Alien mammal eradication and quarantine on inhabited islands in the Seychelles

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Abstract During the period 1996-2000, eradication of five introduced mammal species (feral cat (*Felis catus*), rabbit (*Oryctolagus cuniculus*), ship rat (*Rattus rattus*), Norway rat (*R. norvegicus*) and house mouse (*Mus domesticus*)), was attempted on four inhabited islands, including three resort islands, ranging in size from 101–286 ha in the Seychelles group, Indian Ocean. Objectives were to avert extinctions of, and restore urgently-needed habitat for, localised threatened endemic animals and to facilitate ecological restoration in line with a national biodiversity strategy. Local political, economic and biological constraints meant that adaptations were necessary to traditional poisoning and trapping methods and regimes. Furthermore, since no rat-free island was available to which native animals at risk from primary and/or secondary poisoning might be transferred, it was necessary to maintain approx. 590 individuals of three threatened animal species in captivity for the three months of the eradication programme. Strategies and techniques developed, and some of the many challenges encountered in conducting eradication and quarantine programmes on inhabited, tropical islands are outlined, together with progress to date. One island (Bird) has been maintained free of rats and rabbits since their eradication in 1996. Two others (Denis and Curieuse) are now free of feral cats but have been recolonised by *Rattus rattus* since eradication attempts in 2000. The fourth (Frégate), was successfully cleared of *R. norvegicus* and mice in 2000, in time to avert extinctions of localised threatened endemic animals. These positive results will, we hope, inspire similar effort on other inhabited islands with high biological values or potential.

Keywords threatened species recovery; ecological restoration; eradication on inhabited islands; rodent eradication; cat eradication; Indian Ocean islands

INTRODUCTION

In 1964 when ship rats (*Rattus rattus*) irrupted on Big South Cape, a remote 939 ha island off southern Stewart Island, New Zealand, few anticipated the massive ecological impact, or the extent to which this event would shape future island conservation policy and practice both within New Zealand and beyond. Big South Cape was the final refuge for several endemic New Zealand animals – three birds, one bat and an unknown number of invertebrate species. Swift action by NZ Wildlife Service staff averted extinction of one bird, the South Island saddleback (*Philesturnus carunculatus carunculatus*), but all others were exterminated by the rats (Bell 1978; Merton 1978; Atkinson 1985). Although some conservation workers of that era recognised the threat rats pose to island biotas, many did not (Bell 1978; Galbreath 1993). The ecological collapse of Big South Cape was thus, both nationally and internationally, an important and timely lesson from which modern island rodent quarantine, contingency policies and protocols largely originate (Moors *et al.* 1989).

Thirty years on, in spite of major advances in both knowledge and eradication capability, and in the full glare of the international conservation spotlight, it is indeed remarkable that the biological tragedy of Big South Cape was very nearly repeated in the Seychelles. In 1995, Norway rats (*R. norvegicus*) reached Frégate Island, the Seychelles' last remaining rat-free island greater than 100 ha in area. Frégate is the principal refuge of two birds, three invertebrates and a mollusc endemic to the Seychelles, and supports the largest populations of six endemic reptiles. Five years were to elapse before any sustained eradication attempt was made, and this was driven largely by the negative impacts of rats on commercial tourism interests rather than threats to biodiversity conservation, such as the impending extinction of a giant tenebrionid (*Polposipes herculeanus*) (Parr *et al.* 2000). How, in this age of environmental awareness, could this situation arise, and how can we ensure prompt and effective action is taken next time an important conservation island is invaded by rats?

In this paper, we describe eradication campaigns against invasive mammals on four Seychelles Islands and protocols to prevent re-invasion.

The Seychelles

The Seychelles (Fig. 1) is an isolated archipelago of approx. 115 granitic and coral islands that occupy a land area of 445 km^2 and span 1200 km of the tropical Indian Ocean between 4^o and 8^o S. The four islands included in the eradication programme are within the "inner group" comprising the most northerly cluster of approx. 40, mainly granitic islands rising from a continental shelf of Gondwanan origin. The Seychelles had no indigenous human population. Europeans first discovered the group in 1609. Although known to other seafarers, such as Arabs, possibly as early as the 10th century (Benedict 1984), permanent human settlement began in 1770. Today, four large islands

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within the inner group hold almost all the human population of 76,500 with over 90% found on the largest island Mahé (152 km^2) (Benedict 1984).

Like other long-isolated oceanic islands, the Seychelles had no indigenous land mammals other than bats. Consequently, its animals and plants had few innate defences against such animals once introductions began in the late 18th century. Of surviving endemic birds, most have undergone a massive retraction in range and numbers (Stoddart 1984; Diamond 1985). For example, by the 1980s only approx. 20 Seychelles magpie-robins *(Copsychus sechellarum)* survived on a single island (Frégate); currently the Seychelles fody (*Foudia sechellarum*) exists only on four islands, three of them less than 50 ha in area; the grey white-eye (*Zosterops modestus*), now virtually extinct on the main island, survives elsewhere on just one approx. 60 ha island; the Seychelles brush warbler (*Bebrornis seychellensis*) was until the 1980s confined to one small island (Cousin, approx. 29 ha); and the black paradise flycatcher (*Terpsiphone corvina*) has a severely restricted range on only two islands. By 1997, introduced mammalian predators had colonised all but a few small islands, leaving a total of only 280 ha free of cats and/or rats.

Watson *et al.* (1992) suggested that the feral cat (*Felis catus*) was the cause of Seychelles magpie-robin extinctions on Aride and Alphonse as well as their serious decline on Frégate. It is, however, difficult to separate the effects of rats and cats because both species are present on most islands – cats were often introduced in an attempt to control rats.

The four inner-group islands of Bird, Curieuse, Denis and Frégate were the focus of recent attempts to eradicate introduced invasive mammal populations. Frégate has a small harbour with a wharf where small boats can tie up; the other islands are accessed by light fixed-wing aircraft or by dinghy ferrying goods and passengers from a launch standing offshore.

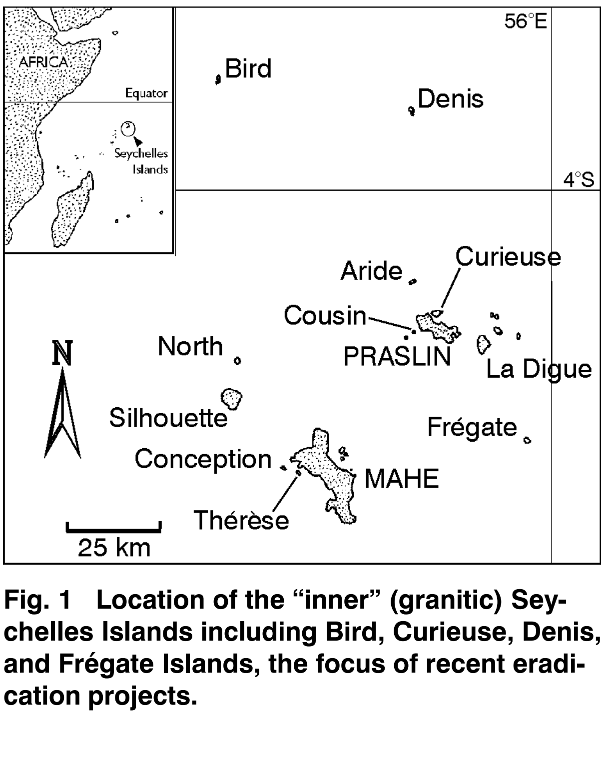

Fig. 1 Location of the “inner” (granitic) Seychelles Islands including Bird, Curieuse, Denis, and Frégate Islands, the focus of recent eradication projects.

