Eradicating black rats from the Chagos – working towards the whole archipelago

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Abstract The Chagos Archipelago comprises some 58 islands covering 5,000 ha in the centre of the Indian Ocean. Black rats (*Rattus rattus*) were introduced about 230 years ago and have likely had a severe impact on the native terrestrial fauna, which is dominated by seabirds and land crabs. Most of the archipelago's terrestrial land mass is vegetated with old coconut plantations, with over 75% of the native forest cleared for coconut from 26 of the largest islands. Likely as a result of this colonisation and clearance, at least 30 islands have rats present (95.3% of the Chagos landmass) along with feral cats (*Felis catus*) on 62%, which suppresses the recovery of native fauna and flora. Efforts at rat eradication include the failed attempt on Eagle Island (252 ha) in the northern Chagos Archipelago in 2006 and the recent success of a ground-based eradication on Île Vache Marine in 2014, where two applications of brodifacoum poison were hand-spread at a rate of 18 kg/ha. Two islets on the nearby Salomon atoll were also cleared of black rats during the same operation with single bait applications. The 2014 operation was successful on what are regarded as difficult islands for rat eradication, being 'wet' tropical islands with land crabs and coconut plantations present, and has engendered confidence to proceed with additional rat eradications on other northern Chagos islands.

Keywords: atoll, *Birgus*, Chagos, eradication, hand-broadcast, *Rattus*, seabirds, tropical

INTRODUCTION

Invasive species have caused 75% of terrestrial vertebrate extinctions on islands (McCreless, et al., 2016) and of these species' rats are probably the most pervasive, having been introduced to more than 85% of oceanic islands and archipelagos (Harper & Bunbury, 2015). Rats have been responsible for some 40–60% of all bird and reptile extinctions (Howald, et al., 2007). Rats prey upon and compete with animals and can consume all parts of plants, which disrupts ecosystem function and can cause direct or indirect cascades of collapse, through interruption of pollination and nutrient pathways, seed predation, and in some cases leading to forest collapse (Towns, et al., 2006; Athens, 2009; Towns, 2009; Hilton & Cuthbert, 2010).

Black rats (*Rattus rattus*) have been present on the Chagos Archipelago, in the mid-Indian Ocean, since the late 1700s when the archipelago was settled (Wenban-Smith & Carter, 2016). Diego Garcia is in the southern Chagos Archipelago and is the largest (~2,900 ha) and only inhabited island, with a transient population associated with a military base. It has rats and cats (*Felis catus*) present and there are no current plans for rat eradication. In the northern Chagos Archipelago (~2,100 ha total combined area), 26 of the 55 islands are known or suspected to have black rats present (Carr & Harper, 2015). These rat-infested islands comprise some 1,700 ha in combined total land area or some 47% of the islands in the group. Only 4.7% of the entire Chagos terrestrial space is regarded as mammalian predator free and seabird population density is approximately 20 times higher on rat-free islands (Hilton & Cuthbert, 2010). (Fig. 1).

Low-lying, remote and geologically young (49 mMYA, Duncan & Hargraves, 1990), the Chagos Archipelago has not had the speciation that has developed on similarly isolated elevated archipelagos such as Hawaii and the Mascarene Islands. The atolls of the Chagos Archipelago are largely formed from marine sand deposits with some raised rock formations. Many islands had their native forest removed during settlement and replaced with a dense monoculture of coconut palms (*Cocos nucifera*). As several seabird species preferentially nest in native trees, this destruction of nesting habitat was probably the first major impact on the previously large seabird colonies that existed there (Carr, 2013). This was followed by direct persecution by man and other introduced predators; principally this was rats, cats, dogs and pigs. By the start of the 1900s, the vast seabird colonies now indicated by guano deposits had disappeared (Carr, 2011).

