Title
Rodent Eradication on Cocos Island, Guam: Integrating Wildlife Damage Management, Resort Operations, and Non-Target Concerns

Journal
Proceedings of the Vertebrate Pest Conference, 24(24)

ISSN
0507-6773

Authors
Lujan, Dana T.
Vice, Daniel S.
Guerrero, Jesse P.
et al.

Publication Date
2010

DOI
10.5070/V424110353

Rodent Eradication on Cocos Island, Guam: Integrating Wildlife Damage Management, Resort Operations, and Non-Target Concerns

Dana T. Lujan, Daniel S. Vice, Jesse P. Guerrero, and **Clifford C. Candaso**
USDA Wildlife Services, Hawaii/Guam/Pacific Islands, Barrigada, Guam

ABSTRACT: Introduced Polynesian rats threatened native bird populations and forest habitat on Cocos Island, Guam. To eliminate the threat posed by rat populations, a rodent eradication was conducted on the 33.6-hectare off-shore island in March and April 2009. An integrated approach to eradication was implemented that included trapping, bait stations, and hand broadcast of rodenticide bait. Trapping was conducted within the resort buildings, where human activity precluded the use of rodenticides. Bait stations, employed in commensal resort settings, were designed to prevent terrestrial crabs from accessing the bait. In addition, bait station deployment and retraction methods were used to reduce impacts on daily resort operations. Non-target concerns, primarily with native forest birds during broadcast operations, supported a decision to use diphacinone, a rodenticide with low avian toxicity risk. Bait consumption by the locally threatened Micronesian starling was evident during the broadcast application, but substantial monitoring for non-target impacts revealed no mortality or sublethal effects for starlings or other potential non-targets. Eradication operations on Cocos Island present a prime example of integrated wildlife damage management, combining traditional eradication methods with novel approaches to address site-specific challenges.

KEY WORDS: bait stations, broadcast application, eradication, Guam, island ecosystem, non-target hazards, Polynesian rat, *Rattus exulans*, rodent control, rodenticides

Proc. 24th Vertebr. Pest Conf. (R. M. Timm and K. A. Fagerstone, Eds.)
Published at Univ. of Calif., Davis. 2010. Pp. 9-13.

INTRODUCTION

The Guam Department of Agriculture (GDOA) has embarked on a project to restore and enhance the Cocos Island ecosystem by removing non-native plants and animals, and establish federally-endangered Guam rails (*Gallirallus owstonii*) on the island. To increase rail survival on Cocos Island and protect the existing ecosystem, GDOA solicited the assistance of U.S. Department of Agriculture's Wildlife Services (WS) to eradicate invasive rodents. Cocos Island, a 33.6-ha atoll-like island located 2.5 km southwest of Guam (Figure 1), provides a rare opportunity for native flora and fauna recovery because it lacks feral ungulates, cats, and an established population of brown treesnakes (*Boiga irregularis*). However, high populations of Polynesian rats (*Rattus exulans*), and possible presence of house mice (*Mus musculus*), presented a predation risk to Guam rail eggs and impact forest regeneration by directly consuming or damaging seeds, thereby reducing recruitment. Although it is unclear when Polynesian rats were established on Cocos Island, it is highly likely that this occurred during prehistoric times.

Invasive rodents on oceanic islands present numerous challenges to native ecosytems. They have been responsible for an estimated 40-60% of all bird and reptile extinctions worldwide (Atkinson 1985) and can have an adverse impact on island floral species (Campbell and Atkinson 1999, Smith et al. 2006), intertidal environments (Navarrete and Castilla 1993), and sea turtle nests and hatchlings (NMFS and USFWS 1998, Meier and Varnham 2004, Witmer et al. 2007, Caut et al. 2008). Eradication programs have been implemented worldwide, mostly in response to the detrimental impacts of rodents to island environments. In addition, numerous planned introductions/reintroductions of native species onto oceanic islands have centered on the eradication of invasive rodents (Lovegrove et al. 2002, Bell 2002, McClelland 2002, Witmer et al. 2007). Approximately 90% of all documented eradication attempts on islands have been successful (Howald et al. 2007).