Bird Island

Bird Island (101 ha) is a privately owned, low-lying, modified coralline sand cay 105 km northwest of Mahé. It is the northern-most of the Seychelles group. A tourist lodge built in the 1970s caters for up to 40 visitors with around 40 resident staff and their families. Although known internationally for its massive sooty tern *(Sterna fuscata)* nesting colony numbering about half a million breeding pairs, the island has no legal protective status. Ship rats reached the island in bundles of *Latania* fronds used for roofing thatch from Praslin Island (G.Savy pers. comm.) during construction of the lodge in the 1970s. Rats reached remarkably high densities during the sooty tern breeding season and were an ongoing serious problem for both the island’s management and resident wildlife. Rabbits (*Oryctolagus cuniculus*) and mice (*Mus domesticus*) were present by the early 1900s.

Curieuse Island

Curieuse (286 ha) is a granitic island situated 52 km northeast of Mahé and 1 km off the northwestern coast of Praslin. The island rises steeply to a central ridge that reaches 172 m at its highest point. Coastal plateaux and lower slopes are heavily forested. The island is renowned for its outstanding biological values which include some of the least modified vegetation associations to be found in the Seychelles, as well as a number of threatened endemic plants and animals. From 1833–1965 the island was occupied by a leper colony. It has since been designated part of Curieuse Marine National Park and is managed by the Marine Parks Authority with about seven rangers in residence. Feral cats, ship rats, and mice were present prior to the current eradication attempt. Since the island is relatively large and already conservation estate, its potential for re-introduction of threatened endemics has long been recognised. Eradication of cats and rats was considered essential if the island was to function as an effective reserve for indigenous animals and plants.

Denis Island

A 143 ha, privately owned coralline island situated 95 km north of Mahé, Denis is low-lying; its highest point being only ~4 m above sea level. The island is forested but for the airstrip and clearing associated with a tourist lodge near the northern coast. Most natural vegetation was cleared last century and the island managed as a coconut *(Cocos nucifera*) plantation until the 1950s, when the plantation was abandoned. Wild coconut is now dominant both in the canopy and understorey, however significant native forest remains. Feral cats, ship rats and mice have long been present. Although the island’s natural values have been degraded, it has potential for the conservation of indigenous plants and animals. The island has no conservation protective status.

Frégate Island

Frégate (219 ha), is a privately owned granitic island situated 55 km east of Mahé. Apart from a 35 ha plateau near the north-eastern coast where a tourist lodge, staff houses, cultivations, airstrip and small boat harbour exist, the island is forested. The highest point, Mont Signale, is 125 m above sea level. All natural vegetation was cleared last century and the island was managed as a copra plantation until the 1950s. The plantation has since been abandoned and a forest association dominated by coconut, cashew (*Anacardium occidentale*), sandragon (*Pterocarpus indicus*), cinnamon (*Cinnamomum* sp.), citrus (*Citrus* sp.) and other formerly-cultivated species now covers the greater part of the island. Feral cats were eradicated in the 1980s by C. R. Veitch and V. Laboudallon with local assistance (Watson *et al.* 1992).

The first Norway rat was reported on the island on 11 September 1995 (M. Rands pers. comm.; Jones and Merton 1995; Merton 1996; Thorsen *et al.* 2000). By July 1998 the population had irrupted and dispersed throughout the island (Merton 1999). Frégate is an important refuge for many endemic animal species considered highly vulnerable to rat predation. Prior to the 1990s the Seychelles magpie-robin was confined to Frégate, which still supports the largest population of magpie-robins, along with the largest of only four remaining Seychelles fody populations. Frégate provides vital habitat for at least six endemic reptile and several invertebrate species, and is the sole refuge of a giant endemic tenebrionid (*Polposipes herculeanus*), and endemic molluscs (*Pachnodus fregatensis* and *Conturbatia incisa*) – the latter, a genus known only from Frégate. The island has no formal conservation status.

Ecological collapse, similar to that of Big South Cape Island in the 1960s, seemed likely on Frégate. Merton (1996) therefore recommended that an immediate attempt be made to eradicate the colonising rats and that ongoing monitoring of key endemic animals, such as the giant tenebrionid, be carried out to establish population baselines and future trends. DM recommended that other islands with conservation potential be cleared of rats at the same time to increase the severely restricted rat and cat-free habitat remaining for vulnerable Seychelles endemics and so the Frégate operation might benefit from economy of scale.

Thorsen *et al.* (2000) describe initial attempts to contain and eradicate rats while their population was small and localised during their early colonisation of Frégate. The project was abandoned when several Seychelles magpie-robins disappeared and one was found moribund with symptoms consistent with rodenticide poisoning. BirdLife Seychelles instigated regular monitoring of some threatened endemics in early 1996. During the period March 1996–November 2000, the adult population of the giant tenebrionid declined by about 80% (Parr 1999). In the 1999/2000 breeding season, 19 magpie-robin fledglings disappeared within the first few days after leaving the nest (Millett pers. comm.). Both events were linked to predation by rats (Parr *et al*. 2000).

Background to eradication campaigns

In November 1995, at the owner's request, DM visited Bird Island to study the feasibility of eradicating rats and rabbits. The successful outcome on Bird (Feare 1999), coupled with the arrival of Norway rats on Frégate Island in 1995 (Merton 1996; Thorsen *et al.* 2000) sparked interest in ecological restoration of further islands.

In 1997, the Seychelles Ministry of Environment and Transport (MET) resolved to eradicate alien mammals from Curieuse Island as part of its ecological restoration programme, and to coordinate similar work on other islands (Ministry of Environment 1997). The Conservation Division within MET funded DM, via a Dutch Trust Fund grant, to study the feasibility of eradicating rats and feral cats from Curieuse, Denis, Conception and Thérèse Islands, and rats from Frégate Island. DM, assisted by VL and other MET conservation staff, visited the five islands in July – August 1998 and submitted a report and eradication proposal to MET (Merton 1999).

Three islands (Curieuse, Denis and Frégate) eventually formed the basis of the eradication plan adopted and implemented by the Seychelles Government, in collaboration with management of Frégate and Denis Islands and BirdLife Seychelles (Merton 2001). The project was coordinated by MET, funded by island owners and management, together with a grant from the Dutch Trust Fund, and organised by DM, who led the eradication team comprised of New Zealanders and Seychellois.

Goals of the proposed programme were:

- to prevent global extinction of endemic Seychelles animals confined largely or entirely to Frégate Island;
- to provide urgently needed habitat, free of alien mammalian predators, for the expansion in range and numbers of threatened endemic animals whose relict populations currently occupy dangerously restricted ranges – an essential first step towards ecological restoration in line with a national biodiversity strategy;
- to enhance these island environments from a human use perspective including eco-tourism. These benefits were important because the eradication and subsequent rodent quarantine could not proceed without the support of local communities and government, and funding from island owners.

To meet these goals the following objectives had to be achieved:

- rodent quarantine and contingency plans developed for, and accepted and implemented by, management and staff on each of the islands;
- local conservation staff trained in eradication techniques;

- rats eradicated from Curieuse, Denis and Frégate Islands, and cats from Denis and Curieuse. (While not a core objective, it was hoped that mice would also be eradicated, due to their potential impacts as predators of invertebrates and reptiles if they reached high densities after the removal of rats and cats.)

A ground-based operation was less practicable on these islands due to their larger size, dense vegetation cover and, in the case of Curieuse and Frégate, more rugged topography. Some economy of scale was achieved through incorporating the three islands into a single eradication operation.

