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Detecting RODENTS in the Presence of Land Crabs: Indicator Blocks Outperform Standard Rodent Detection Devices at Palmyra Atoll

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ABSTRACT: Indicator blocks, also called “chew-tag-cards,” made from a small square of corrugated plastic partially filled with an attractant, are an established rodent detection tool used in many different settings. Here, we discuss the utility of indicator blocks in detecting the presence of rats at Palmyra Atoll National Wildlife Refuge (Palmyra) in the Northern Line Islands. The detection of invasive rodents, in this case black rats, can be challenging in the presence of non-target species that may interfere with detection devices. Palmyra supports a robust community of land crabs. Five of the 7 species of land crabs found at Palmyra routinely interfere with commonly-used rodent detection devices: snap traps, live-capture traps, tracking tunnels, motion-sensing cameras, and gnaw sticks. Interference by crabs renders some of the detection methods useless (gnaw sticks) and reduces the sensitivity of others through false triggering (traps and cameras). Coconut crabs, which can exceed 7 kg and are found throughout Palmyra Atoll, can easily destroy tracking tunnels, traps, and even ruggedized motion-sensing cameras. Prior to the successful eradication of rats from the atoll in 2011, we compared the rate of detecting rats using indicator blocks with that of live-capture traps and tracking tunnels in paired, independent samples (90 chew block versus trap samples, 20 chew block versus tracking tunnel samples). Sampling occurred in September and October 2010 and measures were collected consecutively for 19 days. The frequency at which the indicator blocks detected rats was significantly higher ($P < 0.001$) than that for traps or tracking tunnels, even when interference by land-crabs was minimized by placing the devices on overturned 5-gallon buckets. The results from this study suggest that indicator blocks are an effective and efficient tool for detecting rodents in the presence of non-target species that interfere with rodent detection devices.

KEY WORDS: chew block, detection device, indicator block, monitoring, non-target, Palmyra Atoll, rodent detection

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INTRODUCTION

Global island biodiversity has benefited from the eradication of invasive vertebrate species (IVS), especially rodents which are blamed for the majority of extinctions on islands (Towns et al. 2006). On tropical islands, rats prey on a wide range of native plants and animals, often causing population level impacts to these species (Varnham 2010). If eradication of invasive rodents is not undertaken, the associated impacts can lead to extinction of native species and loss of unique biodiversity (IC 2013a). The use of eradication as a conservation tool has increased in recent years; to date invasive alien vertebrates have been successfully eradicated from more than 800 islands (IC 2013b).

Advances in eradication technology have made the eradication of IVS an effective conservation tool for the preservation of biodiversity on islands (Towns and Broome 2003, Veitch et al. 2011). Variations in eradication environment and factors that impact project success preclude the development of a general recipe for eradication (Wegmann et al. 2012), and the adaptation of innovative eradication tools has led to the successful removal of IVS from increasingly large and complex islands (Howald et al. 2007, Phillips 2010, Veitch et al. 2011), yet use of such tools often goes unpublished and adoption and awareness of such tools by global practitioners is limited (Donlan et al. 2003).

Detection of invasive rodents is key to informing eradication planning and critical in confirming the success of eradication efforts (Sweetapple and Nugent

2011). Following a rodent eradication campaign, use of reliable detection methods can increase confidence of success when working in novel locations (Samaniego-Herrera et al. 2013). Accurate detection of invasive rodents can be costly, time consuming, and challenging especially in the presence of non-target species such as land crabs. Traps and tracking tunnels are detection tools, but they require considerable time to deploy and maintain, and have inherent logistical constraints (the size, weight, and number of each device makes it difficult to transport large numbers into remote areas). Alternative methods should be developed to decrease project costs and effort (Sweetapple and Nugent 2011).