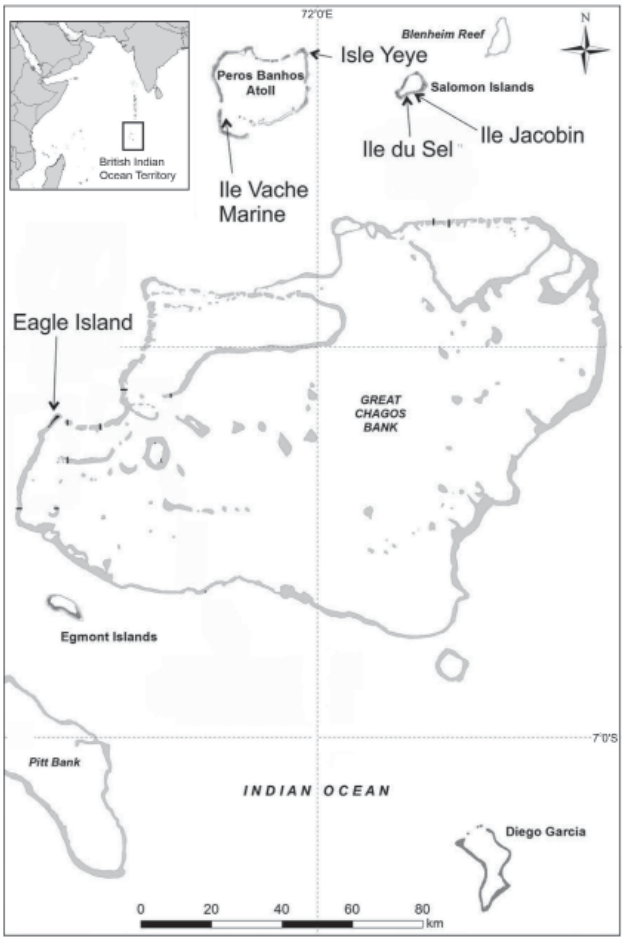

Fig. 1 Map of the Chagos Archipelago showing location of islands mentioned in the text.

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On less anthropogenic-impacted islands the architecture of the native oceanic rain forest allows arboreal nesting by lesser noddy (*Anous tenuirostris*) and red-footed booby (*Sula sula*), whereas the open areas are used by species such as brown booby (*Sula leucogaster*), brown noddy (*Anous stolidus*), sooty tern (*Onychoprion fuscatus*) and the tropical shearwater (*Puffinus bailloni*). Two introduced birds, the domestic chicken (*Gallus gallus*), and Madagascan fody (*Foudia madagascariensis*) are the only land birds resident in the northern Chagos, the former found on only a few islands. Fodies are found on most of the vegetated islands. Land crabs are the dominant invertebrates, with the coconut crab (*Birgus latro*) being the most obvious. Smaller hermit crab species, the burrowing land crab (*Cardisoma carniflex*) and other land crab species are present (Stoddart, 1971a; PC pers. obs.). There is a reviving population of green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) that nest on some islands (Mortimer & Day, 2009). No native mammals, including bats, exist on the islands.

Rat eradication planning

The Chagos Conservation Trust is championing the eradication of rats from the archipelago, to provide an environment for populations of existing native species to recover and to restore the ecosystem to a state prior to rat invasion (<https://chagos-trust.org/about/vision-and-mission>). This endeavour is in concert with The British Indian Ocean Territory Interim Conservation Management Framework of 2014 (<https://biot.gov.io/biot-interim-conservation-management-framework-september-2014.pdf>), which has an overarching vision: "To maintain and, where possible, enhance the biodiversity and ecological integrity of the British Indian Ocean Territory (BIOT)".

All eradication attempts require comprehensive planning before implementation and this was particularly true for a rat eradication programme on a highly isolated tropical island, which presented a novel suite of problems. Invasive mammal eradication work in the Chagos Archipelago faces both logistical and ecological challenges due to the archipelago's remoteness and inaccessibility, along with the wet climate and the vegetation composition with the significant component of coconut 'chaos'. Île Vache Marine was selected for the initial rat eradication because it was: deemed a realistic and manageable size for a start-up operation; the risk of reinvasion was considered negligible due to its distance from other islands; there were no susceptible non-target species; it nestled in amongst five confirmed or proposed IUCN classified Important Bird Areas (Carr, 2011); there was some anecdotal evidence that shearwaters had once bred on the island and, if successful, the probability of re-colonisation by marine avifauna was likely.

