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Challenges and Unique Solutions to Rodent Eradication in Florida

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ABSTRACT: Once established, invasive rodents cause significant impacts to island flora and fauna, including species extinctions. There have been numerous efforts to eradicate invasive rodents from islands worldwide, with many successes. For a number of reasons, many invasive vertebrates have become established in Florida, including several rodent species. We have implemented rodent eradication efforts on two Florida islands. Using the successful eradication strategy developed for Buck Island, U.S. Virgin Islands, we have attempted the eradication of roof rats from Egmont Key off Tampa Bay. We also are attempting to eradicate Gambian giant pouched rats from Grassy Key in the Florida Keys. On Egmont Key, we used a grid of bait stations containing diphacinone rodenticide bait blocks and hand tossing of bait blocks into thickets. On Grassy Key, we used a grid of bait stations containing a zinc phosphide bait along with intensive live-trapping. We discuss the eradication planning, efforts to minimize non-target animal losses, and follow-up activities. We also discuss some of the difficulties encountered in each of these two different situations.

KEY WORDS: *Cricetomys gambianus*, diphacinone, eradication, Florida, Gambian pouched rat, invasives, islands, *Rattus rattus*, rodenticides, rodents, roof rat, traps, zinc phosphide

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INTRODUCTION

Introduced rodents pose a serious threat to the native flora and fauna of islands (Moors and Atkinson 1984, Witmer et al. 1998, Veitch and Clout 2002, Engeman et al. 2006). Rodents can be very prolific on islands where they have few to no predators, and their omnivorous foraging has led to the endangerment or extinction of numerous island species (Moors and Atkinson 1984, Veitch and Clout 2002). Most seabirds that nest on islands have not evolved to deal with predation and are very vulnerable to introduced rodents and other species' introductions. There has been a concerted worldwide effort to eradicate introduced rodents from islands with numerous successes (Howald et al. 2007). These efforts have relied heavily on the use of various rodenticides (Howald et al. 2007, Witmer et al. 2007a). We summarize two invasive rodent eradication efforts in Florida, the southeastern-most state of the United States.

EGMONT KEY: ROOF RATS (*Rattus rattus*)

Egmont Key is a part of the U.S. National Wildlife Refuge System's Chassahowitzka National Wildlife Refuge Complex. The island is about 280 acres and lies off the mouth of Tampa Bay, Florida (Figure 1). The island has a historic lighthouse and numerous ruins of Fort Dade on the north end of the island. It is co-managed as a wildlife refuge and state park (Egmont Key State Park) by U.S. Fish and Wildlife Service (FWS) and Florida Division of Recreation and Parks (Florida Parks). The island provides nesting, feeding, and loafing habitat to more than 110 species of migratory and resident birds and there is a large, grassy ground-nesting area on the south end of the island (USFWS 2008). The island is

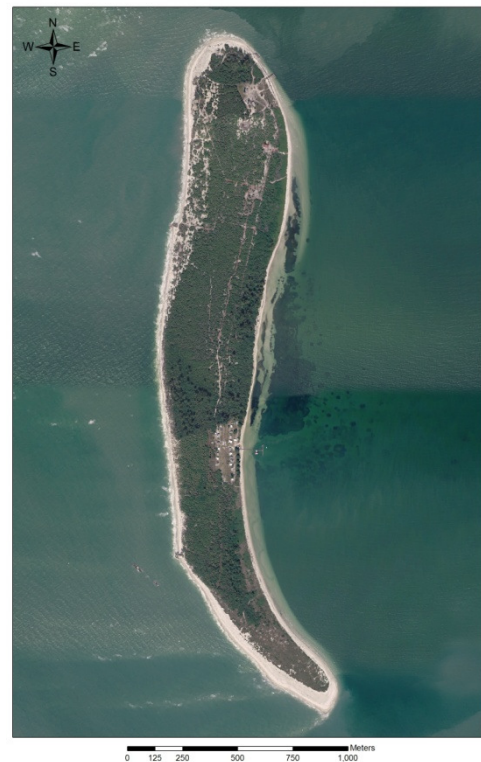


Figure 1. Map of Egmont Key, Florida. The remains of historic Fort Dade can be seen in the northern portion of the island. The Tampa Bay Pilots Association housing area can be seen on the east-central area of the island.

