The eradication of feral cats from Ascension Island and its subsequent recolonization by seabirds

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Abstract The introduction of mammal predators to islands often results in rapid declines in the number and range of seabirds. On Ascension Island the introduction of cats in 1815 resulted in extirpation of large seabird colonies from the main island, with relict populations of most species persisting only in cat-inaccessible locations. We describe the eradication of feral cats from this large and populated island. The campaign had to minimize risk to humans and maintain domestic animals in a state that prevented them re-establishing a feral population. Feral cat numbers declined rapidly in response to the strategic deployment of poisoning and live trapping, and cats were eradicated from the island within 2 years. During the project 38% of domestic cats were killed accidentally, which caused public consternation; we make recommendations for reducing such problems in future eradications. Since the completion of the eradication campaign cat predation of adult seabirds has ceased and five seabird species have recolonized the mainland in small but increasing numbers. Breeding success of seabirds at Ascension was low compared to that of conspecifics elsewhere, and the roles of food availability, inexperience of parent birds and black rat predation in causing this warrant further investigation. It is likely that the low breeding success will result in the rate of increase in seabird populations being slow.

Keywords Ascension Island, cat eradication, invasive species, island restoration, recolonization, tropical seabirds

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Introduction

Seabirds have life histories characterized by longevity and low fecundity (Weimerskirch, 2002) and many species nest in colonies on the ground. These are traits that render them vulnerable to mammalian predation. Introduction of mammalian predators to oceanic islands hosting seabird colonies typically results in a rapid decline in numbers (Moors & Atkinson, 1984), with relict populations persisting only on cliff ledges or islets that are inaccessible to predators. Predation by invasive mammals has resulted in the probable global extinction of two seabird species (Guadalupe storm petrel *Oceanodroma macrodactyla* and Jamaica petrel *Pterodroma caribbaea*) and contributes to the globally threatened status of many others (BirdLife International, 2000). Among the mammalian predators widely introduced to islands by man, cats *Felis silvestris catus* are particularly damaging because they are capable of preying upon adults of all but the largest seabird species, as well as their chicks (Moors & Atkinson, 1984).

Removing cats from affected islands can benefit seabirds by reducing mortality (Keitt & Tershy, 2003; Rodriguez et al., 2006; Peck et al., 2008), allowing recolonization of areas from which they were extirpated (Hänel & Chown, 1998; Wolf, 2002) and population recovery (Cooper et al., 1995). Cat eradication campaigns have been conducted on 75 islands using a variety of techniques (Donlan & Wilcox, 2008). Most islands have been small as these are logistically easier to treat (Nogales et al., 2004) but the treatment of larger islands is desirable because these have the capacity to host greater species diversity and larger populations compared to small islands (Rosenzweig, 1995). However, campaigns on large islands are complicated by the fact that they are more likely to have human habitation (Nogales et al., 2004; Genovesi, 2007), and the risk of primary or secondary poisoning of the human population has to be completely eliminated. Moreover, cats are popular as pets and eradication campaigns may face opposition from inhabitants wishing to keep and import domestic animals during and after eradication and because of concerns for the suffering of feral animals. Methods that allow eradication campaigns to be conducted on inhabited islands, including public relations and field protocols, are therefore required (Nogales et al., 2004).

Ascension Island is an infamous example of the adverse impacts of cats on seabird populations. Historical records

and palaeoecological studies show that Ascension Island once hosted huge seabird colonies (Olson, 1977; Ashmole et al., 1994). Cats were introduced in 1815 and preyed heavily on seabirds such that all but one species (sooty tern *Onychoprion fuscata*) were extirpated from the main island and confined to cat-free cliff ledges, stacks and isles where their population sizes were limited by nest site availability (Ashmole et al., 1994). Moreover, cats continued to prey heavily on sooty terns and any other seabird species attempting to roost or breed on the main island (Ashmole et al., 1994; Hughes et al., 2008). Conservationists have therefore advocated the removal of cats from the mainland of Ascension Island to allow restoration of seabird numbers (Ashmole et al., 1994).

Here, we describe the cat eradication campaign on Ascension Island. We outline the methods used to eradicate feral cats while preserving domestic cats in a state that prevented them from founding a new feral population, and make recommendations for future cat eradications on large inhabited islands. We describe the recolonization of the Ascension mainland by seabirds, present data on their breeding success, and discuss factors that may now limit population growth in the absence of cat predation.