Île Vache Marine (12.4 ha, 2 m elevation) is situated on the southern rim of the Peros Banhos atoll (05°25› S, 71°49› E, Fig. 1). It is a typical tropical low-lying oceanic coralline island and the vegetation comprises a shoreline perimeter of *Scaevola taccada* on the exposed southern coast with introduced coconut and the occasional *Guettarda speciosa* and *Morinda citrifolia* on the coast facing the atoll. The mean annual rainfall for the Peros Banhos atoll (data from 1950–1966) is approximately 4,000 mm, distributed bi-modally, with a slightly drier period through the austral winter (Stoddart, 1971b). Île Vache Marine was never inhabited, but was visited until 1974 for coconut harvesting. The plantation workers would have come from Île du Coin (126 ha), some 6 km distant, the former plantation headquarters and likely source of rats. In 2014 there were very limited numbers of seabirds present.

Previous rat eradication attempts in the Chagos

There was an attempt to eradicate black rats from Eagle Island (252 ha) in 2006. A team of 11 established 2,864 bait stations on a 30 m × 30 m grid of cut tracks starting in early February. The bait stations were loaded with Talon™ wax blocks (0.05 g/kg brodifacoum with bitrex) that was maintained in the stations until the team departed in late April (Meier, 2006). Later checks revealed that the operation had failed.

The Île Vache Marine eradication served two purposes. Firstly, it was an opportunity to undertake a rat eradication operation, albeit small, as proof that the method could be successful in the northern Chagos islands and engender confidence in the technique as a management tool for biodiversity gains in the region. Secondly, it added Île Vache Marine to a string of rat-free islands in eastern Peros Banhos, which were situated amongst Important Bird Areas and within an area designated as a Strict Nature Reserve under BIOT Law.

Rat eradications on tropical islands have a higher failure rate than temperate islands for a variety of reasons, including the presence of coconuts, land crabs as bait competitors, and on 'wet' tropical islands, in particular (Russell & Holmes, 2015; Holmes, et al., 2015). Ground-based operations also have had a higher failure rate than aerial bait applications but are usually cheaper to undertake on small islands, with less logistical and technical input required. Hence, for the rat eradications on the northern Chagos a ground-based eradication was planned for cost and logistical reasons but needed to be very cognisant of the risk factors associated with the islands. A successful outcome for the eradication operation in the face of these impediments would promote confidence in the technique for tropical islands with similar characteristics.

As an adjunct to the planned eradications, an additional bait trial was carried out on Diego Garcia in order to measure bait-take by rats at a measured rat population density and refine bait application rates for future rat eradications on Chagos atolls (Harper & Carr, 2015).

METHODS

Île Vache Marine rat eradication, Peros Banhos atoll

Parallel lines were cut at 25 m intervals across the island in June 2014. This was undertaken by volunteers from the British Forces stationed on Diego Garcia. The timing was important, in that it needed to be done long enough before the operation so that any disturbance did not affect rat behaviour but not too early as re-growth was rapid, particularly in *S. taccada* thickets.

August was chosen as the month for bait application as it was one of the driest months of the year (Stoddart, 1971b) and when a vessel was available. The eradication operation staff assembled the equipment and supplies in Diego Garcia on 31 July 2014 prior to departure on 1 August. The team, GH, PC and members of the British Forces on Diego Garcia, landed on Île Vache Marine early on 2 August to allow passage over the coral reef at high tide. The cut lines were checked and, where required, were either re-cut or additional lines slotted in between existing lines. Sites for bait throwing were marked at 25 m along the cut lines and black plastic bait stations (Protecta LP, Bell Labs, USA) laid at these sites for post-broadcast bait deployment. The bait stations were raised 40 mm off the ground with wooden blocks to reduce interference by hermit crabs. By the end of the first day there was a 25 m × 25 m grid of 154 sites across the entire island. The island

size was also reconfirmed at 12 ha by walking the coast of the island with a GPS unit (Garmin 62S).

Bait application trials and eradications on other Indian Ocean islands showed that bait could be spread at a rate of >15 kg/ha and be available to all rats for four nights (Merton, et al., 2002, Harper & van Dinther, 2014). Bait was spread on Île Vache Marine on 3–4 August. Pollard pellet bait (Bell Labs 25W) was hand spread at a rate of 18 kg/ha by GH and PC. This involved hand-throwing bait at each of the grid sites. Bait (280 g) was thrown in four directions at right angles to each other, such that it reached about 10–12 m, along with 280 g spread at the throwing point. Bait spreading by the two operators began at each end of the island and lines were traversed such that the operators were converging on each other. Bait coverage was almost completed on the first day, except for a strip of about 2 ha in the centre of the island. This was covered the next morning and a little additional bait was spread above the high tide mark around the coast of the island where hermit crabs were abundant. All the equipment and empty poison bait containers were removed by the end of the morning. The team departed for Diego Garcia shortly thereafter.

