Eradication of rats and rabbits from Saint-Paul Island, French Southern Territories

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Abstract Introduced black rats (*Rattus rattus*) have decimated the seabird colonies on Saint-Paul Island (Southern Indian Ocean). Only six of the 13 seabird species originally breeding on Saint-Paul are now represented by only a few individuals confined to an islet located 150 m from the main island. This led us to believe that recolonisation was possible on Saint-Paul Island if all rats were removed from it. The Administration of Terres Australes et Antarctiques Françaises decided to eradicate rats and part of the funding was provided by the European Development Fund. Two preliminary trials were conducted in 1995 and 1996, and in January 1997 13.5 tonnes of brodifacoum bait (Pestoff Rodent Bait) were spread by helicopter. The island was intensively checked for rat presence during three months after the drop and during two more follow-up operations in late 1997 and early 1999, when respectively 48, 18 and five rabbits (*Oryctolagus cuniculus*) were killed. We are now confident that black rats are eradicated but eradication of rabbits still needs to be confirmed. Mice were not eradicated, presumably due to lack of good cover of baits, linked to spreader malfunction. The Saint-Paul Island project demonstrates the efficiency of the aerial technique against rats, but shows that rabbit eradication needs a more sustained effort. Breeding of endemic Macgillivray's prion (*Pachyptila macgillivrayi*) and of great winged petrels (*Pterodroma macroptera*) has already begun on Saint-Paul Island.

Keywords *Rattus rattus*; rabbit; introduced species; eradication; *Pachyptila* sp.

INTRODUCTION

Saint-Paul Island (38°42"30'S, 77°32"30'E) belongs to the French Southern Territories whose management is regulated by the Administration of Terres Australes et Antarctiques Françaises (TAAF); together with Amsterdam Island, 80 km to the north, they are among the most isolated islands in the world, being 3200 km from Australia, 4200 km from South Africa and 3300 km from Antarctica (Fig. 1).

Amsterdam Island and Saint-Paul Island offer a classic example of seabird decline after introduction of alien mammals. There are several aspects of environmental protection by TAAF, and restoration programmes are the most recent (Jouventin and Micol 1995). In 1988-1989 a programme of rehabilitation was carried out on Amsterdam Island (55 km^2; Micol and Jouventin 1995; Micol *et al*. 1999), with the island subdivided by an 8 km long fence and the removal of feral cattle from one side. This allowed the protection of Amsterdam albatrosses (*Diomedea amsterdamensis*) and of native vegetation. Cats (*Felis catus*) and rats (*Rattus norvegicus*) were still a threat to smaller birds and Amsterdam Island was too large to attempt control of these pests. Saint-Paul Island, 80 km south, is a smaller island of 8 km^2, consisting of the eroded top of a single volcano rising to 268 metres. It is now ear-shaped as on the lower east side, the rim of the crater has broken down and been invaded by the sea (Fig. 1). Since time immemorial, this vast sheltered amphitheatre of bare basaltic rocks has been a favoured spot for fur seals (*Arctocephalus tropicalis*) and elephants seals (*Mirounga*

