2011

Attempting to eradicate invasive Gambian giant pouched rats (*Cricetomys gambianus*) in the United States: lessons learned

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Attempting to eradicate invasive Gambian giant pouched rats (*Cricetomys gambianus*) in the United States: lessons learned

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Abstract Gambian giant pouched rats (*Cricetomys gambianus*) are native to Africa, but they are popular pets in the United States. They caused a monkeypox outbreak in the Midwestern United States in 2003 in which 72 people were infected. A free-ranging population became established on the 400 ha Grassy Key in the Florida Keys, apparently after a release by a pet breeder. This rodent species is known to cause extensive crop damage in Africa and if it reaches the mainland US, many impacts, especially to the agriculture industry of Florida, can be expected. An apparently successful inter-agency eradication effort has run for just over three years. We discuss the strategy that has been employed and some of the difficulties encountered, especially our inability to ensure that every animal could be put at risk, which is one of the prime pre-requisites for successful eradication. We also discuss some of the recent research with rodenticides and attractants, using captive Gambian rats, that may help with future control and eradication efforts.

Keywords: Bait station, Florida, inter-agency project, rodent, traps, zinc phosphide, human attitudes

INTRODUCTION

Introduced omnivorous rodents have endangered or eradicated numerous native species on islands where the rodents have few or no predators (Moors and Atkinson 1984; Veitch and Clout 2002; Engeman *et al*. 2006; Witmer *et al*. 1998). For example, most seabirds that nest on islands have not evolved to deal with mammalian predation and are very vulnerable to introduced rodents and other species introductions. In response, there has been a concerted worldwide effort to eradicate introduced rodents from uninhabited islands, often successfully (Howald *et al*. 2007). These efforts have relied heavily on the use of rodenticides (Howald *et al*. 2007; Witmer *et al*. 2007a). While eradication is generally the preferred management approach to an invasive vertebrate species (e.g., Panzacchi *et al*. 2007), in some situations, sustained control is the only viable option (Parkes 1993; Parkes and Murphy 2003).

Native to Africa, Gambian giant pouched rats or Gambian rats (*Cricetomys gambianus*) are an invasive species on the island of Grassy Key, Florida (Engeman *et al*. 2006). Gambian rats shifted from a domestic pet to invading species after a suspected release by a pet breeder (Perry *et al*. 2006). Because of their large size (i.e., up to 1 m in length and 2.8 kg in mass; Kingdon 1974), Gambian rats pose a serious threat to native species (e.g., particularly nesting species) and agricultural crops (Fiedler 1998), especially if they rats invade mainland Florida where there is intensive agriculture (Peterson *et al*. 2006). Gambian rats also transmit disease and in 2003 were implicated as facilitators of a monkeypox outbreak that infected 72 people in the Midwestern United States (Enserink 2003).

In this paper, we describe an attempt to eradicate Gambian rats from the Florida Keys, USA. The United States Department of Agriculture, Wildlife Services (WS) initiated eradication and detection efforts in the Florida Keys, but trapping the sparse population of Gambian rats after a rodenticide baiting operation required a lengthy period of time. Trapping is commonly used as part of eradication efforts for carnivores (e.g., Bloomer and Bester 1992, Ebbert 2000, Nogales *et al*. 2003) and feral ungulates (Campbell and Donlan 2005; Lowney *et al*. 2005), but rarely for small rodents. However, long-term trapping efforts have successfully removed some large-bodied, invasive rodent populations including nutria (*Myocastor coypus*) and muskrats (*Ondatra zibethicus*) in the United Kingdom (Gosling and Baker 1989) and nutria at the Blackwater National Wildlife Refuge in Maryland USA (Kendrot and Sullivan 2009). Other efforts to eliminate invasive rodents with trapping have been less successful (e.g., Carter and Leonard 2002; Panzacchi *et al*. 2007). The effort on Grassy Key has been a collaboration of WS, Florida Wildlife Commission (FWC), Florida Parks, United States Fish and Wildlife Service (FWS), and the South Florida Water Management District (SFWMD) and was designed to copy the successful eradication of ship rats (*Rattus rattus*) from Buck Island in the U.S. Virgin Islands (Witmer *et al*. 2007a).