Study area

Ascension is an oceanic island in the tropical South Atlantic Ocean (Fig. 1). It has an area of 97 km^2 and rises to a maximum altitude of 859 m. The terrain is rugged and largely barren, although the slopes above 450 m are densely vegetated with non-native plants. It is a UK overseas territory with a population of c. 900 people. Infrastructure includes four settlements, a harbour, an airstrip and a network of roads and dirt tracks that allow access over much of the island (Fig. 1). Ascension is an important seabird colony in the tropical Atlantic, hosting 12 species, including the endemic Ascension frigatebird *Fregata aquila* and a distinct form of masked booby *Sula dactylatra* (Steeves et al., 2005). All species were confined to stacks, cliff ledges and the 5-ha Boatswain Bird Island except for the sooty tern that nests on the south-west plain of the mainland and small numbers of tree-nesting white terns *Gygis alba* (Fig. 1).

Methods

Public relations

Education and public relations work and consultation with stakeholders began 6 months prior to the initiation of the actual eradication campaign. Permission and support from the UK government, main employers on the island and the Ascension Island Society for Prevention of Cruelty to Animals (AISPCA) were obtained. Animal welfare organizations (Royal Society for Prevention of Cruelty to Animals and the Cats Protection League) based in the UK were consulted to agree acceptable practice. A public awareness

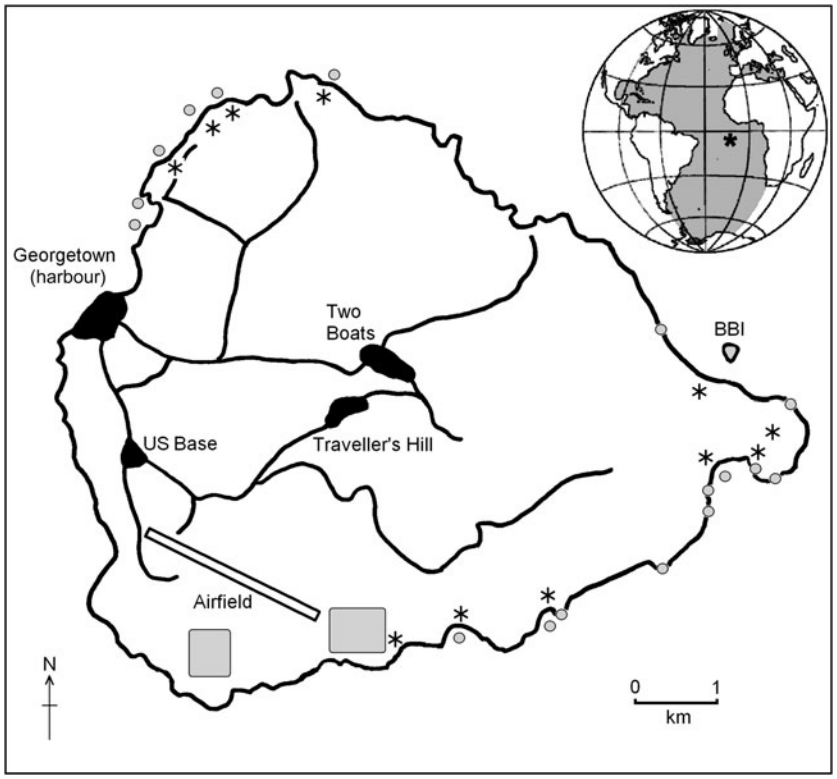

FIG. 1 Map of Ascension Island (7°57′S, 10°22′W) showing the locations of the main settlements, roads and airfield. The locations of seabird colonies prior to eradication are shown by grey symbols: the rectangles are the areas within which sooty tern colonies occur; the grey circles off the coastline are the locations of colonies on stacks; those overlapping the coastline are on cliff ledges. Boatswain Bird Island (BBI) is the main breeding colony for several seabird species. The black stars indicate the areas that seabirds have recolonized since cat eradication. The asterisk on the inset shows the location of Ascension in the South Atlantic.

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project (involving public meetings, articles in the local newspaper, e-mail circulars to employers and casual conversations) was conducted throughout the project to ensure people were informed of the project's progress. A conservation office was formed and local people were trained and employed to conduct the seabird and cat monitoring work, which provided local economic benefits and assisted the integration of the project into the community. The office included a visitor's centre that contained educational displays, leaflets and a field guide to promote interest in seabirds and to point out the detrimental impacts of cats. The eradication campaign was conducted by external contractors with appropriate expertise. This meant that any hostility caused by harm to public or domestic animals as a result of the project's activities would be targeted at outsiders, who would eventually leave the island, rather than at resident members of the conservation office.

