after baiting was undertaken for three nights at all sites with the exception of Grid 3 that was run for five consecutive nights. In total 38 mice were kill-trapped, although numbers varied between sites (Table 1). Of the 38 mice captured after baiting 37 (97%) were positive for bait with pyridine dye clearly visible in the intestines and at the anus. However one mouse on Grid 1 was negative for bait. With 38 mice captured in total the dichotomous 95% confidence limits on the proportion of mice positive for bait (97%) range from a lower limit of 86.2% to an upper limit of 99.9%.

Both of the mice that were ear-tagged and subsequently recaptured were positive for bait. These two mice were re-caught at distances of 96m and 178m from their original capture site, indicating relatively large movements for these individuals. A further four mice were captured on a snap-trapping line relatively close to the outer baiting areas of Grid 3 at Nuñez Peninsula,

and two of these mice were positive for bait. These two mice had made minimum movements of 75m and 82 m from the baiting area to their trapping sites.

Bait persistence

The persistence of bait on the trapping grid was recorded by placing a bait pellet at each trapping station and checking for the presence or absence of pellets over the duration of the trapping period. During periods when snow covered the ground pellets were not systematically checked and data for these days are not utilised in the analysis. Bait remained on the four grids throughout the trapping period (up to seven days; Figure 8) and was consumed at an average rate of 0.92% and 2.13% per day for grids baited at 8 kg/ha and 4 kg/ha, respectively (Table 2). The upper 95% confidence limit for these rates of bait consumption were 1.36% and 3.43% respectively.

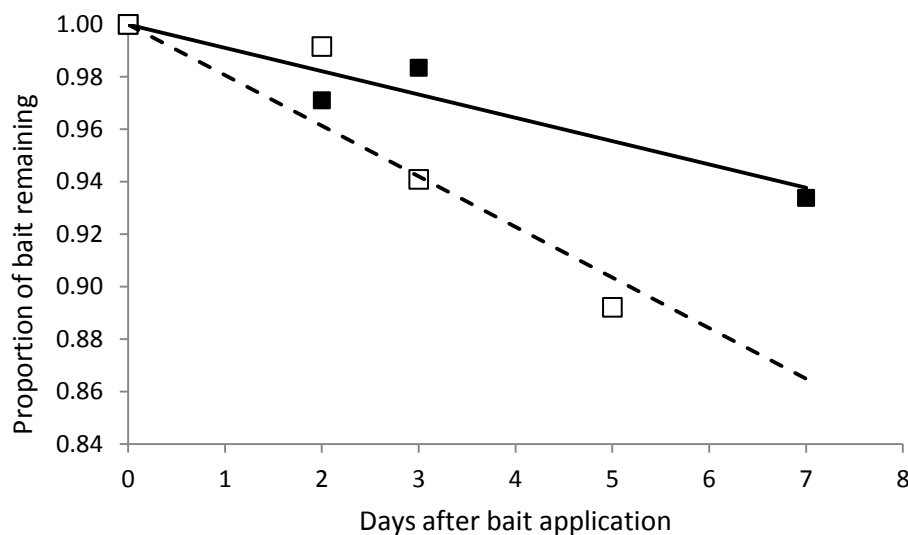


Figure 8 Proportion of bait remaining after bait application at 8 kg/ha (filled squares and solid line) and bait application at 4 kg/ha (unfilled squares and dashed line)

These percentage consumption rates are converted in to the equivalent mass of bait removed per hectare per day in Table 2, providing a mean consumption rate 0.079 ± 0.014 kg/ha/day. If the rates of bait consumption are representative of tussac habitat on Cape Rosa and Nuñez and if a constant mass is removed each day then after six days (the median time to death for mice exposed to brodifacoum baits; Cuthbert *et al.* 2011) bait should be remaining at around 7.52 kg/ha and 3.52 kg/ha for baiting rates of 8 kg/ha and 4 kg/ha respectively (based on the mean consumption rate of 0.079 kg/ha/day). Using the upper 95% rate of removal, bait should be

depleted to 7.26 and 3.26 kg/ha respectively after six days. If bait were to continue to be consumed at the same rate (which is unlikely as the vast majority of mice will be dead after 10 days (Cuthbert *et al.* 2011) then after 10 days bait and using the upper 95% confidence interval of the bait consumption rate, then 6.8 kg/ha and 2.8 kg/ha of bait should be remaining after 10 days for initial baiting rates of 8 kg/ha and 4 kg/ha, respectively. These estimates of bait remaining exclude climatic events such as heavy rainfall or any other factors that may wash away or remove bait.

Table 2 Estimated rate of bait consumption \pm one standard error and upper 95% confidence limit and estimated mass of bait consumed for initial baiting rates of 8 kg/ha and 4 kg/ha and the estimated mean consumption for all four sites

| | Bait consumption %/day | | Mass consumed kg/ha/day | |
|---------|------------------------|----------------|-------------------------|----------------|
| | Est rate | Upper 95% rate | Est rate | Upper 95% rate |
| 8 kg/ha | 0.92 \pm 0.16% | 1.36% | 0.074 \pm 0.013 | 0.108 |
| 4 kg/ha | 2.13 \pm 0.41% | 3.43% | 0.085 \pm 0.016 | 0.137 |
| Mean | - | - | 0.079 \pm 0.014 | 0.123 |

Estimated mice density

Too few mice were captured on the trapping grids to utilise mark-recapture methods as originally intended, instead mice densities were estimated using removal sampling (the Hayne method; Hayne 1949). Because so few captures were made on each grid the four grids were pooled and the estimated population was divided by the total area of all four trapping grids to provide a density estimate. Based on the Y intercept of Figure 9 there were an estimated 31 mice within the four trapping grids (the lower and upper 95% confidence limits of this intercept are 29 – 34). Based on the area of all four trapping grids mice densities in vegetated areas of Rosa and Nuñez are around 2.1 \pm 0.1 mice/ha (95% CI 1.9 – 2.3 mice/ha).

Results from snap-trapping lines on the Shallop Cove side of the Nuñez Peninsula indicated that the majority of captures were on trap-lines close to the shore line (see next section). This result was confirmed on Grid 4 on the Nuñez Peninsula where the majority of captures (94%) were made from traps situated on the shore line (10 mice captured) and 20 m from the shoreline (5 mice). In contrast only one further mouse was captured from the grid for traps set 40-120m from the shoreline. Using data from these two trapping lines on Grid 3 and from four snap-

trapping lines on the shore line of Shallop Cove, and assuming an effective trapping width of 30 m, produces an estimated density (using the removal sampling method) of around 8.6 ± 0.8 mice/ha in these coastal areas (95% CI 5.0 – 12.2 mice/ha).