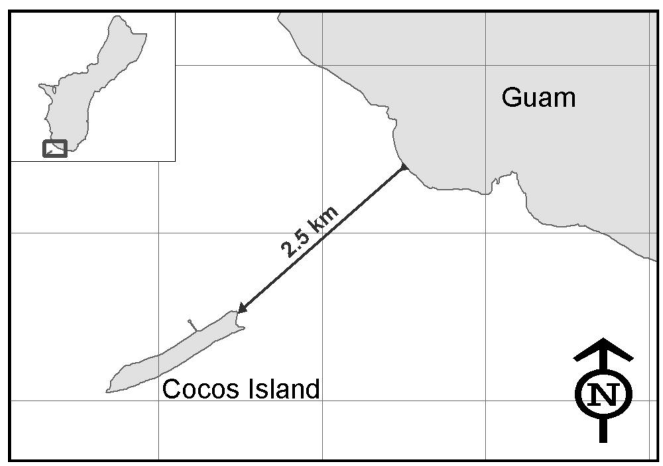

Figure 1. Location of Cocos Island, Guam.

The application of rodenticide baits was the selected for this eradication program due to its success in other island settings. Island-wide trapping was cost prohibitive, given the size of the 33.6 ha island and the abundance of terrestrial crabs. The same constraints precluded the use of bait stations island-wide. Therefore, we decided to apply rodenticide via bait stations within the resort compound, and to broadcast bait in the forested areas. Although rodent eradication is the logical solution to the negative effects of invasive rodents, eradication attempts can be hampered by funding, logistics, localized politics, non-target concerns and an inadequate understanding of effective eradication techniques and strategies. In this paper, we summarize the challenges with planning and implementing rodent eradication operations on Cocos Island. We also present the actions taken to mitigate these concerns, while not negatively impacting the goal of eradicating rodents.

STUDY SITE

Cocos Island is 1.93 km long and 0.15 km wide. The northeastern 24.8 ha of the island (approximately 2/3 of the island's total area) is privately owned and managed as a resort that primarily caters to tourists and limited local clients. Resort operations include aquatic recreational activities (e.g., parasailing, jet ski, introductory scuba, and snorkeling), a restaurant, snack bar, and go-cart rides. The number of visitors ranges from 50 to 400 daily, with a peak in arrivals generally during the summer months. The remaining 8.8-ha parcel is a public park managed by the Guam Department of Parks and Recreation.

Cocos Island supports breeding populations of several native wildlife species, including the locally endangered Micronesian starling (*Aplonis opaca*), lizards, crustaceans, and seabirds, and it is a prime nesting site for federally threatened green sea turtles (*Chelonia mydas*). Conversely, the island supports several non-native wildlife species, including the Polynesian rat, monitor lizard (*Varanus indicus*), and possibly the house mouse. Other rat species (i.e., *Rattus rattus* and *R. norvegicus*) that are currently found on mainland Guam have not been reported on the island.

The resort is a daytime-only operation, with resort staff and patrons present on the island only during daylight hours (the exceptions are a lone security guard and occasional organized camping trips for school-aged tourists). Resort staff are ferried to the island at 0730 and depart the island at 1930 each business day. Tourists usually begin arriving on the island via the ferry at 0930-1000, depending on the volume of ticketed passengers. Tour packages include half-day and full-day tours, with half-day tours occurring from 0930-1230 or 1330-1630.

METHODS

We conducted site visits to the island, discussed operational approaches with regional experts, and reviewed both published and gray literature on rodent eradications. Public informational meetings were held in order to receive input from local citizens regarding their concerns with the proposed eradication. Lastly, we performed field trials of operational methods to determine if selected techniques were logistically feasible, given the complexities of resort operations.