Treatment of domestic cats

Excluding domestic cats from the eradication campaign was a prerequisite for obtaining consent for the implementation of the project. In 2000 the Ascension Island Dogs and Cats Ordinance was passed, which made it a legal requirement for all resident or imported pet cats to be registered, microchipped and neutered. The AISPCA provided the tagging service to owners gratis. Owners were initially invited to have their pets treated and an island-wide inspection was conducted to ensure compliance during the eradication campaign. Reflective cat collars were issued to all cat owners so that their pet could readily be recognized as domestic during day or night.

Control methods

Methods used in previous feral cat eradications include poisoning, introduction of feline pathogens, trapping and shooting (Nogales et al., 2004). The Ascension Island campaign could not use pathogens as they would have resulted in infection of domestic cats. Shooting with a .22-calibre rifle was only conducted opportunistically when feral cats were encountered by chance during other control operations. The campaign instead relied on poison baiting and live trapping.

The poison used was sodium monofluoroacetate (1080), which is acutely toxic to cats (Eason & Frampton, 1991) and has been used successfully in eradication campaigns elsewhere (Nogales et al., 2004; Phillips et al., 2005). It degrades rapidly into harmless components in the environment but has no antidote and so has to be used with extreme caution on inhabited islands. Poison baits comprised 2 mg of 1080, sufficient to deliver a lethal dose to a cat, injected into a 15-g chunk of raw fish. Baits were laid atop rock-filled plastic tubs to reduce bait removal by land crabs *Johngarthia lagostoma*. Tubs were labelled 'poison' with a skull-and-crossbone insignia on the sides so that the public knew to avoid them. Baits were replaced each evening to maintain their palatability, with unused ones being buried at 1.2 m depth. Typically, bait stations were placed in sand or dust so that spoor could be used to determine whether a cat had ingested the bait. In rocky or vegetated areas bait removal could not be confidently assigned to species, and in some cases a single cat could have taken more than one bait and thus numbers killed by poisoning are uncertain. In the latter stage of the project tracking pits (see below) were constructed around bait stations so that removal of bait by cats could be confirmed with greater confidence.

Cage traps baited with fish or cat biscuits were placed along likely cat thoroughfares in locations that were concealed from the public. These were set in the evening and checked the following morning. All captured cats were scanned for microchips: if one was detected, the cat was released; otherwise, it was euthanized.

Humane leg-hold traps with padded jaws (Victor 1.5 soft-catch; Woodstream Corp., Lititz, USA) were baited or set in artificially constructed thoroughfares that channelled cats into the trap (Veitch, 1985, 2001). Traps were set just before dusk and removed at dawn.

Tracking pits were used to detect the presence of cats without killing or detaining them. These comprised a 1-m-diameter circle of smoothed sand with an attractant (either fish bait in a wire mesh basket or an auditory lure; Felid Attracting Phonics, Westcare Electronics, Perth, Australia), secured by a stake in the centre. Pits were checked for cat spoor on a weekly basis.

Eradication strategy

Risks of primary poisoning to the public and domestic animals were reduced by creating a 1-km buffer around each settlement within which no poison baits were laid. Feral cats within these areas were captured by setting up to 330 cage traps per night. The remainder of the island was treated using poison bait. Land crabs are the only indigenous terrestrial scavenger on Ascension and are unaffected by 1080 (Pain et al., 2007), and thus the poison baits presented no risk to native fauna. Secondary poisoning of humans was prevented by a moratorium on crab claw consumption (Pain et al., 2007). The area outside the 1-km buffers was divided into six sections and bait stations were placed every 50 m along parallel transects with a maximum spacing of 500 m. Sections were treated in rotation for four consecutive nights from Monday to Thursday; cessation of baiting during weekends reduced conflict with outdoor recreation. The areas under treatment were publicized with signs at entry points and via the public awareness programme, allowing people to avoid these areas. This knock-down phase of the project (February

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2002 to October 2002) was designed to kill the majority of feral cats on the island.

The strategy then switched to a mop-up phase (October 2002 to January 2004), designed to establish the location of remaining cats using tracking pits and chance encounters of cat spoor, fresh scats and prey remains. If sign was detected, control measures were targeted at the surrounding area. The final remaining feral cats outside the buffer areas exhibited avoidance of poison bait, and leg-hold traps were set to capture these individuals.

