The rat problem on oceanic islands—research is needed

N. M. Wace

In October 1983 a rat was reported to have been seen on Gough Island, an outlier of the Tristan da Cunha Group in the South Atlantic. Gough Island has no permanently resident human inhabitants, but supports one of the largest and most diverse assemblages of breeding seabirds now remaining anywhere in the temperate zones. The author was a member of a small team of biologists that spent three weeks on Gough Island, in October–November 1984, to try to confirm whether there were any rats on the island, and if so to make recommendations for their control and extermination. The following proposals result from experience in carrying out this survey, and from writing World Conservation Strategy proposals for Oceanic Islands for the IUCN.

Since the pioneering work of Charles Darwin and Alfred Russel Wallace, study of the biotas of islands has been of central importance in the development of scientific ideas concerning the evolution and dispersal of plants and animals. At the same time, the breakdown of the biological isolation of the world's oceanic islands by seafaring people in both prehistoric and historic times has had devastating effects upon their indigenous plants and animals. The ecological and evolutionary reasons for the vulnerability of remote islands to biological invasion by exotic species were first clearly formulated by Elton (1958), and have since been elaborated mathematically by MacArthur and Wilson (1967), whose concepts have been applied to the conservation of island biotas (Diamond, 1975; Simberloff and Abele, 1976; Reed, 1985). The extinction of the dodos and their relatives on the Mascarene Islands, of the palms on Easter Island, and of the diverse avifaunas of St Helena and the Hawaiian Islands are striking examples, from each of the world's major oceans, of island species that have been rapidly exterminated as a result of human activities. More extinctions have taken place within historical time on oceanic islands than in areas of comparable size and habitat diversity on the continents (Boag, 1983). Risk of extinction decreases with the area available to the isolated population (Diamond, 1984, 1985).

Some of the most destructive effects have been due to the import of domesticated and commensal animals that have run wild. Pigs and mongooses in the Hawaiian Islands, donkeys and goats on St Helena, cats and rabbits on Marion and Kerguelen Islands, respectively, are well-known examples. Of all unintentionally introduced vertebrates, ship-borne rats have probably had the most widespread and devastating impact on island reptiles and birds, as well as very considerable effects on native vegetation. Atkinson (1985) reviewed the history and impacts of commensal rats introduced to islands worldwide (Figure 1), and has shown that the avifaunas of islands in the temperate zones appear to have been most affected by rat invasions. The black (or ship) rat *Rattus rattus* has been more destructive to bird life overall than the larger brown rat *R. norvegicus*, or the smaller Polynesian rat *R. exulans*, but brown rats are particularly effective predators of ground-nesting seabirds and endemic landbirds (Bourne, 1981). The severity of rat predation on birds had previously been discounted by Norman (1975), but Atkinson's sifting of the historical evidence has shown that at least some rat invasions of oceanic

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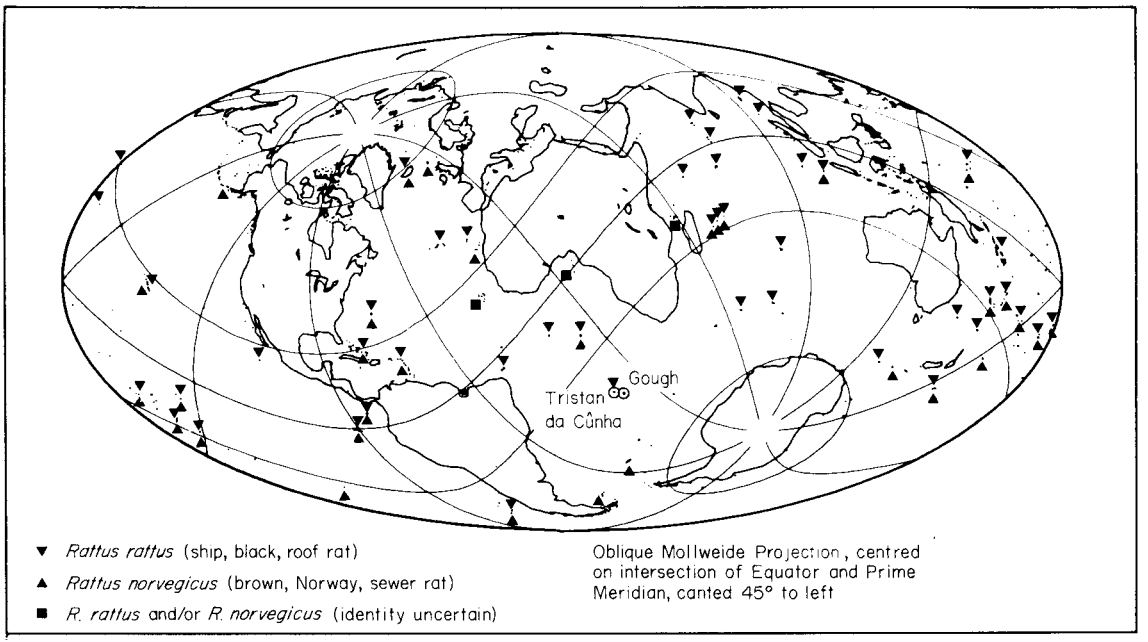