Although island-wide reconnaissance trapping in 2008 with snap and live traps yielded only Polynesian rats, house mice had been seen on the island previously on two occasions within the resort compound. Therefore, the eradication strategy needed to be robust enough to address the removal of both rodent species. Most successful eradications focus on ensuring enough bait is applied to incur a lethal effect and is available to all target species in their habitats. Because the home range of a house mouse is much smaller than that of a Polynesian rat, the spacing of rodenticide application must be condensed. Successful rat and mice eradications with bait stations have utilized a spacing of 50 m and 25 - 50 m, respectively (Clapperton 2006). However, Bramley (1999) suggested that 20 to 25-m spacing may be necessary for Polynesian rats, and Moro (2001) noted that 10-m spacing may be more effective for mice. Targeting the mouse population with a 10-m spacing strategy would also successfully target rats.

Resort operations presented challenges to broadcast methodology, as bait could not be broadcast in areas of human habitation. In addition, food preparation and dining areas precluded the use of conventional rodenticide delivery systems, such as bait stations. Furthermore, the presence of broadcasted bait pellets littered across the landscape of the resort compound during operations was not appealing and presented a potential risk to human safety.

Mitigating Non-Target Concerns

The impact of anticoagulant rodenticides on non-target species has been well documented, yet many rodent eradication programs have successfully occurred in the presence of other non-target species, some considered locally rare or endangered (Garcia et al. 2002, Merton et al. 2002). Non-target uptake can be classified into the following categories: primary (direct exposure/uptake of poison) and secondary (predation or scavenging on primary target species that have ingested bait). Exposure risk can be further classified based on the type of anticoagulant used, first- (e.g., diphacinone) or second-generation (e.g., brodifacoum). Eason and Spurr (1995) commented that the risk associated with primary and secondary poisoning is greater for second-generation than for first-generation anticoagulants.

Micronesian starlings are locally listed as endangered under Government of Guam law because of low population levels throughout Guam, primarily due to the brown treesnake (Savidge 1987). However, starling populations are abundant on Cocos Island, as the island appears to be free of brown treesnakes. Forest birds could be affected, if directly or indirectly exposed to bait. We decided to reduce risks by limiting exposure with short-duration baiting, using an intermittent "pulse baiting" methodology that is likely to be less hazardous to non-target species (Eason and Spurr 1995), and utilize the first-generation anticoagulant rodenticide diphacinone. The formulation selected, "Diphacinone-50: Pelleted Rodenticide Bait for Conservation Purposes" (USDA APHIS, Riverdale, MD), is dyed green, which has been shown to deter consumption by birds (Day and Mathews 1999, Hartley et. al. 1999). We also conducted field tests of a green-colored placebo bait, broadcast within the island forested areas, and we found that starlings were not interested in the bait.

Shorebirds are observed on Cocos Island during the wintering months (e.g., Pacific golden plovers, *Pluvialis fulva*; ruddy turnstones, *Arenaria interpres*; wandering tattlers, *Heteroscelus incanus*; and whimbrels, *Numenius phaeopus*) but occur in very low numbers. Their diet primarily consists of invertebrates residing along the intertidal zone (Hayman et. al. 1986). While no baiting would be conducted along the intertidal zone, crabs and other invertebrates can consume the bait, travel to the intertidal areas, and thus become exposed to shorebird predation. A majority of the project occurred during the dry season when shorebirds are less likely to be present. Diphacinone and other anticoagulant rodenticides do not affect crabs, due to their digestive physiology (Pain et al. 2000). However, land crabs (*Cardisoma carnifex*) and coconut crabs (*Birgus latro*) are readily consumed by locals, thus the risk of secondary poisoning is present. Captured crabs are fed (primarily with coconut), for at least 1 week prior to consumption, to purge their digestive systems. In addition, crabs are thoroughly washed and scrubbed in preparation for cooking. Whole small hermit crabs (*Coenobita* spp.) or their parts are used by local fisherman as bait on their hooks. Tanner et al. (2004) found diphacinone residue in coconut crab tissues after feeding bait and diphacinone-poisoned rats to coconut crabs, and although no recommendation for safe levels of consumption were given, Eisemann and Swift (2006) indicated that the residues in crab tissues were much lower than the residues used for risk measurements. Thus, risk from eating crabs was negligible. Pain et al. (2000) found no rodenticide residue in land crab tissues 30 days after exposure. GDOA issued a moratorium on any crab collection on the island during and for 60 days post-broadcast or bait station application of rodenticides. In addition, crab activity is relatively low during the dry season, and consumption of bait would be minimal (H-C Liu, pers. commun.).