After the capture of the last feral cat, the strategy entered the confirmation phase (January 2004 to January 2006). This involved use of 800 tracking pits that were set across the whole island (outside the 1-km buffers) at 100-m intervals along 19 monitoring lines of 2–12 km in length that were checked for spoor in rotation twice weekly. Workers were also vigilant for any cat sign during seabird and turtle monitoring operations. Live-trapping and time-lapse video recording were used to establish whether any cat spoor detected had been left by domestic or feral animals. Trapped domestic cats were returned to owners, rehomed if the owners had left the island or, failing these, euthanized.

Seabird counts and breeding success

A complete census of all coastal seabird colonies on Ascension mainland was conducted each month during 2002 only. Counts were made from vantage points, a boat or by walking transects through the colonies. Species largely confined to Boatswain Bird Island and with nest sites that are difficult to detect (Madeiran storm petrel *Oceanodroma castro*, white-tailed and red-billed tropicbirds *Phaethon lepturus* and *Phaethon aethereus*, respectively, and white terns) were not counted because of practical and logistical difficulties. Baseline counts of these were taken from the literature. Monthly counts of seabirds colonizing the mainland were conducted from 2002 onwards and involved walking transects through suitable breeding habitat. The highest of the monthly counts in each calendar year for each species were taken as their annual population estimates in units of breeding pairs. For details of count methods, see Ratcliffe (2001).

To estimate seabird breeding success and infer potential for future recruitment into the breeding population, the nests of any breeding seabirds found were marked and their fates documented on subsequent visits. Visits to brown noddy *Anous stolidus* nests were made at 1- to 2-week intervals to ensure sufficient visits were made during their relatively short incubation and fledging periods. Hatching success, fledging success and overall breeding success were estimated by modelling daily nest and chick survival rates using the Stephens method, implemented with the *SAS* (SAS Institute, Inc., Cary, USA) code described in Rotella et al. (2004). In this the likelihood of an egg or chick surviving each day between consecutive visits to the nest is modelled as a binary response variable using logistic regression. Survival during the egg stage was assumed constant and that during the chick stage was modelled as a function of chick age. Years were pooled for analysis because of small sample sizes. The product of the daily survival rates over the entire duration of the hatching, fledging and breeding periods (taken from Dorward, 1962; Dorward & Ashmole, 1962; Stonehouse, 1962) was taken as the hatching success, fledging success and breeding success in terms of number of chicks per pair. This procedure corrects estimates for nests failing prior to them being found by observers, which was necessary given the relative infrequency of searches. Estimates were compared with those from the same species elsewhere by compiling colony-year estimates from the literature and ranking them in descending order. The percentile of the value in the current study was used to assess the relative level of productivity on Ascension Island compared to elsewhere.

Results

Cat eradication campaign

The cost of the entire restoration project during the period of the campaign from February 2002 to January 2006, including eradication effort and monitoring of cats and seabirds, was c. GBP 650,000. The number of man-hours occupied by cat eradication and cat monitoring totalled 24,200 and 14,480, respectively, and these varied markedly through the course of the project (Fig. 2).

A total of 168 domestic cats were presented voluntarily by their owners to be neutered and microchipped and an additional 18 were treated during the pre-eradication inspection. High mortality during the campaign (see below) and natural mortality have subsequently resulted in a domestic cat population of c. 74 animals. The high cost of cat importation has resulted in a low number of new animals being brought to Ascension (c. 3 per year), and so further declines in domestic cat numbers are likely as resident animals age and die.

The monthly control effort using each method and the number of feral cats killed are presented in Fig. 3. A total of 42,008 cage-trap nights resulted in the capture of 70 feral cats, 36 domestic cats, 40 Indian mynah *Acridotheres tristis*, six black rats *Rattus rattus* and 97 land crabs. All except the feral cats and black rats were released unharmed. Leg-hold traps were used from July 2002 to January 2003 in an attempt to capture cats that were avoiding poisoned bait: 298 trap-nights resulted in the capture of three feral cats. In addition, four feral cats were captured by hand in settlements and two were shot.