ERADICATION AREA

Grassy Key is a part of the Florida Keys, which extend from the southern tip of Florida and curve south and westward into the Gulf of Mexico. Most of the islands are connected by the major highway, U.S. Highway 1, so the islands are not truly isolated. Grassy Key is about 400 hectares and of very low relief ($\leq$ 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 invasive species (Long and Lakela 1971; FNAI 1990) including various species of mangroves, palms, Australian pine (*Casuarina equisetifolia*), Brazilian Pepper (*Schinus terebinthifolius*), and numerous ornamental plant species. Periodic tropical storms and hurricanes damage vegetation and structures, and flood many areas. There are about 300 private residential properties on the island, the majority of which are $\leq$ 1 ha in size. In total, these properties comprise about 40% of the island area.

METHODS

In 2006-07, WS conducted Gambian rat distribution surveys on Grassy Key, using cage traps and motion-sensitive cameras. Gambian rats were found over much of the island with the exception of some areas of standing water. Surveys on other islands of the Florida Keys did not reveal any Gambian rats. Two animals were radio-collared and monitored for about a week, during which time they ranged 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 large numbers of Gambian rats), we used a 40 by 40 m grid spacing, whereas, in other areas, we used a 50 by 50 m grid spacing (Fig. 1). The

From: Pages 131-134 In: Veitch, C. R.; Clout, M. N. and Towns, D. R. (eds.). 2011. Island invasives: eradication and management. IUCN, Gland, Switzerland.

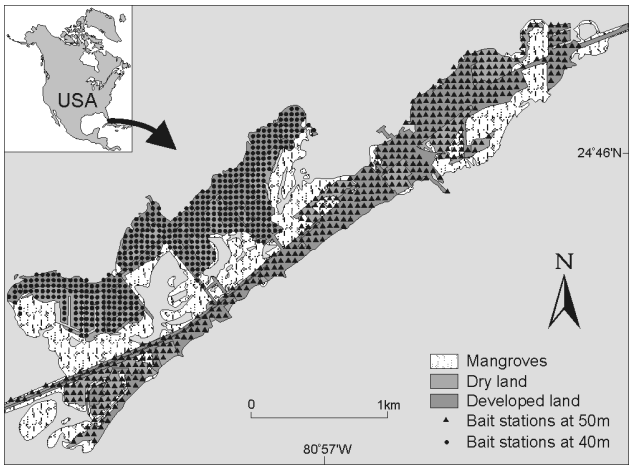

Fig. 1 The grid of bait stations used in the Gambian giant pouched rat eradication attempt, Grassy Key, Florida. US Highway 1 runs the length of the island.

SFWMD hired private contractors to cut trails through dense vegetation in order to establish the grid and provide access to bait stations. GPS units were used to assist with the establishment of a symmetrical, consistently spaced grid of approximately 1000 bait stations over the 400 ha. Six private properties, totalling about 2 ha in area, did not allow access by WS personnel.

WS conducted preliminary rodenticide bait trials, using wild-caught animals maintained in pens, 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 100% mortality in a short period of time (generally a few hours or less) after consumption of a few grams of the bait in a single feeding session. The final bait 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 risk of non-target animal exposure to the bait. WS also designed a bait station that allowed access by Gambian rats, but seemed to prevent access by most non-target raccoons (*Procyon lotor*) , opossums (*Didelphis virginiana*), cats (*Felis catus*) and dogs (*Canis familiaris*), based on remote camera surveillance (Fig. 2).

Fig. 2 Bait station designed and used in the Gambian giant pouched rat eradication attempt on Grassy Key, Florida.

The large number of bait stations relative to staff available precluded filling and monitoring of all bait stations in less that 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. The operation started with a 3-day pre-baiting period 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.

Before, during, and after the baiting session, cage traps and remote cameras were also used to detect and remove individual Gambian rats. 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. Captured rats were euthanased by gunshot to the head. 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 non-target mortalities and cage trap interference which was reducing the efficacy of trapping the target species. Any ship rats, another invasive rodent in Florida, captured were euthanased.

An additional baiting session was conducted in September 2007, in the same manner as previously described along with intensive trapping in those areas still inhabited by Gambian rats. 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 believed that the remaining rats might not be attracted to the previous baits used in bait stations and cage traps.

For many species of rodents, an eradication can be considered successful if intensive, periodic surveys do not reveal any individuals of the target species for two years (Witmer *et al*. 2007b). This did not happen in the first 2.5 years after the initial eradication effort, despite 280 cage traps and 80 remote cameras being used in the subsequent "mop-up" effort.

