

UC Agriculture & Natural Resources

Proceedings of the Vertebrate Pest Conference

Title

Rats to Palm Trees: Baiting the Canopy During the Palmyra Atoll Rat Eradication Project

Permalink

<https://escholarship.org/uc/item/6cf4349v>

Journal

Proceedings of the Vertebrate Pest Conference, 26(26)

ISSN

0507-6773

Authors

Wegmann, Alexander
Stansbury, Rory
Alifano, Aurora
et al.

Publication Date

2014

DOI

10.5070/V426110462

Rats to Palm Trees: Baiting the Canopy During the Palmyra Atoll Rat Eradication Project

Alexander Wegmann

Island Conservation, Honolulu, Hawaii

Rory Stansbury, Aurora Alifano, Erik Oberg, and Madeleine Pott

Island Conservation, Santa Cruz, California, USA

Pete McClelland

Lord Howe Island Board, Lord Howe Island, New South Wales, Australia

Gregg Howald

Island Conservation, Santa Cruz, California, USA

ABSTRACT: Rodent eradication campaigns on tropical islands face challenges not experienced in temperate climates, such as competition for bait by land crabs and extensive use of the forest canopy by rats. In 2011, black rats were successfully eradicated from Palmyra Atoll with a campaign built on lessons learned from a prior, unsuccessful ground-based eradication attempt. The 2011 eradication team, at considerable cost and effort, ensured that bait (brodifacoum, 0.0025%) was placed in every potential rat territory, including the atoll's coconut palm canopy. Coconut palm is the dominant canopy tree at Palmyra, covering 45% of the 235 ha land area. Bait applied to palm crowns is not available to land crabs and persists longer than bait placed on the ground. Rats were frequently observed traveling to and from the crowns of palms overhanging the water, yet this important habitat could not be treated by aerial broadcast (the primary bait application method) as this would place bait into the marine environment. To deliver bait to overhanging palms lining Palmyra's shoreline, we developed a "bola" canopy bait (BCB) – two cotton-gauze sacks connected by 20 cm of twine, each containing 12.5g of bait. A manufacturing system was created to produce the quantities of BCBs needed to treat Palmyra's overhanging palm habitat. BCBs were slung by hand or with a sling-shot, or dropped into palm crowns by a team member suspended beneath a helicopter. Handheld GPS units were used to record the location of each palm crown treated with a BCB so that the bait application could be tracked. We believe that the successful outcome of the 2011 eradication was due, in part, to the comprehensive treatment of Palmyra's palm canopy.

KEY WORDS: baiting strategy, brodifacoum, canopy, coconut palm, *Cocos nucifera*, conservation, invasive species, island, Palmyra Atoll, *Rattus rattus*, rodent eradication

Proc. 26th Vertebr. Pest Conf. (R. M. Timm and J. M. O'Brien, Eds.)
Published at Univ. of Calif., Davis. 2014. Pp. 73-77.

INTRODUCTION

Introduced rodents threaten the biodiversity and ecological integrity of the islands that they invade (Towns et al. 2006, Varnham 2010). Over the last 50 years, the control or eradication of introduced rodents from islands has been an important tool for the preservation of island biodiversity (Howald et al. 2007, Phillips 2010, IC 2014). Successful rodent eradication projects adhere to the following principle: all individuals within the target population are put at risk by the eradication methods (Cromarty et al. 2002). Nearly all successful campaigns to eradicate introduced rodents from islands used bait containing an anticoagulant rodenticide as the primary removal method (Howald et al. 2007). Rodent eradication campaigns on tropical islands are challenged to satisfy the aforementioned principle; degradation of bait caused by warm, wet topical conditions (Berentsen et al. 2014), non-target bait consumers such as land crabs (Griffiths et al. 2011, Cuthbert et al. 2012), and extensive use of *Cocos nucifera* (coconut palm) crowns by rats (Strecker et al. 1962) can rapidly reduce the availability of bait to rodents and increase the probability that one or more individuals could escape lethal exposure to the rodenticide.

