

Introduced mammal eradications in the Falkland Islands and South Georgia

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Abstract Within the past decade, Norway rats (*Rattus norvegicus*) have been removed from 20 islands in the Falkland Islands and one island at South Georgia. The islands range in size from <1 to 305 hectares. Islands were selected on the basis of accessibility, size, distance offshore, operating cost, landowner support, and availability of suitable habitat for threatened bird species. The assumption that these islands have a high potential for re-colonisation by native species has been confirmed by the return of tussacbirds (*Cinclodes antarcticus*) and South Georgia pipits (*Anthus antarcticus*) and an apparent increase in the size of white-chinned petrel (*Procellaria aequinoctialis*) and sooty shearwater (*Puffinus griseus*) populations. With no helicopters available, the main method of bait application was hand broadcasting. Initially, local operators were supervised by New Zealand experts, thereby gaining the experience required to run their own programmes which now employ local fieldworkers. Campaigns between 2000 and 2009 used Pestoff 20R (20 ppm brodifacoum) cereal-based pellets and Ditrac wax blocks (50 ppm diphacinone). Recent developments in the Falklands include the first multispecies eradication attempt. Patagonian grey foxes (*Lycalopex griseus*) were eradicated from 320ha Tea Island in 2008, followed by Norway rats in 2009.

Keywords: Norway rats, *Rattus norvegicus*, Patagonian grey fox, *Lycalopex griseus*, hand broadcasting, trapping

INTRODUCTION

The Falkland Islands and South Georgia are located in the South Atlantic Ocean between 51°S and 54°S. The Falklands are farmed and inhabited by 3000 people who privately own approximately 75% of all land. South Georgia is Crown land with no permanent human population. Both island groups have an exceptional abundance of seabirds and no native terrestrial mammals.

Bird populations in both island groups have been significantly impacted by introduced predators, beginning in the late 1700s when Norway rats (*Rattus norvegicus*), ship rats (*R. rattus*) and house mice (*Mus musculus*) arrived on whaling and sealing vessels. Cats (*Felis catus*), feral pigs (*Sus scrofa*) and Patagonian grey foxes (*Lycalopex griseus*) were introduced to the Falklands with significant impacts on native birds (Strange 1992; Woods and Woods 1997). Species that are particularly vulnerable to rat predation in the Falklands are the tussacbird (*Cinclodes antarcticus*), Cobb's wren (*Troglodytes cobbi*) and several species of burrowing petrels. At South Georgia, populations of the endemic South Georgia pipit (*Anthus antarcticus*) and burrowing petrels have been heavily reduced by Norway rats (Pye and Bonner 1980; McIntosh and Walton 2000).

The Falkland Islands (12,200 km²) lie 450 km north-east of Tierra del Fuego and north of the Polar Front. The archipelago encompasses about 260 km by 140 km with a maximum elevation of 705 m. The climate is temperate oceanic, with an average annual temperature at sea level of 6°C, ranging from 2°C in the winter to 10°C in summer. Annual precipitation varies from 300 mm at the west end of the group to 600 mm at the east; average wind speed is about 16 knots. The main vegetation type is oceanic heathland dominated by whitegrass (*Cortaderia pilosa*) and diddle-dee (*Empetrum rubrum*) with remnant stands of tussac (*Poa flabellata*) now mostly restricted to ungrazed offshore islands. The Falkland Islands Biodiversity Database held by the Falklands Islands Government lists over 700 islands in the archipelago. Excluding the two main islands of East and West Falklands, islands range in size from 21,800 ha to small stacks. About 600 islands are covered in oceanic heath or tussac. Of these, more than 400 are known to have exotic terrestrial mammalian predators, at least 130 are believed to be rat-free, and the rest are unsurveyed.