critical habitat for the endangered piping plover (*Charadrius melodus*). To reduce disturbance to the bird community, visitors are not allowed in this area. There are also nesting endangered Atlantic loggerhead sea turtles (*Caretta caretta*). Numerous gopher tortoises (*Gopherus polyphemus*) and Florida box turtles (*Terrapene carolina bauri*) occur on the island. No native mammals occur on the island. The island has a long history of human habitation, and its habitats are highly modified by both exotic plants and past human activities. The primary vegetation types include sea oats (*Uniola paniculata*) meadows, Australian pine (*Casuarina equisetifolia*) groves, and extensive forests with a mix of cabbage palms (*Sabal palmetto*), Australian pine, and Brazilian pepper trees (*Schinus terebinthifolius*) (Dodd 1998). There are also dense thickets of sea grape shrubs (*Coccoloba uvifera*). The island has little topographic relief and an average elevation of ≤ 2 m above mean sea level. The south central part of the island also houses a small community of houses and facilities for the Tampa Bay Pilots Association who direct freighters in and out of Tampa Bay. Their dock allows access to the island by the U.S. Corps of Engineers (Corps); FWS; Florida Parks; and Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Wildlife Services (WS) personnel. There is also a dock near the north end of the island that is used by commercial ferries that transport visitors to the island. Overnight stay on the island by visitors is not allowed. Florida Parks maintains a continuous presence on the island with a manager residing in a house near the lighthouse. Florida Parks' rangers patrol the island on a regular basis. Access about the island by agency personnel is by all terrain vehicles (ATVs) and golf carts using a small system of brick, cement, and dirt roads. The beaches can also be used to circumnavigate the entire island.

At the request of the Corps and in collaboration with the FWS and Florida Parks, the WS has designed and conducted an eradication project for roof rats on Egmont Key. The rats were first detected on Egmont Key in the summer of 2006. They may have been introduced to the island incidentally to a shoreline stabilization project in which a large dredging vessel was anchored near the island.

Several site visits occurred to Egmont Key in preparation of this roof rat eradication project. Site visits were essential to survey and assess the specific conditions and potential management options and so that any potential non-target hazards or environmental considerations could be identified and mitigated. A final site visit occurred in September 2008, during which major planning for the proposed roof rat eradication occurred. Additional needs and concerns were also identified. WS, FWS, and Florida Parks personnel participated in that site visit. WS and the Corps entered into a Cooperative Agreement in December 2008. This agreement defined the scope of work for the project and the roles and responsibilities of WS and the Corps. The agreement also described the work plan, set a timeline, and established the budget for the project. The basic approach to the eradication followed that used in the

successful eradication of roof rats from Buck Island in the U.S. Virgin Islands (Witmer et al. 2007a).

An important preliminary aspect to an invasive rodent eradication is an assessment of the target population. This was accomplished from February-August 2008, primarily by the efforts of FWS, the Florida Audubon Society, and Florida Parks. The effort also served the purpose of reducing the rat predation on birds using the grassy area on the south end of the island. About 250 rat snap traps were used and mainly mounted on wooden stakes and baited with peanut butter. About 515 rats were captured in about 14,000 trap-nights on the south end of the island between February 12 and April 7. This equates to a capture success rate of about 4 rats per 100 trap-nights and indicated that a sizable rat population existed on the island, especially considering that the intensively trapped area was only about 30 acres of the 280-acre island. An additional 70 traps were also deployed to the central and northern parts of the island, mainly along roads. The capture of rats in these areas confirmed that the rats occupied the entire island. During the entire trapping effort from February 12 to August 10, 2008, 760 roof rats were trapped.

The FWS completed an Environmental Assessment (EA) in November 2008 for the proposed roof rat eradication on Egmont Key in compliance with the National Environmental Protection Act (NEPA). This document described the features and resources of Egmont Key and the harm posed by the invasive rat population. The EA recommended that the invasive rodents be eradicated from the island using rodenticides. The rodenticides were to be used in a manner to minimize potential non-target animal and environmental hazards. A finding of no significance (FONSI) of adverse impacts of the proposed project was determined (February 11, 2009), allowing the project to proceed.