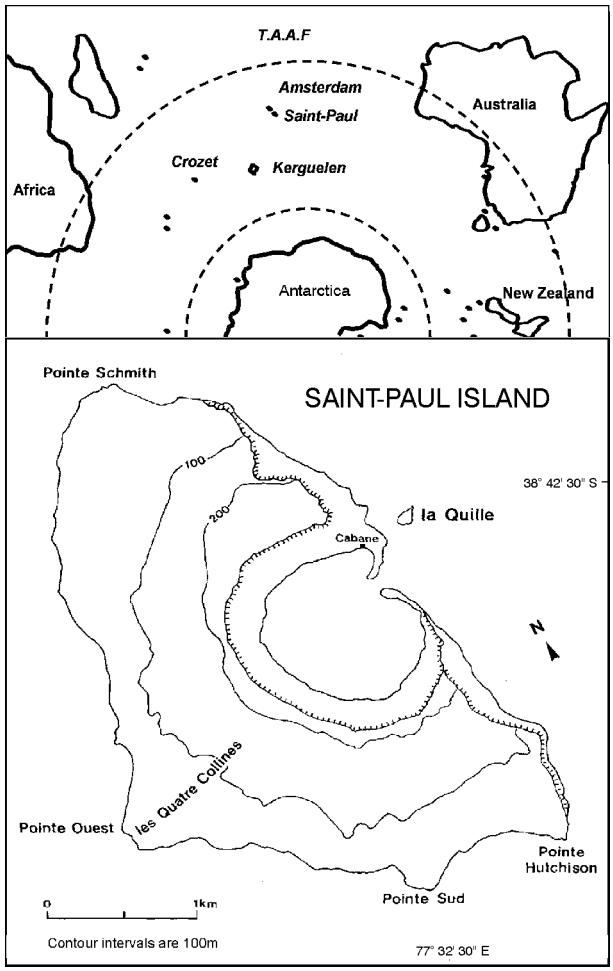

Fig. 1 The location (upper) and features (lower) of Saint-Paul Island.

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leonina) to breed and bear their young. Apart from the inner shores of this shallow crater, the terrain is very broken and hard to traverse. Dissected rock flows descend sharply from the high crater rim down to the sea to end abruptly in precipitous cliffs. There are some springs of hot water and other signs of active volcanic activity smouldering beneath the surface. Smoke or steam sometimes issues from the dark basalt walls surrounding the basin. Saint-Paul Island lies too far north to be within the true subantarctic zone, but has a relatively mild, wet oceanic climate like that of Tasmania and New Zealand at the same latitude. Mean sea-level temperature is 13.8°C. The coldest month is August with a mean of 11.2°C, while the warmest is February with a mean of 17.0°C. Mean annual rainfall is 1115 mm with a short dry season in summer (February-March) when evaporation exceeds rainfall (data from the Meteorological Office Recording Station on Amsterdam Island).

Saint-Paul Island was discovered in 1559 and subsequent sightings of the island occurred throughout the seventeenth century, but the first detailed description of it, and perhaps the first landing, was by William De Vlamingh in 1696 (Richards 1984). From its discovery, the island has never been permanently inhabited. While on these islands the transient sealers almost exterminated the subantarctic fur seals between 1790 and 1810, they also decimated the original flora and fauna through repeated carelessness with fire and through the introduction of new species (Richards 1984). Through accounts of sealers (Peron 1824), fishermen, sailors, shipwrecked mariners and scientific expeditions (Velain 1878), it is possible to provide a general description of the early flora and fauna of the island. The shore was covered with such a multitude of seals that visitors were obliged to disperse them before they could land. The whole island was covered with a kind of coarse long grass or reeds and yielded various seabirds, especially a blue petrel, as hundreds of thousands of breeding pairs were nesting in the rocks.

As with most of the subantarctic islands visited in pursuit of fur seal skins (Johnstone 1985), many of these visits lasted several years, and the men frequently, but unintentionally, brought rats and mice with them. Cats were subsequently introduced for controlling rodents. Pigs (*Sus scrofa*), goats (*Capra hircus*) and rabbits (*Oryctolagus cuniculus*) were also introduced as food. All of these introductions contributed to the destruction of the seabird populations. Before the start of this project only rabbits, rats (*Rattus rattus*), and mice (*Mus musculus*) still existed on Saint-Paul Island. Rats and rabbits have a negative impact by preventing recolonisation of seabirds, the first preying on the birds, the second using the same burrows. From subfossil bones found on Amsterdam Island (Worthy and Jouventin 1999), we know that several species of petrels and prions are now extinct from the Amsterdam/Saint-Paul Islands group. However, some seabird species now extinct on Saint-Paul Island and Amsterdam Island breed on nearby La Quille islet, 150 m from Saint-Paul Island, which has no introduced mammals, but is only 1 ha in size (Fig. 1).

This paper describes the rat eradication on Saint-Paul Island, which comprised four phases: (1) feasibility study in New Zealand in 1994, (2) two exploratory surveys in 1995 and 1996, (3) the eradication campaign in 1997, and (4) two follow-up surveys in 1997 and 1998-99.