Rodent eradication operations centered around the dry season, which not only reduced non-target risk but also increased the likelihood of success, since island rodent populations in dry seasons are generally reduced and food stressed (and subsequently reproductively stressed). This makes the bait more palatable, increasing competition for the bait (Howald et al. 2007) and increasing the toxic affect of the rodenticide.

Bait and Trap Application

We used a two-pronged approach to address the resort area compound. In buildings, we used snap, sticky, and live traps. Traps were baited with roasted coconut and peanut butter. A higher density of trap placement of was used in the restaurant and dining room building. Traps were also placed on the rooftops of all buildings, including the crossbeams of several buildings. Traps were set in discreet locations where they would not be disturbed, and they were checked and re-set as necessary. In the landscaped areas of the compound, we used modified bait stations: Protecta® bait stations (Bell Laboratories, Madison, WI) were attached to 5-liter pails with heavy-duty Velcro® (Velcro USA Inc., Manchester, NH) (Figure 2), to prevent terrestrial crabs from accessing the bait.

Rodent eradication operations commenced with commensal trapping and bait station deployment on February 23, 2009. Trapping and bait stations deployment ceased on April 3 and 7, 2009, respectively. Sixty-seven traps (snap and live traps) were deployed within the resort's 5 buildings, with areas where rodenticides could not be used being targeted (kitchens, pantries, dining areas, administrative offices, etc.). A total of 239 bait stations were placed in a 10 × 10-m grid throughout the resort grounds and were baited with brodifacoum (Havoc® Chunks). These bait stations were deployed every evening between the hours of 1730-1900, after resort patrons had left the island. Every morning between the hours of 0600-0730, bait stations were collected and stored, before resort staff arrived for the day. The bait was checked daily and replenished as necessary. As there were no ferry operations during necessary operational periods, a personal watercraft was used to transport field technicians to and from the island in support of this activity.

Figure 2. Modified bait stations in 10 × 10-m grid.

We used brodifacoum bait (Havoc® Chunks, Hacco Inc., Randolph, WI) in the stations to address resistance concerns due to previous diphacinone baiting by a local pest control company. Searches for rodent carcasses in the resort compound were conducted in conjunction with bait station retrieval and storage. We made two applications of rodenticide bait in the forested areas, using "Diphacinone-50: Pelleted Rodenticide Bait for Conservation Purposes", which was selected primarily due to concerns about non-target risks. Diphacinone-50 was hand-broadcast along established transects in the forested areas on March 12 and 19, 2009, with 334.6 kg and 266.5 kg applied, respectively. The bait application rate was reduced on March 19 because bait persistence remained high after the first application in the northern and southern thirds of the island.

RESULTS

Three days after the first application, a resort employee witnessed a Micronesian starling take a pellet from the forest floor and fly off with it. On the same day, WS staff reported greenish bird droppings on the outer edge of the resort; further investigation revealed that the droppings were from starlings. We notified GDOA, and island-wide surveys of starlings by WS biologists discovered additional greenish droppings in the northern portion of the island. However, observations of starlings showed only normal starling behavior (i.e., foraging, vocalizations, interactions). Given the low toxicity of diphacinone and the apparent lack of visible toxic effects on starlings, GDOA agreed to proceed with the second broadcast bait application. WS was asked to continue starling monitoring for the duration of the project.