South Georgia (3755 km²) lies south of the Polar Front and approximately 1450 km east-south-east of the Falklands. The island is 170 km long, between 2 and 40 km wide, and rises to 2960 m. Mean temperature at sea level is -1.2°C in winter when snow covers most of the island, rising to 5°C in the summer. More than 50% of the island is under permanent ice with many large glaciers reaching the sea. Virtually all flora and fauna are found along the coastal margins. The dominant vegetation is tussac grassland. Tussac also provides Norway rats and house mice with food and shelter, and is the key to their survival at this latitude and extreme climate. Two thirds of South Georgia's 1300 km mainland coastline is inhabited by rats, and a further 50 km are known to have house mice. Rats are also recorded on at least 50 offshore tussac islands, including Saddle Island (103 ha) which has been colonised within the past 20 years. This island is separated from the mainland by a 270 m wide passage and was last recorded as rat-free in 1987 (S. Poncet data).

Successful eradications of Patagonian grey foxes and feral cats in the Falklands were carried out by farmers at least as early as the 1960s, but only in the last decade has the knowledge, funding and public support become available for rat eradication campaigns. Between 2000 and 2009, eradication of Norway rats has been attempted on 39 islands in the Falklands and one island (Grass Island) at South Georgia. Islands range in size from less than 1 ha to 320 ha, where an island is defined as land that is completely surrounded by water at lowest astronomical tide.

Organisations running invasive mammal eradication programmes in the Falklands are the conservation interest group Beaver Island LandCare (BILC) and the charity Falklands Conservation (FC). Funding sources include the United Kingdom's Foreign and Commonwealth Overseas Territories Environmental Programme, Falkland Islands Government (FIG), the RSPB's South Atlantic Invasive Species Programme, Falklands Conservation and the Antarctic Research Trust.

In 2001, FC commissioned Derek Brown, Lindsay Chadderton and Kerry Brown from New Zealand to undertake a series of Norway rat eradications with FC staff and volunteers. The New Zealanders also drafted

“Guidelines for Eradication of Rats from Islands within the Falklands Group”, developed criteria for prioritising islands selected for rat eradications and proposed an island restoration plan (Brown 2001). At South Georgia, rat eradication plans for the entire island are being prepared by the South Georgia Heritage Trust.

METHODS

In the Falklands, islands were usually selected for eradication on the basis of landowner support, terrain accessibility, size, distance offshore, operating cost and habitat suitability for re-establishment of threatened bird species. The targeted species were the Norway rat and Patagonian grey fox. Rat eradication operations used bait stations on two islands, and hand broadcasting on the remainder. Leghold traps and snares were used to remove foxes. To date, there have been no attempts to eradicate house mice or ship rats.

Rat eradication by hand broadcasting

There are no commercial helicopters available in the Falklands, so rat eradication has been achieved principally by hand broadcasting of either Pestoff 20R 2 g cereal-based pellets (active ingredient 20 ppm brodifacoum) or Ditrac 28 g wax blocks (active ingredient 50 ppm diphacinone). Operations are scheduled towards the end of winter (August/September) when rat numbers are lowest and food is scarce. With the return of burrow-nesting Magellanic penguins (*Spheniscus magellanicus*) in mid-September, food for rats, such as guano and regurgitations, becomes increasingly abundant.

The hand broadcasting method for Ditrac blocks was developed by BILC between 2007 and 2009 on 11 islands in the Beaver Island group. It was designed to replicate an aerial baiting operation, following recommendations from New Zealand experts Andy Cox and Ian McFadden of the Department of Conservation (DOC), and Derek Brown who have advised on, and participated in, eradications in South Georgia and the Falklands since 2000.

Each operation consisted of the following stages.

1. Surveys of the terrain, wildlife and habitat at the target eradication islands and also of islands and mainland areas in the vicinity each island, in order to assess: a) rodent status, habitat types, bird abundance and distribution and suitable habitat for re-colonisation by tussacbirds, Cobb's wrens and burrowing petrels; b) re-invasion potential from adjacent islands or mainland areas; and c) the feasibility and logistical requirements of an eradication operation.