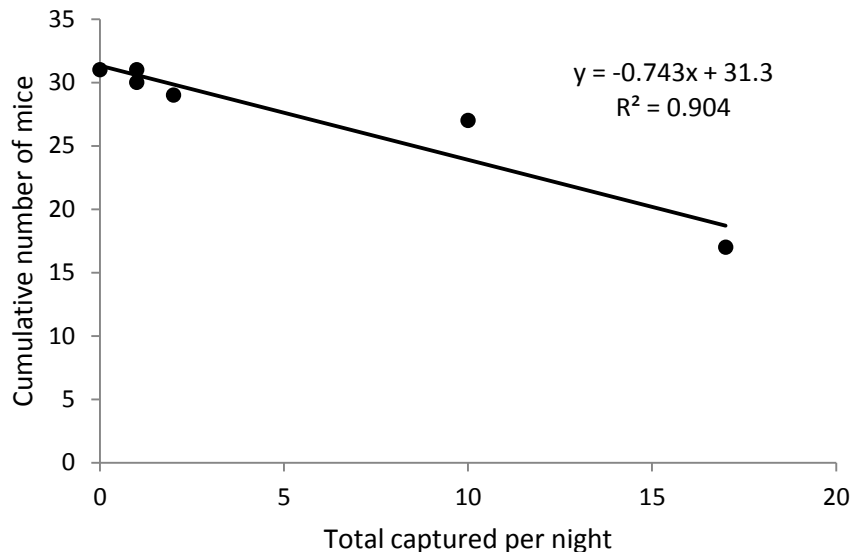


Figure 9 Pooled numbers of mice captured per night across all four trapping grids and the cumulative number of mice per night for all four trapping grids over six nights of capture, and the fitted regression line, equation of the line and R^2 value.

Distribution and abundance

A total of 34 snap-trapping lines were run during the study, with 10 lines located to the east and west of the camp site at Cape Rosa, and with 24 lines on the Nuñez Peninsula at both Shallop Cove and Holmestrand (Figures 6 & 7). Snap-trapping lines were run through a variety of habitats which were categorised as: shoreline, seal-disturbed tussac, burrowed tussac, non-burrowed tussac, mixed *Acaena*/grasses/moss vegetation, and higher altitude fell-field (thinly vegetated rock and scree, with South Georgian Diving Petrel burrows in some areas). The total number of captures was expressed as the number of mice caught against the number of effective trap nights (ETN) to account for traps that were unavailable to mice due their being sprung, covered in snow or having already caught a mouse (Cunningham and Moors 1996). Furthermore, due to heavy snowfall on several nights some snap-trapping lines could not be checked and these trap nights (120 in total) were excluded from all calculations.

Mice were captured in all habitats other than in higher altitude fell-field areas (Table 3). Highest capture rates were found on traps set close to the shoreline. Capture rates were similar in all other habitats (ranging from 2.9-3.4%), with the exception of seal disturbed tussac grass areas where only a single mouse was captured (Table 3). The overall trapping index was 3.4% on the snap-trapping lines. Capture rates on the four baiting grids ranged from 0.3% to 5.3%, with an overall index of 1.7% from a total of 1833 effective trap nights. These four grids encompassed a range of habitats from shoreline areas to seal-disturbed tussac grass and patches of fell-field. The highest trapping index on the grids was obtained on Grid 4 on the Nuñez Peninsula, which included 320 m of shoreline and where the overall index was 5.3%.

Table 3 Habitat types, number of traps set, total trap nights, unavailable traps (sprung, covered in snow, mouse capture), number of Effective Trap Nights (ETN), total number of mice caught and resulting capture rate from the 34 snap-trapping lines on Cape Rosa and the Nuñez Peninsula.

| Habitat | Traps | Trap nights | Unavailable | ETN | Mice | Index |
|-----------------------------|-------|-------------|-------------|-------|------|-------|
| Shoreline | 55 | 175 | 20 | 165.0 | 16 | 9.7% |
| <i>Acaena</i> /grasses/moss | 59 | 151 | 12 | 145.0 | 5 | 3.4% |
| Burrowed tussac | 51 | 152 | 9 | 147.5 | 5 | 3.4% |
| Non-burrowed tussac | 41 | 106 | 4 | 104.0 | 3 | 2.9% |
| Seal tussac | 58 | 178 | 20 | 168.0 | 1 | 0.6% |
| Fell-field | 78 | 203 | 21 | 192.5 | 0 | 0.0% |
| Overall | 342 | 965 | 86 | 922 | 31 | 3.4% |

Mice biology

A total of 45 mice were trapped at the Nuñez Peninsula and 23 at Cape Rosa. There was no significant difference between the mean mass and size of male or female mice at either Nuñez or Rosa (T-test $P > 0.05$ for all parameters), and consequently data from both sexes were combined for each site. Mice at Cape Rosa were significantly heavier and larger for all measured size variables with the exception of hind foot and head length (Table 4). These differences might be expected given the higher proportion of immature mice at the Nuñez

Peninsula (see below), however significant differences in both body length and tail length were still found between the sites when the analysis is restricted to only include adult individuals (Table 4).

Table 4 Body mass and measurements for House Mice at Nuñez Peninsula and Cape Rosa for all age classes (adult and immature) and adult age class. Data are presented as the mean \pm 1 standard deviation with sample size in parentheses, along with the *t* statistic from T-tests and corresponding *P* value.

| | Nuñez Peninsula | Cape Rosa | <i>t</i> statistic | <i>P</i> |
|------------------|---------------------|---------------------|--------------------|----------|
| All age classes | | | | |
| Mass (g) | 18.6 \pm 5.5 (45) | 22.1 \pm 3.2 (23) | 2.85 | <0.01 |
| Body length (mm) | 81.0 \pm 7.9 (45) | 89.2 \pm 5.7 (23) | 4.42 | <0.001 |
| Tail length (mm) | 69.7 \pm 5.4 (44) | 76.1 \pm 4.1 (23) | 4.95 | <0.001 |
| Foot length (mm) | 18.2 \pm 0.8 (45) | 18.5 \pm 0.7 (14) | 1.39 | N.S. |
| Ear length (mm) | 13.1 \pm 0.8 (44) | 13.6 \pm 0.6 (13) | 2.38 | <0.05 |
| Head length (mm) | 24.9 \pm 4.2 (41) | 26.8 \pm 1.6 (13) | 1.61 | N.S. |
| Adult age class | | | | |
| Mass (g) | 20.8 \pm 5.4 (30) | 22.2 \pm 3.3 (22) | 1.03 | N.S. |
| Body length (mm) | 84.9 \pm 5.9 (30) | 89.0 \pm 5.7 (22) | 2.39 | <0.02 |
| Tail length (mm) | 71.9 \pm 4.8 (30) | 76.0 \pm 4.2 (22) | 3.2 | <0.01 |
| Foot length (mm) | 18.3 \pm 0.8 (30) | 18.6 \pm 0.6 (13) | 1.27 | N.S. |
| Ear length (mm) | 13.3 \pm 0.4 (29) | 13.6 \pm 0.6 (12) | 1.25 | N.S. |
| Head length (mm) | 24.9 \pm 5.1 (27) | 26.7 \pm 1.7 (12) | 1.18 | N.S. |