BIRD ISLAND FEASIBILITY STUDY

In November 1995, DM assessed densities and distribution of target species on Bird Island (ship rats, rabbits and mice); the most preferred and appropriate bait and means of presentation; non-target species at risk and how these risks could be managed; optimum timing of poison application; logistics, costs, and resourcing requirements. The ability to implement and sustain quarantine and contingency measures to prevent re-introduction of rats was assessed through discussions with the owner and island staff.

Rodent indices and population data were obtained through cage trapping. Twenty-three mesh cage traps, baited with grilled coconut pieces, were sited at 50 m intervals along an index line which took in open terrain, forest and part of the sooty tern colony. Traps were opened on specific nights only. Rat index trapping results (using the method of Cunningham and Moors (1996) to obtain a standardised index of rat abundance expressed as captures per 100 corrected trap nights (CTN)), age, sex, weight, and breeding status were recorded (Appendix 1).

Index trapping in November 1995 indicated that rats were present at high densities (26.5 rats/100 CTN) (Appendix 1). Their ecological impact was evident from the high level of rat predation on nesting sooty terns during the breeding season (S. Robert pers. obs.). Mice were seen only occasionally throughout the island but could be expected to become more numerous and problematic should they survive the eradication attempt. Rabbits were rarely seen and were localised on the airstrip.

Eight commercially-available rodenticide bait types, of which three were available in non-toxic form, were compared for acceptance by target and non-target animals, and durability in a tropical environment (Table 1). Bait preference by rats was ranked by placing a measured weight of each bait under each of eight stations (upturned buckets with a 50mm diameter hole cut in the side) overnight and weighing how much of each type remained the following morning. For each station, there was a paired control comprising a similar selection of baits placed in the open where they were vulnerable to disturbance and removal by the full range of target and non-target species. This process was repeated for five nights. Land crabs (*Cardisoma* sp.) often removed 100% of baits from open plots in coastal sites. Preference trials were also conducted with caged rats. The three non-toxic bait types were offered at a feeding table traditionally visited by a range of bird species. Bait preference to birds was assessed by direct observation. To assess weathering, baits placed under 1 m x 1 m wire 10mm mesh covers, which excluded all animals other than small invertebrates, were monitored for signs of breakdown, mould, and removal by ants or cockroaches.

Wanganui No. 7 standard 12 mm pelleted bait (20 ppm brodifacoum; Animal Control Products Ltd (ACP), Wanganui, NZ) was chosen for hand broadcasting to target rats, mice, and rabbits. This was more acceptable to rats than other pelleted baits trialed, was more durable, less prone to ant damage, and also less acceptable to non-target species – presumably because it was green-dyed to deter birds (Caithness and Williams 1971) (Table 1). Talon 50WB^{TM} wax blocks (50 ppm brodifacoum; 18 g per block) were sufficiently acceptable and durable to be maintained in bait stations throughout the programme, which was to extend through the "wet season" (November–March).

Non-target species at risk included ruddy turnstone (*Arenaria interpres*) accustomed to feeding at a bird table, cattle egret (*Bubulcus ibis*), introduced Madagascar turtle dove (*Streptopelia picturata*), barred ground dove *(Geopelia striata)*, Madagascar fody *(Foudia madagascariensis)*, Indian mynah (*Acridotheres tristis*), and domestic poultry, pigs and a dog, as well as young children. Poisoning of individuals of more numerous, introduced, ground-feeding species was considered inevitable, but acceptable to the owner and unlikely to have any significant or lasting impact on populations. The potential risk to reptiles was considered to be low (Merton 1987). However, as a precautionary measure, it was agreed that all three Aldabran giant tortoises (*Geochelone gigantea*) would be held in captivity during the campaign (i.e. from before the first poison application until after all baits had been removed).

BIRD ISLAND ERADICATION CAMPAIGN

The one child under four years old was removed from the island for the duration of the programme. Domestic livestock, a dog, and three Aldabran giant tortoises were confined to prevent access to baits. Domestic poultry and pig feeding regimes were modified to prevent rats gaining access to stock foods, and protocols were implemented to prevent rats gaining access to stored foods or refuse.

Parallel transect lines to provide foot access were cut at 50 m intervals across the entire island and marked with tape. Index trapping, using the same method as in November 1995, was carried out before and during the November 1996 eradication operation.

The poisoning operation began on 30 October 1996, immediately after the majority of the sooty tern chicks, a major food source for the rats, had left the island, but before the NW monsoon and associated wet season began in late November. The tourist lodge remained open throughout.

Three to five Talon 50WB wax blocks were placed in each of 800 bait stations sited at 50 m intervals along each transect line. Bait stations were made from 1 *l* plastic drink bottles with one end cut off, or from 400 mm lengths of 110 mm PVC pipe. To reduce bait consumption and scattering by non-target species, especially skinks, masking tape was stretched across the lower portion of station openings. Hermit crabs, which were especially abundant in the coastal zone, were largely excluded by elevating bait stations 1-2 m above the ground; this was achieved by tying each bait station to the central rib of a cut coconut palm frond lodged horizontally in the fork of a low growing palm.

Approximately 60 kg of Talon wax block bait was laid in the first loading of bait stations. Four days later, each was replenished with 2 blocks of bait because many bait stations were empty after the first night. It was apparent at this point that many rats were already dead because most of this second pulse of bait remained after three nights.

Table 1 Rodent baits trialed on Bird Island, November 1995 after five days exposure and 10 mm rainfall. (The three pellet types produced by Animal Control Products (ACP), N. Z. were available in both toxic and non-toxic forms; the remaining six products were available only as toxic baits).

Trade name	Active ingredient	Exposed on damp forest floor	In covered bait stations	Comments
"Tornado" blue cubes South Africa	Difenacoum 100ppm	No change	No change – become soft during heat of day, but maintain shape	Excellent durability, no bird/ant interest, little loss to crabs
"Klerat" dark blue wax blocks ICI, UK	Brodifacoum 50ppm	No change	No change	Excellent durability, no bird/ant interest, little loss to crabs
"Storm" Light blue–pillow shape, 16.5 g Shell, UK	Flocoumafen (50ppm)	No change	No change	Excellent durability, no bird/ant interest, little loss to crabs
"Ditrac" blue wax blocks	Diphacinone (50ppm)	No change	No change	Very good durability; Some ant damage, little loss to crabs
"Talon 50WB" wax blocks, 18 g ICI, NZ	Brodifacoum 50ppm	Little change Melt readily in direct sunlight	No change Soft during day	Good durability; relatively low melting point a disadvantage, little loss to crabs
"Wanganui rodent pellets", cereal, 7mm diam. ACP, New Zealand	Non-toxic (normally Brodifacoum 20ppm)	Soft, crumbling, heavily attacked by ants, many partially buried	Considerable ant damage to some	Good durability, ants and crabs a serious problem, break down rapidly in rain
"Wanganui No. 7" standard 12 mm diam. cereal pellets = "PestOff 20R" ACP, NZ	Non-toxic (normally Brodifacoum 20ppm)	Swell slightly under humid conditions, no crumbling or erosion, colour fading, 10% partially buried by ants	No change, little interference by ants, some mould on one	Excellent durability except in very wet, relatively little interest by ants and birds; significant loss to crabs
"Agtech R5" pellets ACP, NZ	Non-toxic (normally Brodifacoum 20ppm)	Swollen, eroding & crumbly	Significant erosion of surface, ant and structural damage	Poor durability, due to erosion by climate and ants, significant loss to crabs
Wax candle (gnaw-stick)		Melt and droop in heat	Melt and droop in heat	Melt badly, rodent sign confused by that of crabs and cockroaches

Stations were subsequently restocked at monthly intervals. Monthly refilling continued until April 1997, when all but 12 designated permanent bait stations were removed. In total, 200 kg Talon 50WB was used. This method facilitated ongoing poisoning of any rats that survived into the wet season (when it was not feasible to broadcast pellets since they would break down rapidly under the wet conditions) and provided more targeted delivery of toxin over an extended time frame (considered important for eradication of mice).