A second bait application was undertaken 11 days later. This was to ensure all rats had access to bait, particularly if breeding was occurring and suckling mothers or young animals may have been missed in the first bait application. The island was revisited on 14–15 August and poison bait pellets (Pestoff 20R) were hand laid at a rate of 18 kg/ha. Differing bait types were used for the two applications as ship rats have been observed with distinct preferences for one or other bait, thus circumventing possible bait avoidance (Harper & van Dinther, 2014). Several recently dead rats were located during the second bait application, suggesting rats had readily consumed the poison bait laid in the first application. The bait stations were also then loaded with wax-based poison baits (Ditrac™ 0.005% w/w brodifacoum, Bell Labs) at a rate of three bait blocks (150 g) secured inside each station. This was to ensure that if heavy rain degraded the bait post-departure, or any rats missed the hand-laid bait, then poison bait was still available for several weeks after the operation. The team departed Île Vache Marine on 15 August at midday. It did not rain during either of the bait deployments.

Bird counts on Île Vache Marine had been undertaken by PC since 2009. Counts in 2014 revealed fewer than five pairs of brown noddy and white tern (*Gygis alba*) and ten pairs of great crested terns (*Thalasseus bergii*), were breeding on the island. About 15 pairs of the one introduced passerine, the Madagascar fody (*Foudia madagascariensis*) were present.

In April 2015, the bait stations were removed by PC and a Connect Chagos graduate (a Zoological Society/CCT project with funding from the UK FCO) during a different expedition.

The eradication phase of Îles du Sel and Jacobin, Salomon Islands atoll

Additional poison bait intended as a contingency for the Île Vache Marine operation was deployed on two islets, Îles du Sel (2.2 ha) and Île Jacobin (1.6 ha), in the Salomon atoll, some 25 km east of the Peros Banhos. These two islands were selected for their small size and their relative isolation from other islands. This meant there was a lower probability of re-invasion by rats than other islands in the area and a single application of the remaining bait was deemed practical. On arrival, a quick survey was carried out immediately before each operation to assess the likelihood of success. Both islands were dominated by coconut, with varying amounts of native forest present, with few other factors that would limit the probability of success, as identified by Holmes, et al. (2015). Of note was the lack of large seeds or seedlings of native trees.

Bait was deployed on Île du Sel and Île Jacobin on 16 August 2014. The islands were circumnavigated and waypoints marked at 25 m intervals on each side of the islands using a GPS unit (Garmin 62S). The operators (GH & PC) then walked from the first waypoint on one side to the corresponding waypoint on the opposite side of each island without cutting the vegetation. Pellet bait (Pestoff 20R) was broadcast at 25 m intervals, using the same method as on Île Vache Marine. Bait was spread at a higher rate of 20 kg/ha on Île du Sel and 25 kg/ha on Île Jacobin as it was a single application. The difference in application rate was due to slightly more bait remaining after the first island was treated.

There were opportunities for post-eradication monitoring on Île Vache Marine by PC as part of other expeditions. The first check was made seven months later in April 2015 with a Connect Chagos graduate during daylight, and during an overnight stay, and no sign of rats was seen. A second daytime check was made by PC in February 2016 and again no rat sign was recorded but signs of vegetative recovery were noted (Table 1). An opportunity for both GH and PC to undertake a more comprehensive survey of the island became available over 9–10 April 2017, when 45 rat snap-traps and wax tags were deployed over a 24-hour period. In addition, coconuts were cut open and placed on the ground near the campsite and searches were made for gnawed seeds/coconuts, rat tracks/caches etc. Additional searches were conducted at night by torchlight to detect rats.

During the same expedition, surveys were made at Île du Sel and Île Jacobin on 15 April and 15 rat detection devices (snap traps, wax tags, secured portions of coconut flesh) were deployed overnight on each island. Searches

Table 1 Initial checks of Île Vache Marine for rat sign.