Climatic factors like precipitation further complicates the use of rodent detection tools. Programs aiming to detect rodents on mesic to wet tropical islands often face a suite of unique challenges including interference by land crabs, regularly available natural food items, and high rainfall (Wegmann et al. 2011) that decrease the effectiveness of conventional rodent detection devices. Despite technical and logistical challenges, tropical island eradications are growing in number and leading to innovations that improve current methods and establish new benchmarks (Wegmann et al. 2012). In wet tropical locations, the climate is characterized by persistent rainfall and high temperatures, which hinder the ability of the project team to deploy detection devices and retrieve data effectively. Development of techniques best suited to unique environments will facilitate the accurate detection of invasive species and potentially allow teams

Figure 1. Distribution of paired chew block and trap or tracking tunnel sites across Palmyra Atoll during the 2010 study.

implementing rodent eradication projects to locate and remove residual individuals or populations following an eradication effort (Samaniego-Herrera et al. 2013).

Reliable detection of rats with conventional methods, such as snap-traps, tracking tunnels, gnaw sticks, and tracking powder at Palmyra was made challenging by several factors: land crab interference with detection devices (Wegmann 2008), the potential for harming shorebirds with snap traps (USFWS 2011), and heavy, persistent precipitation. Here we examine a paired trial of conventional methods for detecting rodents (live traps and tracking tunnels) alongside a novel method (plastic detection tags, or “chew blocks”). The paired trials were conducted in 2010, prior to the successful eradication of black rats (*Rattus rattus*) from the atoll (Wegmann et al. 2012).

METHODS

Study Site

Palmyra is at the northern end of the Line Islands and consists of 235 hectares (580 acres) of emergent land fragmented into 25 islands (Figure 1). Palmyra is the only federally protected moist tropical forest ecosystem in the Central Pacific (USFWS 2011). Located within the low pressure area of the Inter-tropical Convergence Zone, the atoll lies at 6° N and 162° W. Palmyra has a wet tropical climate with over 400 cm of rainfall each year (USFWS 2011). Palmyra is a globally important refuge for many native plant and animal species, and it provides important breeding habitat for 10 seabird species and winter foraging habitat for several migratory shorebirds (USFWS 2011). It also supports one of the last remaining habitats for the tropical broadleaf tree, *Pisonia grandis*. Palmyra also hosts a robust population of the world’s largest terrestrial invertebrate, the coconut crab (*Birgus latro*), and 5 other species of land crab (Wegmann 2009). Initial studies conducted prior to the eradication suggested that there could be as many as 139 rats/ha, resulting in a maximum population size of 32,000 rats across the atoll (Wegmann and Middleton 2008, Alifano et al. 2010).

Palmyra is also home to a diverse and abundant community of land crabs which reach densities greater than 1,400 crabs per hectare (Howald et al. 2004). Land crabs compete with target species for bait and interfere with traps and detection devices (Wegmann 2008, Griffiths et al. 2011). The presence of land crabs at Palmyra necessitated a creative approach to the detection of rodents. Several conventional methods of trapping and detection had to be adapted for use at Palmyra. Live traps (Tomahawk® 102ss, and Hagaruma® basket traps), tracking tunnels, and chew blocks were used to confirm the presence of rats on Palmyra’s islands and to establish a baseline detection rate (i.e., successful captures per trap-night) prior to the eradication.

Detection Devices

Chew Blocks

Chew blocks consist of small (2 cm × 2 cm) square sections of corrugated plastic, filled at one end with a hard candy (peanut butter and melted sugar mixture). When chewed by a rat, rodent incisor marks were easy to spot (Figure 2) (Alifano et al. 2010). Sweetapple and Nugent (2011) discuss the development and use of a new detection tool, “Chew track cards (CTC),” as a cost-effective method. Like the CTC, the chew block is constructed out of similar materials – a corrugated plastic with internal channels – into which an attractant can be placed (Sweetapple and Nugent 2011). The plastic provides a medium into which animals can leave identifying marks (chew or claw) that can be clearly determined regardless of weather or consumption. Once the last of the attractant is consumed, a piece of the plastic card remains with the distinct markings of the species who consumed the attractant, allowing for quick and reliable identification. Rodents make easily identifiable chew marks, and in cases of multispecies locations, chew blocks may be used to detect more than one species at a time (Sweetapple and Nugent 2011).