The FWS conducted a prescribed burn on about 40 acres of the southern end of Egmont Key in January 2009. Prescribed burns are an important habitat management method in the southeastern U.S. (Komarek 1966). While the FWS had been planning this burn for some time, it was noted that the burn would also aid in a successful eradication of the roof rats for several reasons. The burn removed vegetation that provided food and cover for the rodents and thus increased the effectiveness of eradication tools and strategies. Of particular importance was the over-story of cabbage palms. Roof rats are very good climbers and often live in the canopy of trees where they can find water and food. In these cases, they seldom come to the ground, making ground-based eradication efforts less likely to succeed. Also, removal of plant food sources increased the likelihood of rats consuming the rodenticide bait. The prescribed burn also made ground actions more efficient and improved post-eradication monitoring efficiency. Ideally, much more of the island would have been burned before the rat eradication effort.

WS personnel began the task of trail cutting and flagging for the project in January-February 2009. The trail system through the thick brush was essential to allow access to all areas of the island for the eradication. In particular, the trail system allowed the placement of a grid

of rodenticide bait stations over the entire island. This assured that all rats would have access to the rodenticide bait during the eradication effort.

In February 2009, a 40 × 40-m grid of bait stations was established over the entire island (except for sea grape thickets; see below). The bait stations used were heavy plastic Protecta Tamper-Proof Bait Stations (Bell Laboratories, Inc., Madison, WI). The grid comprised 69 lines of bait stations perpendicular to the long axis of the island. There was an additional line of bait stations placed along the edge of the sea grape thickets along the east side of the island. An additional set of bait stations was placed under houses and support buildings at the housing complex. A total of about 638 bait stations were deployed for the eradication.

WS evaluated the potential rodenticides to be used for the roof rat eradication. The need for, and use of, rodenticides for conservation purposes was reviewed by Witmer et al. (2007b), along with their advantages, disadvantages, methods of use, and potential mitigation measures. APHIS has U.S. Environmental Protection Agency (EPA) pesticide registrations for 3 rodenticides to be used for island conservation purposes (i.e., invasive rodent eradications), including the first-generation anticoagulant diphacinone (1 formulation), and the (more toxic) second-generation anticoagulant brodifacoum (2 formulations). We chose to use a diphacinone (0.005% active ingredient) rodenticide because it is less toxic and less likely to accumulate toxic residues than brodifacoum (Witmer et al. 2007b). Additionally, birds are less susceptible to diphacinone poisoning than to brodifacoum. Diphacinone baits have been successfully used to eradicate roof rats from several small islands in the U.S. Virgin Islands (see Witmer et al. 2007a).

It is important to assure that the proposed rodenticide formulation will be highly effective with the targeted population. WS conducted a rodenticide efficacy trial (QA-1605) at their Gainesville Florida Field Station with 2 formulations of diphacinone baits, using wild rats from Egmont Key (Witmer 2009). Ramik Mini Bars (Hacco, Inc., Randolph, WI; EPA Reg. 61282-26) were highly effective, killing 9 of 10 rats (90%) in the brief, 10-day exposure trial. Ramik Green pellets were slightly less effective (80% mortality). We also found that gopher tortoises did not attempt to eat the placebo bait bars, but would readily place bait pellets (M. Avery, unpubl. data). Consequently, we decided to use Ramik Mini Bars for the Egmont Key roof rat eradication.

WS requested an Emergency Use Permit (FIFRA Sec. 18) from the EPA and the Florida Department of Agriculture to use the diphacinone bait for the Egmont Key roof rat eradication. Once the permit was received, rodenticide bait blocks were deployed in bait stations on Egmont Key, beginning on February 11, 2009. Bait stations were checked daily and refilled as needed. The bait uptake from bait stations dropped off dramatically by February 17, 2009. The first dead rat was found on February 14, 2009. The field crew was instructed to remove any dead rats found. They were also instructed to look for and report any dead non-target animals; none were found during the entire eradication operation. The

baiting operation was ended on March 11, 2009.

In addition to the grid of bait stations, bait was used in bait stations in and below the houses and other buildings at the River Pilots housing complex and in some of the buildings at the island's lighthouse and its support buildings. Bait was also placed in the 2 historic bunker buildings on the north end of the island because rats might occupy those structures.

Sea grape thickets posed a particular problem in the baiting operation. These thickets could not be penetrated adequately with the trail system, and hence contained very few bait stations. WS applied for and received permission from the EPA, in February 2009, to hand-toss bait blocks into those areas. WS did this every few days to assure that any rats living in those thickets would be exposed to the rodenticide.

Monitoring the rodent population after an eradication effort was essential to assure that the eradication has been successful. It also allowed for a rapid response if any remaining rodents were detected. Finally, it was also important because invasive rodents can regain access to the island, and the timely knowledge of this occurring allows management actions before the entire island is again infested.