The Administration of TAAF funded phases 1 to 4 and the European Development Fund co-funded phases 1 to 3.

METHODS

Phase 1 - Feasibility study in NZ

The feasibility of the operation, and the best method to use had to be assessed before starting the project. In 1994 a feasibility study was conducted in New Zealand by one of us (TM), consulting with people involved in similar operations from Department of Conservation, Auckland Conservancy (David Towns and Ian MacFadden) and from Landcare Research, Nelson (Rowley Taylor and Bruce Thomas). A comparison was established between the two most widespread techniques; aerial drop versus bait stations (Taylor and Thomas 1989; McFadden and Greene 1994). The first was more rapid, and the second was more likely to prevent primary poisoning of non-target species. It thus appeared that the eradication was feasible and that, with the presence of numerous cliffs around Saint-Paul Island and the absence of non-target species except non-breeding skuas, the use of an aerial drop was the best solution. We decided to focus on the eradication of rats as they caused the most significant damage to the avifauna. Eradication of rabbits was also planned as possible but not certain, as it was the first time these two species were involved together in an eradication programme. A previous eradication of rabbits on an island of similar size, Enderby Island (700 ha), had been successfully conducted in 1993 (Torr 2002). It appeared that 99% of the rabbit population were killed by poison but that the remaining rabbits had to be killed with dogs and guns. We then assumed that the same schedule would be applicable to Saint-Paul Island and that for a successful eradication we would need hunting experts and dogs.

Phase 2 - Exploratory surveys

Two exploratory surveys were conducted in February-March 1995 (four people) and April-July 1996 (five people). The aim of these surveys was to estimate (1) the density and the dispersal of target species as some data on the biology of rats, (2) the palatability of baits and (3) the status of seabird populations.

Target species survey

Rats. Densities of rat populations were assessed using snap traps. Forty sites were chosen around the island, 15 along external coasts, six at mid altitude of the external slopes, nine at the edge of the inside crater, and 10 along the coast of the inside crater. At each site, a line was established, each 100 m long and consisting of 10 traps spaced 10 m apart. The trap-lines ran parallel to the shoreline when applicable. Each site was sampled once and the sampling

consisted of 2-3 nights during which traps were checked once or twice. In addition to the snap traps, some live traps allowing multiple captures were set occasionally near the penguin colony and near the flesh footed shearwater colony.

After having determined the distribution of rats we then wanted to assess what would happened if by mistake an area was not poisoned. Do the rats living in an area with no poisoned baits move into a nearby poisoned area where rats have disappeared?

Ten snap traps were set around the hut in order to create a sink experiment simulating the death of rats in a poisoned area. At the same time we used radio telemetry to investigate sizes and spatial distribution of home ranges of 12 rats in an area located 500 m away. Adults were fitted with radio transmitters in the field under anaesthesia and released upon recovering. Radio collars consisted of button cell tags (Biotrack Ltd, Wareham, UK) that were mounted on plastic cable ties and coated with acrylic. Transmitters weighed on average 6.5g, 3% of the mass of the average 200 g rat to which they were attached. We located rats using two three-element Yagi antennas. Rats were tracked regularly at night from 10 May to 11 June 1996.

Rabbits. Rabbit populations were assessed using visual counts of faeces and observations of living rabbits along transects across the island while we were in search of seabirds and rat presence.

Palatability tests

Bait palatability was assessed with 100 kg of non-toxic baits, some coloured with the dye Rhodamine B which colours the internal tissues and faeces of consumers pink. To determine the proportion of rats and rabbits having eaten baits, dyed baits were spread by hand over a 1.5 ha area. In order to test possible shyness due to Rhodamine B we did the same experiment in an adjacent area with non-dyed baits. After spreading the pellets we marked in each area five 100m² control sites where: (1) we counted the number of baits on the ground, and (2) removed all rats' and rabbits' faeces. We then checked the number of baits remaining per site daily, and we counted the number of faeces, coloured or not, before removal. A first trial at 10 kg/ha was conducted in a high rat density area (HRDA) and in a low rat density area (LRDA). A second trial at 20kg/ha was conducted in the HRDA.