2. Submission of an Operational Plan to the Falkland Islands Government's Environmental Planning Department and the land owner for review.

The plan included designs of the baiting grid using mapping software OziExplorer for a bait spread regime of 4 kg/ha on inland areas and 8 kg/ha on the coast and in dense vegetation such as tussac.

For the two largest islands treated (Tea Island 320ha and Governor Island 270 ha), tracks were created for a central 'backbone' line down the middle of each island. This central line was the starting point for cross-island transects that were 50 m apart and ran at right angles from either side of the central line out to the coast. On the smaller islands, cross-island transects started from the coast and headed parallel across to the opposite coast. Each transect line was individually numbered. Co-ordinates (waypoints) were also created for the position of bait depot points along the transect lines. These depot points were flagged by bamboo canes. The distance interval between depot points along

each line was 200 m for a baiting regime of 8 kg/ha and 400 m for 4 kg/ha. A map displaying the pre-established numbered transect lines and depot points was given to each operator.

The depot points were positioned using hand-held GPS units uploaded with the pre-determined waypoints and tracks. Each depot point was individually numbered.

3. On site, one bait tub (a sealed plastic bucket containing 8 kg of bait) was deposited at each depot point. The number of the depot point was written on each tub. The bait was hand broadcast by 2 to 6 operators, depending on the size of the island and operator experience. Operators walked as a front, one along each cross-island transect line, using hand-held GPS units to follow GPS tracks while broadcasting bait. Any gaps in coverage were detected by the units which recorded tracks walked while broadcasting. Each operator collected a tub at each depot point and spread its contents along the interval between points. For a baiting regime of 8 kg/ha, 14 blocks of bait were broadcast every 10 m (7 blocks were broadcast every 10 m for 4 kg/ha). The broadcast swathe was approximately 30 m, with 5 blocks thrown to the left, 5 to the right and 4 at the feet of the operator. Along the coastline, one operator distributed one tub (8 kg) of bait every 100 m. Once baiting was complete, all equipment was removed from the island.

4. Submission of a post-baiting report to FIG's Environmental Planning Department.

5. Post-baiting checks were conducted at the end of the second summer after baiting to search for fresh rat sign and check chew sticks (edible oil-soaked pine sticks) deployed three months or longer after baiting.

Fox eradication by trapping

The 2008 BILC fox eradication programme on Tea Island adopted the Alaska Maritime Wildlife Refuge's methods for fox trapping in the Aleutian Islands (Ebbert 2000). Steve Ebbert of the US Fish and Wildlife Service visited the Falklands in March 2008 to advise on the campaign. Four local operators were trained by Rick Ellis, a trainer-trapper from Alaska who also supervised the first phase of the Tea Island operation that ran from 15 September to 25 October 2008. Sets included 8 snares and up to 80 leghold traps baited with commercial lures and positioned along the 12 km coast, less than 100 m from the shoreline. Another three traps were set in the interior, approximately 500 m from the coast.

RESULTS

Eradication of Norway rats has been declared successful on Grass Island at South Georgia and on 30 of the 39 islands baited between 2001 and 2009 in the Falklands (Table 1).

Treatment failed on seven islands, some of which were subsequently re-baited.

Tussacbirds have re-established on five islands cleared between 2001 and 2003 in the Falklands. There are anecdotal reports of an increase in the white-chinned petrel (*Procellaria aequinoctialis*) and sooty shearwater (*Puffinus griseus*) populations. There is evidence to suggest that the number of songbird species and the number of birds increases after eradication (D. Brown data; S. Poncet data; R. Woods pers. comm.), although there is no record of any island being re-colonised by Cobb's wrens.

South Georgia pipits have re-established on Grass Island at South Georgia, with anecdotal reports of an increase in the white-chinned petrel population.

Patagonian grey foxes have been eradicated from two islands in the Falklands.

Table 1 An inventory of island restoration operations between 2000 and 2009 in the Falklands and South Georgia.