To intensify the initial knockdown of all three target species, one tonne of Wanganui No. 7" pelleted bait was broadcast by hand in two pulses at 10 day intervals (Nov. 8-12 and 18-20) (Appendix 2). The operator stopped every 25 m along each transect line to cast one measured cupful (approx. 100g) to the north, south, east, and west, and deposit a fifth at his/her feet, thus achieving a coverage of 4-5 kg/ha. Higher concentrations of bait were applied along coastal strips, where bait loss to land crabs was highest, and in areas of dense cover, in and under buildings and in ceilings. Lower concentrations of bait were laid in open areas of dry mown grass (approx 30 ha), which supported rabbits but few rodents.

Capture rates of rats prior to the first application of pellets reached 141 rats/100 CTN (Appendix 1). This high population density may have been associated with the unusually late departure of sooty terns from the breeding colony. Index trapping also confirmed that some breeding was in progress. It was therefore important to ensure that baiting catered for juveniles initially confined to nests or denied access to baits by dominant adults.

Nine days into the poison campaign, rat indices had dropped to 15.2/100 CTN and the majority were juveniles. No rats were caught when traps were again opened 16 and 17 days after poisoning commenced. By the third week there was no sign of live rats, mice, or rabbits.

Records were kept of any dead non-target species found but carcasses were not analysed to confirm cause of death. Non-target deaths detected (Table 2) included turnstone, cattle egret, Asiatic whimbrel *(Numenius phaeopus variegatus)* and introduced Madagascar fody, Indian mynah, Madagascar turtle dove and barred ground dove. Although Seychelles skinks were seen feeding on rain-softened pellets, there was no observed mortality.

Follow-up monitoring included regular examination of Talon WB baits in permanent bait stations, and checks of the sooty tern colony during subsequent breeding seasons for signs of rat predation on eggs and chicks. While the eradication of rats and rabbits proved to be successful, mice were seen in the lodge in early 1998, having either survived the eradication attempt or been accidentally reintroduced. Mice are now widespread and abundant on Bird Island.

CURIEUSE, DENIS AND FREGATE ISLAND CAMPAIGNS

The feasibility study carried out in July-August 1998 (Merton 1999) indicated that rats were at a relatively-high density on all three islands (Appendix 1) and that there was no evidence of more than one rat species on each island. An assessment was made of non-target species at risk from poisoning and we established mitigation measures, including aviaries and enclosures. Discussions with stakeholders, including island owners and staff, addressed optimum timing of poison application, logistics, costs, resourcing requirements and, most importantly, the ability to implement and sustain quarantine and contingency measures to prevent re-introduction of rats. Appendix 3 provides an example of the recommended protocol for Frégate Island. Timing of the operation, starting in early June rather than July/August, was dictated by the seasonal low in tourism rather than biological factors. An operation at any other time would have necessitated closure of the Denis and Frégate Island resorts in the height of the tourist season, with the loss of considerable revenue.

On Frégate Island, 39 magpie-robins and 330 Seychelles fodys were taken into captivity before the poison operation began in June 2000 and were held in rat-proof enclosures until baits were no longer available (11 weeks). A total of 215 Aldabran giant tortoises were also held captive on the three islands (see Table 2). In addition to the measures taken on Bird Island to minimise impacts on other non-target species, it was necessary during each aerial drop to protect aquatic fauna (e.g. endangered, endemic freshwater fish and terrapins) by covering ponds with polythene film. Roof water catchment down-pipes were disconnected and water tanks covered. Frégate giant tenebrionids had previously been established in captivity at London Zoo, U.K.

Livestock feeding regimes, human and livestock food storage and refuse disposal protocols were implemented on

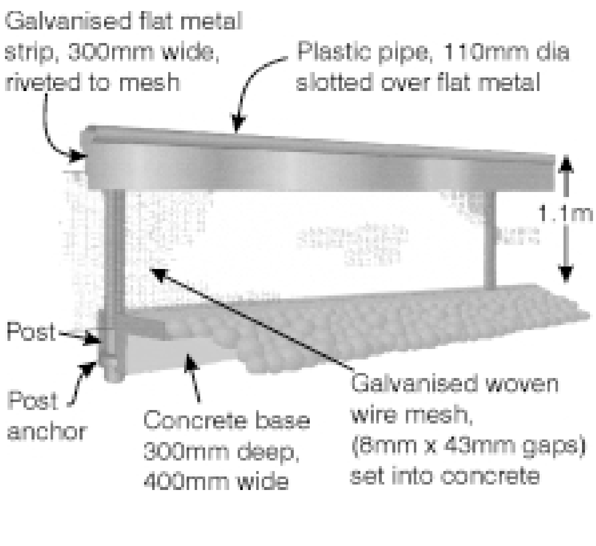

Fig. 2 Frégate Island Harbour rodent fence.

each island to deprive rats of alternate food sources, and rodent quarantine and contingency plans were put in place (Appendix 3). On Frégate Island, a rodent-proof harbour fence, designed by DM in consultation with MET and Frégate Island management, was constructed by Frégate staff (Fig. 2).

To determine when it was safe to release the several hundred threatened animals from protective confinement on Frégate Island, bait degradation was monitored within six exclosures. These exclosures were sited in representative vegetation types, at different elevations, aspects and exposures, and were designed to protect baits from interference by all animals other than invertebrates. Each exclosure comprised a rigid 1 m x 1 m wire bird-mesh (10 mm x 10 mm mesh size) cover 10 cm high. Twenty-five pellets were placed on the ground beneath each cover on the same day that bait was applied to the island. Pellets within each exclosure were counted and the number and condition recorded at least weekly thereafter until all pellets had broken down to such an extent that they were no longer recognisable and no longer posed a risk to wildlife.

Three 10 m x 10 m (100 m^2) open quadrats were established on each of Denis and Curieuse, and four on Frégate, in order to sample bait densities immediately after each aerial application and subsequently to monitor the rate of bait consumption/loss to both target and non-target species. So far as practical, sites were selected in different vegetation associations, and at different elevations, aspects and exposures. Each quadrat was measured using a tape measure, and wooden or metal stakes 40 cm in length were driven into the ground at each corner. Fine white string was then stretched and tied between stakes. For ease of counting, each quadrat was sub-divided into quarters using further stakes and string. Pellets falling within quadrats were counted immediately following aerial bait application and, where practicable, daily thereafter until all pellets had either disappeared or broken down to such an extent that they were no longer recognisable (Fig. 3).