Of the 75,902 poisoned baits laid, 6,497 (8.6%) were taken, c. 488 by feral cats and the remainder by land crabs,

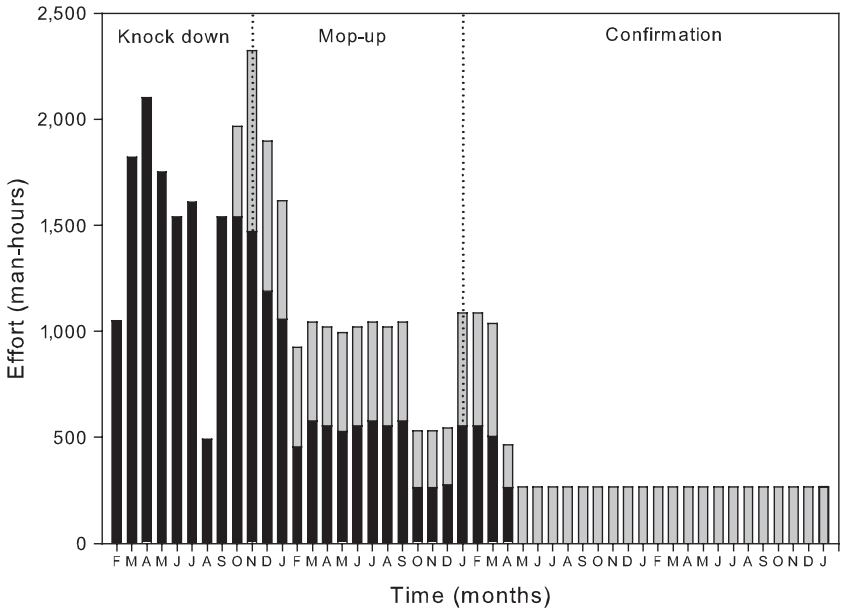

FIG. 2 Effort in terms of man-hours occupied by cat eradication (black bars) and cat monitoring (grey bars) from February 2002 to January 2006. The vertical dotted lines indicate divisions between the project's phases (see text for further details).

black rats, house mice *Mus musculus* and domestic cats. Sixty-nine domestic cats, or 38% of the total registered, were reported missing during the project and were assumed to have died after ingesting poisoned bait laid outside the 1-km buffer. This is supported by data from the mop-up and confirmatory phases that detected 26 incursions of domestic cats into a zone 1–2 km from a settlement boundary. Only one domestic cat was detected beyond the 2-km limit, this being an unusual event in which a pet was taken on a picnic.

The last feral cat was killed on 31 January 2004. During the subsequent 2-year confirmatory phase, 584,000 tracking-pit nights resulted in detection of the sign of 23 cats outside the 1-km buffers. All these were eventually identified as registered domestic animals. In three cases the cats had become feral after their owners had left the island; these could not be rehomed and so were euthanized. It is highly unlikely that any cats capable of reproducing remain on Ascension Island.

Seabird numbers and breeding success

The peak counts of seabirds breeding on cliff ledges, stacks and Boatswain Bird Island in 2002, and on cat-accessible sites during 2002–2007, are presented in Table 1. Five species have now recolonized the mainland and the numbers of each have increased through time. In all cases the maximum numbers recorded in cat-accessible sites represent a small percentage of those in cat-inaccessible sites, suggesting that increases in numbers on Ascension Island as a whole since cats were removed have been small. In all cases recolonization occurred in mainland localities adjacent to extant colonies (Fig. 1).

Maximum likelihood breeding success estimates with 95% confidence limits are presented in Table 2 and comparisons with other studies in the Appendix. The percentiles for the productivity values in this study ranked against those from studies in other site-years were low for masked booby (18.2), brown booby *Sula leucogaster* (25.0) and brown noddy (31.0) but high for white-tailed tropicbird (78.9), a species that showed relatively low spatio-temporal variation in productivity. The productivity of the first three species during this study only exceeded those values in studies where authors reported adverse effects of poor food availability or high levels of predation (Dorward, 1962; Nelson, 1978; Morris, 1984; King et al., 1992; Megyesi & Griffin, 1996; Pascal et al., 2004; Ramos et al., 2006).

Public relations

The public relations campaign was largely successful in informing the Ascension public of the aims of the campaign, and elevated awareness of conservation and environment more generally. The majority of the populace were supportive of the project, although two main sources of contention were encountered. High incidental mortality of domestic cats was the source of considerable anguish to their owners and led to demands for a cessation of poisoning. An extreme example of opposition was an unsuccessful attempt by a resident to conceal breeding cats and kittens during the campaign.