Figure 1. World map showing the distribution of black and brown rats on oceanic islands in 1980. Data plotted from Atkinson (1985).

islands can be categorized as ornithological catastrophes, and his survey should be read as a background to the proposals put forward here. The invasion of Gough Island or other rat-free islands in the Tristan da Cunha Group by black or brown rats would undoubtedly lead to a marked decline in the large number of seabirds that breed there, as it has on Tristan da Cunha itself (Richardson, 1986).

Control of pest rodents in the wilderness

Commensal rodents are seen as pests almost exclusively in the man-made environments of cities (houses, sewers, commercial food stores), in the managed environments of agriculture (cereal cultivation, tree plantations), or in rangelands. In such situations the aim is to control the economic losses or risks to human health due to rodents by reducing the pest populations to acceptable levels rather than by attempting their extermination. This is realistic where reinvasion of areas cleared of pests can easily take place from the peripheries—and also where pest control companies do not want to destroy the market for their services.

In natural environments, which are uninhabited by humans, and which are not managed for economic gain by the exploitation of primary resources, there can be no 'pests', and therefore no economic incentives to attempt control unless such pest species invade adjoining agricultural or urban regions. It is not, therefore, surprising that techniques for the control of rodents that are pests in association with man have been little developed for the control of the same species in the wild.

Three approaches are possible, used singly or in combination, in attempting to control pest rodents in unconfined environments.

(i) *The use of food as a lure.* Food baits are generally used in conjunction with traps or poisons, of which the slow-acting anticoagulants are probably the most important.

(ii) *The use of rodent pathogens or predators.* Pathogens seem to have been little used in

attempts to control pest rodents commercially. The traditional predators of the commensal rodents (cats, dogs, mongooses) have been widely used domestically and in managed environments, but are not valued for commercial use, or even thought to be particularly efficient (Meehan, 1984).

(iii) *The use of social (including sexual) interaction, and genetic and chemosterilant methods of control of reproduction.* The pest species themselves, or even their body exudates, seem to have been little used as lures in rodent control. This is in contrast to the use of insect pheromones and 'sterile male' techniques in insect control.

Confirmation of the existence of commensal rats, which may be present initially only in very small numbers, in the wilderness is not generally of any concern to pest controllers; but if rats get ashore on oceanic islands with vulnerable populations of birds or other animals, early detection, containment and extermination of rats are essential, and techniques must be developed for this purpose.

New techniques for detecting and exterminating pest rodents in the wild should have the following properties:

(i) be capable of rapid deployment, and need only simple equipment;

(ii) have no adverse immediate or long-term effects on the native plants or animals;

(iii) be specific to a single species of rat, and be capable of exterminating all the individuals of an incipient invasion (rather than merely reducing numbers) in situations where reinvasion is unlikely or impossible;

(iv) be capable of attracting and trapping rodents, which may be present in very small numbers, in such a way that their identity can be confirmed at an early stage of an invasion.