Rodents were last seen on the island on March 23, 2009, 2 weeks after the second broadcast application. Since that time, monitoring stations using wax gnaw blocks, specialized tracking stations, and trapping have indicated no rodents present. Starlings continue to thrive on Cocos Island with no apparent ill effects from the rodenticide application. Although Diphacinone-50 was designed to deter bird uptake by its size and greenish color, starling consumption of bait without demonstrated lethal or sub-lethal effects supports its use in other conservation programs.

ACKNOWLEDGEMENTS

The project was funded through a cooperative service agreement with the Guam Department of Agriculture. We thank resort management and staff for providing logistical support. We express our thanks to the numerous WS Guam employees who assisted with this project. In particular, P. Babauta, J. Benavente, J. Cruz, K. DeLeon Guerrero, K. Dhillon, J. J. San Nicolas, and J. Q. San Nicolas, expended long hours on the island in all phases of the eradication, enduring bee stings and hot, humid conditions.

LITERATURE CITED

ATKINSON, I. A. E. 1985. The spread of commensal species of *Rattus* to oceanic islands and their effects on island avifaunas. Pp. 35-81 *in*: Moors, P. J. (Ed.), Conservation of island birds: Case studies for the management of threatened island species. Technical. Publ. 3, International Council of Bird Preservation, Cambridge.

BELL, B. D. 2002. The eradication of alien mammals from five offshore islands, Mauritius, Indian Ocean. Pp. 40-45 *in*: C. R. Veitch and M. N. Clout (Eds.), Turning the tide: the eradication of invasive species. Proceedings, International Conference on Eradication of Island Invasives, Occasional Paper No. 27 of the IUCN Species Survival Commission, Gland, Switzerland.

BRAMLEY, G. N. 1999. Habitat use and responses to odours by rodents in New Zealand. Ph.D. thesis, University of Waikato, Hamilton, New Zealand.

CAMPBELL, D. J., and I. A. E. ATKINSON. 1999. Effects of kiore (*Rattus exulans* Peale) on recruitment of indigenous trees on northern offshore islands of New Zealand. J. Royal Soc. N. Z. 29(4):265-290.

CAUT, S., E. ANGULO, and F. COURCHAMP. 2008. Dietary shift of an invasive predator: rats, seabirds and sea turtles. J. Appl. Ecol. 45:428-437.

CLAPPERTON, B. K. 2006. A review of the current knowledge of rodent behaviour in relation to control devices. Science for Conservation 263, New Zealand Department of Conservation, Wellington, N.Z. 55 pp.

DAY, T. D., and L. R. MATHEWS. 1999. Do colours that deter birds affect cereal bait acceptance by possums (*Trichosurus vulpecula*)? NZ J. Ecol. 23(2):261-266.

EASON, C. T., and E. B. SPURR. 1995. Review of the toxicity and impacts of brodifacoum on non-target wildlife in New Zealand. NZ J. Zool. 22:371-379.

EISEMANN, J. D., and C. E. SWIFT. 2006. Ecological and human health hazards from broadcast application of 0.005% diphacinone rodenticide baits in native Hawaiian ecosystems. Proc. Vertebr. Pest Conf. 22:413-433.

GARCIA, M. A, C. E. DIEZ, and A. O. ALVAREZ. 2002. The eradication of *Rattus rattus* from Monito Island, West Island. Pp. 116-119 *in*: C. R. Veitch and M. N. Clout (Eds.), Turning the tide: the eradication of invasive species. Proceedings, International Conference on Eradication of Island Invasives, Occasional Paper No. 27 of the IUCN Species Survival Commission, Gland, Switzerland.

HARTLEY, L., C. O'CONNER, J. WAAS, and L. MATHEWS. 1999. Colour preferences in North Island robins (*Petrica australis*): Implications for deterring birds from poisonous baits. NZ J. Ecol. 23:255-259.

HAYMAN, P., J. MARCHANT, and T. PRATER. 1986. Shorebirds: An Identification Guide. Houghton Mifflin Company, Boston, MA. 412 pp.