Of the mice captured a significantly greater proportion of mice were immature individuals at the Nuñez Peninsula (33%, 15 of 45 mice; as defined by their reproductive status) than at Cape Rosa whereas only 4% of mice (1 of 23) were immature (Log-likelihood test, $G'_1 = 6.54$, $P < 0.02$). Of the mature perforate females captured 71% (10 of 14 mice) were found to be pregnant ($n = 8$) or lactating ($n = 2$) at Nuñez Peninsula, and 20% of females (1 of 5) were pregnant at Cape Rosa. These proportions were not significantly different (Log-likelihood test, $G'_1 = 2.17$, $P = 0.14$) and combining both sites 58% of mature females (11 of 19) were pregnant or lactating at the time of capture. The litter size of pregnant females ranged from 4 to 11 embryos, with a mean litter size of 7.1 ± 2.3 . The two lactating mice had 5 and 8 suckled teats.

Discussion

Ecology and distribution

One of the most striking findings of this study was the extremely low numbers of mice encountered, with estimated densities of around 2 mice/ha in vegetated areas. Further (qualitative) evidence for the very low numbers of mice comes from the camping sites, as on many islands House Mice quickly locate sources of food and are often a major pest around camp sites or huts. At both Nuñez and Rosa we encountered no mice, nor any evidence of mice, visiting our camp sites despite food being stored and cooked outside. The densities of mice estimated for South Georgia are far lower than House Mice populations reported at other sub-Antarctic islands where summer densities in coastal tussac areas are reported to be 147 mice/ha on Antipodes Island (Russell 2012), 242 mice/ha at Marion Island (Gleeson 1981) and 300 mice/ha on Gough Island (R. Cuthbert unpublished data). Higher densities were found on South Georgia along a narrow strip of shoreline habitat in some areas of the Nuñez Peninsula, but even these densities of around 9 mice/ha are low in comparison to other islands.

The only previous mice research on South Georgia was undertaken in January 1978, following the discovery of House Mice on the Nuñez Peninsula in 1976 (Bonner and Leader-Williams 1977; Berry *et al.* 1979). This work occurred within the same general area of the Nuñez Peninsula as our study and with one trapping area identical in location (Grid 4 corresponds to the “bay mouth site” of Berry *et al.* 1979). Descriptions of the trapping sites in 1978 indicate that all trapping took place in the same habitats (tussac and more open *Acaena* and moss dominated habitats close to the coast from 0-30 m in altitude and with fur seals and elephant seals present) and that very similar methods were followed (mice were live-trapped in Longworth traps baited with peanut butter and corn) (Berry *et al.* 1979). Trapping in 1978 was undertaken from the 11-19 January and captured 109 individuals from 706 trap-nights, an overall trap success rate of 15.4%, with highest catch rates at the “bay mouth site” of 23.3% (Berry *et al.* 1979). These capture rates are markedly higher than that recorded in the four grids and snap-trapping lines in our study where the overall trapping success rate was 1.7% and 3.4% respectively. Like Berry *et al.* (1979), we recorded the highest catch in Grid 4 the “bay mouth site” from 1978. However, catch rates in our study (5.3%) were still four times lower than the catch rates reported from 1978. While trapping indices may not give a true indication of mice numbers (as they are likely sensitive to the abundance of other food resources) nonetheless it seems apparent that higher numbers of mice were present in 1978 in comparison to 2012. It is unknown if either study is typical of mice numbers on South Georgia, but it is very possible that mice normally occur at higher densities than indicated in our study.

Comparison of trapping indices indicated that mice occurred at similar abundances in burrowed and non-burrowed tussac habitats and in mixed *Acaena*/grasses/moss habitats. In contrast House Mice were less abundant in tussac habitat that was heavily disturbed by seals, with an index of abundance for this habitat around five times lower than other vegetated areas. Trapping of rats on South Georgia also suggests that rats avoid tussac areas that hold large numbers of seals (A. Black personal observations). The flattening and damage of Tussac Grass crowns and other vegetation by seals is likely to reduce the abundance of seeding and fruiting plants and invertebrate numbers, to the extent that both rats and mice avoid these areas. Snap-trapping lines confirmed the same findings as from baiting grids that mice occur at a higher abundance along the shoreline. However, this result was only found on the Shallop Cove side of the Nuñez Peninsula, with no mice being captured on the Holmestrand side of the peninsula. The shoreline at Holmestrand is bordered by a 100-120 m wide strip of seal dominated tussac habitat where mice occur in low abundance, potentially limiting the numbers of mice along the shore line in this area. Trapping at Cape Rosa did not encompass the shoreline. However the similarity between the shoreline and bordering habitats of many areas of Cape Rosa and the Nuñez Peninsula makes it likely that mice occur at higher densities along the coast of coast of both areas. No mice were trapped in higher altitude fell-field habitats, even in areas containing large numbers of South Georgian Diving-petrel burrows, which we thought mice may utilise. Given the absence of substantial vegetation in fell-field habitats (which comprise bare rock, scree and a spare cover of mosses and lichens) it seems likely that mice are absent or only occur at extremely low numbers in these areas.

Body measurements and the breeding ecology of House Mice at South Georgia are similar to House Mice on other islands, with the exception of Gough Island: adult body mass on South Georgia averaged 21-22g which is similar to adult mass of mice at Antipodes Island (20-21g, Russell 2012), Tristan da Cunha (20g, RSPB unpublished data) and Marion Island (21g, Avenant and Smith 2004), but lower than the average mass of House Mice at Gough Island (26-27g, RSPB unpublished data) which are known to be large sized (Berry *et al.* 1978). As expected mice were breeding at both study sites in March, close to the end of the Austral summer on South Georgia. However, a higher proportion of immature mice were found at the Nuñez Peninsula in comparison to Cape Rosa, suggesting delayed or less successful rates of reproduction at the latter site. Mice were also lighter and smaller at Cape Rosa, which with the lower number of immature mice possibly indicates that harsher conditions are found at this site. Litter size of females averaged 7.1, a similar value to the litter size of 6-8 embryos reported for mice on other southern ocean islands (Pye 1979; Gleeson 1981; Murphy and Pickard 1990; RSPB unpublished data).

Implications for the proposed eradication of House Mice

The robustness of the conclusions that can be drawn from the baiting trials at both Cape Rosa and Nuñez Peninsula are unfortunately limited by the number of mice that could be captured since the planned methods for the study were predicated upon marking and recapturing a reasonable sample of mice (several hundred). Nonetheless the low densities of mice, high rates of bait acceptance (97%), relatively large movements (75-180 m) made by mice and the small areas of habitat (the coastline and vegetated habitat) containing mice populations are all encouraging for the eradication operation.