The use of food lures followed by trapping or poisoning may be quite ineffective on islands with small initial rat populations because of the abundance of natural food, and because the poisoning or trapping of non-target species is unacceptable. Therefore, methods designed to attract and/or destroy only commensal rodents would have to be based on genetic or biological control, or on the exploitation of social or sexual interaction amongst the unwanted rodents themselves, or on a combination of these approaches. The use of predators in the control of rodents on islands has generally been quite ineffective, and has merely added to the intensity of predation on birds (Moors and Atkinson, 1985). Addressing the joint impact of cats and rats together, Atkinson (1985) noted:

'This indirect adverse effect of rats, where cats are present, has been particularly devastating for seabirds. Outside the breeding season such birds may be absent for several months, but cats sustain their own numbers on rats as an alternative food source until the seabirds return to breed.'

Although not enough is known about rodent diseases to employ them as a means of control, experiments with this technique could be set up on remote islands infested with rodents, but free of other mammals (Wace, 1980). However, the use of any form of biological control, whether by pathogens or predators, would be ineffective in ridding islands of rats because of coadaptation between pathogen and host or predator and prey.

The direct use of sexual or social interaction amongst rodents, possibly combined with genetic or chemosterility methods of reducing or frustrating reproduction, is the most specific approach to control, and therefore potentially the least damaging to other species. Because of the necessity of sexual contact if an immigrant population is to increase, the use of sterilized animals (or more easily handled surrogates such as rodent pheromones) as lures may be the best approach, especially in detecting rodents at low densities. Radio-tracking of sterilized animals ('Judas rats') could be used to locate rat-infested regions, as with the 'Judas goat' technique employed in ridding some of the Kermadec Islands of goats by New Zealand workers (Thomas, 1982). Such techniques, using live pest animals as lures and as indicators of pest populations, could be developed in conjunction with disease, chemosterilants and genetic control (Marsh and Howard, 1973).

Rats and mice on Gough Island and Tristan da Cunha

The four oceanic islands of the Tristan-Gough Group have temperate isothermal climates, and extremely rugged and steep terrain, which is mostly mantled by peat (Wace and Dickson, 1965). Between 17 and 21 species of seabirds and six endemic species of landbirds breed there (Williams and Imber, 1982; Richardson, 1986), some in huge numbers (Swales, 1965). The smaller seabirds (which are most vulnerable to predation by introduced mammals) mostly nest in rock crevices or excavate burrows in the peat. Many of these have probably been exterminated on Tristan by cats, dogs and pigs, and particularly by black rats, which got ashore there in 1882, are present all over the island and are a major pest to the islanders (Wace and Holdgate, 1976). The brown rat has never been recorded on any of the islands, and, except for black rats on Tristan, no rats had been reported from any of the islands until the sighting of an alleged rat (species unknown) on Gough Island in October 1983. House mice *Mus musculus* have run wild on both Tristan and Gough. They are inconspicuous on Tristan, but very abundant on Gough, where they greatly complicate any attempt to detect, catch or control rats. The presence of a large mouse population, of birds breeding throughout the year, and of plants that are known to be a major food for rats elsewhere (notably the large maritime tussock grasses *Spartina arundinacea* on Tristan and *Parodiochloa flabellata* on the Falklands), together with a benign climate, few predators and ample cover, all render Gough Island a particularly favourable habitat for rats.

The search for rats on Gough Island

In January 1984, three months after the sighting of the alleged rat near the outfall of the stream in Transvaal Bay, some Tomahawk traps were sent to Gough Island and set near where the sighting was made, and at the nearby South African weather station (Figure 2). No rats were caught up to October 1984, but food-baited breakback traps were frequently sprung by mice.

From 21 October to 15 November 1984, a rat-hunting team of three biologists spent 26 days on Gough Island (Wace, 1986). Details of their work were submitted to the sponsoring organization, the South African Scientific Commmittee for Antarctic Research (Bester, Breytenbach and Wace, 1985). Their tasks were:

(i) to establish if there were any rats on Gough Island, and if so, to identify the species and estimate their numbers and range;

(ii) to make recommendations for the control of any rats found, and the improvement of existing preventive measures to deny rats access to the island.