Estimation of seabird populations

Saint-Paul Island was known to support antarctic terns (*Sterna vittata*), sooty terns (*Sterna fuscata)*, flesh footed shearwaters (*Puffinus carneipes)*, rockhopper penguins *(Eudyptes chrysocome)* and sooty albatrosses (*Phoebetria fusca)* (Segonzac 1972). Some large and dark petrels were seen flying in the vicinity of Saint-Paul Island (Segonzac 1988) but the exact species and the status are unknown.

An intensive search for seabirds was carried out in 1995 on Saint-Paul Island by night sightings, visual inspections of burrows along the coasts and listening for songs at night. New species were particularly investigated, as it was the first such survey for a long time.

Phase 3 - Eradication

Following the feasibility study, the rat breeding biology was not important for the timing of the operation and suitable weather conditions was the priority as the bait breaks down in the rain. The dry season of January-February was chosen as the best time. Two drops of 10 and 5 kg/ha separated by 3-4 weeks were planned but the calendar of the ship supplying TAAF did not allow this and we had to manage with only one drop.

The bait was spread using a Lama helicopter (HéliRéunion, France) with a bait bucket (like a monsoon bucket with a base plate adapted to spread the bait and regulate the bait flow). Allowing for the speed and height of helicopter flight necessary to get a good coverage of baits, the whole coverage of the island by the helicopter would last 10 hours. Fifteen tonnes of Pestoff Rodent Bait (a 2 g grain based pellet containing brodifacoum at 20 ppm), and the bucket, were ordered from Animal Control Products (Wanganui, New Zealand). For safety reasons, the helicopter was due to fly with the supply ship Marion-Dufresne around Saint-Paul Island. The ship was planned to stay six days at the island, in order to get at least two days of good weather conditions. The bucket was loaded with baits directly from two sites on the island, with staff moving to the second site after completion of the first site. Six people were necessary for refilling the bucket, two opening the bags, two pouring the baits in the bucket, and two holding the empty bags.

Following the airdrop approximately 300 kg of Pestoff Rodent Bait was spread by hand in some places missed by the drop.

Coverage check

After departure of the ship, five people and two dogs stayed for three months on Saint-Paul Island to check the coverage of baits and to search for sign of rats and rabbits. During this stay there were also searches for any signs of non-target losses.

From the 8 February 1997 a total of 260 stakes to check for rat sign were set 100m apart along the external coast, the edge of the crater, the internal coast of the crater and along eight lines running from the top of the crater to the coast (Fig. 2). Candles and slices of sausage were placed on each stake and checked biweekly. Additionally, 100 snap traps baited with sausages, fish or apples were set near these stakes and moved each three days to check new sites.

Phase 4 – Follow-up surveys

A follow-up using methods similar to those used in 1997 was conducted in November-December 1997, with six people and the two dogs used during the eradication campaign.