The use of overseas contractors for the eradication work generated resentment because this denied local people employment opportunities. However, the use of an experienced overseas team probably facilitated the execution of the project within the timescale. With hindsight, however, recruiting some local people to assist with the eradication campaign would have been worthwhile, to provide them with a longer period of training in cat monitoring and

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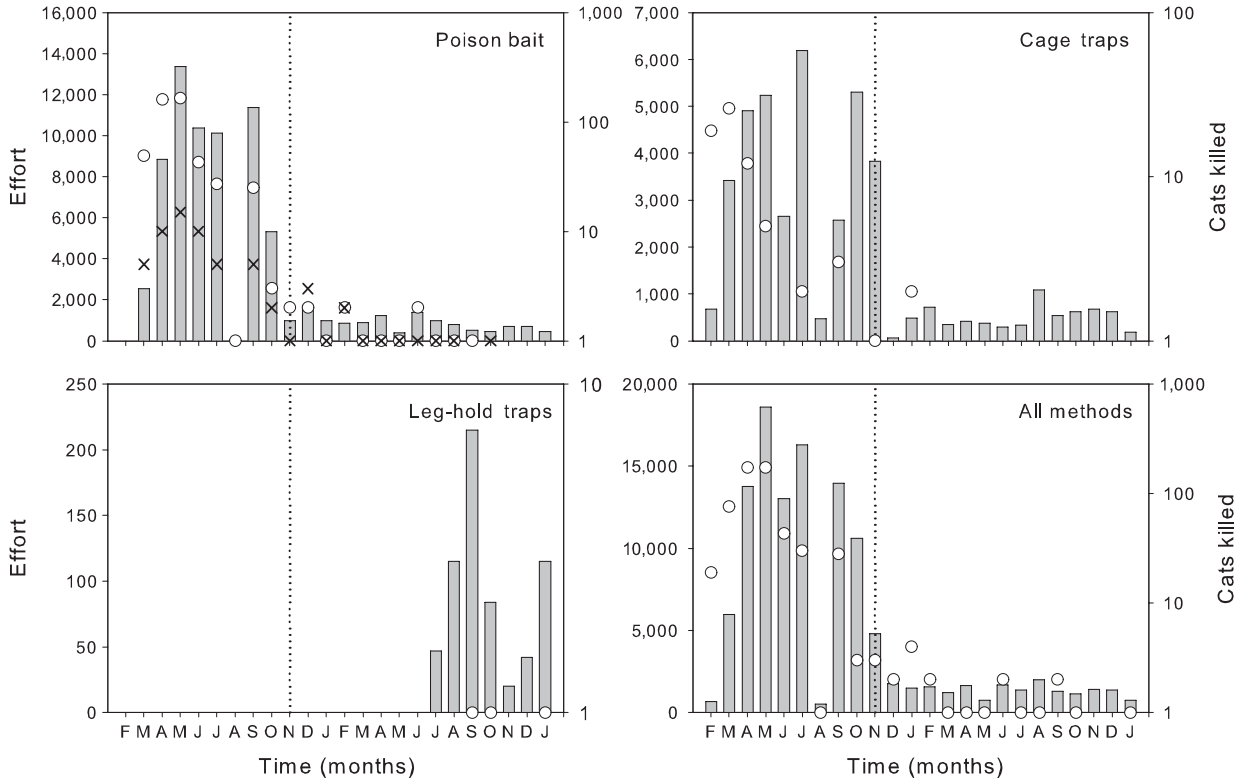

FIG. 3 Control effort and number of feral cats killed on Ascension Island from February 2002 to January 2004. The bars indicate effort (trap-nights or poison bait-nights) in each month; open circles and crosses represent the number of feral and domestic cats killed, respectively (on a log10 scale). The dotted vertical lines represent the month when the campaign switched from the knock-down to mop-up phase (see text for further details). Note that scales differ. The number of cats killed by poison bait is subject to uncertainty because the animal responsible for bait removal could not be identified with complete confidence in all cases, and single cats may have consumed multiple baits.

control methods prior to the external contractors' departure. The conservation office has flourished since the eradication campaign ended, continuing seabird monitoring and broadening its remit to include restoration of native plant communities, research on green turtles *Chelonia mydas* and development of a national park.