Of the 38 mice captured on the baiting grids 37 of these were positive for bait, with one mouse negative. While the percentage bait acceptance of 97% is close to 100% it is nonetheless a concern for the prospects of a successful eradication that a small percentage of mice (one mouse in this instance) did not consume bait, and the results from this trial contrast with a bait acceptance study on Gough Island where bait uptake by ear-tagged mice was 100% (Cuthbert *et al.* 2011b). While the results from this study produce an element of caution there are also some major differences to the work on Gough Island. On Gough mice occurred at densities of around 120-140 mice/ha in the winter months (when trials were undertaken) and the majority of mice (95%) were recorded moving over distances of less than 40-50 m (Cuthbert *et al.* 2011b). These high densities and relatively small movements meant that the baited grids of 160 x 160 m were encompassing the home ranges of a large number of mice which would all have had access to bait pellets. In contrast mice on Cape Rosa and the Nuñez Peninsula occurred at very low densities (2 mice/ha) and the limited movement data available indicates they were making minimum movements of up to 180 m. Given these large movements it is very likely that the 400 x 400 m baited areas would not encompass the home range of many mice in these areas, with many individuals likely to have ranges that encompassed baited and adjoining non-baited areas. Consequently we consider it most likely that the absence of 100% bait uptake in this study is most likely to be due to the spatial design of the study being insufficiently large in comparison to the distances that mice were moving over, rather than any systematic avoidance of bait pellets by mice.

If 2012 was typical of mice populations in these areas of South Georgia then the proposed baiting strategy of 8 kg/ha in vegetated areas and 3 kg/ha in non-vegetated areas appears to be more than adequate, given the very low population density of mice encountered and persistence of bait pellets on the ground. A lower baiting rate could potentially be considered, such as the 4 kg/ha that was tested on Grids 2 and 4. If a lower baiting strategy is adopted, special attention will still need to be paid to the coastal fringes as mice were most abundant within a narrow strip close to coastal areas. However, coastal areas should already be treated

with extra bait, as it is usual for aerial eradications to spread an extra application of bait along the island's coastline (Broome 2006).

The low densities of mice present in the two sites meant that the bait was consumed at a very slow rate, and taking the upper 95% limit of the bait consumption rates suggests that bait should be depleted to around 6.8 kg/ha and 2.8 kg/ha after ten days, for initial baiting rates of 8 kg/ha and 4 kg/ha, respectively. Based on these bait consumption rates (excluding climatic or other events that may wash away or remove bait from the sites), adequate bait should remain on the ground to target any surviving mice and young mice emerging from burrows, as may occur given mice are breeding at the time of the proposed bait applications. Given the amount of bait likely to be remaining, the main benefits of a second bait application would be to ensure there are no gaps in coverage, rather than the need to provide more bait to areas where this has been fully consumed. Proposed bait application rates for non-vegetated areas of Cape Rosa and Nuñez Peninsula are for a rate of 3 kg/ha, on the premise that these areas will contain lower numbers of mice. The trapping results from this study support this premise, with no mice captured from any higher altitude areas of fell-field habitat, indicating an absence or very low numbers of mice in these areas. Trapping of heavily burrowed (by South Georgian Diving-petrels) areas of fell-field also yielded no mice, despite these areas potentially offering more food and shelter for mice than other fell-field areas.

While the results of this study are potentially encouraging for the prospects of eradicating mice some cautions should be applied. Firstly it appears that in some years mice numbers are greater than those encountered in this year's study, and whether mice densities are typically higher (as found in 1978; Berry *et al.* 1979) or similar to the densities in 2012 is unknown. Hence, higher densities of mice could be present in 2013 in comparison to 2012, and the bait application rates and planning should consider this. Secondly the study was disrupted on two occasions by relatively heavy snowfalls, which occurred on the on 12 March and 23-26 March. The latter occasion buried bait pellets for several days making these inaccessible to mice. Planning of dates for bait spreading should consider the weather risks and potential likelihood of bait being covered by snowfall for several or more days.

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Output 2 Observations of Kerguelen Petrels at the Nuñez Peninsula

Introduction

Kerguelen Petrels *Lugensa brevirostris* are known to breed on Kerguelen Island, Crozet Islands and the Marion and Prince Edward Island in the Indian Ocean and on Gough Island in the South Atlantic Ocean (Weimerskirch *et al.* 1989; Cuthbert and Sommer 2004). The global population is estimated to be around 1,000,000 individuals (Brooke 2004) and the species large, apparently stable, population and large range result in an IUCN status of Least Concern (BirdLife International 2012).

Around South Georgia, Kerguelen Petrels have long been known as non-breeding winter visitors (Black 2005, Clarke *et al.* 2012). However there are only two records of Kerguelen petrels actually occurring on, or close to land, at South Georgia, with birds reported dazzled in the lights of a ship at in the Bay of Isles in 1974 and the collection of a single skull from the Barff Peninsula in the same year (Prince and Payne 1979). Between October 2002 and September 2004, monthly seabird and marine mammal surveys were conducted in the waters around South Georgia (Black 2005). Within this period, over 19,000 km of survey effort within the South Georgia Maritime Zone produced 883 records of this species. The results of these surveys indicate that the presence of Kerguelen petrels within South Georgia waters is highly seasonal. Kerguelen Petrels are apparently absent from South Georgia waters from November to February. Birds arrive within South Georgia waters in March with a peak in abundance recorded in June and July (Figure 1).