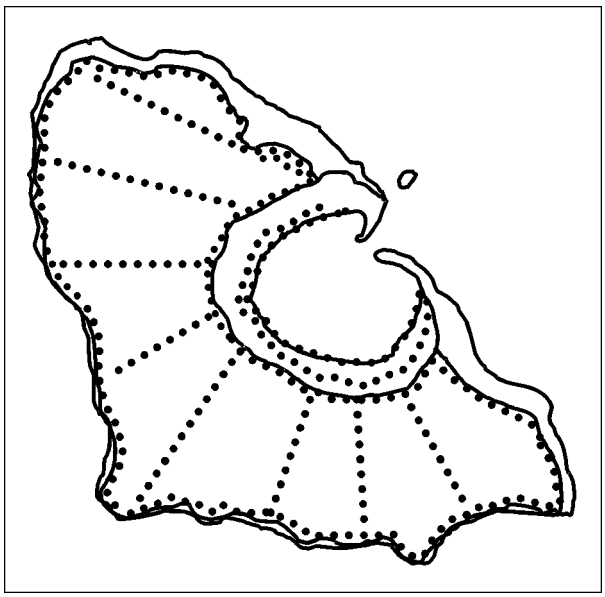
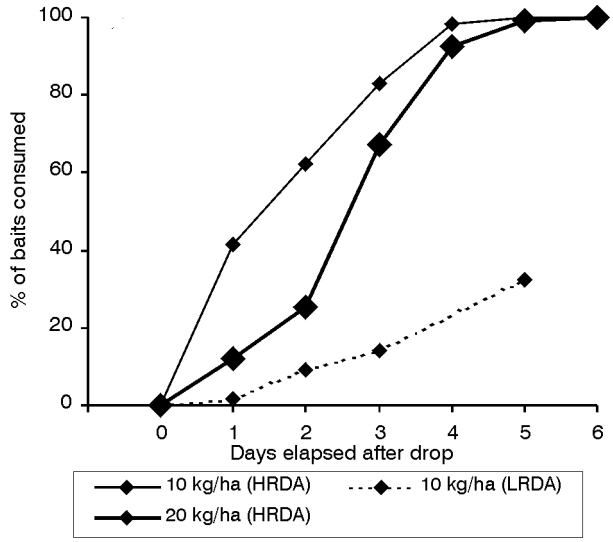


Fig. 2 Location of post-drop monitoring sites. Each dot represents a stake set 100m apart.



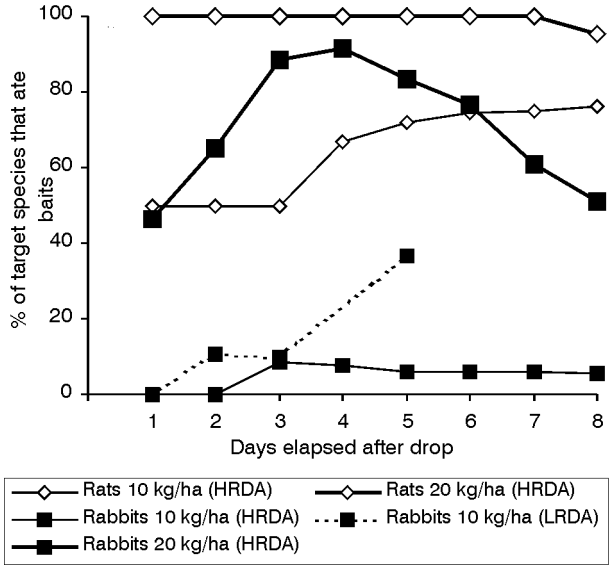


Fig. 3 Upper: Bait-take in non-toxic trials. Lower: Target species consumption of bait during non-toxic trials.

Unfortunately one dog died before arriving on Saint-Paul Island and the job had to be done with only one dog. A last follow-up was organised in December 1998–February 1999 with five people and two dogs.

RESULTS

Exploratory surveys

Density of target species

Signs of presence of rats and rabbits were found all around the island, with the highest density inside the crater.

The penguin colony live trap was very successful and on one occasion caught 12 rats together. Overall trapping results indicated that rats were 10-20 times more dense in the crater than the outside part of the island, varying from 5/ha on most of the island to 100/ha around the penguin colony and the hut. Rat density seemed to be determined mainly by food, as they were more numerous in and around the penguin colony, and around the hut where the vegetation was denser.

Bait palatability

One hundred per cent of the baits of both 10kg/ha and 20kg/ha were eaten four days after their dispersal in the HRDA but only 30% were eaten in the LRDA five days after its placement at 10 kg/ha when rain caused desegregation of the pellets (Fig. 3). The second trial conducted with baits at 20 kg/ha in the HRDA showed that ninety percent of the baits had disappeared five days after the dispersal.

When checking the HRDA spread at 10kg/ha, a maximum of 76% of rats and 8% of rabbits had eaten baits eight days after bait dispersal (Fig. 3). The trial at 20kg/ha in the same area gave better results with 100% of rats and 92% of rabbits having eaten baits four days after the spread.

It was thought that rats consumed baits before the rabbits, which may have left no available bait to eat. The relative density of baits and target species was thus very important when trying to eradicate the two species together.