RESULTS

Within a few days, the field crew could smell decomposing carcasses in some areas, even though no carcasses were found on the surface during field work. However, camera surveillance soon made it clear that some Gambian giant pouched rats remained after the main baiting effort in May-June 2007.

Captures of Gambian rats steadily declined from September 2007-2009. Between May and August 2008 only 19 Gambian rats were caught. A hurricane before this period may also have killed numerous individuals. After several months of no captures, an adult female Gambian rat was captured in September 2009. She was radio-collared and found to rarely leave a 1 ha private property that WS was not permitted access to during the eradication programme. Of the six private properties that WS did not have access to, five were $\leq$ 0.2 ha and one, of about 1 ha, was where the last Gambian rat was caught and radio-collared. Intensive trapping was conducted around these properties throughout the eradication effort. While these areas were only about 2 ha of the 400 ha island, they may be an important contributor to the protracted eradication effort. We believe that the radio-collared female is now dead as her radio-signal location has not changed from a limestone structure on the property for over 6 months. An intensive two-week trapping and camera session in June 2010 using 300 cage traps and about 40 remote cameras

did not reveal the presence of any Gambian rats. WS is working with the FWC to establish a quarterly monitoring schedule for the next two years.

Evidence of the potential for emigration from Grassy Key towards mainland Florida emerged during the eradication. In 2008, a single, dead (presumably vehicle-killed) Gambian rat was reported along a highway in Islamorada, on Upper Matecumbe Key. WS confirmed that the dead animal was a Gambian rat. 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 linked to Grassy Key by multiple bridges, some of which are several kilometres long. Cage traps and motion-sensitive cameras were set in a grid in the area and operated for several days after the carcass was discovered. No further Gambian rats have been detected on Upper Matecumbe Key and its origins remain unclear. 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 with wild-caught Gambian rats from Grassy Key at the WS' National Wildlife Research Center in Fort Collins, Colorado, and has identified other potential attractants (Witmer *et al*. 2010a) and rodenticides (Witmer *et al*. 2010b) for use in future efforts with invasive Gambian rats wherever they may show up. Hopefully, the invasive rodent eradication effort on Grassy Key will end with the complete removal of all Gambian giant pouched rats, if any still remain on the island.

DISCUSSION

Recent intensive trapping and camera monitoring suggests that eradication has been achieved, but it will take additional monitoring to verify success. We found that, despite extensive eradication and detection efforts by WS in the Florida Keys, detecting and trapping the presumably few remaining Gambian rats on Grassy Key proved difficult. We know that getting the last few individuals in an eradication effort is often the most difficult part of the project and is virtually impossible if there are refuges available that protect some individuals from the eradication technology. Hence, a 99% success in an eradication attempt generally means the operation has failed. Some of the following factors may have contributed to the protracted effort Grassy Key.

Lack of data on the target species. Most rodent eradications deal with species of *Rattus* and *Mus*. Compared with these, relatively little was known about the biology and ecology of the Gambian rats on Grassy Key before we started the eradication project. While a rapid response to a newly discovered invasion is necessary for achieving a successful eradication before wide dispersal and establishment, it is important to understand the species and its use of its new environment. Published literature on Gambian rats is sparse and unpublished and/or obscure sources in Africa are not readily available to us in the United States except for informative websites maintained by persons keeping exotic pets. Time and funds permitting, the Gambian rats on Grassy Key should have been more intensely studied before the eradication effort. If Gambian rats ultimately survive this eradication effort, aspects of their behavioural ecology should be studied that will enable better design of an eradication strategy.

Adequate funding and resources are essential to successful invasive species eradication. We faced funding and staffing limitations from the start. We often worked on a "shoe string" budget which made planning and execution of the project difficult at best. There were times when funds and field staff were not available for a period of time during the eradication. At times, we functioned with one person in the field. Efficient planning and use of funds and staff help with these conditions, but cannot totally overcome the problem. Eradications require contingency planning and quick actions after unexpected occurrences or situations — these responses require adequate funds at hand.