We drafted a monitoring protocol and a rapid response protocol for Egmont Key. Following this protocol, we conducted the first rodent monitoring session in April 8-13, 2009, about 1 month after the eradication effort was completed. Five hundred snap-trap nights were conducted in a 5-day session over the island. No rats were captured. A dead rat was found during this process, but it appeared to have been dead for a considerable period of time (i.e., from when the rodenticide baiting session was conducted). Nonetheless, we placed an extra 15 snap traps in this area and maintained them for 5 nights. No rats were captured in the area of the old rat carcass.

Wildlife Services and Florida Parks personnel have been watching for rat sign since the eradication effort. Florida Parks personnel do this while patrolling the island's roads, trails, and entire shoreline. To date, no sign of rats has been detected. The staff of the River Pilots housing unit also reported no sign of rats.

Additional rat monitoring sessions need to be conducted. In general, it is recommended that periodic monitoring occur for a period of 2 years after an eradication effort before managers can feel assured that a successful eradication was probably achieved (Witmer et al. 2007a).

GRASSY KEY: GIANT GAMBIAN POUCHED RATS (*Cricetomys gambianus*)

Grassy Key is a part of the Florida Keys, a chain of islands extending from the southern tip of Florida that curves down and westward into the Gulf of Mexico. Most of the islands are connected by the major highway, U.S. Highway 1. Grassy Key (Figure 2) is about 1,000 acres and of very low relief (≤ 2 m above mean sea level). The substrate is coral and the water table is very near the surface, so that there is often standing water in some areas. The vegetation consists of a mixture of native and



Figure 2. Map of Grassy Key, Florida. U.S. Highway 1 transects the island from east to west. The many private residences over most of the island are also evident.

invasive species (Long and Lakela 1971, FNAI 1990). Most areas that have not been developed are covered with trees and shrubs. These species include various species of mangroves, various species of palms, Australian pine, Brazilian pepper, and numerous ornamentals. Periodic tropical storms and hurricanes occur, damaging vegetation and structures and flooding many areas.

Native to Africa, Gambian giant pouched rats (henceforth, Gambian rats) are considered a threatening invasive species on a Florida island, Grassy Key (Engeman et al. 2006). The status of Gambian giant pouched rats shifted from being a domestic pet to that of an invading species after the suspected release from a pet breeder (Perry et al. 2006). Because of the large size of Gambian rats (i.e., up to 1 m in length and 2.8 kg in mass; Kingdon 1974), they pose a serious threat to native species (e.g., particularly nesting species) and agricultural crops (Fiedler 1998), especially if Gambian rats invade mainland Florida (Peterson et al. 2006). Also, Gambian rats pose a threat from disease, as they were implicated in a monkeypox outbreak in the midwestern United States in 2003 (Enserink 2003). WS initiated eradication and detection efforts in the Florida Keys, but trapping the sparse population of Gambian rats has proven difficult. The effort has been a collaboration between WS, Florida Wildlife Commission (FWC), Florida Parks, FWS, and the South Florida Water Management District (SFWMD). The basic approach to the eradication followed that used in the successful eradication of roof rats from Buck Island

in the U.S. Virgin Islands (Witmer et al. 2007a).

WS completed an EA in 2001 for wildlife management activities to protect threatened and endangered species in Florida (USDA 2001). A FONSI for the proposed actions was determined (January 18, 2002), allowing the project to proceed. Public meeting, mailings, and door-to-door visits were conducted to the over 450 residences and businesses to answer landowner questions and to gain permission to access properties for the eradication activities. Additionally, the FWC established a toll-free hotline to provide information on eradication time lines and progress and so that sightings of Gambian rats could be readily reported.

In 2006-07, WS conducted Gambian rat distribution surveys on Grassy Key, using cage traps and motion-sensitive cameras. Gambian rats were found to occur over much of the island with the exception of some areas of standing water. Two Gambian rats were radio-collared and monitored for a short period of time. They were found to range at least 60 m per day. The survey and movement data served as the basis for the spacing of a bait station grid over the entire island. In the 'core area' (residential areas known to support relatively abundant numbers of Gambian rats), we used a 40 × 40-m grid spacing, while in other areas we used a 50 × 50-m grid spacing. The SFWMD hired private contractors to cut trails through the brush for the establishment of the grid and to facilitate efficient access to the bait stations. GPS units were used to help assure establishment of a very

symmetrical grid with even and consistent spacing. The final grid consisted of about 1,000 bait stations.