In 2011, Island Conservation, the U.S. Fish and Wildlife Service (USFWS), and The Nature Conservancy (TNC) successfully eradicated black rats (*Rattus rattus*)

from Palmyra Atoll with an innovation-packed campaign built on lessons learned from a prior, unsuccessful ground-based eradication attempt (Wegmann et al. 2012). The eradication team applied Brodifacoum-25W Conservation bait (0.0025%, manufactured by Bell Laboratories, Madison WI, and registered to USDA APHIS) using aerial and hand broadcast, bait stations, and thousands of specially-designed bola canopy baits (BCB).

C. nucifera along Palmyra's shoreline, termed "overhanging palms," extend out over the water to escape shade produced by neighboring trees. *R. rattus* nested and foraged in overhanging palms at Palmyra (Wegmann unpubl. 2005), yet the overhanging palm habitat could not be treated by aerial broadcast as this would result in direct application of bait into the marine environment, a violation of the Federal Clean Water Act (71 CFR 227 pp. 68483-68492), and most of the crowns were too high (5-30 m) to treat by hand-placing bait. The risk of missing one or more rats by not baiting this habitat was deemed significant by the project's implementation partnership. During the 2011 eradication project, BCBs were slung into overhanging palms along Palmyra's coast with slingshots and from the air by a team member harnessed to the end of a 15-m line attached to a helicopter. This paper discusses the development and utility of the BCB tool for the Palmyra Atoll rat eradication project and future rodent eradication or

control projects where canopy baiting is required.

METHODS

Palmyra Atoll National Wildlife Refuge (5° 53' N, 162° 05' W) is at the northern tip of the Northern Line Islands in the Central Pacific. Palmyra's emergent land area consists of 25 low coral islands (235 ha) that support a regional flora that is typical of Central Pacific moist forests (Wester 1985). Palmyra's 25 islands encompass two large lagoons and have 38.9 km of shoreline. Palmyra is home to a robust community of land crabs composed of 9 species and reaching mean densities of 460 crabs/ha (Howald et al. 2004). With ample resources provided by Palmyra's aseasonal climate and heavy rainfall, and the absence of predators, Palmyra's rat population sustained high densities of 90 to 120 rats per hectare (Flint et al. 1992, Wegmann and Middleton 2008).

C. nucifera is the dominant canopy tree at Palmyra, covering 45% of the 235 ha land area (Wegmann 2009). By sampling the number of overhanging palms along representative stretches of shoreline, we estimated that 166 (n = 9, SE = 15.7) and 109 (n = 9, SE = 18.3) overhanging palms occurred within every km of lagoon-facing and ocean-facing shoreline, respectively (Alifano and Wegmann 2010). In total, we estimated 5,762 overhanging palms along Palmyra's 38.9 km of shoreline.

During pre-eradication studies conducted at Palmyra, several BCB prototypes were field-tested (Buckelew et al. 2005, Alifano et al. 2010). We assessed prototype BCBs according to the following criteria: durability of the packaging, accessibility of bait by rats, and ease of applying the BCB to palm crowns. Prototypes bola designs consisted of tea filter bags, cheesecloth, and cotton Surgitube® dressing. During the pre-eradication trials, the prototype BCBs containing a placebo version of the bait used in the eradication were slung into trees to test durability and function, hung in front of motion-sensing cameras to test accessibility by rats, and left in rat- and crab-proof cages to assess their robustness in Palmyra's warm, wet climate.

To test the durability and function of the different packaging materials, prototype BCBs were launched into *C. nucifera* crowns using 3 different tools: a HyperDog™ Ball Launcher (HyperPet™, Columbus, GA) (a large arm-mounted slingshot designed to shoot a tennis ball over 60 m), The Big Shot® (Sherrill Tree, Greensboro, NC) (a sling-shot mounted on an 2.5-m fiberglass pole), and the Squall 250 (Air Cannons, Inc., Aurora, CO) compressed air cannon (intended to launch tee-shirts and other paraphernalia into crowds at distances up to 75 m). All three tools were tested on trees of varying heights.

To determine the extent to which the BCB prototypes persisted within Palmyra's tropical climate, the different designs were placed in *C. nucifera* crowns and in exclusion cages (0.9 m × 0.9 m × 0.45 m) and checked daily for 12 days. Motion-sensing cameras were focused on the prototype BCBs placed in *C. nucifera* crowns to determine if rats could readily access the bait and to identify bait consumers other than rats.