A chew block was deployed at every detection site across the atoll (Figure 1). The chew block was placed within 1 m of the paired detection device at each location.

Table 1. A comparison of the efficacy of different rat detection devices at Palmyra Atoll.

Stations (n)	Paired detection devices	Adjusted detection nights (ADN)	Detections per detection nights (DDN)	df	t-value	P-value
90	Live trap	539.5	30.9 (SD 46.2)	644	-4.55	< 0.001
	Chew block	510.5	42.7 (SD 49.2)			
20	Tracking tunnel	72	13.3 (SD 34.2)	74	4.21	< 0.001
	Chew block	59.5	39.3 (SD 48.8)

Figure 2. Chew blocks gnawed by rat incisors, indicating rat presence. The smooth edges of the block are untouched; the chewed sides were originally filled with hard candy.

Chew blocks were installed by pushing a nail through the non-baited portion of the corrugated plastic perpendicular to the flat surface. The nail was then hammered approximately half its length into the trunk of a coconut palm (*Cocos nucifera*) or a branch of a tree at 1-2 m above the ground. To reduce exposure to additional moisture, the chew block was then pulled away from the tree to the head of the nail to allow for air flow between the tree and the chew block.

The attractant used in the chew blocks was designed to persist for several days in a warm, wet climate while maintaining palatability to rats. The recipe for the attractant included peanut butter and sugar that was cooked to a liquid, mixed together, inserted into the channels of the chew block, and cooled to a solid form. When the attractant was hot liquid, it was worked into the corrugated plastic by pressing one end of the plastic into the attractant several times until the interior channels were filled to approximately half the width of the chew block. As the mixture cooled it solidified into a hard, candy-like material that became “locked” into the corrugated plastic. The hard “candy” attractant persisted for several days with exposure to sunlight, high temperatures, rain, and consumption by ants.

Similar to CTCs, chew blocks are easily deployed in any environment, and are not known to cause an adverse association for the species of interest (Sweetapple and Nugent 2011). Conversely, a rodent captured in a live trap may develop a negative association with the location, the trap, or bait. Once educated that animal is less likely to re-visit such a detection method, black rats have been

observed routinely passing by the traps they would rarely enter, making the method less accurate over time (Recht 1988). Wax blocks are made of wax that is non-palatable to target species resulting in reduced detection over time, as animals are less likely to chew them multiple times (Sweetapple and Nugent 2011). Chew blocks detect the presence of rodents without negatively impacting future detection efforts. Chew blocks require few resources to manufacture, are relatively inexpensive, and can be created at the project site as needed. During the trapping effort, 645 chew blocks were deployed, spaced with every other trap (Table 1).

Live Traps

Trap lines were established using predetermined GPS points with 25-m spacing between traps, where obstructions prevented the placement of detection devices at the predetermined point, the devices were installed as close as possible (Alifano et al. 2010). Each live trap location was paired with a chew block. Traps were baited with a piece of coconut dipped in peanut butter and checked each morning to minimize distress to captured animals. Over the course of a 20-day trapping period, a total of 304 rats were captured.

Trap status was checked daily, and resulted in 1,178 trap nights during the sampling period. No activity, meaning that bait was untouched and the trap door was open, was the most frequent occurrence. Rat capture was the second most frequent occurrence, indicating that the traps worked effectively when rats entered.