Discussion

Cat eradication

At 97 km² Ascension Island is the third largest island, after Marion Island (290 km²; Bester et al., 2000) and Macquarie Island (120 km²; Nogales et al., 2004), from which feral cats have been successfully eradicated. It is one of only two from which cats have been successfully eradicated with a significant human population; the other being Natividad Island with >400 occupants (Donlan & Keitt, 1999; Aguirre-Muñoz et al., 2008). The large size of the island, the fact it was populated, and the requirement to maintain the domestic cat population made the Ascension campaign complicated. Despite this, the removal of feral cats from Ascension was achieved within 2 years, which is a fraction of that taken to eradicate them from Marion Island (14 years) and Macquarie Island (25 years). Several factors contributed to this rapid success. The eradication methods and strategy were effective in maintaining a high rate of decline in feral cat numbers throughout the project, and we advocate their application elsewhere. The government land ownership of Ascension made obtaining access consent relatively straightforward. This may be more problematic on islands subdivided into multiple private ownership. Access to and around the island was facilitated by the harbour, airport, road/trail network and the relatively open terrain of the island, and the settlements provided accommodation and subsistence for staff. Thus inhabitation of an island can provide benefits as well as barriers to eradication campaigns.

The eradication campaign resulted in a large proportion of the domestic cat population being killed accidentally. Extending the 1-km poison bait buffer to 2 km is likely to have substantially reduced mortality but would have resulted in a three-fold increase in the area requiring treatment by live trapping, which is more labour intensive and less efficient than poison baiting (Veitch, 1985). This would have been justified to reduce the public opposition to the project. Distances domestic cats travel from settlements are likely to be island specific, and we recommend that their

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TABLE 1 The number of seabird breeding pairs in cat-inaccessible sites on Ascension Island in 2002 and in cat-accessible sites from 2002 to 2007.

Species	Cat inaccessible	Cat accessible						Population increase (%)[1]
	2002	2002	2003	2004	2005	2006	2007	
Madeiran storm petrel *Oceanodroma castro*	1,500[2]	0	0	0	0	0	0	0.00
Audubon's shearwater[3] *Puffinus lherminieri*	p	p	p	p	p	p	p	
White-tailed tropicbird *Phaethon lepturus*	1,100[4]	1	8	6	5	11	25	2.27
Red-billed tropicbird *Phaethon aethereus*	500[4]	0	1	1	3	0	8	1.60
Ascension frigatebird *Fregata aquila*	6,250[5]	0	0	0	0	0	0	0.00
Masked booby *Sula dactylatra*	4,500	2	10	16	25	37	152	3.38
Brown booby *Sula leucogaster*	1,000	6	20	11	21	24	29	2.90
Red-footed booby *Sula sula*	20	0	0	0	0	0	0	0.00
Brown noddy *Anous stolidus*	470	0	3	31	37	68	79	16.81
Black noddy *Anous minutus*	10,100	0	0	0	0	0	0	0.00
White tern *Gygis alba*	5,300[6]	0	0	0	0	0	0	0
Sooty tern *Onychoprion fuscata*	1	394,000[7]						

[1]The maximum number in cat-accessible sites in any 1 year expressed as a percentage of those in cat-inaccessible sites to give an index of total population increase since cat eradication, assuming numbers at cat-accessible sites remained constant during the study
[2]Allan (1962)
[3]p, present in small numbers; breeding not confirmed but possible on Boatswain Bird Island and Green Mountain (Ashmole et al., 1994; R. White, pers. obs.)
[4]Stonehouse (1962)
[5]Ratcliffe et al. (2008)
[6]Blair (1989)
[7]Average of years 2002–2007 from Hughes et al. (2008)

ranging behaviour from settlements is studied prior to any feral cat eradication campaign so that an optimal buffer zone can be determined. However, if this range overlaps with concentrations of vulnerable species, maintaining domestic cats on the island may be incompatible with conservation aims, especially because even a single cat is capable of causing extinction of insular island species (Fuller, 2000; Vázquez-Domínguez et al., 2004).

TABLE 2 Estimated survival rates over the entire incubation period (hatching success), fledging period (fledging success) and breeding period (breeding success) for three seabird species at mainland colonies. Estimate is the average survival over the specified period, with lower and upper 95% confidence limits in parentheses.

Parameter	Estimate (95% confidence limits)
White-tailed tropicbird	
Hatching success	0.51 (0.43–0.59)
Fledging success	0.72 (0.07–0.95)
Breeding success	0.37 (0.03–0.55)
Masked booby	
Hatching success	0.51 (0.48–0.54)
Fledging success	0.37 (0.15–0.58)
Breeding success	0.19 (0.07–0.32)
Brown booby	
Hatching success	0.50 (0.44–0.55)
Fledging success	0.57 (0.15–0.82)
Breeding success	0.28 (0.06–0.82)
Brown noddy	
Hatching success	0.47 (0.43–0.51)
Fledging success	0.54 (0.25–0.74)
Breeding success	0.26 (0.11–0.38)