The palatability tests confirmed that rat eradication on Saint-Paul Island was achievable using the Pestoff Rodent Bait but that not all the rabbits would be killed, as was the case on Enderby Island (Torr 2002).

Movements of rats

At the start of the radio tracking study in the penguin colony, rats moved no further than 100 m. A total of 167 rats were then killed from 28 April to 26 June 1996 around the hut. After creating this ‘sink’ around the hut, at least one rat moved away from the penguin colony and was caught twice in a live trap around the hut before returning to the penguin colony 500 m away. It was thus believed that even if an area was missed with baits we could obtain an effective eradication of rats.

During the same time three radio-tracked rats disappeared, being eaten by skuas. Based on the New Zealand experience, most poisoned rats were expected to die in their burrows, thereby reducing the risk of secondary poisoning of the 10-12 non-breeding skuas living in the area.

Seabird species

In 1995 the only small petrels to breed on Saint-Paul Island were confirmed to be 20-100 pairs of storm petrels in a 60m elevated cliff located south of the island. Ten to fifty pairs of white-bellied storm petrel (*Fregetta grallaria*) were discovered and also 10-50 pairs of Wilson's storm petrel (*Oceanites oceanicus*) that were not previously known to breed in this area. It was also confirmed that there were still five petrel species breeding on La Quille: endemic Macgillivray's prion (*Pachyptila macgillivrayi*); fairy prion (*Pachyptila turtur*); little shearwater (*Puffinus assimilis*); white-bellied storm petrel and we established that 40-60 pairs of great-winged petrels (*Pterodroma macroptera*) were breeding on La Quille.

Eradication

Poisoning

From the results of the trials it was calculated that 15 tonnes of bait were needed. The bait was shipped from New Zealand through Singapore taking two months to reach La Réunion. Some bags arrived mouldy, as there was a problem with condensation from the ceiling of the container dripping over the product. Each of the six hundred 25kg bags was thus opened to sort out the bad pellets leaving 13.5 tonnes available for the drop. It was decided to proceed. The condensation problem was solved by erecting a polythene tent inside the container for later shipments and it seems that no more trouble has occurred with bait going mouldy.

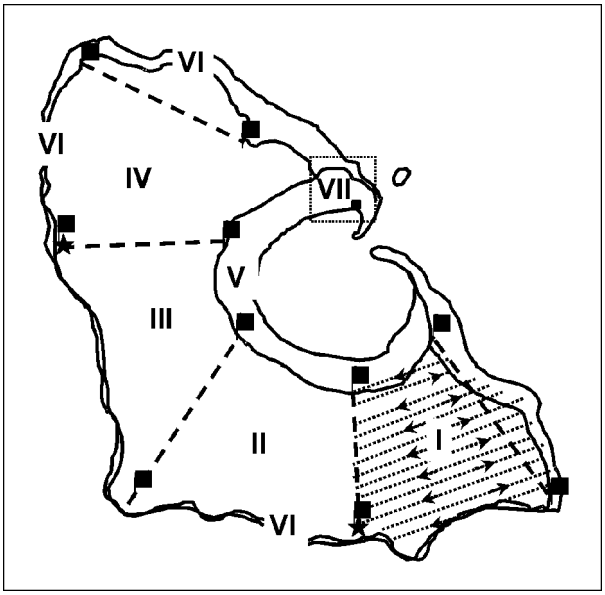


Fig. 4 Bait treatment areas and flight lines. Areas I-IV = low density 10kg/ha, area V = high density 20 kg/ha, area VI = low density 10kg/ha and area VII = very high density up to 40kg/ha. Stars indicate the sites where the bucket was loaded with baits. Flags represent the extremities of the lines with people indicating the transect lines to the helicopter. Dotted lines represent those flight lines.

The island was divided into seven main areas to be covered with bait densities varying from 10 kg/ha to 40kg/ha (Fig. 4). Poison was dropped by helicopter, following parallel lines as indicated by two groups of four people moving with flags along lines running from the top of the crater to the coastal cliffs. Four main areas were determined that covered the outside part of the crater where the target species densities were the lowest. A fifth area covered the inside cliffs of the crater and was covered at 20 kg/ha, and a sixth area covered the outside cliffs where baits were laid directly from the bucket at 10 kg/ha. The seventh area covered the penguin colony and surrounds and the hut where baits were spread up to 40 kg/ha.