WS conducted preliminary rodenticide bait trials with a variety of commercial baits, including several anticoagulants and a zinc phosphide (ZP)-grain mix. The ZP bait seemed the most efficacious, resulting in complete mortality in a short period of time (generally a few hours or less) after consumption of a small amount of the bait (a few grams) in a single feeding session. The final formulation consisted of mostly peanut butter with some horse sweet mix (mainly grains and molasses), and enough ZP concentrate to result in an active ingredient concentration of 2%. This mixture formed a paste that could not be readily removed from the bait stations, thus reducing the movement of bait to places where non-target animals might be exposed to the bait. WS also designed a bait station that allowed access by Gambian rats but seemed to prevent access by most non-target mammals (e.g., raccoons, opossums, cats, and dogs).

With the large number of bait stations, all bait stations on the entire island could not be filled and monitored in less than several days. Hence, WS used a 'rolling front' strategy whereby the island was divided longitudinally into zones. Bait was applied to one zone at a time, moving from east to west. A 3-day pre-baiting period occurred in which grain mixed with peanut butter was placed in the bait stations to get Gambian rats used to entering the bait stations for food. Next, ZP bait was placed and maintained in the stations during late May and early June 2007. Within a few days, the field crew could smell decomposing Gambian rat carcasses in some areas, even though no carcasses were found on the surface during field work. Before, during, and after the baiting session, cage traps and remote cameras were also used to detect and remove Gambian rats. Captured rats were euthanized by gunshot to the head. If a Gambian rat was detected by one of the cameras, several cage traps were set in the area and nearby bait stations were filled with the ZP bait. When non-target animals (raccoons, opossums) were captured in a cage trap, they were released on a nearby island as directed by the FWC. This reduced the chances of non-target losses and also reduced, over time, cage trap interference which was reducing the chances of capturing a Gambian rat. If roof rats, another invasive rodent in Florida, were captured, they were euthanized.

Camera surveillance soon made it clear that some Gambian giant pouched rats remained after the main baiting effort. An additional baiting session was conducted in September 2007, along with intensive trapping in those areas. Additionally, a different formulation of the ZP bait was used (no peanut butter, but with cantaloupe oil added) and WS switched from baiting cage traps with peanut butter to cantaloupe fruit. These changes were made because it was surmised that the remaining rats might not be attracted to the previous baits used in bait stations and cage traps.

If we use the '2-year rule-of-thumb' (Witmer et al. 2007b), the eradication effort on Grassy Key can be considered successful when intensive, periodic surveys do not reveal any Gambian rats for a 2-year period. Unfortunately, this has not happened, despite about 280 cage traps and 80 remote cameras being used in the

"mop-up" effort. While the capture of Gambian rats has steadily declined over the months, WS still captures or detects one occasionally. The most recent capture was an adult female in September 2009. A radio-collar was placed on this animal and she was found to rarely leave a parcel of private property that WS has not been allowed to access during the eradication program. A total of 6 private properties are off-limits to WS, and this may be the main reason why the eradication effort has been so protracted.

There was an interesting occurrence during the eradication effort. A single, dead Gambian rat was reported along a highway in Islamorada, a town on Upper Matecumbe Key. This Key is about 33 km east of Grassy Key and about half way to the mainland of Florida from Grassy Key. The Key is also separated from Grassy Key by multiple bridges, some of which are several miles long. WS personnel confirmed that the presumably vehicle-killed rodent was a Gambian rat. Cage traps and motion-sensitive cameras were set in a grid in the area and operated for several days. No Gambian rats have been detected on Upper Matecumbe Key other than the dead one originally found. WS surmised that the individual had either been released there by someone or had 'hitched' a ride on a garbage truck or other vehicle. This example illustrates the need for a good bio-security system if we are to prevent invasions by foreign species and their spread from infested areas (Broome 2007). Additional research has been conducted at the WS' National Wildlife Research Center in Fort Collins, Colorado, with wild-caught Gambian rats from Grassy Key. The research has identified other potential attractants and rodenticides for use in future efforts with invasive Gambian rats (Witmer et al. 2010). Hopefully, the invasive rodent eradication effort on Grassy Key will end with the complete removal of all Gambian giant pouched rats.

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