Seabird responses to management

The removal of cats from Ascension resulted in the number of adult sooty terns found dead in their colonies being reduced from > 4,500 per year to negligible levels (Hughes et al., 2008), which is likely to have resulted in increased adult survival. Studies on two other islands found similar reductions in sooty tern mortality following feral cat removal (Rodriguez et al., 2006; Peck et al., 2008). Moreover, four species of seabird have recolonized and bred in areas of the mainland that were formerly accessible to cats. Breeding boobies had been recorded on the mainland prior to cat eradication (Dickey et al., 1997; Simmons & Prytherch, 1997) but their occurrence was sporadic, and the remains of dead adult seabirds scattered throughout these areas suggest they fell prey to cats (Ashmole et al., 1994). Eradication of cats is therefore likely to have relaxed density-dependent adult mortality by allowing seabirds overspilling from established colonies onto the mainland to survive.

Breeding success of boobies and noddies was low compared to values for conspecifics elsewhere, and there are three possible reasons for this. (1) Low breeding success could be because of poor food availability in the seas

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around Ascension Island, as observed at predator-free colonies at Ascension in the 1950s and 1960s (Dorward, 1962; Nelson, 1978). (2) The majority of birds recruiting to mainland Ascension will lack prior breeding experience and this is known to result in poor breeding performance in seabirds (Pyle et al., 1991; Ratcliffe et al., 1998). (3) Black rats are known to eat the eggs and chicks of tropical seabirds elsewhere (Schaffner, 1991; Pascal et al., 2004; Caut et al., 2008) and their predation on those of sooty terns and boobies on Ascension has been observed only since cats were eradicated (Hughes et al., 2008, pers. obs.). Further research to discriminate among these candidate explanations for poor breeding success is required.

The appearance of rat predation on seabirds since cat eradication is not an example of the mesopredator release effect postulated by Courchamp et al. (1999), in which removal of cats allows an increase in rat numbers and a consequent elevation of overall predation upon birds. Following cat eradication, rat numbers, and their predation on sooty tern eggs and chicks, have fluctuated in response to rainfall and vegetation growth (Hughes et al., 2008), and thus rat numbers appear to have been regulated by food availability rather than cat predation. Predation of booby eggs has only been observed following cat eradication because this food source has only become available since cat eradication; prior to this, adult birds fell prey to cats before they laid eggs.

The initial responses of seabirds to removal of cats have been encouraging but future population trajectories are difficult to predict. New seabird colonies grow slowly at first because colonial birds are reluctant to breed alone or in small groups, then rapidly because of the social attraction of immigrants by these pioneers, and thereafter at a reduced rate because of low natal recruitment (Dunlop, 2005; Kildaw et al., 2005). Similarly, new colonies on Ascension were founded by a few individuals and growth rates have increased with time, which is certainly because of immigration given that tropical seabirds first breed at c. 4 years old (Woodward, 1972; Schreiber & Norton, 2002; Schreiber et al., 2004; Dunlop, 2005), and insufficient time has elapsed to allow significant natal recruitment. This immigration may continue in future years but growth of the new colonies because of natal recruitment is likely to be slow given the poor observed productivity. Further monitoring of both productivity and population trends will be essential to assess the success of the restoration project in terms of population growth in addition to the expansion of breeding range.

Public relations

Establishing good relations with the general public, and particularly landowners, prior to an eradication campaign is essential to success. A public relations campaign should promote economic benefits to the community, such as capital investment, employment opportunities and increased potential revenue from ecotourism following success. On Ascension Island the public relations campaign was initiated 6 months prior to commencement of cat eradication, and we view this as a minimum lead-in time. Experiences on Ascension show that minimizing the incidental mortality of domestic cats is vital to avoid opposition during an eradication campaign. The Ascension project demonstrates that campaigns can provide impetus for development of wider long-term conservation initiatives on islands, and future campaigns elsewhere should plan to leave a similar legacy.

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Appendix

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Biographical sketches

Norman Ratcliffe is interested in the population dynamics of seabirds and their relationships with predation and the marine environment. Mike Bell and Dave Boyle have worked on a wide range of eradication campaigns of several species of invasive mammals. Tara Pelembe and Raymond Benjamin work to conserve indigenous species on Ascension Island, particularly seabirds and plants. Richard White has extensive experience of surveying seabirds, both at their colonies and at sea, throughout the Atlantic. Brendan Godley is interested in the ecology and conservation of higher marine vertebrates. Jim Stevenson and Sarah Sanders work to conserve globally threatened bird species on UK overseas territories.

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