For each area, in order to have the best coverage by the helicopter, transect lines spaced 100m apart were marked at each end by people with flags, each person moving to the next position after having been overflown by the helicopter. Two teams of three people were initially tasked to mark the lines but once the drop started it appeared that the helicopter crossings were faster than people could run over the tussocks and one more person was dedicated to each line. Thus eight people were needed for showing tracks to the helicopter and six to reload the bucket. Each group had a VHF radio and a supervisor coordinated the groups, the helicopter, and the ship. The airdrop of 13.5 tonnes of Pestoff Rodent Bait was conducted on the day of arrival on Saint-Paul Island, 21 January 1997. The forecast was good for the following days and no rain or heavy wind occurred during the operation.

The total aerial operation was due to last 10 hours but after a few hours work the engine on the spreader-bucket malfunctioned. The spreading was finished without the spinner (i.e. with baits falling directly from the bucket). In order to increase the coverage width without the spinner, the helicopter pilot moved the helicopter from side to side. This meant that the dropping operation lasted longer than planned and was finally finished on the morning of 23 January after a day off because the ship was not operational.

Coverage check

Dropped pellets missed only one area which was consequently hand-baited with 100 kg Pestoff Rodent Bait. The areas covered when the bait spinner was out of order were alternatively covered and not covered with baits, along bands approximately 50m wide. This was estimated to be enough to achieve the rat eradication.

At the conclusion of the eradication follow-up in April 1997, 12 dry bait stations were left in particular areas as a precaution against any remaining rats.

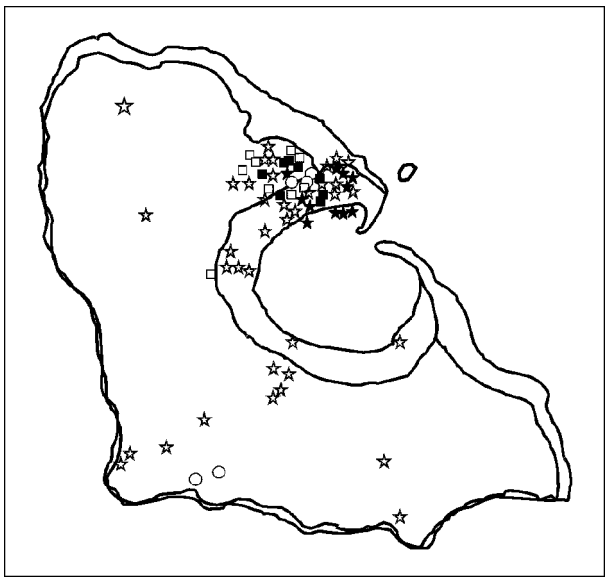


Fig. 5 Rabbits killed using dogs and guns during the follow-up surveys, from 10 Feb to 7 April 1997 (white star adult, black star young) and 25 Nov. to 18 Dec. 1997 (white square adult, black square young) and 25 Dec. 1998 to 18 Feb. 1999 (white circle adult).

Sign of rats and rabbits

The first dead rat was found five days after the bait drop and the first rabbit seven days after the drop.

The last living rat was seen two weeks after the bait drop.

Cockroaches around the hot springs ate some candles and some sausage slices from the stakes that were set out to signal any rat presence. Although mice nearly disappeared during the first weeks, they reappeared in late March 1997 and also ate baits, and were sometimes killed by snap traps. During the three-month stay in 1997, and during the follow-up surveys, no rat sign was found although the island was covered tens of times, while checking of the stakes and while looking for rabbits.

From 10 February to 8 April 1997 we killed 48 rabbits of which 17 had eaten baits (Fig. 5) as revealed by stomach inspection. Some rabbits known to live in areas where baits were hand spread 4-5 times never ate baits and were only killed after a long period of hunting. From November to December 1997, we killed 18 rabbits and from December to February 1999 we killed 5 more (Fig. 5). Most of the surviving rabbits were killed in areas vegetated with rushes (*Juncus effusus*).