Tracking Tunnels

Tracking tunnels were constructed from 4-in-diameter PVC pipe cut into 25-cm sections (to protect tracking materials from rain) and secured to the lid of a 5 gallon bucket with cable ties. The bucket elevated the tracking tunnel to reduce interference by land crabs. Each tracking tunnel contained a felt pad coated with oil-based black ink mixed with peanut oil affixed to a 10-cm-wide strip of cardstock paper. The scent of peanut oil attracted rats, which entered the tunnel and left paw prints behind on the paper as they exited (Alifano et al. 2010). Tracking tunnels were deployed across the atoll, along with traps and chew blocks.

Data Collection

At Palmyra, data collection was conducted during daily visits to each detection station. Data were collected using ruggedized field computers – Archer® PDA (Juniper Systems, Logan, UT) that allowed the project team to easily select and record the results at each

detection site. The fate of each chew block, trap, and tracking tunnel was selected from a customized drop-down menu. Options within the drop-down menu for chew blocks included: “chew,” “no chew,” “ants,” “crab,” and “missing.” We measured the detection efficacy of traps, chew blocks, and tracking tunnels by calculating the detection per detection night (DDN). The DDN for a given device was determined by dividing the number of successful detections (D) by the adjusted detection nights (ADN):

$$D = D/A$$

The ADN for a given device was determined by subtracting 0.5 nights for every night that a device was “tripped” without detection (traps tripped without capture, chew blocks removed from the study site, and ink pads removed from the tracking tunnels) from the total number of nights that the device was monitored.

Because the samples were drawn independently from each other, we used a 2-tailed paired t-test ($\alpha = 0.05$) to compare the sensitivity of chew blocks vs. live traps, and chew blocks vs. tracking tunnels in detecting rats at Palmyra.

RESULTS

From September 25, 2010 to October 14, 2010, we measured the relative effectiveness of chew blocks, live traps, and tracking tunnels in detecting rats at Palmyra. Chew blocks were paired with live traps at 90 independent sites, and with tracking tunnels at 20 independent sites. We found that chew blocks were significantly more effective ($P < 0.001$) at detecting rat presence than were live traps or tracking tunnels (Table 1).

DISCUSSION

The ability to accurately and efficiently detect the presence of rodents is a key factor in any rodent eradication campaign. An increasingly popular method of detecting rodents is use of wax blocks that animals bite out of curiosity, leaving teeth indentations that provide evidence of the animal's presence. Wax blocks may provide an inexpensive, commercially available, and practical rodent detection method (Samaniego-Herrera et al. 2013); however, interference by native land crabs on tropical islands compromises the efficacy of detection efforts because land crabs can remove or destroy the wax blocks (Buckelew et al. 2005). Furthermore, high temperatures on tropical islands can cause the wax to melt, which can degrade the block's ability to retain rodent incisor marks.

The study discussed here allowed the Palmyra Atoll rat eradication project team to assess the relative efficacy of three rodent detection tools within Palmyra's environment. By identifying that chew blocks were more effective at detecting rat presence than live traps or tracking tunnels, we maximized the effectiveness and efficiency of the post-eradication rat detection effort. With chew blocks as the primary detection method, we were able to achieve high resolution, full-atoll coverage with a 2-person monitoring team. Over 250 detection stations were established and monitored throughout the entire atoll. Stations were checked every 3 days over a 15-day period in 2011 (2 months after the eradication) and 2012 (1 year after the eradication). The failure to detect rats

during both monitoring trips gave us the confidence to declare the rat eradication project successful.

By measuring the DDN for chew blocks prior to the rat eradication, we established a baseline mean rat detection value to which the post eradication DDN could be measured. Had chew blocks only been used after the eradication was completed, we would have little confidence in a result of zero rat detections. We recommended that DDN for chew blocks, or any detection device is measured at each eradication site prior to the eradication. If time and resources allow it, we also recommend that the DDN for several detection devices is measured at the eradication site prior to the eradication so that the devices that are most sensitive to the presence or rodents at that site are used during the post eradication rodent detection effort. Use of chew blocks for pre and post-eradication rodent detection will increase our understanding of the utility and limitations of this tool.

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