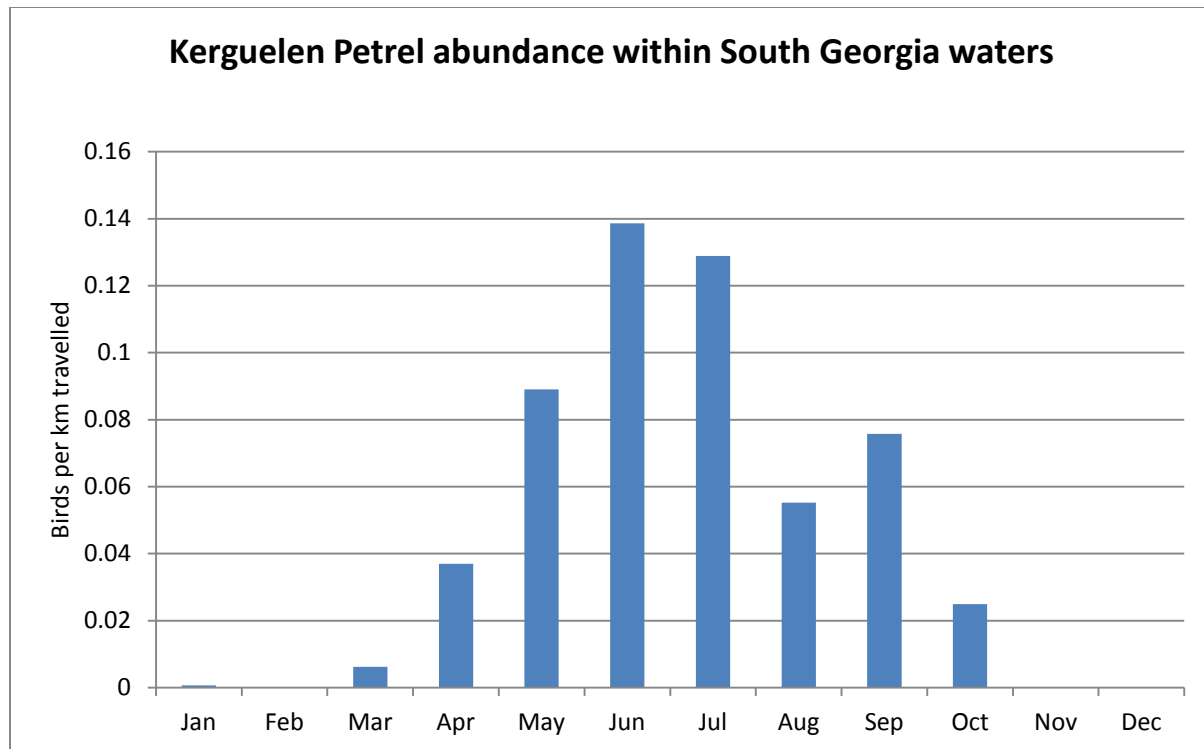


Figure 1. Results of at-sea visual surveys within South Georgia waters (Black 2005)

Observations

On 15 March 2012, a team of five were deployed in Shallop Cove on the Nuñez Peninsula South Georgia (Figure 2) to conduct bait acceptance trials on the local mice population. Shortly after arriving, two observers noted unusual burrows, in the vicinity of the camp site; very wet and mid-way in size between Antarctic Prion *Pachyptila desolata* and White-chinned Petrel *Procellaria aequinoctialis*. From 16 March, and every other evening until leaving the site on 28 March, the calls of Kerguelen Petrels were heard at night from both birds flying overhead and from within burrows.

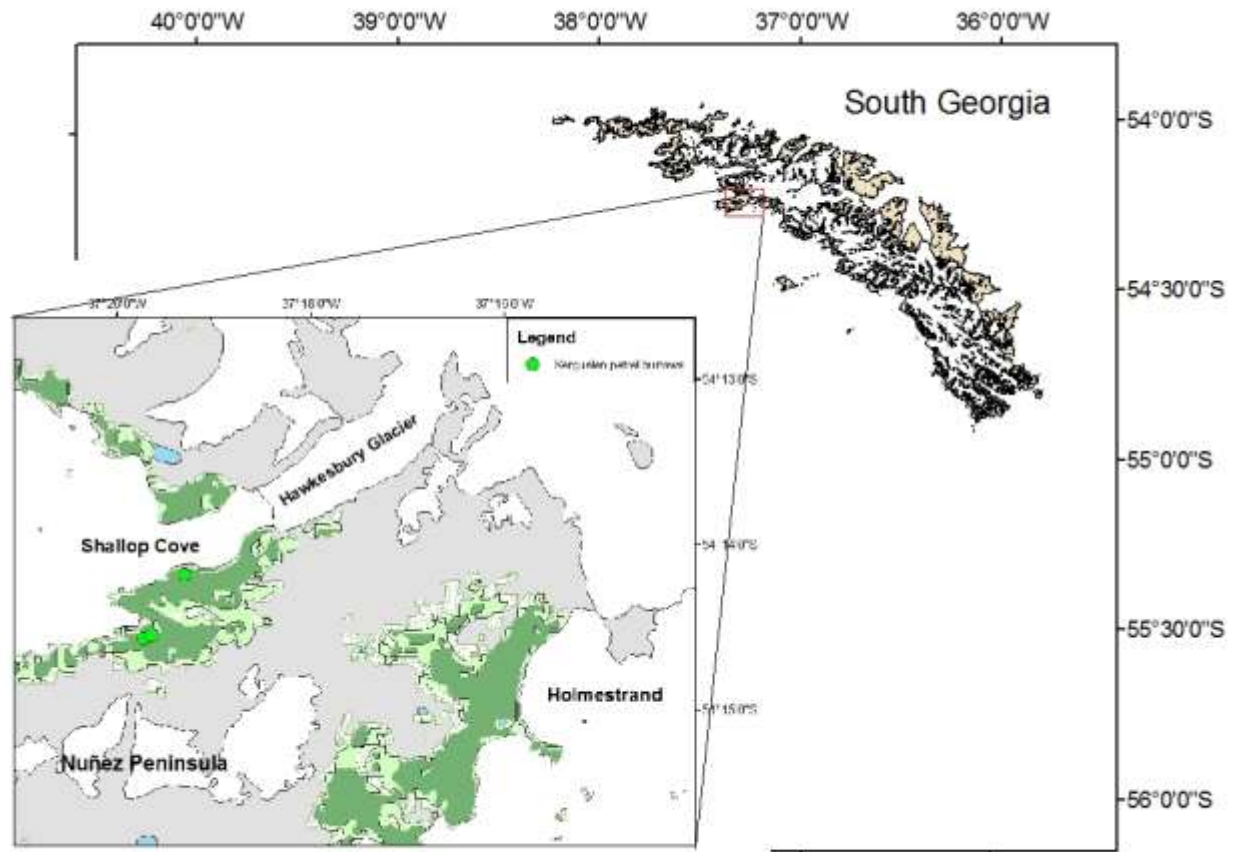


Figure 2. Map showing the location of the study site and the distribution of Kerguelen Petrel burrows at Shallop Cove

Species identification was confirmed by capturing an individual, which was brought down from flight by use of a spotlight. Subsequent searches found a bird occupying a burrow during the daytime and birds calling from burrows at night. Along with photographs (Figure 3), morphometric measurements were taken to confirm species identification (Table 1), which all fall within the range of Kerguelen Petrels breeding on Crozet (Jouventin *et al.* 1984), Marion (Schramm 1983) and Gough Island (R.J Cuthbert unpublished data). Examining the plumage of three birds indicated that they were adults and with freshly moulted body and flight feathers (both primaries and rectrices were newly moulted).