A helicopter (Bell Jet Ranger) was hired from Helicopter Seychelles Ltd for each of the seven rodent bait applications. A differential global positioning system (DGPS) brought from New Zealand was installed into the helicop-

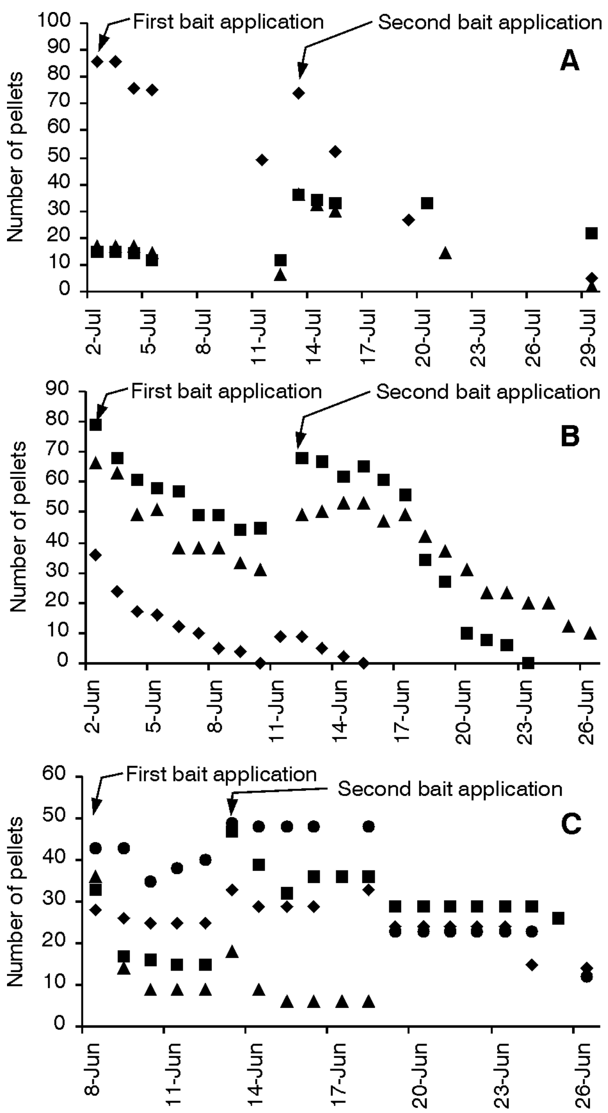

Fig. 3 Pellet density and rate of consumption or loss from 10 m x 10 m quadrats following aerial baiting on three Seychelles islands in the year 2000. The number of pellets in each quadrat can be translated to kg of bait per ha in the table:

Pellets/100m^2	10	20	30	40	50	60	70	80
kg/ha	2.5	5	7.5	10	12.5	15	17.5	20

The upper graph (A) for Curieuse Island shows: Quadrat 1 (diamonds) at Anse St Jose, sand beneath open mature coastal plateau forest; Quadrat 2 (squares) at Badamier Saddle, exposed, arid, hillside (65 m a.s.l.), eroded granite with sparse stunted tussock and scrub; Quadrat 3 (triangles) at Anse Badamier, damp forest floor beneath closed canopy of mature Badamier/Takamaka forest, 100 m from coast.

The centre graph (B) for Denis Island shows: Quadrat 1 (diamonds) in coastal *Scaevola* scrub, with high density land crab population; Quadrat 2 (squares) in mature forest near the centre of the island; Quadrat 3 (triangles) in open, close-cropped, grassland 50 m from coast.

The lower graph (C) for Frégate Island shows: Quadrat 1 (diamonds) at Au Salon in mature sandragon forest; Quadrat 2 (dots) at Grande Anse in open coastal cultivation with sparse, mature coconut; Quadrat 3 (triangles) at La Cour, mowed grass, coastal plateau near airstrip; Quadrat 4 (squares) at Gros Bois Noir in mature sandragon forest, inland plateau 75m a.s.l.

ter before each baiting. Prior to each bait drop the DGPS differential unit was set up on some nearby vantage point, taking its power supply from the battery of a tractor or other vehicle, the motor of which had to remain running throughout the baiting operation in order to cope with power demands. The helicopter was flown by an experienced New Zealand pilot with an "agricultural rating". Before the initial aerial baiting on each island, the island's boundary was flown and coordinates logged into the computerised DGPS system. Parallel transects at 40 m spacing were generated on the GPS screen. The pilot then overflew these transects to evenly distribute baits from a motorised spreader hopper with an 80 m swath, slung beneath the helicopter. Thus, each swath overlapped 50% with the previous swath, so ensuring complete coverage. The spreader hopper and bait were imported from New Zealand.

The PestOff 20R pelleted rodenticide bait (20 ppm brodifacoum; ACP) used was identical to the Wanganui No. 7 pellets hand broadcast on Bird Island in 1996. Aerial applications were broadcast in two pulses with an 11-day interval on Curieuse and a nine-day interval on Denis. Three pulses, five and 24 days apart, were applied to Frégate Island (Appendix 2). An additional pass was made over the coastal zones of each island to compensate for anticipated heavy bait loss to crabs, with the intention that each 80 m coastal strip would receive a 50% heavier bait application rate than elsewhere.

Rat indices and non-target mortality were monitored as on Bird Island, except that the traps were set and checked daily without interruption before and during the campaign. The proportion of reproductively-active females (pregnant or lactating) present in May-June 2000 ranged from 5.8% on Curieuse (among 34 adult females caught, two were pregnant and none were lactating) to 66% on Denis (where only three adult females were caught, of which two were lactating). On Frégate, 38% were reproductively active. Catch rates plummeted immediately after the first aerial baiting. For example, on Denis and Frégate, no rats were caught after the first baiting, while on Curieuse, the trap catch rate over the first four nights following the initial bait application was 4/100 CTN and no rats were trapped subsequently (Appendix 1).

Checks of the 100 m^2 quadrats within hours of each aerial drop, before the nocturnal land crabs had opportunity to remove baits, indicated that bait application varied widely from the intended delivery rate of 12 kg/ha for inland sites and 18 kg/ha for coastal strips. However, even with bait applications of 10 kg/ha onto coastal quadrats with high density crab populations, baits were available at >2 kg/ha for at least four nights after each bait drop (Fig. 3). On all three islands, a significant amount of bait was also taken by ants, cockroaches, and introduced doves of two species.

After five days of exposure, pellets within Frégate Island exclosures were baked hard by the sun and upper surfaces had faded to a pale straw colour. Between seven and 12 days, ants had significantly eroded and partially buried many baits, and white mould had developed. After 12 to 20 days of exposure, most baits were encased in black mould. Those baits remaining above the surface after 25 to 30 days were heavily eroded and were hardly recognisable. By 44 days, no recognisable pellets remained and the exclosures were removed.

At least eight cats are believed to have died as a result of brodifacoum poisoning on Curieuse and Denis Islands. Three cats on Curieuse and one on Denis were found dead 14 days after the first rat bait application and before the first 1080 poison was laid for cats. Four others on Curieuse disappeared at this time. Some of these deaths are likely to have been due, at least in part, to secondary poisoning through eating poisoned rats. However, with a brodifacoum LD50 of 25mg/kg it is doubtful that cats would have been physically capable of consuming sufficient poisoned rats during this period to constitute a lethal dose (W. Simmons pers. comm.), and we suspect that in the absence of rats, these cats consumed rain-softened rat bait and died from primary poisoning.

Cat eradication commenced one week after the second rodent bait applications on Curieuse and Denis Islands (Appendix 2), the rationale being that cats deprived of their primary food source (rodents) would be more susceptible to poisoning and trapping. Also, it was important to minimise the use of 1080 toxin on these inhabited islands (Eisler 1995). Rats would have consumed much of the 1080 if it had been applied earlier, and bait aversion may have occurred if sub-lethal doses had been consumed.

Thirty cat bait feeding stations (modified "Philproof" mini bait stations; ACP) had previously been established near refuse dumps and other traditional cat feeding sites on Denis, and 70 stations were in place on Curieuse. These were stocked for the first week with non-toxic cat bait (PestOff non-toxic pelleted chicken meal cat bait; ACP), which was then replaced with toxic bait of identical type containing 0.1% 1080 (PestOff 1080 chicken meal cat bait). Some bait was also laid in selected natural sites in areas remote from human habitation.