Map Ref. in Fig. 1	Island Name	Area (ha)	Year treated, Supervisor, Organisation	Method	Status, year of last check
Norway rat (<i>Rattus norvegicus</i>)					
20	Grass Island (South Georgia)	30	2000, A Cox & I McFadden/ GSGSSI	Pestoff 20R; 10 kg/ha; hand broadcast	Rat-free 2008
5	Top + Bottom Islands	12 + 8	2001, D Brown/FC	Pestoff 20R; 1.6 kg/ha, 0.6 kg/ha; bait stations	Rat-free 2009
6	Outer, Double + Harpoon Island	22 + 9 + 3	2001, D Brown/FC	Pestoff 20R; 5.5 kg/ha, 5 kg/ha, 4.2 kg/ha; hand broadcast	Rat-free 2009
7	Rookery, Cucumber + Rat Islands	25 + 3 + 1	2002, N. Huin/FC	Pestoff 20R; 3.6 kg/ha, 8.6 kg/ha, 5 kg/ha; hand broadcast	Rat and Rookery rat-free 2008, re-inv. 2010; Cucumber rat-free 2010
8	North East, Hutchy's + Ella's Islands	305 + 12 + <4	2003, D Brown/FC	Pestoff 20R; 4.2 kg/ha; hand broadcast	Rat-free 2008
9	Pete's Islet	<1	2003, D Brown/FC	Pestoff 20R; 4.2 kg/ha; hand broadcast	Rat-free 2011
10	Outer North West Is.	65	2004, N. Huin/FC	Pestoff 20R; 6 kg/ha; hand broadcast	Failed or re-invaded 2007
11	South West Horse Is.	3	2005, N. Huin/FC	Pestoff 20R; hand broadcast	Failed or re-invaded 2011
12	Halt Island	13	2006, D Christie/ landowner	Pestoff 20R; 9 kg/ha; hand broadcast	Rat-free 2009
13	Inner North West Is. + islet	36.5 + 1.5	2007, N. Huin/FC	Pestoff 20R; 7.5 kg/ha; hand broadcast	Failed or re-invaded 2009
14	Channel east + west, Stick in the Mud, Skull Bay, Green, Coffin + islet & Letterbox Is.	21 + 26 + 3 + 7 + 24 + 23 + <1 + 3	2007, S Poncet/BILC	Ditrac; 10.5 kg/ha; hand broadcast	Rat-free 2009
15	Governor Island	270	2008, S Poncet/BILC	Ditrac; 10 kg/ha; hand broadcast	Rat-free 2010
4	Tea Island	320	2009, S Poncet/BILC	Ditrac; 10.3 kg/ha; hand broadcast	Rat-free 2011
16	Amy Is. + the Knobs	3.6 + 1 + <1	2009, S Poncet/BILC	Ditrac; 20 & 16 kg/ha; hand broadcast	Rat-free 2011
17	Sniper Island	3.4	2009, S Poncet/BILC	Ditrac; 21 kg/ha; hand broadcast	Rat-free 2011
10	Outer North West Is. (2 nd attempt)	65	2009, L Poncet/FC	Pestoff 20R; 10 kg/ha; hand broadcast	Pending
13	Inner North West + islet (2 nd attempt)	36.5 + 1.5	2009, L Poncet/FC	Ditrac; 10 kg/ha; hand broadcast	Pending
18	Pitt Island	16	2009, S Poncet/BILC	Ditrac; 10 kg/ha; hand broadcast	Rat-free 2011
19	Big + Little Samuel Islands + 3 islets	50 + 25 + 1 + 1 + 1	2009, B. Summers/FC	Ditrac; 8 kg/ha; hand broadcast	Rat-free 2011
Patagonian grey fox (<i>Lycalopex griseus</i>)					
1	Sedge Island	330	1966-81, W McBeth	Shooting; trapping	Eradicated
2	Weddell Island	21850	1997-98, J & S Ferguson	1080; bait stations & aerial broadcast; shooting & trapping	Failed
3	Beaver Island	3800	1997-98, S Poncet	1080; shooting; bait stations	Failed
4	Tea Island	320	2008, R Ellis	Trapping	Eradicated
Feral cat (<i>Felis catus</i>)					
3	Beaver Island	3800	ca. 1986, T Felton	Shooting; trapping	Eradicated