HOWALD, G., C. J. DONLAN, J. P. GÁLVAN, J. C. RUSSEL, J. PARKES, A. SAMANIEGO, Y. WANG, D. VEITCH, P. GENOVESI, M. PASCAL, A. SAUNDERS, and B. TERSHY. 2007. Invasive rodent eradication on islands. Conserv. Biol. 21(5):1258-1268.

LOVEGROVE, T. G., C. H. ZEILER, B. S. GREENE, B. W. GREEN, R. GAASTRA, and A. D. MACARTHUR. 2002. Alien plant and animal control and aspects of ecological restoration in a small 'mainland island': Wenderholm Regional Park, New Zealand. Pp. 155-163 *in*: C. R. Veitch and M. N. Clout (Eds.), Turning the tide: the eradication of invasive species. Proceedings, International Conference on Eradication of Island Invasives, Occasional Paper No. 27 of the IUCN Species Survival Commission, Gland, Switzerland.

MCCLELLAND, P. J. 2002. Eradication of Pacific rats (*Rattus rattus*) from Whenua Hou Nature Reserve (Codfish Island), Putauhinu and Rarotoka Islands, New Zealand. Pp. 173-181 *in*: C. R. Veitch and M. N. Clout (Eds.), Turning the tide: the eradication of invasive species. Proceedings, International Conference on Eradication of Island Invasives, Occasional Paper No. 27 of the IUCN Species Survival Commission, Gland, Switzerland.

MEIER, G. G., and K. VARNHAM. 2004. Rat eradication as part of a green turtle (*Chelonia mydas*) conservation programme in Indonesia. Marine Turtle Newsletter 106:11-12.

MERTON, D., G. CLIMO, V. LABOUDALLON, S. ROBERT, and C. MANDER. 2002. Alien mammal eradication and quarantine on inhabited island in the Seychelles. Pp. 182-198 *in*: C. R. Veitch and M. N. Clout (Eds.), Turning the tide: the eradication of invasive species. Proceedings, International Conference on Eradication of Island Invasives, Occasional Paper No. 27 of the IUCN Species Survival Commission, Gland, Switzerland.

MORO, D. 2001. Evaluation and cost-benefit of controlling house mice (*Mus musculus*) on islands: An example from Thevenard Island, Western Australia. Biol. Conserv. 99(3): 355-364.

NAVARRETE, S. A., and J. C. CASTILLA. 1993. Predation by Norway rats in the intertidal zone of central Chile. Marine Ecology Press Series 92:187-199.

NMFS and USFWS (NATIONAL MARINE FISHERIES SERVICE and U.S. FISH AND WILDLIFE SERVICE). 1998. Recovery Plan for U.S. Pacific Populations of the Green Turtle (*Chelonia mydas*). National Marine Fisheries Service, Silver Spring, MD.

PAIN, D. J., M. DE L. BROOKE, J. K. FINNIE, and A. JACKSON. 2000. Effects of brodifacoum on the land crab of Ascension Island. J. Wildl. Manage. 64(2):380-387.

SAVIDGE, J. A. 1987. Extinction of an island forest avifauna by an introduced snake. Ecology 68:660-668.

SMITH, D. G., E. K. SHIINOKI, and E. A. VANDERWERF. 2006. Recovery of native species following rat eradication on Mokoli'i Island, O'ahu, Hawaii. Pacific Sci. 60(2):299-303.

TANNER, M., C. ORAZIO, W. STEINER, and G. LINDSEY. 2004. Method for the definitive analysis of rat poison diphacinone in exposed coconut crabs (*Birgus latro*). Poster and abstract. SETAC 4th World Congress/25th Annual Meeting in North America, Soc. Envir. Toxicol. and Chemistry, November 14-18, Portland, OR.

WITMER, G. W., F. BOYD, and Z. HILLIS-STARR. 2007. The successful eradication of introduced roof rats (*Rattus rattus*) on Buck Island using diphacinone, followed by an irruption of house mice (*Mus musculus*). Wildl. Res. 34:108-115.