Public cooperation and universal land access for operators are crucial to an invasive species eradication effort. Meeting with landowners is very important to help gain their trust and cooperation. Taking a list of predetermined talking points to public meetings can be very useful because proposed residential eradication attempts will draw much attention from the public and media. In the case of Grassy Key, most property was privately owned. While most landowners cooperated with the eradication effort and allowed access to their property, some did not, thereby causing a violation of the most important pre-requisite for successful eradication: that there be no refuges where individuals can avoid detection and removal. The last remaining Gambian rats seem to be associated with the six inaccessible properties. Based on limited radio-telemetry data, it appears that those Gambian rats found all they needed (food, water, shelter) on a single property and rarely left it. Because these few properties were small in size (< 1 ha), our recourse was to place cage traps (and in some cases, bait stations) around the perimeter of those properties with the hope that we would remove all the Gambian rats over time. Needless to say, this required a focused effort by our limited staff to check traps, process animals and re-set traps each day over an extended period.

Some property owners support invasive rodent rat eradication, but do not want rodenticide (i.e., toxicants) used on their property. Understandably, there is a general distrust of the use of chemicals in the environment by some individuals which hindered our effort in a few cases. In these situations, as with property owners refusing access to their properties, we had to use labour-intensive cage trapping over an extended period of time.

Human attitudes often cause unexpected problems for invasive species control in inhabited areas. On Grassy Key, some local residents maintained feeding and watering stations for feral cats. These resources might unintentionally support Gambian rats and other invasive species. Some people will also spring cage traps, damage or remove traps, or let captured animals loose. In our operation, over 100 cage traps were stolen or destroyed. As well as the waste of WS funds and effort, once an animal has been in a trap and then turned loose, it may become trap-shy and difficult to capture in future attempts. All these activities can reduce the chances that eradication will succeed.

Severe weather (e.g., tropical storms) on tropical islands is often unpredictable and can hinder eradication efforts. On Grassy Key, Hurricane Katrina damaged vegetation and transect access, disrupted cages, and caused a power outage during part of the eradication operation. Meeting such a challenge requires contingency planning activities and extra resource commitment, and prolongs the eradication project and increases its cost. On the other hand, it is often important to incorporate seasonal weather conditions into the eradication process to take advantage of, for example, periods when migratory birds are not present or when natural food resources for rodents are scarce so that the rodents will be attracted to rodenticide baits or baited traps.

When there is an unexpected leap or dispersal event of the localised invasive species during an eradication, resources have to be diverted to investigate it. This

happened when a dead Gambian rat was discovered miles and islands away from Grassy Key. WS sent staff from the Grassy Key operation to investigate the incident. Several days were spent setting up remote cameras and cage traps. No other Gambian rats were detected or captured and the effort was ended with staff returned to resume the eradication effort on Grassy Key.

While this is not meant to be a complete list of complications that arose during our eradication effort, it might remind operators and others of some common difficulties. Finally, while those involved in eradication efforts should be positive in their efforts, they should not prematurely assume or voice a positive outcome before it is achieved. Detection and "mop-up" of the last individuals after an eradication effort can be the most difficult part of the entire operation. Eradications of an established invasive species are difficult at best and not to be undertaken by the weak of heart!

CONCLUDING COMMENTS

Invasive vertebrates are a serious threat to human resources, health and the environment. Efforts to prevent introductions, control, or eradicate these invasive species are warranted and should continue. However, Parkes (1993) noted that "management that is not inclusive of pests, resources, people, and their interactions usually fails." Good collaboration between federal, state, and local governments is essential, as is consultation with stakeholders to ensure the support and cooperation of landowners and to minimise sabotage of the project. Increased public education should help prevent future introductions and encourage rapid reporting, resulting in early response to the invasion. Increased funding (based on risks, hazards, and priorities) is essential to combat the threat of invasive species in the United States and worldwide.

ACKNOWLEDGEMENTS

We would like to thank the many colleagues that we have worked with on island eradications. These include Frank Boyd, Bernice Constantin, Anthony Duffiney, Scott Wease, John Woolard, Peter Dunlevy, Steve Kendrot, and Dan Vice of USDA Wildlife Services; Katie Swift, Earl Campbell, Steve Ebbert and Claudia Lombard of USDI Fish and Wildlife Service; Michael Avery, John Eisemann and Richard Engeman of USDA Wildlife Services' National Wildlife Research Center; Scott Hardin of the Florida Wildlife Commission; and Gregg Howald of Island Conservation. We also thank the countless field staff that have helped implement island invasive rodent eradications for their tireless efforts and dedication to success. We also acknowledge the interactions and discussions with our many international colleagues.

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