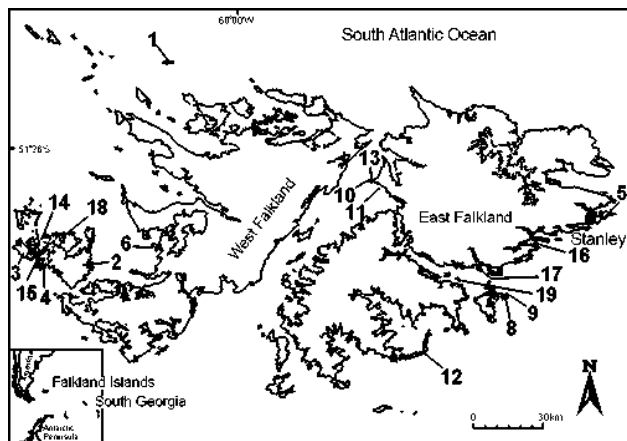


Fig. 1 The Falkland Islands, showing islands where rat eradication operations have taken place between 2001 and 2009. Names for the numbered islands are given in Table 1.

A core group of local operators with rat and fox eradication experience and skills is now in place.

Eradication projects since 1997 have created public interest in and awareness of the effects of introduced species and the benefits of eradication and biosecurity.

Case studies

1. Norway rats on Grass Island, South Georgia. This project was commissioned by the South Georgia Government in 2000, as part of a rat eradication feasibility study for South Georgia (Poncet *et al.* 2002). In 2000, Pestoff 20R was hand broadcast at 10 kg/ha over a 50 m grid. South Georgia pipits had returned to the site by 2003, with anecdotal reports of an increase in the white-chinned petrel population.

2. Norway rats on 21 islands in the Falkland Islands 2001-2009, using Pestoff 20R and Ditrac. These campaigns provided FC staff and volunteers with training. Restoff 20R was placed in bait stations on two islands (12 ha and 8 ha) and hand broadcast on another three (9 ha, 3 ha and 20 ha) (Brown *et al.* 2001). The operations were successful and within three years tussacbirds had returned to two of the five islands (Ingham *et al.* 2005; Forster 2007). A further 11 islands were baited between 2002 and 2007, including the largest island attempted at this time in the Falklands, North East Island (302 ha, with a baiting regime of 4.2 kg/ha). Of these 11 operations, five were successful (notably North East Island) and six either failed or the islands were re-invaded (Woods *et al.* 2003; Ingham *et al.* 2005; Poncet 2006; Forster 2007; S. Poncet data). Five islands were successfully treated with Ditrac in 2009.

3. Norway rats on 15 islands in the Falklands 2007-2009, using Ditrac wax blocks. These campaigns were designed by BILC and provided training and employment for the local community. Bait was hand broadcast on islands ranging in size from <1 ha to 320 ha. The nine islands baited in 2007 and 2008 were confirmed rat-free in 2009 and 2010 (S. Poncet data). The remaining six islands (which include one of 320 ha) were baited in 2009, and were rat-free in 2011.

4. Patagonian grey fox in the Falklands. Foxes were introduced from Argentina to Weddell Island in 1929 for fur-farming. Animals were further released on Beaver Island (3,800 ha), Tea Island (320 ha), Staats Island (500 ha), Split Island (220 ha), Sedge Island (330 ha) and River

Island (450 ha) in the 1930s. The Sedge Island population was eradicated over a period of 15 years by the land owner/farmer using a combination of trapping, shooting and snares. An unsuccessful campaign to eradicate foxes on Beaver Island and Weddell Island in 1997 and 1998 used mainly 1080 poison (Foxoff, 3 ppm sodium fluoroacetate) supplemented by shooting and cage traps (Ferguson and Ferguson 1998; Poncet 1998). Traps and snares were used successfully in 2008, to eradicate foxes from Tea Island (320 ha). A total of 33 foxes were trapped, and after thorough checks in August 2009, the island was declared clear of foxes.