To establish that rats are *not* present on an island as large (63.5 sq km planar area), as rugged, as heavily vegetated, and as full of food and hiding places as Gough Island in less than a month, was a difficult task. Absence of evidence can seldom be accepted as evidence of absence, especially with animals as secretive as commensal rats. The methods described below were developed for the special conditions on Gough island. Preventive (quarantine) aspects are important, but are not considered here.

The use of food-baited traps

Lines of food-baited Sherman traps were set out at four places on the island (Figure 2). The results are shown in Table 1.

The number of occupied trap-nights is exceeded by the mouse numbers because several mice sometimes entered the same trap. No rats were caught in any of these traps, even when the number of mice fell to some 12 per cent of the initial nightly yield, after about a week of trapping.

Evidence of rat activity on Gough Island

No rat sightings and no signs of rat activity were observed on Gough Island, despite searches by 11 scientists and a number of others visiting different parts of the island during the October/November 1984 relief of the weather station (Figure 2). Signs of rat activity sought were:

Table 1. Results of setting food-baited Sherman traps on Gough Island

Place	Traps set	Nights out	Trap-nights		Captures	
			Total	Empty	Mice	Rats
1. Weather Station rubbish pit	50	13	650	446	220	0
2. Weather Station huts, stores	40	11	440	329	114	0
3. 1983 alleged rat sighting place	50	12	600	286	323	0
4. The Glen, huts and streamside by beach	40	9	360	270	90	0
			2050	1331	747	0