Bait presentation had to be modified due to low acceptance by cats on Curieuse and Denis (in contrast to high acceptability by feral cat populations elsewhere (Morgan *et al.* 1990)). Satisfactory acceptance was achieved by grinding the 1080 cat pellets and mixing the resulting powder at a ratio of one part ground pellets to five parts by weight of canned tuna in vegetable oil. Two lethal doses were contained within 10 g of this mixture. Baits were monitored and replaced daily for 2–3 weeks. The first cat deaths attributable to 1080 poison were discovered on 26 June on Denis Island (three days after the first baiting) and in late July on Curieuse, where 1080 poisoning began on 22 July.

Cat trapping began one week after toxic cat baits were first laid. Lanes Ace and Victor 1.5 leg-hold traps were spaced at 100 m intervals along tracks and baited with (non-toxic) canned tuna. Ninety traps were deployed on

Table 2 Estimated mortality in non-target organisms resulting from rat eradication using brodifacoum, mitigating measures, and impacts. No non-target mortality is known to have resulted from use of 1080 for cat eradication. (Table adapted from Parr *et al.* 2000).

Non-target species	Status	Distribution	Mitigation measures	Estimated mortality
Pets and livestock	Introduced	All islands	Housed and penned	None
Seychelles magpie-robin *Copsychus sechellarum*	Critically endangered endemic	Frégate	Captive management 39 (100% of population)	None
Seychelles fody *Foudia sechellarum*	Vulnerable endemic	Frégate	Captive management 330 (50% of population)	7.5% of captive population (n=25); no observed mortality in free-living (50%)
Turnstone *Arenaria interpres*	Non-threatened migrant	All islands	Use of green-dyed bait and low (20ppm) brodifacoum loading.	Bird 12 (50%) Curieuse 5 (25%) Denis 25 (80%) Frégate 30 (90%)
Asiatic whimbrel *Numenius phaeopus variegatus*	Non-threatened migrant	All islands	Use of green-dyed bait and low (20ppm) brodifacoum loading	Bird 2 (20%)
Madagascar turtle dove *Streptopelia picturata*	Hybrid of introduced/ native stock	All islands	Use of green-dyed bait and low (20ppm) brodifacoum loading	Bird 20 (30%) Curieuse 20 (10%) Denis 80 (40%) Frégate 200 (80%)
Barred ground dove *Geopelia striata*	Introduced	All islands	Use of green-dyed bait and low (20ppm) brodifacoum loading	Bird 75 (50%) Curieuse 20 (40%) Denis 150 (40%) Frégate 300 (80%)
Indian mynah *Acridotheres tristis*	Introduced	All islands	Use of green-dyed bait and low (20ppm) brodifacoum loading	Bird 30 (70%) Curieuse 20 (40%) Denis 100 (60%) Frégate 25 (50%)
Madagascar fody *Foudia madagascariensis*	Introduced	All islands	Use of green-dyed bait and low (20ppm) brodifacoum loading	Bird 80 (50%) Curieuse 20 (40%) Denis 50 (40%) Frégate 200 (70%)
Cattle egret *Bubulcus ibis*	Native	All islands	Use of green-dyed bait and low (20ppm) brodifacoum loading	Bird 5 (50%)
Aldabran giant tortoise *Geochelone gigantea*	Introduced	All islands	Penned – Bird 3 (100%) Curieuse 70 (60%) Denis 5 (100%) Frégate 140 (90%)	Curieuse 1 Frégate 2 (No toxin-related mortality)
Skink and gecko spp	Endemic	All islands, especially Frégate	None	No observed mortality
Invertebrates	Endemic	All islands, especially Frégate and Curieuse	*Ex situ* populations established for certain species	No observed mortality

Curieuse, and 52 on Denis Island. Local conservation staff were trained in eradication techniques. Cat trapping and poisoning has since been continued by Division of Environment, MET staff on Denis, and MPA staff on Curieuse, working on a cycle of two weeks on and two weeks off. This regime continued through 2001 until eradication was achieved.

No formal measures were put in place to detect rat and cat survival because we considered it unlikely that any individuals could escape detection for long on inhabited islands. In effect, PestOff Rodent block baits within 180 permanent rodent bait stations on the islands would serve to indicate the presence of any rodent.

The capture and captive management of Seychelles magpie-robins and Seychelles fodys on Frégate by BirdLife Seychelles staff, and of Aldabran giant tortoises by Frégate Island Ltd staff on Frégate and Marine Parks Authority staff on Curieuse, was an outstanding success (Table 2). Avicultural knowledge and capability advanced enormously. Not only did magpie-robins breed successfully during three months in captivity, but chicks were artificially hatched, hand-raised and fostered between nests for the first time (Millett *et al.* 2000). All tortoises and Seychelles fodys were released in late July-early August, and the majority of the magpie-robins were released in mid August 2000.

The successful eradication of rats and mice from Frégate Island was confirmed in June 2002, 24 months after the eradication campaign. A mouse, which apparently arrived with cargo, was captured and killed on 27 September 2001 but there has been no sign of mice since (Millett and Shah 2001b). The absence of any rat sign, as of June 2002 (Millett pers. comm.), is encouraging. However, lack of commitment to the ongoing implementation of rat abatement measures to a sufficient standard (Millett *et al.* 2000; Climo 2001) remains the greatest challenge and continues to jeopardise the long-term success of the campaign.

Unfortunately, ship rats were discovered by BirdLife Seychelles staff on Denis and Curieuse Islands in August 2001, and have become widespread and abundant on Curieuse (Millett and Shah 2001b). Since initial reports indicated relatively small and localised populations, it is suspected that ship rats came ashore once again with building materials. In late 2001 it was also discovered that mice had reinvaded Denis Island or survived the eradication attempt there.

The last cat was trapped on Curieuse in February 2001, and the last two cats were destroyed on Denis Island between July and September 2001. There has been no evidence of cats surviving on either of the two islands since (Millett and Shah 2001b).

DISCUSSION

The biological and conservation benefits of eradicating alien pest animals from uninhabited or sparsely-inhabited islands have long been recognised. However, the practicability of permanently removing such pests (especially rodents) from oceanic islands supporting human settlement and/or development, together with information on any enduring ecological benefits, appear largely unknown. Eradication and, in particular, effective rodent quarantine on such islands has generally been considered impractical – if not impossible. Most rodent eradications to date have involved uninhabited conservation estate. However, the majority of the world's half million islands have no formal conservation status and are inhabited. Many have biological values or potential and warrant ecological restoration – including removal of invasive animals.

Successful outcomes on Bird and Frégate Islands have shown that rat eradication and quarantine on resort islands within the Seychelles is both feasible and beneficial, bringing immediate economic and biological benefits.
For instance, on Frégate Island:

- Eradication efforts appear to have come just in time to avoid extinctions;
- There has been no recorded mortality among dependent recently-fledged magpie-robins since the rat eradication on Frégate in June 2000 – a stark contrast to the loss of 19 (virtually all) newly-fledged young in the year prior to rat eradication (Millett pers. comm.);
- Production of fruit and vegetables, free of rat damage, for the lucrative local resort market is at last a reality.

On Bird Island:

- Following eradication of rats in 1996, Feare (1999) reported that "common noddies (*Anous stolidus*) have begun nesting successfully on the ground and turtle doves (*Streptopelia picturata*), many showing characteristics of the endemic race *rostrata*, became numerous; they had not been seen on the island since 1973";
- Predation of sooty tern eggs and young by rats, previously widespread, has ceased.