During the rat eradication at Palmyra, BCBs were applied to every third interconnected (fronds touching)

and every standalone overhanging palm along Palmyra's shoreline. Howald et al. (2004) found that rats at Palmyra can occupy home ranges smaller than 500 m². To apply bait to every potential rat home range while minimizing the number of BCBs required, we decided that three interconnected palm crowns (mature *C. nucifera* crowns are approximately 10 m in diameter) represented an area that would be less than or equal to the smallest rat home range. BCBs were applied by gloved-hand, with HyperDog™ Ball Launchers, or dropped into palm crowns by a team member suspended beneath a helicopter. Handheld GPS units were used to record the location of each palm crown treated with a BCB so the baiting manager could keep track of the bait application.

RESULTS

The packaging of all three BCB prototypes remained intact throughout the 12-day exposure period in the exclusion cages. However, the bait inside the teabag prototype deteriorated quicker than the bait in the cheesecloth and Surgitube® prototypes. Of the 29 BCBs placed in *C. nucifera* crowns (9 teabags, 7 cheesecloth, 13 Surgitube®), 82% disappeared within the first 24 hours, and all disappeared within 48 hours of deployment. Every instance where the motion-sensing cameras detected a rat near to or interacting with the BCB, the bait from the BCB was removed by the rat, suggesting that BCBs that remained untouched the first night may not have been encountered by a rat. Rats readily accessed bait from all three prototypes and we found no preference for one prototype over another. We did not observe consumers other than rats accessing the bait within the prototype BCBs placed in *C. nucifera* crowns.

The final BCB design incorporated two cotton-gauze sacks made from Surgitube® connected by 20 cm of twine, each containing 12.5 g of bait and a small cork; the corks allowed team members to retrieve BCBs that missed the mark and landed in the water. The cotton sacks were secured on each end and to the connecting twine by small hog rings. A manufacturing system that automatically fed bait and corks into the Surgitube® and allowed for quick attachment of the twine with a foot-pedal-driven pneumatic hog ring pliers was created to produce the 8,050 BCBs brought to Palmyra to treat the overhanging palm habitat.

The 2011 eradication team applied BCBs to 8,883 overhanging palms (including the two adjacent palms connected to the treated palm) over three applications (Table 1, Figure 1). Assuming a 10-m diameter for the crown of each overhanging palm, 8.9 ha or 3.8% of the total potential rat habitat at Palmyra was treated with BCBs. Combined, the three BCB applications required approximately 400 person-hours and 11 hours of helicopter flight time.

DISCUSSION

For a rodenticide-based rodent eradication project to succeed, every individual within the target population must incur a lethal exposure to the rodenticide. The most direct pathway for a lethal exposure to occur is through consumption of bait containing the rodenticide. To ensure that every rat has the opportunity to consume an

Table 1. Summary of BCB application during the Palmyra atoll rat eradication project, June-July 2011.

Treatment	Bait used (kg)	Palm crowns treated	Bait application rate (g/crown)
Application 1	72.3	4,185	17.2
Application 2	71.5	4,350	16.4
Rat detection response	5.1	351	14.5
Total	148.9	8,883	mean = 16