Date	Event	Results	Responsible
24–25/03/2015	Rodent survey including: a. 50 × snap-traps deployed overnight b. Check for rat gnawing on fallen fruit and flowers c. Check for rat excrement d. Daytime visual inspection of island e. Nocturnal inspection of island (overnight stay)	No sign of rat presence	P Carr C Narina J Schlayer
09/02/2016	Rodent survey including: a. Check for rat gnawing on fallen fruit and flowers b. Check for rat excrement c. Daytime visual inspection of island	No sign of rat presence. Obvious signs of native tree seed germination especially *Guittarda speciosa and* extensive flowering of *Scaevola taccada*	P Carr

were made for signs of rats similar to the operation on Île Vache Marine. The islands were revisited the following morning and detection devices recovered and further searches made.

Diego Garcia bait trial

Two 1 ha plots were set out 200 m apart in disused coconut plantation forest some 2 km west of the small township on western Diego Garcia. The plots were divided into a 5 × 5 grid at 25 m intervals. Within the plots an internal trapping grid of 15 Victor snap-traps was established on an interval of 25 m × 12.5 m. The internal grid was centrally located so that there was a 25 m buffer from the plot perimeter.

Poison bait (Pestoff 25R pellets, Animal Control Products, NZ) was hand-spread on both 1 ha plots at a rate of 15 kg/ha on 7 August 2014. The bait had been dyed with Rhodamine-B, which fluoresces under UV light. After one night to allow rats to access the bait the snap-traps were baited with coconut and peanut butter and set. Trapped rats were collected morning and evening for the next three days. The rats were dissected and their gut cavities examined under UV light for evidence that the dyed bait had been consumed.

To give a simple estimate of rat population density, the number of rats caught was divided by the effective trapping area (ETA). To estimate ETA for rats, a boundary strip was added to the edge of the trapping grids (Dice, 1938). The width of the boundary strip was set by adding the average radius (15 m) of a home range of ship rats from mangrove forest on Aldabra Atoll and forest on Juan de Nova and Europa (Harper, et al., 2015, Ringler, et al., 2014).

RESULTS

Rat eradications in northern Chagos Islands

None of the various indicators used to detect rats during the overnight stay on Île Vache Marine on 9–10 April 2017 showed that rats remained on the island. Prior to the eradication rats had been seen on every previous inspection and were easily trapped both diurnally and nocturnally. Moreover, there had been an increase in breeding pairs of seabird species for pre- and post-eradication counts, including a significant increase in numbers of white tern (T_1= -2.32, d.f. = 6, p = 0.03), which are vulnerable to rats, and great crested terns (T_1= -4.73, d.f. = 3, p = 0.009).

Similarly, none of the indicators for detecting rats on Îles du Sel and Jacobin showed sign of any rats. Many seeds of the large native tree *Intsia bijuga* had germinated and there was a carpet of 300 mm high seedlings on the forest floor of both islands, along with many untouched seeds. These large seeds appear to be a favoured food of rats, as the seeds and seedlings are rarely found on rat-infested islands.

Diego Garcia bait trial

Sixty rats were removed from traps over the three days; 30 from each plot. There was significant interference with, and removal of, trapped rats by land crabs so this is highly likely to be a minimum number of rats trapped. Of the 60 rats, 59 (98.3%) had eaten dyed bait. The one rat that had not consumed bait was an adult female that was trapped in the first morning after the bait application, so bait had been available for a little over 36 hours. Some bait was still present on the last day of trapping.

Of the trapped rats, only two were juveniles (both female) and there was a slight sex bias towards males (32:28). Several adult male rats were in poor condition, whilst some rats were in good condition with substantial amounts of mesenteric fat. Of the 26 adult female rats trapped, two were pregnant.

The trapping grids within the bait grids were 25 m in diameter and adding a 15 m boundary strip gave a total radius of the ETA of 40 m, for an area of 0.5 ha. At least 30 rats were caught on each trapping grid, which translates to a minimum population density of 60 rats/ha.