Table 1 Morphometric measurements ± 1 standard deviation for Kerguelen Petrels from South Georgia and from three other breeding localities, sample size in parenthesis.

| Location | Weight (g) | Wing length (mm) | Culmen (mm) | Tarsus (mm) | Source |
|---------------|-----------------------|----------------------|-------------------------|-------------------------|------------------------------|
| South Georgia | 337 \pm 40 (3) | 260 \pm 6 (3) | 27.6 \pm 1.5 (3) | 39.4 \pm 1.4 (3) | This study |
| Crozet | 331 \pm 40 (29) | 259 \pm 8 (33) | 27.0 \pm 1.4 (33) | 38.5 \pm 1.5 (33) | Jouventin 1985 |
| Marion | 357 \pm 43 (126) | 257 \pm 6 (121) | 26.7 \pm 1.5 (121) | 39.5 \pm 1.2 (121) | Schramm 1983 |
| Gough | 344 \pm 34 (20) | 261 \pm 5 (22) | 27.5 \pm 1.1 (22) | 39.4 \pm 1.5 (22) | RJ Cuthbert unpublished data |

Although no eggs or chicks were found, the behaviour of the birds (pairs calling from burrows, calling at night overhead and on the ground, and actively digging in burrows) is typical of burrowing petrels and indicates that they are likely to be breeding on South Georgia. At their main breeding islands Kerguelen Petrels are recorded to lay eggs in October with chicks fledging by late January to early February (Swales 1965; Schramm 1983; Jouventin *et al.* 1984) and if (as is likely) the timing of breeding on South Georgia is the same as on these islands then our observations would coincide with the post-fledging period of these birds. Kerguelen petrels appear to be unusual as they frequently return to burrows during the non-breeding period (Jouventin *et al.* 1984). Weimerskirch *et al.* (1989) state that “Displaying birds are present from the beginning of April up to the end of July” and similarly on Gough Island Kerguelen Petrels were most often heard calling and seen at night from February to May (M-H Burle in lit.) despite birds fledging in late January (Swales 1965). Kerguelen Petrels differ from *Pterodroma* species in the short duration of their chick-rearing period (*ca* 2 months for Kerguelen Petrels on

Marion Island versus 3 months for the smaller Soft-plumaged Petrel *Pterodroma mollis* at the same site; Schramm 1983) and observations off South Africa of large numbers of birds at-sea in advance moult during February-March (P Ryan pers com) suggests that the short breeding period enables adults to moult and then return to the colonies in late summer for courtship and prospect for burrows prior to returning to breed in the following Austral spring.



Figure 3. Kerguelen petrel extracted from a burrow

Burrow characteristics

Burrows that were thought to belong to Kerguelen Petrels were typically very wet around the entrance, some with substantial moats (Figure 4). A sample of 25 burrows was measured, mean height 161mm (st.dev. 3.0) and width 176mm (st. dev. 3.7). Most burrows that were investigated were too deep to examine by hand. Burrows that were thought to belong to Kerguelen petrel were usually situated in sparse tussock grass *Parodiochloa flabellata* habitat on slopes approximately 20-30m asl, with a west to north-east aspect. Although fieldwork was carried out throughout most of the vegetated areas of Shallop Cove and Holmestrand, burrows were only found in two relatively small areas. Seventy four possible Kerguelen Petrel burrows were counted within an area of approximately 5,000m², although many burrows apparently had more than one entry/exit.



Figure 4. Showing a typically wet burrow entrance, on the left, and on the right a burrow showing signs of recent activity, tracks in the snow and fresh digging.

Discussion

There has been some speculation that Kerguelen Petrels might breed on South Georgia, however, these observations are the first to provide evidence that these birds are likely to be breeding on South Georgia. Future visits to the Shallop Cove area during the breeding season should attempt to confirm the breeding status of the birds reported here. Fieldwork was also undertaken in areas with apparently similar habitat at Cape Rosa, however no burrows matching the size or description were observed and no birds were observed. The earlier timing of this fieldwork on Cape Rosa (from 4 to 14 March) and/or the much denser tussock habitat where we were camped may have precluded observations from this site, although it is more likely that they were not present in the vicinity of our study sites.

Surveys elsewhere on South Georgia have not found evidence of breeding Kerguelen Petrels, although Peter Prince suspected the species was breeding and surveyed Cape Rosa, Cooper Island and Annekov Island in 1988 searching for this species (Sally Poncet pers. com). The absence of this species from other areas suggests that on South Georgia this species is confined to small and/or infrequently visited sites. The lack of sightings of Kerguelen Petrel within South Georgia waters during the summer also suggests that only a small population of breeding birds is present, and we hypothesise that most at-sea observations of birds in the vicinity of South Georgia are likely to be of individuals from other breeding islands. The discovery of Kerguelen Petrels on the Nuñez Peninsula increases the number of species breeding on South Georgia from 29 (Clark *et al.* 2012) to 30 species, and extends the breeding range of this species by more than 2,500 kilometres.

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Output 3 Wandering Albatross counts at Cape Rosa and Prion Island

Wandering Albatross census on Prion Island, South Georgia, March 2012

Introduction

Prion Island is a rat free island situated within the Bay of Isles, South Georgia (Figure 1). This is the only wandering albatross colony that receives regular visits from cruise ship passengers. In order to facilitate passenger access, prevent damage and disturbance to nesting birds and protect delicate plant communities; a boardwalk was installed in 2007 (Figure 2).

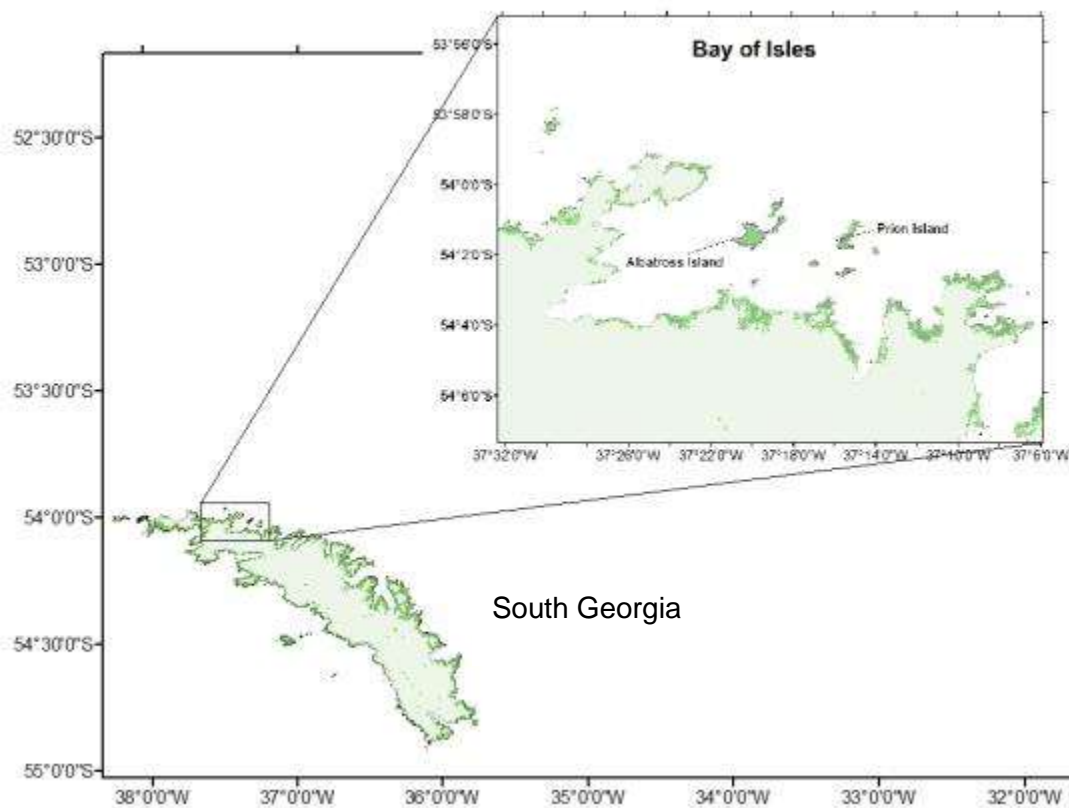


Figure 1. Prion Island, situated in the Bay of Isles off the north coast of South Georgia