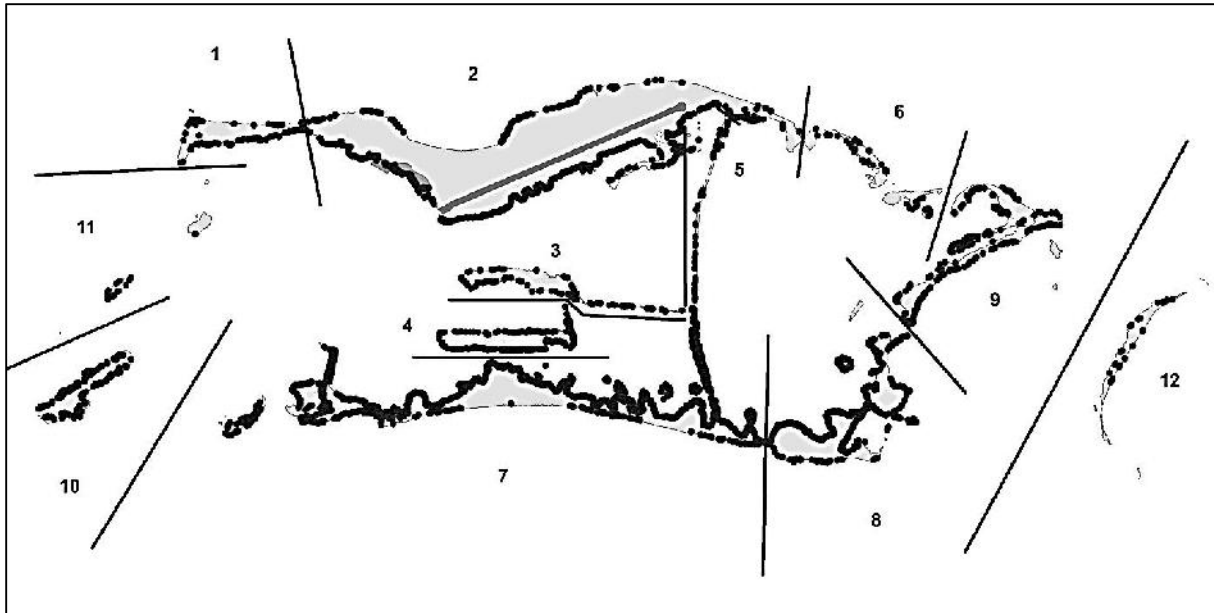


Figure 1. A map of Palmyra Atoll with black dots that represent overhanging palms that were baited with BCBs during the 2011 rat eradication project. The numbers and lines describe the strategy for parceling Palmyra’s land area to allow for a systematic bait application.

amount of bait that delivers a lethal dose of rodenticide, enough bait must be placed in every potential rat territory. This was a challenging criterion for the Palmyra rat eradication project. Land crabs, primarily *Coenobitids* and *Gecarcinids*, compete with rats for bait pellets broadcast across Palmyra’s islands (Buckelew et al. 2005, Wegmann et al. 2008a), and Palmyra’s warm, wet climate results in relatively rapid degradation of bait pellets (Berentsen et al. 2014). While land crabs will consume several grams of bait containing anticoagulant rodenticide per day (Alifano and Wegmann 2010), they do not appear to be negatively affected by the rodenticides (Pain et al. 2000).

The first attempt to eradicate rats from Palmyra (2000-2001) utilized second-generation anticoagulant bait placed in stations on a 50 m × 50 m grid; eradication was not achieved and an independent assessment of the project suggests that rats frequenting the *C. nucifera* canopy were not exposed to rodenticide through the consumption of bait placed in stations on the ground (Howald et al. 2004).

The abundant *C. nucifera* at Palmyra likely aided the atoll’s population of *R. rattus* by providing foraging opportunities and refuge (Strecker et al. 1962, Wegmann et al. 2008a); however, the palm crowns also provide the only crab-free habitat in which bait could be placed for rats. During the eradication project, bait was broadcast

by helicopter and by hand over Palmyra’s land area at 80 kg/ha for the first bait application and 85 kg/ha for the second bait application (Engeman et al. 2013). Low quantities of bait pellets are retained by the concave shape of *C. nucifera*’s inner crown, and these pellets tend to persist longer than pellets that pass through the canopy to the ground (Berentsen et al. 2014). In several locations throughout Palmyra, bait did not remain readily available on the ground for more than 24 hours following the bait broadcast (Berentsen et al. 2014), which was shown by Wegmann et al. (2008a) to be too short of a time period for all rats to encounter and consume bait at Palmyra. While stands of *C. nucifera* dominate 45% of Palmyra’s land area, individual *C. nucifera* trees are common throughout the remaining 55% of the atoll. We suspect that bait retained in *C. nucifera* crowns extended the period during which bait was available to rats. Similarly, the treatment of overhanging palms with BCBs allowed us to place bait in every potential rat territory throughout the atoll and bait within the BCBs remained available to rats longer than bait that fell to the forest floor (Berentsen et al. 2014).