DISCUSSION

Rats were eradicated on three small 'wet tropical' islands in the northern Chagos with two hand-spread application rates of 18 kg/ha each on the larger Île Vache Marine and single applications of 20 and 25 kg/ha respectively, on the smaller islets Îles du Sel and Jacobin.

Of particular interest was the success of the rat eradications on the very small islets, considering that only one bait application, albeit at a higher initial rate but cumulatively less than on Île Vache Marine, was made on each. Best practice suggests two applications, although it is generally acknowledged that the second application acts as an insurance policy against unforeseen confounding factors, such as heavy rain ruining bait (Keitt, et al., 2015), and because rats can breed year-round in the wet tropics (Russell & Holmes, 2015). In this case the small size of the islands, selection of the driest period of year and well planned rapid bait deployment by a small team is likely to have assisted with operational success as the factors associated with eradication failure on tropical islands were reduced (Holmes, et al., 2015).

Of crucial importance were the parallel and well-cut lines cut in the thick vegetation on Île Vache Marine, such that there were no gaps in bait coverage due to converging tracks. The bait application took 1.5 days, at a rate of about 5 ha/person/day. The bait applications began at both ends of the island simultaneously and a gap in bait coverage was left for one night in both cases, which did not affect the operational success. It is not known whether the bait was degraded by any heavy rain in the days immediately after bait deployment as the team left the area shortly after both applications. Although there were several land crab species, including hermit crabs, present on the island, coconut crabs that can outcompete rats for bait were absent.

It can be concluded that rats can be eradicated from small Chagos Archipelago islands with a minimum toxic bait application of 20 kg/ha, and the trials on Diego Garcia indicate that a 15 kg/ha application rate is too low. This suggests that on similar small islands at least, single applications of poison can successfully remove rats and should be considered in appropriate circumstances. A single bait application has advantages in reduced logistics, cost and possible impact on the environment. Where possible, further bait trials will be undertaken on islands in the northern Chagos Archipelago, to gain more confidence with the amount of bait and bait presentation required. These trials are of particular importance on islands largely dominated by coconut crabs, and with burrowing crab species present (Holmes, et al., 2015; GH & PC, pers. obs.) and where mangrove or *Pemphis acidula* is present at periodically flooded sites (Harper, et al., 2015).

This operation has provided evidence that rats can be eradicated from small wet tropical islands that contain large populations of land crabs and coconut forest that has previously been deemed difficult to achieve (Holmes, et al., 2015). We demonstrate that careful assessment and planning prior to the operation can result in a successful outcome (Keitt, et al., 2015). Given the success of ground-based rat eradication operations on the three small islands in the Chagos Archipelago, an eradication is being planned

for larger islands in the near future, such as Île Yéyé (61 ha), which is the only remaining rat-infested island in the eastern Peros Banhos Strict Nature Reserve. If this is successful a larger operation to eradicate rats from all of the northern Chagos Archipelago is likely to be pursued.

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REFERENCES

Athens, J.S. (2009). '*Rattus exulans* and the catastrophic disappearance of Hawai'i's native lowland forest'. *Biological Invasions* 11: 1489–1501.

Carr, P. (2011). A guide to the birds of the British Indian Ocean Territory. *Information Press, Oxford, UK.*

Carr, P. (2013). 'Factors Influencing Breeding Island Selection of Red-footed Booby *Sula sula* (Linn. 1766) in the Chagos Archipelago, Central Indian Ocean, and the Implications for Future Island Management Plans'. MSc thesis. UK: Warwick University.

Carr, P. and Harper G.A. (2015). 'The distribution of ship rat *Rattus rattus* in the Chagos Archipelago'. *Chagos News* 47: 20–31.

Dice, L.R. (1938). 'Some census methods for mammals'. *Journal of Wildlife Management* 2: 119–130.

Duncan, R.A. and Hargraves, R.B. (1990). '^{40}AR/^{39}AR Geochronology of Basement Rocks from the Mascarene Plateau, the Chagos Bank, and the Maldives'. In: R. A. Duncan, J. Backman, L.C. Peterson, et al. (eds.) *Proceedings of the Ocean Drilling Program, Scientific Results* Vol. 115, pp. 43–51. Texas: College Station.

Harper, G.A. and van Dinther, M. (2014). *Bait and Trap Trials for Invasive Rats and Cats on Aldabra Atoll and Implications for Their Eradication*. Unpublished report for the Seychelles Islands Foundation, Republic of Seychelles.