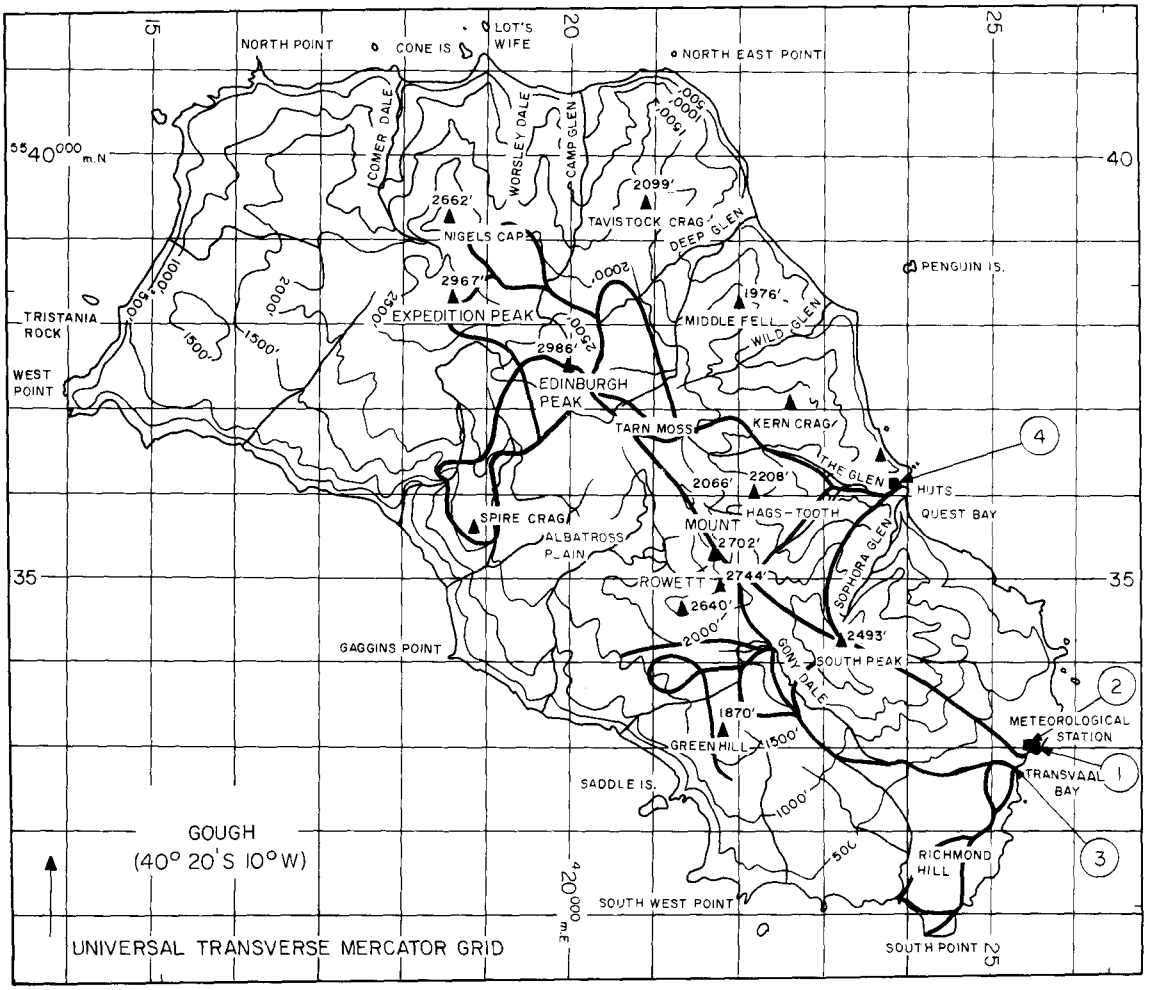

Figure 2. Map of Gough Island, showing the routes followed by scientific parties that looked for signs of rats in October–November 1984, and the four sites of food-lure and sex-lure trapping. The map is on a kilometre-grid.

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(i) rat droppings or feeding sites in vegetation;

(ii) rat trails or runs through the vegetation;

(iii) rat tooth marks on plant shoots, rhizomes, fruits and seeds (especially on tussock grasses and *Phylica arborea*, the berry-bearing small tree in fern-bush vegetation below *circa* 300 m altitude);

(iv) grease smears, hair, gnawings, or rat droppings in or around the weather station buildings.

Live lure ('Delilah') trapping on Gough Island

Six laboratory albino female brown rats, which had been sterilized by bilateral ovariectomy, were caged together in pairs and were kept in oestrus by injections of oestradiol every six days. These three paired female lures were fed and watered and provided with bedding in closed Tomahawk traps, each of which was placed next to, or between, one or two empty but otherwise similar open traps. These arrangements were called 'Delilah Units'. Any wild rats attracted to the caged rats would have been trapped in the empty cages (Figure 3). The three Delilah Units were deployed near each of the four sites where the Sherman traps were set for a total of 50 trap nights. During this time, no visiting rats were caught and no evidence of free-ranging wild rats was seen nearby. The open traps mostly remained unsprung, and only mouse droppings were found occasionally near the trap containing the caged rats.

Attempted validation of the Delilah lure technique on Tristan da Cunha

The six rats used as lures on Gough Island were subsequently taken to Tristan da Cunha, where black rats are abundant. This work on Tristan was intended to test the ability of one species of commensal rat to act as a lure for the other, and thus to try to validate the Delilah lure technique used on Gough, with brown rats, if wild black rats had been present there.

Delilah units similar to those used on Gough Island were set up from November 19–29 at the Tristan rubbish dump, and in a poultry shelter on the Hillpiece pastures; both sites are about a mile from the Settlement. Each Delilah unit had a control unit nearby, in which three Tomahawk traps were arranged similarly to those with live lures, but without captive rats. In a total of 86 trap-nights, 11 black rats were caught (six male, four female, one escaped unsexed). Seven were caught in the control cages, and four (two of each sex) in the Delilah traps. Sterilized laboratory albino female brown rats were thus shown *not* to be effective lures for wild black rats, under these conditions.