DISCUSSION

This past decade's efforts to eradicate Norway rats from offshore islands in the Falklands Islands are the fruition of the 2001 island restoration plan. The majority of islands treated were identified in Brown (2001), who also recommended the use of standardised biological surveys of islands, regular surveys to check for rodent presence following eradication and the establishment of a local group responsible for island management and restoration.

In 2008, the list of islands suggested as priorities in 2001 was reviewed at a rat eradication workshop organised by the South Atlantic Invasive Species Programme (Miller 2008). The revised list has been incorporated into the framework for prioritising future hand broadcasting operations. The procedures process was further refined in 2009, with the introduction of a rat eradication register (Excel format) for recording details of each operation, peer-reviewed pre-baiting surveys, and operational plans designed for each island's specific requirements and the type of bait available (Pestoff20R, Brodifacoum-25W Conservation, or Ditrac).

The success of rat eradications over the past decade in the Falklands has not only resulted in major ecological gains with the return of tussacbirds to 5 of the 41 islands treated and increases in small songbirds; it has had a positive impact on community understanding of island restoration and biosecurity. This has been further strengthened by the establishment of a core group of operators with the capacity to develop eradication techniques for local conditions and to participate in eradications at South Georgia. Furthermore, the use of local operators ensures that overseas funding for each project is spent within the Falklands. Expenditure on local employment, training opportunities, goods and logistics also increases community involvement and support for future eradications and biosecurity.

The apparent inability of Cobb's wrens to recolonise islands raises the question of whether flight distances from source populations are too great for the birds. In this event, translocation may be the only way to speed up the process.

Of highest concern however, is the risk of rats re-invading treated islands by swimming. The re-invasion of Rat Island and Rookery Island six years after successful treatment in 2002, may be evidence to suggest that rats first re-colonised Rat Island, 300 m from Beaver and then swam the 500 m to Rookery Island. The previously accepted 350 m maximum swim distance of rats in Falklands waters has been revised in the light of these incursions. Additionally, the rat status and separation distance of 208 islands in the Falklands were analysed in order to obtain more information on rat dispersal. Islands closer than 500 m to the nearest rat-infested land were found to have a 1 in 3 chance of being re-invaded; this decreased to 1 in 10 for islands further than 1 km, while the 50 islands that

were over 2 km distant were rat-free (Martinez del Rio and Tabak pers. comm.). This information is now being used when assessing the suitability of islands for eradication. However, the various factors that cause rat incursions remain unknown.

Since 2009, a further 13 islands have been baited with either Pestoff 20R or Brodifacoum-25W Conservation pellets, bringing the total of islands treated to 52. One of the islands, First Passage (750 ha) is the largest island to have been treated by hand broadcasting. The South Georgia operation began in 2010 when Saddle Island and over 12,000 ha of the main island were baited by helicopter.

The following lessons were learnt from our experiences in the Falklands and South Georgia:

1. Operational plans based on pre-baiting surveys are essential for avoiding mistakes.
2. Familiarity with the eradication site is crucial for good planning.
3. Employ trained locals: a team of paid, locally based and experienced operators who are familiar with the environment reduces operator error, increases efficiency and provides skills and capacity for future eradication projects.
4. Specialist advice at all stages of planning and for every new situation is invaluable: the attempted fox eradication on Beaver Island in 1997-98 reduced the population to a few individuals but ultimately failed due to lack of funding, labour, specialist advice and momentum.
5. Ensure that checks for rodent presence are made once a year for at least two years following an eradication attempt in order to monitor for potential incursions.

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