The project has helped advance our knowledge and confidence in eradication capability. For instance:

- Eradication of rats is feasible while rats are breeding;
- Cats and rats can be effectively poisoned and trapped in the presence of massive, alternative food sources such as those provided by colonial breeding seabirds (Denis and Frégate), fruit and produce (Bird, Frégate) and kitchen refuse (Denis and Frégate);
- Rat eradication is practicable in the presence of high-density land crab, hermit crab, ant and cockroach populations, such as on Bird and Denis Islands, and coastal zones of Curieuse and Frégate Islands. Following each aerial bait application, bait removal by crabs proved less of a problem than anticipated from bait preference trials on these islands. The initial trials likely over-estimated the degree of bait interference because crabs were converging on a limited food source avail-

able at few sites whereas, during the eradication campaigns, baits were available throughout their entire habitat. This was fortuitous because the amount of bait actually delivered within some open quadrats was significantly less than calculated bait delivery rates (Fig. 3), despite the skills of an experienced pilot with DGPS support.

- Rat eradication is practicable at seasons other than during late winter (i.e. July – September in the Southern Hemisphere);
- Circumstantial evidence from Curieuse indicates that rain-softened 20 ppm brodifacoum rodent pellets are eaten by cats, and that this bait is capable of incurring significant mortality;
- Private land tenure, human habitation and commercial tourism activities need not be viewed as barriers to alien mammal eradication projects. As in this case, island-based tourism activities can provide a sustainable means by which to restore and maintain threatened endemic biodiversity.

The current rodent-free status of Frégate Island would appear to be a case of good luck rather than good management. By September 2001, the rodent harbour fence, damaged by tidal action and poorly mended, was no longer rodent-proof; also, bait station maintenance and food disposal protocols were not being adequately implemented (Climo 2001). The recent re-invasions on Denis and Curieuse Islands illustrate the consequences of failing to implement rodent quarantine protocols – an impossible task unless there is total community awareness and support. The importance of acceptance and strict implementation of accepted rat quarantine protocols cannot be overemphasised (e.g., the landing of building materials, particularly roofing thatch on rat-free islands, without first fumigating the materials, poses an exceedingly high risk of rat invasion). Though simple in principle, this can be difficult to achieve in practice, especially if island owners are absent for long periods or there is a high turnover of itinerant island staff. Workers coming from Mahé, a highly-modified ecologically-degraded island, may have a limited appreciation of the importance of threatened endemic populations surviving on islands such as Frégate, their vulnerability to predation by rats and cats, how easy it is to accidentally bring rodents ashore with cargo, and how such carelessness can potentially affect them (i.e. ecotourism is an important generator of employment in the Seychelles). Hopefully, the level of conservation awareness among Seychellois will continue to improve as a result of BirdLife Seychelles' ongoing programme of community education.

The colonisation by rats of Frégate Island in 1995 was monitored and documented (BirdLife Seychelles reports 1995 - 2001; Jones and Merton 1995; Merton 1996, 1999; Thorsen *et al.* 2000). Never before had a rat invasion of a biologically important island been recorded in depth. This event provided the opportunity to test whether it was possible to eradicate a rat population during the colonisation phase, something rodent contingency protocols assume is feasible but had not yet been rigorously tested. Prompt intensive action while the invading population is localised and relatively small would, if successful, have minimised eradication costs and impacts on threatened species. Why then did it take five years to mount an effective rat eradication campaign?

The first rat was sighted on the island several weeks before conservation managers became aware of the invasion (Thorsen *et al.* 2000). Greater awareness among island owners and staff of the potential impacts of rats would have facilitated immediate reporting of the first sighting.

Although monitoring and control efforts were initiated promptly, the initial eradication attempt was seriously constrained by delays in obtaining funding and fears for the safety of threatened endemics at risk from rodenticide poisoning (Thorsen *et al*. 2000; Merton 2001). Clearly, as in the 1964 rat irruption on Big South Cape Island, some stakeholders, including local biologists, under-estimated the potential impacts of rats on the island's threatened endemics (i.e. the cost of doing nothing) and doubted the feasibility, and ecological and economic benefits of rat eradication (Gerlach, J. 1997, 1999; Gerlach, R. 2000).

In any such future event, funds may be more rapidly forthcoming if a conservation agency such as BirdLife International were to take a more pro-active role as watchdog and facilitator between private land owners and government agencies. Land owners, island staff, and all affected parties need to be made aware of the potentially-devastating impacts of rats on endemic island fauna, the feasibility of eradicating rats, of maintaining an island's rat-free status, and of where to quickly access expert advise and assistance.

The successful eradication of rats from Bird and Frégate Islands will, we hope, inspire similar effort on other islands with high biological values or potential – regardless of tenure or occupancy! However, the re-colonisation by rats of Denis and Curieuse Islands illustrates the need for ongoing conservation education and awareness programmes, which can ultimately foster a sense of responsibility, pride and stewardship among local communities. It can be difficult to assess the level of understanding of (and support for) a pest eradication proposal among the local population, particularly on islands where workers are often transient. However, the feasibility of eradication and quarantine projects on inhabited islands is more likely to be limited by lack of public support or awareness than by lack of technical capability.

Unfortunately, cats and rats are not the only introduced predators threatening Seychelles endemics. For example, barn owls (*Tyto alba*) and Indian mynahs are subject to control programmes on islands where they are predators of Seychelles magpie-robins, their chicks or eggs (Millett *et al.* 2000). The exotic yellow crazy ant (*Anoplolepis gracilipes*) has been present at low densities on Mahé since 1960 and has also colonised Denis and Bird Islands. The Bird Island population, first noticed in 1991, apparently remained small and localised until 1997, after rats were eradicated. By 1998, crazy ants had become widespread and abundant, with serious impacts on the island's endemic fauna and flora (Feare 1999). There is no real evidence that this ant irruption resulted from the removal of rats, as suggested by Feare (1999). Unfortunately, the re-colonisation by rats of Denis Island, where crazy ants remain at low density, prevents further evaluation of this theory. We agree that plans to eradicate alien vertebrates should include investigation of the presence of other exotic animals and plants that might benefit from the target species' removal. However, such "knock-on" effects are seldom easily predicted. Documentation of the major ecological impacts of the Bird Island crazy ant irruption should at least ensure that this species is not under-estimated in the future. Island quarantine protocols should extend to minimising the risk of importing crazy ants to new islands, monitoring to ensure their early detection, and implementing containment and eradication measures of any new colonies immediately they are detected.

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Appendix 1 Summary of rat index trapping results, weights and measurements on four Seychelles islands ([1] prior to first poison application; [2] after first poison application; * Head and body length; [ ] number of traps set per night; TN trap-nights; CTN corrected trap-nights (see Cunningham and Moors 1996)).

	Trap nights	Rats caught	Rats/ 100TN	Rats/ 100 CTN	Weight adult male	Weight adult female	HBL* adult male	HBL* adult female
Rattus rattus								
Bird Is (Nov. 95)	108	22	20.3	26.5	132 70-180	139 55-190	175 145-190	168 115-190
Bird Is [1] (Nov. 96)	43 [23]	31	72	141	-	-	-	-
Curieuse Is (Jul. 98)	75	37	49	82.2	114 73-147	105 90-134	167 145-180	158 150-170
Curieuse Is [1] (Jun./Jul. 00)	109 [26]	61	56	84	114 61-205	101 75-150	167 145-180	160 135-180
Curieuse Is [2] (Jul. 00)	302 [26]	11	3.6	4	-	-	-	-
Denis Is (Jul. 98)	89	29	23.5	35.6	118 73-170	106 62-24	168 123-195	163 140-180
Denis Is [1] (May/Jun. 00)	49 [19]	14	28.6	35.4	119 70-147	112 94-133	163 155-174	153 146-160
Denis Is [2] (Jun. 00)	133 [19]	0	0	0	-	-	-	-
Rattus norvegicus								
Frégate Is (Jul. 98)	97	26	27	38.8	363 270-402	289 170-420	255 225-320	215 185-240
Frégate Is [1] (May/Jun. 00)	374 [25]	76	20.3	27.2	305 167-455	279 175-375	219 183-260	213 180-295
Frégate Is [2] (Jun. 00)	125 [25]	0	0	0	-	-	-	-