Harper, G.A., van Dinther, M. and Bunbury, N. (2015). 'The response of black rats (*Rattus rattus*) to evergreen and seasonally arid habitats: informing eradication planning on a tropical island'. *Biological Conservation* 185: 66–74.

Harper, G.A. and Bunbury, N. (2015). 'Invasive rats on tropical islands: Their population biology and impacts on native species'. *Global Ecology and Conservation* 3: 607–627.

Harper, G.A. and Carr, P. (2015). **'**An initial trial to determine an effective rat bait application rate at Diego Garcia, British Indian Ocean Territory'. *Chagos News* 47: 17-19.

Hilton, G.M. and Cuthbert, R.J. (2010). 'The catastrophic impact of invasive mammalian predators on birds of the UK Overseas Territories: A review and synthesis'. *Ibis* 152: 443–458.

Holmes, N. D., Griffiths,R., Pott, M., Alifano, A., Will, D., Wegmann, A.S. and Russell, J.C. (2015). 'Factors associated with rodent eradication failure'. *Biological Conservation* 185: 8–16.

Howald, G., C. J. Donlan, C.J., Galván, J.P., Russell, J.C., Parkes, J., Samaniego, A., Wang, Y., Veitch, D., Genovesi, P., Pascal, M., Saunders, A. and Tershy, B. (2007). 'Invasive rodent eradication on islands'. *Conservation Biology* 21: 1258–1268.

Keitt, B., Griffiths, R., Boudjelas, S., Broome, K., Cranwell, S., Millett, J., Pitt, W. and Samaniego-Herrera, A. (2015). 'Best practice guidelines for rat eradication on tropical islands'. *Biological Conservation* 185: 17–26.

McCreless, E.E., Huff, D.D. Croll, D.A., Tershy, B.R., Spatz, D.R., Holmes, N.D., Butchart S.H.M. and Wilcox, C. (2016). 'Past and estimated future impact of invasive alien mammals on insular threatened vertebrate populations'. *Nature Communications* 7: 12488.

Meier, G.G. (2006). 'Rat eradication on Eagle Island'. *Chagos News* 28: 2–4.

Merton, D.V., Climo, G., Laboudallon, V., Robert, S. and Mander, C. (2002). 'Alien mammal eradication and quarantine on inhabited islands in the Seychelles'. In: C.R. Veitch and M.N. Clout (eds.) *Turning the tide: the eradication of invasive species,* pp. 182–198. Occasional Paper SSC no. 28. IUCN SSC Invasive Species Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK .

Mortimer, J.A. and Day. M. (2009). 'Sea Turtle Populations and Habitats in the Chagos Archipelago'. In: C.R.C. Sheppard and M.R.D. Seaward (eds.) *Ecology of the Chagos Archipelago.* Westbury, England: Linnean Society Occasional Publications 2.

Ringler, D., Russell, J., Jaeger, A., Pinet, P., Bastien, M. and Le Corre, M. (2014). 'Invasive rat space use on tropical islands: Implications for bait broadcast'. *Basic Applied Ecology* 15: 179–186.

Russell, J.C. and Holmes, N.D. (2015). 'Tropical island conservation: Rat eradication for species recovery'. *Biological Conservation* 185: 1–7.

Stoddart, D.R. (1971a). 'Terrestrial fauna of Diego Garcia and other Chagos atolls'. *Atoll Research Bulletin* 149: 163–170.

Stoddart, D.R. (1971b). 'Rainfall on Indian Ocean coral islands'. *Atoll Research Bulletin* 147: 1–21.

Towns, D.R., Atkinson I.A.E. and C.H. Daugherty, C.H. (2006). 'Have the harmful effects of introduced rats on islands been exaggerated?' *Biological Invasions* 8: 863–891.

Towns, D.R. (2009). 'Eradications as reverse invasions: lessons from Pacific rat (*Rattus exulans*) removals on New Zealand islands'. *Biological Invasions* 11: 1719–1733.

Wenban-Smith, N. and Carter, M. (2016). *Chagos: A History; Exploration, Exploitation, Expulsion*. London: Chagos Conservation Trust.