Would the 2011 Palmyra rat eradication have failed if the overhanging palms were not baited? There is insufficient information to answer this question without risking a type I or type II error. However, prior to the eradication of *R. rattus* from Palmyra, earlier versions of

the BCB were applied to inland and overhanging *C. nucifera* crowns in concert with a hand-broadcast application of Brodifacoum-25W Conservation bait to successfully eradicate *R. rattus* from Pein Mal Island (Wegmann et al. 2008b) and *R. exulans* from Dekehtik Island (Wegmann et al. 2008a) offshore of Pohnpei, Federated States of Micronesia. As with Palmyra, the successful eradication of rats from the small islands offshore of Pohnpei should not be interpreted as a validation of the effectiveness of applying bait to *C. nucifera* crowns or BCBs to overhanging palms, yet three successful applications of this strategy indicates that the benefit is at least neutral and likely positive.

In addition to the potential increase in efficacy achieved by baiting overhanging palms at Palmyra with BCBs, we significantly decreased the amount of bait that would have entered the marine environment had the overhanging palms been treated by aerial broadcast. Engemann et al. (2013) reported the aerial broadcast of bait to Palmyra's tortuous land area resulted in bait drifting into the marine environment in some areas, and the exposure of fish (*Moolgarda engeli* and *Liza vaigiensis*) and fiddler crabs (*Uca tetragonon*) to brodifacoum was documented (Pitt et al. 2012). These findings point to the undesirable short-term environmental costs that can result from the eradication of rodents from islands by broadcasting bait containing a rodenticide. However, had we treated Palmyra's overhanging palms by aerial broadcast, the amount of bait drifting into the marine environment would have been significantly greater. Or, had we chosen to not treat the overhanging palms, the project may have failed to give every rat the opportunity to consume a lethal amount of rodenticide. The development and application of BCBs during the rat eradication at Palmyra demonstrates that baiting *C. nucifera* crowns is feasible and likely beneficial to rodent eradication campaigns on tropical islands.

ACKNOWLEDGEMENTS

We express our sincere thanks to numbers people who have, over the years, dedicated time and effort to the research that informed the planning of the Palmyra rat eradication, and the implementation of the project. Namely, we would like to thank Stacey Buckelew, Jacob Sheppard, Jen Curl, and Matt and Elizabeth Lang. We also thank the Island Conservation staff based in Santa Cruz, CA for the long hours spent making BCBs for this project.

LITERATURE CITED

Alifano, A., and A. Wegmann. 2010. The ecotoxicology and palatability of two rodenticide bait products: Field-based assessment at Palmyra Atoll. Island Conservation, Santa Cruz, CA.

Alifano, A., A. Wegmann, M. Pott, and E. Oberg. 2010. Assessment of rat detection and rodenticide application methods at Palmyra Atoll. Island Conservation, Santa Cruz, CA.

Berentsen, A. R., W. C. Pitt, J. D. Eisemann, and R. M. Engeman. 2014. Longevity of rodenticide bait pellets in a tropical environment following a rat eradication program. *Envir. Sci. Pollut. Res.* 21:2283-2288.

Buckelew, S., G. R. Howald, A. Wegmann, J. Sheppard, J. Curl, P. McClelland, B. Tershy, K. Swift, E. Campbell, and

B. Flint. 2005. Progress in Palmyra Atoll restoration: Rat eradication trial, 2005. Island Conservation, Santa Cruz, CA.

Cromarty, P. L., K. G. Broome, A. Cox, R. A. Empson, W. M. Hutchinson, and I. McFadden. 2002. Eradication planning for invasive alien animal species on islands: the approach developed by the New Zealand Department of Conservation. Pp. 85-91 in: C. R. Veitch and M. N. Clout (Eds.) *Turning the tide: The eradication of invasive species. Proceedings of the International Conference on Eradication of Island Invasives.* Occ. Paper of the IUCN Species Survival Commission, No. 27. IUCN, Gland, Switzerland and Cambridge, UK.

Cuthbert, R. J., M. d. L. Brooke, and N. Torr. 2012. Overcoming hermit-crab interference during rodent-baiting operations: A case study from Henderson Island, South Pacific. *Wildl. Res.* 39:70-77.

Engeman, R. M., W. C. Pitt, A. R. Berentsen, and J. D. Eisemann. 2013. Assessing spatial variation and overall density of aerially broadcast toxic bait during a rat eradication on Palmyra Atoll. *Envir. Sci. Pollut. Res.* 20:480-487.

Flint, E., K. McDermond, D. Herbst, A. Yuen, and D. Woodside. 1992. Survey of the terrestrial biota of Palmyra Atoll, 18 February to 9 March 1992. Administrative Report, USFWS, Honolulu, HI.