Appendix 2 Chronology of baiting and trapping events on four Seychelles islands

	Bird Is (101 ha)	**Denis Is** (143 ha)	**Frégate Is** (219 ha)	**Curieuse Is** (286 ha)
First application of rodent bait	30-31 Oct. 96 (Talon-stations)	2 Jun. 00 (pellets-aerial)	8 Jun. 00 (pellets-aerial)	2 Jul. 00 (pellets-aerial)
Helicopter flying time, excluding ferrying time (hours:minutes)	NA	2:30	2:15	2:45
Bait used (kg)	60	2375	3000	3700
Application rate (kg/ha) (heavier in coastal zone, lighter elsewhere)	0.6	16.6	13.8	12.9
Rainfall over subsequent three days	Nil	1.9 mm (Aride)	Nil	3.2 mm
First dead rat seen	3 Nov. 96	5 Jun. 00 (1)	12 Jun. 00 (6)	5 Jul. 00 (5)
Second bait application	8-10 Nov. 96 (pellets-hand)	11 Jun. 00 (pellets-aerial)	13 Jun. 00 (pellets-aerial)	13 Jul. 00 (pellets-aerial)
Helicopter flying time, excluding ferrying time (hours:minutes)	NA	1:05	1:30	2:00
Bait used (kg)	475	1000	2050	2900
Application rate (kg/ha) (heavier in coastal zone, lighter elsewhere)	4.7	7.0	9.3	10.1
Rainfall during subsequent three days	31 mm	0.9 mm	Nil	22.4 mm
Third bait application	18-20 Nov. 96 (pellets-hand)	-	7 Jul. 00 (pellets-aerial)	-
Helicopter flying time, excluding ferrying time (hours:minutes)	NA	-	1:40	-
Bait used (kg)	495	-	2625	-
Application rate (kg/ha) (heavier in coastal zone, lighter elsewhere)	4.9	-	11.9	-
Rainfall during subsequent three days	Trace	-	2.5 mm	-
Total pellet application rate (kg/ha) excluding block baits	9.6	23.6	35.0	23.0
Rat index trapping commenced	1 Nov. 96	30 May 00	24 May 00	25 Jun. 00
Rat index trapping ceased	17 Nov. 96	9 Jun. 00	13 Jun. 00	15 Jul. 00
Last rat trapped	13 Nov. 96	2 Jun. 00	8 Jun. 00	7 Jul. 00
Non-toxic cat baiting commenced	-	16 Jun. 00	-	17 Jul. 00
Toxic cat baiting commenced	-	23 Jun. 00	-	22 Jul. 00
Cat trapping commenced	-	26 Jun. 00	-	24 Jul. 00
First cat trapping session ended	-	11 Jul. 00	-	16 Aug. 00

Appendix 3 Rodent eradication and island quarantine – some urgent recommendations

Following is a summary of some urgent measures, which I regard as essential to the success of the rodent eradication project and to minimise the risk of re-invasion of Frégate Island by rats and mice.

Administrative responsibility and accountability

Assuming the current eradication attempt is successful, maintaining Frégate Island free of rats and mice will be difficult but by no means impossible. It will require a very high level of commitment and compliance by management and staff. A senior staff member must be given responsibility for overseeing island quarantine and ensuring implementation of a rodent quarantine and contingency plan. Duties of this person must include:

- ongoing promotion of rodent awareness within Frégate Island's management and staff, as well as the crews of visiting boats;
- urgent follow-up of any reported sightings of rats or mice on the island;
- regular replenishment of toxic baits in 86 permanent rodent bait-stations (on land and on boats);
- ordering supplies of bait as necessary;
- ensuring that stores and bulk cargoes arriving on Frégate are correctly packed, are opened inside a rodent-proof compound and are carefully checked for rats and mice.

Any sightings or suspected sightings of rats or mice on Frégate Island must be reported immediately to the Plantation Manager for urgent follow-up action.

Management and disposal of foods and kitchen refuse

It is essential that foods are inaccessible to rats and mice at all times.
All staff houses must have a mouse-proof cupboard or food storage area.
Waste foods and other kitchen refuse must be stored in sealed bins and disposed of in such a way that they are unavailable to rats and mice (i.e. fed to pigs, burned or buried).
Food scraps must never be thrown onto the ground.

Recommendations

- Establish an island rule making it an offence to dispose of food scraps and kitchen refuse other than in bins with tight fitting lids.

- Designated refuse collection sites must be established similar to those in parts of Mahé; ie a concrete platform with low walls, large enough to accommodate three wheelie-bins lined with plastic sacks - a bin each for burnables; food refuse for the pigs; and the third for items for shipment to Mahé for dumping.

- Refuse must be collected and disposed of daily - ie food refuse fed to pigs; burnables incinerated each day; and refuse for shipment off the island stored in large bins (skips) with tight-fitting hinged lids, to be sent off the island at the first opportunity.

- So far as is practical, catering should be centralised – storage and preparation of foods at staff houses should be discouraged.

Packaging and shipment of stores to the island

All stores must be sealed in rodent-proof containers before being transported from Mahé.
The "Coleman 150" polystyrene food containers currently used for cool-store items are ideal. Other foods must be packed in similar plastic or metal boxes with tight-fitting lids, which are to be closed and sealed immediately after packing. Cardboard cartons are likely to harbour rats and mice and must not be used.

All bulk cargoes and containers (especially thatch and building materials) must be fumigated in Victoria. Doors must be locked immediately after, and not opened until arrival on the island.

Appendix 3 continued

Unpacking of stores and bulk cargoes arriving on the island

A rodent-proof compound in which to unpack all stores and equipment is essential and urgently needed to prevent re-infestation of the island by rodents. This rat and mouse-proof compound - either a large storeroom or a rodent-fenced area - must be large enough to take a trailer loaded with a shipping container. On arrival on the island all stores and bulk items (including containers) must be taken immediately to this compound and the gate/door sealed during unpacking. Any rodent can then be confined and destroyed.

Boats visiting the island.

The rodent-proof harbour fence must be completed and maintained to a high standard as a matter of great urgency.

All vessels calling at Frégate must use the boat harbour. Beaches or surge basins must not be used for landing since these sites are not protected by a rodent-proof fence.

All vessels that visit Frégate regularly or occasionally must have at least one bait station loaded with rodenticide bait permanently on board. Baits inside these stations must be checked and if necessary replaced by the island rodent officer each time the vessel visits the island.

Maintenance of permanent rat bait stations

The 86 permanent bait stations positioned near landing sites and other potential rodent "hot-spots" on the island must be serviced regularly if they are to be effective. The rodent officer must ensure that rodenticide baits in each station are carefully checked each month (or more regularly if required) and that baits are replaced as necessary.

Reducing cover for rodents

Rodents thrive in dense cover and cannot survive without cover in which to hide by day. In spite of commendable recent efforts, Frégate Island offers an abundance of cover for rodents. High, ongoing priority must be given to reducing cover - and thus potential rodent habitat.

Recommendations

Higher priority must be given to the clean-up process - removal from the island of all refuse and discarded materials. The long-abandoned African tent camp at Plaine Magnan is a case in point.
Disposal of slashed vegetation and fallen coconut fronds is a problem on the island. Rather than accumulating this material at a few traditional sites (and so creating substantial areas of prime cover for rodents), it may be practical to mulch or disperse some in forested areas, so reducing the pressure on traditional dumping sites.

Don Merton
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