The Wandering Albatross *Diomedea exulans* monitoring programme on Albatross and Prion Islands is managed by South Georgia Surveys in collaboration with the Government of South Georgia and the South Sandwich Islands (GSGSSI). Annual counts of the breeding populations on these islands have been made since 1999. Over this period the number of breeding pairs on Prion Island has declined from 40 in 1999 and 2000 (Poncet2010) to 28 in 2012. Counts are made

in January, March/April and October/November to determine the number of breeding pairs, hatching rate and breeding success respectively.



Figure 2. A section of the boardwalk on Prion Island

Methods

All fieldwork was conducted in accordance with GSGSSI biosecurity measures, and with minimal wildlife and environmental impact a priority.

A census of the number of breeding pairs is conducted in January 2012. During this visit, nests were marked with numbered plastic canes and recorded on a handheld GPS. For each nest, the vegetation type, tussock quality, the numbers of fur seals present and the impact on vegetation caused by fur seals was recorded. If nests were within 20m of the boardwalk, the distance of wanderers from the boardwalk was measured.

On 29th March 2012, the five members of the Darwin funded team landed on Prion Island to determine how many of the nests recorded in January were still active. The nests were located with the aid of handheld GPS units. At each nest, the breeding status, number of adults, numbers of fur seals, the degree of damage to the vegetation caused by fur seals, snow cover and snow depth were recorded.

Results

Of the 28 Wandering Albatross nests recorded during January, 26 had chicks when revisited on 29th March (Figure 3).



Figure 3. Adult male Wandering Albatross brooding young chick

A single fledgling (still with some down) from last year was still on the island. Most chicks fledge in December so this bird was several months late. The extended period of chick rearing and general poor condition of the bird suggests that it may have been reared by a single adult during the latter (post brooding) phase of chick rearing.

References

Poncet, S. (2010) *SGS Albatross and Prion Island monitoring programme: 2010 January fieldwork report*. Unpublished report by South Georgia Surveys.

Acknowledgements

Thanks to the Captain and crew of the FPV *Pharos* SG for transferring the team to and from Prion Island.

Output 4 Rat monitoring on the Greene Peninsula

Introduction

The Greene Peninsula is situated within Cumberland Bay East on the eastern coast of South Georgia (Figure 1) and covers an area of approximately 4,100 hectares, of which 21% is vegetated (SGHT 2010). The Nordenskjöld and Harker Glaciers effectively isolated the population of rats on the Peninsula from those in adjacent zones. As part of Phase 1 of the South Georgia Heritage Trust's rat eradication, the Greene Peninsula was baited via aerial spreading of brodifacoum pellets (supplied by Bell Laboratories, Wisconsin, USA) between 1st and 4th March 2011 (SGHT 2010). Post-baiting monitoring is a critical part of pest eradications, particularly in trial areas where eradication protocols are being tested. Peanut butter-flavoured wax tags (Pest Control Research, Christchurch New Zealand) were deployed around the Greene Peninsula in February 2012 by the South Georgia Government (GSGSSI) (Black & Rexer-Huber 2012) (Figure 1) and checked during this work.



Figure 1 Monitoring for rat sign on the Greene Peninsula, South Georgia. Squares indicate locations of wax tags.

Methods

Kalinka Rexer-Huber and Graham Parker visited the Greene peninsula in early April 2012 to check wax tags for rat sign prior to winter. All tags along the coastal fringe (Sudan Beach,

Balsam Beach and Dartmouth Point area, Figure 1) were checked on the 2 April 2012, while tags located on inland tussock slopes were checked on the 3 April. Each of the 46 wax tags was checked carefully for any sign of rat gnawing or nibbling.

Results

No evidence of rat activity was found on any of the Greene Peninsula wax tags. In two cases the wooden stake that tags are attached to was broken (WT19 and WT23), presumably due to seal activity. Although the stakes were repaired, they should be replaced at the next tag check. At one wax tag (WT29), the peanut butter lure was broken off so the tag was replaced. Again, seal disturbance is the most likely explanation. The entire circuit for checking coastal tags required 7 hours. Checks of the inland tags was slow (~5 hours) due overnight snowfall of 40–60 cm in depth. The red-painted top of the stake mostly showed just above the snow (Figure 2), but three of the poles inland were entirely covered, requiring extra GPS-aided searching.



Figure 2 Monitoring wax-tags on the Greene Peninsula April 2012.

Conclusions

Although it is still too early to declare that rats have been eradicated from the Greene Peninsula, it is encouraging that there is no evidence of rats more than a year after baiting, particularly

since rat populations should peak in autumn. We recommend that all tags are checked again in the early spring.

References

Black & Rexer-Huber (2012) Post-baiting rat monitoring on the Greene Peninsula. Government of South Georgia and the South Sandwich Islands, February 2012.

SGHT (2010) Operational plan for the eradication of rodents from South Georgia: Phase 1. South Georgia Heritage Trust, December 2010.

Acknowledgements

Thanks to British Antarctic Survey personnel at King Edward Point for the boating support which made this work possible.

Output 5 Reindeer bait palatability trial on the Barff Peninsula

Introduction

Two separate herds of Reindeer (*Rangifer tarandus*) were introduced to South Georgia from Norway during the era of shore-based whaling nearly one hundred years ago. Today, the herds are well established on the Barff and Busen Peninsulas, areas that are also home to introduced brown rats. As part of the ongoing programme to eradicate rats from South Georgia these areas will be targeted with brodifacoum laced bait. The bait is delivered in cereal based pellets, which would almost certainly be eaten by Reindeer. If Reindeer consume pellets this could jeopardise the success of the rat eradication, lead to Reindeer poisoning and death, result in secondary poisoning of birds scavenging on Reindeer carcasses and contaminate the Reindeer meat. It was deemed important to assess the palatability of the cereal bait pellets to Reindeer at this early stage of planning.

Methods

Following bait palatability trials on mice at Cape Rosa and the Nuñez Peninsula, a limited amount of time was available to attempt a palatability trial on Reindeer.