Griffiths, R., A. Miller, and G. Climo. 2011. Addressing the impact of land crabs on rodent eradications on islands. *Pacific Conserv. Biol.* 17:347-353.

Howald, G., A. Samaniago, S. Buckelew, P. McClelland, B. Keitt, A. Wegmann, W. C. Pitt, D. S. Vice, E. Campbell, K. Swift, and S. Barclay. 2004. Palmyra Atoll rat eradication assessment trip report, August 2004. Island Conservation, Santa Cruz, CA.

Howald, G., C. J. Donlan, J.-P. Galvan, J. C. Russell, J. Parkes, A. Samaniago, Y. Wang, D. Veitch, P. Genovesi, M. Pascal, A. Saunders, and B. Tershy. 2007. Invasive rodent eradication on islands. *Conserv. Biol.* 21:1258-1268.

IC (Island Conservation). 2014. Database of Island Invasive Species Eradications. Island Conservation. Hosted by the IUCN SSC Invasive Species Specialist Group. <http://eradicationsdb.fos.auckland.ac.nz/>.

Pain, D. J., M. D. Brooke, J. K. Finnie, and A. Jackson. 2000. Effects of brodifacoum on the land crabs of Ascension Island. *J. Wildl. Manage.* 64:380-387.

Phillips, R. A. 2010. Eradications of invasive mammals from islands: Why, where, how and what next. *Emu* 110:i-vii.

Pitt, W. C., A. R. Berentsen, S. F. Volker, and J. D. Eisemann. 2012. Palmyra Atoll Rainforest Restoration Project: Monitoring results for the application of Brodifacoum 25W: Conservation to eradicate rats. QA-1875 Final Report. USDA, APHIS, WS, National Wildlife Research Ctr., Hilo, HI.

Strecker, R. L., J. T. Marshall, W. B. Jackson, K. R. Barbehenn, and D. H. Johnson. 1962. Pacific island rat ecology: Report of a study made on Ponape and adjacent islands, 1955-1958. *Bernice P. Bishop Mus. Bull.* 225:1-274.

Towns, D., I. Atkinson, and C. H. Daugherty. 2006. Have the harmful effects of introduced rats on islands been exaggerated? *Biol. Invas.* 8:863-891.

Varnham, K. 2010. Invasive rats on tropical islands: Their history, ecology, impacts and eradication. Royal Society for the Protection of Birds, Conservation Science Dept., Sandy, Bedfordshire, UK.

- Wegmann, A. S. 2009. Limitations to tree seedling recruitment at Palmyra Atoll. Ph.D. dissert., University of Hawaii at Manoa, Honolulu, HI.
- Wegmann, A., and S. Middleton. 2008. Trip report, Jarvis Island National Wildlife Refuge and Palmyra Atoll National Wildlife Refuge visit and terrestrial assessment, 20 March to 8 April 2008. U.S. Fish and Wildlife Service Pacific Remote Islands Marine National Monument.
- Wegmann, A., J. Braun, and R. Neugarten. 2008a. Pacific rat *Rattus exulans* eradication on Dekehtik Island, Federated States of Micronesia, Pacific Ocean. *Conserv. Evidence* 5: 23-27.
- Wegmann, A., J. Braun, and R. Neugarten. 2008b. Shipp rat *Rattus rattus* eradication on Pein Mal Island, Federated States of Micronesia, Pacific Ocean. *Conservation Evidence* 5:28-32.
- Wegmann, A., J. Helm, A. Samaniego, W. Smith, B. Jacobs, D. Drake, J. Smith, M. McKown, A. Henry, S. Hathaway, and R. Fisher. 2008c. Palmyra Atoll rat eradication: Biomarker validation of an effective bait application rate, 19 June to 5 July, 2008. Island Conservation, Santa Cruz, CA.
- Wegmann, A., E. Flint, S. White, M. Fox, G. Howald, P. McClelland, A. Alifano, and R. Griffiths. 2012. Pushing the envelope in paradise: A novel approach to rat eradication at Palmyra Atoll. *Proc. Vertebr. Pest Conf.* 25: 48-53.
- Wester, L. 1985. Checklist of the vascular plants of the Northern Line Islands. *Atoll Res. Bull.* 287:1-38.