Non-target species

Not a single skua was found dead from January to April 1997 and their numbers were the same as before the operation (10-12 individuals).

Mice

The last mouse was trapped on the 11 February and we did not see a living mouse before the end of March 1997.

DISCUSSION

Eradication of rats and rabbits

The eradication did not proceed according to our original plan but we were able to proceed with a revised plan, and there was no rat activity at the stake stations at the end of the main campaign in April 1997. However, the bucket malfunction illustrates the need for testing all equipment before it is sent to remote places such as Saint-Paul Island.

The absence of any sign of rats on Saint-Paul Island during checks made for three months then 11 months and 24 months after the airdrop confirms the effectiveness of the method.

The good weather conditions with no rain for two months after the drop was a very important factor, as baits remained available and viable all during this time.

After more than two years elapsed, and three surveys, it is now certain that eradication of rats has been achieved. However, as we have had no time after the last rabbit was killed to check the complete island one more time, it is too early to be confident that they are all gone. A last survey will be carried out at Saint-Paul Island in November-December 2001.

Eradication of mice

The baits killed a large percentage of the mouse population but we believe that the presence of non-baited areas due to spreader malfunction allowed some mice to survive and to recolonise the island. We also believe that the inability to do two bait drops prevented the effective eradication of mice. Mice reappeared more numerous than they were, presumably because of the removal of rat predation.

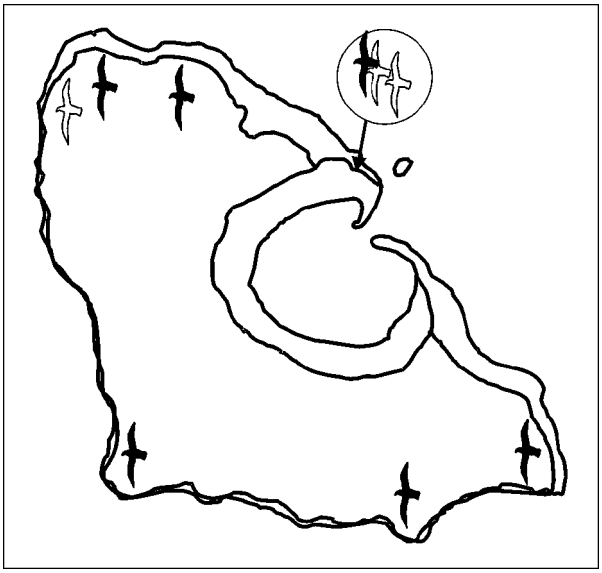


Fig. 6 Location of seabirds found after the eradication. Great-winged petrel (black symbols), Macgillivray's prion (white symbols).

It appeared that mice and cockroaches ate baits left in bait stations, making it doubtful whether the bait stations would have killed any surviving rats.

Recolonisation by seabirds

Two great-winged petrels were found in the flesh-footed shearwater colony on 1 March 1997. Prior to our departure the 9 April 1997, five other places were also found to support great winged petrel individuals (Fig. 6). It is believed that petrels did not re-establish on Saint-Paul Island because of the rat and rabbit activity. Petrels are extremely philopatric birds and they always breed in the same place, young usually being recruited to their natal colony. Because breeding places were limited on La Roche Quille, birds tried to breed on Saint-Paul Island, but they were disturbed or preyed on and no successful breeding occurred.

The first sign of endemic Macgillivray's prion on Saint-Paul Island was found on 11 February 1999 when we discovered three burrows with feathers and a strong smell under rocks located in front of La Roche Quille. Subsequent searches indicated that there were 5-10 pairs frequenting burrows in nearby areas. One lost egg was found intact in one of the burrows. In the same area 10-12 burrows were still being used in February 2000 (D. Pinaud, pers. comm.).

Modelling of the recolonisation processes by Macgillivray's prions suggests that populations will not recover for decades, but preliminary results are very promising.

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