On 2nd April, three members of the Darwin team were deployed at Corral Bay, on the Barff Peninsula, to attempt bait palatability trials with inert bait (without brodifacoum) manufactured by Bell Labs. On arrival, bait was spread in areas where deer are frequently observed feeding (mostly areas of *Poa annua* within Corral Bay (Figure 1) but also areas of mixed grassland in the hills behind Corral Bay). Quadrats were marked and the number of pellets within each was counted (Figure 2). Additionally, a camera trap was set-up overlooking two quadrats near the Corral Bay hut.

Results

Several groups of Reindeer were present in the vicinity of Corral Bay, usually 6-12 females with one or more males in attendance. Two animals were seen feeding, for a short period, in the area where pellets had been spread but they were not observed eating pellets. It was hoped that more deer would move into the Bay over-night and a recount of pellets the following day would indicate if pellets had been eaten. However, we woke on 3rd April to find 5-6 inches of snow on the ground, making the pellets undetectable to the Reindeer or the observers.



Figure 1. Bait pellets spread over open grass (*Poa annua*)



Figure 2 Quadrats were marked with rocks, the number of pellets within each was counted

Conclusions

The time available to conduct this trial was very limited, which combined with heavy snow meant the results are inconclusive. However, the bait pellets will remain viable for some weeks and therefore a return visit to Corral Bay may provide evidence that Reindeer have eaten pellets, as the florescent biomarker (pyridine) within pellets will be visible in the droppings of animals that have consumed pellets. Additionally, a later count of the number of pellets within each quadrat might be useful, although ducks, rats and skuas will also eat/remove the pellets.

Acknowledgements

We would like to thank the British Antarctic Survey personnel based at King Edward Point for facilitating our transfer to and from Corral Bay.

Appendix 1 – Time-table of fieldwork

| | |
|-----------------|--|
| 25 Feb 2012 | R & E arrived in Falklands from Santiago at 15:00 |
| 26 Feb 2012 | R, E and G unpacked all shipping and courier packages and packed for Pharos |
| 27 Feb 2012 | Bought last items of kit and spent day around Stanley |
| 28 Feb 2012 | R, E and G departed Stanley at 09:00 |
| 29 Feb - 02 Mar | At sea from Falklands to South Georgia |
| 03 Mar 2012 | Arrived at KEP in morning, G&K wedding, departed KEP at 16:00 |
| 04 Mar 2012 | Arrived at Cape Rosa and all on shore with gear by 10:30. Established camp. |
| 05 Mar 2012 | Set up 121 live-traps on Grid 1 and 86 on Grid 2 |
| 06 Mar 2012 | Completed Grid 2 and checked traps on Grid 1 |
| 07 Mar 2012 | Marked baiting boundaries for both grids on GPS and baited Grid 1 at 8 kg/ha |
| 08 Mar 2012 | Made core-flute traps covers in morning and opened traps on Grid 1 at 17:00-18:30 |
| 09 Mar 2012 | Baited Grid 2 at 4 kg/ha. 7 mice caught in Grid 1. |
| 10 Mar 2012 | 2 mice on Grid 1. Opened traps on Grid 2. Set out 9 x snap-trapping lines |
| 11 Mar 2012 | 7 mice on Grid 1, 1 mouse on Grid 2, 4 mice on snap lines. 2 more snap traps lines set |
| 12 Mar 2012 | Winds 40-50 knots during night and snow during day. No mice caught. Took in Grid 2. |
| 13 Mar 2012 | Took in Grid 2 and 9 x snap trapping lines. More snow and strong winds. |
| 14 Mar 2012 | Took in last 2 x snap trapping lines. Packed gear in afternoon |
| 15 Mar 2012 | Picked up at 08:00-09:00, on ship for 4 hours, at Nunez at 13:00 and set up camp |
| 16 Mar 2012 | Team walked across Peninsula to Holmestrand side and set up 5 x snap trapping lines |
| 17 Mar 2012 | Opened Grid 3 on Shallop side and 4 more snap-trap lines, checked Holmestrand traps |
| 18 Mar 2012 | No mice on Grid 3, 2 mice on snap lines, set out another 4 x snap lines |
| 19 Mar 2012 | Moved and set 5 x snap-lines at Holmestrand, 1 mouse Grid 3, 10 mice from along coast |
| 20 Mar 2012 | Checked snap trapping lines and moved 3 x lines. Baited Grid 3 at 8 kg/ha in p.m. |
| 21 Mar 2012 | Checked snap trapping lines, set up Grid 4 and opened snap traps on Grid 3 |
| 22 Mar 2012 | Caught 2 mice on Grid 3, checked snap lines. Baited Grid 4 at 4 kg/ha in p.m. |
| 23 Mar 2012 | Lots of snow overnight, 3 mice on Grid 3. Delayed opening Grid 4 because of snow |
| 24 Mar 2012 | Still snow on ground but no new snow. Opened traps on Grid 4 and checked snap lines |
| 25 Mar 2012 | Snow still around, 12 mice caught on Grid 4, 1 mouse on Grid 3 |
| 26 Mar 2012 | Snow still around, 2 mice Grid 4, 1 mouse on Grid 3. Took in traps from Grid 3 |
| 27 Mar 2012 | 2 mice on Grid 4, took in Grid 4. Packed all gear in p.m. |
| 28 Mar 2012 | Picked up by Pharos at 08:00-09:00, rough seas but all onboard safely |
| 29 Mar 2012 | Visited Prion Island by Zodiac and checked Wandering Albatross nests |
| 30 Mar 2012 | Arrived at KEP in morning and unloaded all field gear in afternoon |
| 31 Mar 2012 | Washed and sorted all gear, food and rubbish |
| 01 Apr 2012 | Packed all traps, food and field gear in to container |
| 02 Apr 2012 | R, E, A to Barff Peninsula to check for Reindeer, G, K to Greene to check for rat sign |
| 03 Apr 2012 | Both parties picked up and back to KEP at 15:00 |
| 04 Apr 2012 | Departed KEP on Pharos at 16:00 |
| 05-07 Apr 2012 | At sea from South Georgia to Falklands |
| 08 Apr 2012 | Arrived back at Stanley at 15:00 and ashore at 16:30 |

Appendix 2 – Photos from the fieldwork



Image 1 Lining up the gear for a pick-up from Cape Rosa



Image 2 Trap and trap cover in tussock habitat at Cape Rosa



Image 3 A rare and reclusive South Georgian mouse



Image 4 Checking snap-traps on Grid 4 above Shallop Cove, Nuñez Peninsula



Image 5 Lunch break on the Nuñez Peninsula



Image 6 Inert pellets and an inert young Southern Elephant Seal



Image 7 Trap destruction by a large Southern Elephant Seal in background



Image 8 Pre-honeymoon on Rosa and Nuñez, Graham and Kalinka at King Edward Point