Conclusions from work on Gough Island and Tristan da Cunha in 1984

The overall conclusion from the work on Gough Island is that rats are unlikely to be present there. However, rats could be present in small numbers, difficult to detect by the normal trapping with food lures, or by the observational methods we employed. Failure to validate the Delilah technique on Tristan using sex lures does not mean that such approaches should not be developed. They are likely to be more effective in detecting the presence of rats in very small numbers than any existing techniques, and they are the least damaging to other species of animals. The experiments using brown rats as sex lures were set up hurriedly, without prior experimentation, and without being able to obtain at short notice any sterile black rats. No male lures were employed, because of the imperative that any rats taken to Gough Island be sterile, and the longer time necessary to ensure sterility after operation in the male than in the female. However, sterile male lures may be more useful than females in detecting or confirming the presence of rats at the early stages of a rat invasion, because females lured into cages would indicate whether they were pregnant, and whether they had given birth recently.

At no stage in this work have caged sterile rats been tested for their ability as lures to attract other members of their own species in the wild. Such testing, within and between the two larger commensal rat species, and employing both sexes as lures, could be undertaken experimentally in

Figure 3. 'Lurgy' and 'Hotlips', two female laboratory albino brown rats at work in one of the Delilah Traps on Gough Island, November 1984. Open and set Tomahawk traps are placed on either side of the caged animals. This was in the fernbush, near the place where an alleged rat sighting was made in October 1983.

laboratory, urban or rural situations, and developed in conjunction with established means of control to detect and exterminate rats at very low densities, both in manipulated and natural environments.

Recommendations

At present, there are no techniques for protecting the plant and animal life (and especially the bird life) of oceanic islands from invasion and devastation by rats. The spread of adventure-tourism and ocean cruising, and the increasing use of ocean resources, means that even the remotest islands will be visited more often in future. Even with the utmost care, and enforcement of rigid quarantine controls, shipwrecks and the accidental release of rats will surely occur on islands where they are not established. The conservation movement should anticipate these threats and encourage means of combating rat invasions. Studies could be established at a zoological institute where there is already some emphasis on ethology, physiology, pathology or genetics of small mammals, on some of the following topics:

(i) the development and use of pheromones in influencing rodent behaviour, including the production of synthetic pheromones;
(ii) the development of live lure techniques, with both brown and black rats, but using animals that are themselves incapable of reproduction;
(iii) the use of chemical sterilants, especially to hold founder rat populations in check during the early stages of the colonization of islands;
(iv) the use of tracker techniques in commensal rats, to locate small founder populations, employing sterile 'Judas rats' released in the wild;
(v) the use of rat pathogens, and the development of techniques of genetic control.

These topics are arranged in an order that corresponds with their usefulness in controlling rats in the rather special conditions of oceanic islands. None of the approaches suggested could be the sole solution to the problem, still less a substitute for efficient controls to prevent rats from reaching rat-free islands in the first place. The experience of New Zealand workers in ridding some of their offshore islands of commensal rats is particularly relevant. In attempting to clear brown rats off some small islands near Auckland, Moors (1985) emphasized the difficulty and expense of getting rid of an established rat population (even on very small islands); the importance of using as many techniques as are available, and not relying on one approach; and the necessity for constant monitoring of the presence of rats.

If the live lure technique is to be useful in detecting and controlling rats, it needs to be thoroughly evaluated in conjunction with other techniques

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that concentrate their effects upon the unwanted species alone. Once developed, such techniques of integrated control could have applications in man-made or domestic situations. At the very least, it could help wean the rodent pest-control industry away from its almost exclusive reliance on poisons, which must to some extent affect non-target organisms directly, or indirectly through the food chains into which they are introduced.

Effective conservation of nature demands a forward-looking view of future human impacts, especially in protected areas where endangered species survive. Too often, conservation activities are seen merely as rearguard actions against economic development, or other human activities. This proposal for research on methods of rodent detection and control seeks to anticipate some of the most destructive effects of the human breakdown of the isolation of oceanic islands, and at the same time to develop new approaches to the control of rodents, which may also have commercial applications.

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N.M. Wace, The Australian National University, GPO Box 4, Canberra ACT 2601, Australia.