

# Informational report on the use of Goodnature<sup>®</sup> A24 rat traps in Hawaii

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## INTRODUCTION

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### **Background**

Invasive rodents are known to alter ecosystems worldwide and can be devastating in island ecosystems where species have evolved without the threats posed by rodents (Fukami *et al.* 2006; Simberloff 2008). In the Hawaiian Islands, rats and mice are introduced pests that are known predators of endemic Hawaiian plants, invertebrates and birds (Stone 1985). Consequently, an effective rodent control program is an essential element in a management plan for many vulnerable Hawaiian species.

Rat control in natural areas in Hawaii is currently limited to using snap traps and the new automatic self-resetting Goodnature® A24 rat trap. The use of bait stations with the rodenticide Ramik® was utilized prior to June 8, 2013, when the Ramik® pesticide label expired. Consequently, this method is not an option in natural areas until a new label is approved.

The Goodnature® A24 kill-trap from New Zealand was designed especially for conservation use. These traps are powered by compressed CO<sub>2</sub> and can reset automatically up to 24 times before the CO<sub>2</sub> canister needs to be replaced. This new tool may present advantages over existing methods of rat control including:

- Reduced long-term costs for rat control as a result of less labor and fewer helicopter flights to remote sites
- Increased ability to conduct rodent control in remote sites due to less maintenance required
- Increased rat control efficacy because they are multi-kill devices
- Decreased damage to vegetation because sites are visited less frequently
- Reduced risk for staff resulting from less handling of rat carcasses
- Humanely dispatched rats (Jansen 2011)

Information in this document is derived from a project conducted by OANRP in partnership with and partially funded by Kalaupapa National Historical Park. This project was conducted in Pahole Natural Area Reserve (NAR), located in the northern Waianae range on Oahu, in collaboration with the State of Hawaii Department of Land and Natural Resources Division. To conduct the study, 45 A24s were maintained in a grid around a population of an endangered tree, *Cyanea superba* subspecies *superba*, from October 2012 to August 2013. The four main objectives were as follows:

- 1) Compare A24s to other rat control methods
- 2) Investigate the resource response to the A24 grid
- 3) Monitor changes in rat activity after installing A24s
- 4) Troubleshoot the use of A24s, including trialing various baits

This report discusses some of the findings of the project and serves as a guide for installing, setting, and maintaining the traps. It also discusses monitoring methods and other tips for use. A technical report describing the details and results of the project at Pahole NAR is currently being prepared and will be available on the Pacific Cooperative Studies Unit website (<http://manoa.hawaii.edu/hpicesu/techrep.htm>).

### **Goodnature® A24 Details**

Goodnature® A24 traps (Fig. 1) can kill up to 24 rats using a single 16 gram threaded CO<sub>2</sub> canister. As a rat investigates the scent of the bait stored at the top of the trap, it brushes aside a sensitive wire

trigger. This movement alters the pressure gradient inside the trap by releasing a small amount of gas, which then causes a larger quantity of gas to escape. The gas from the canister then explosively propels a piston to strike the rat in the skull, killing it instantly (Goodnature® 2013). The piston immediately retracts and the rat falls out of the trap. The trap is then ready to fire again. A24s are designed to be baited with a long-lasting attractant to prolong maintenance intervals.

Each A24 trap currently costs \$169 NZD. Digital counters that slide onto the CO<sub>2</sub> canister to record the number of times the trap has been triggered are also available for \$55 NZD. The cost of a trap and counter setup is approximately \$180 USD. See “Carcass Scavenging & Digital Counter Utility” (page 13) for a discussion regarding the counters.

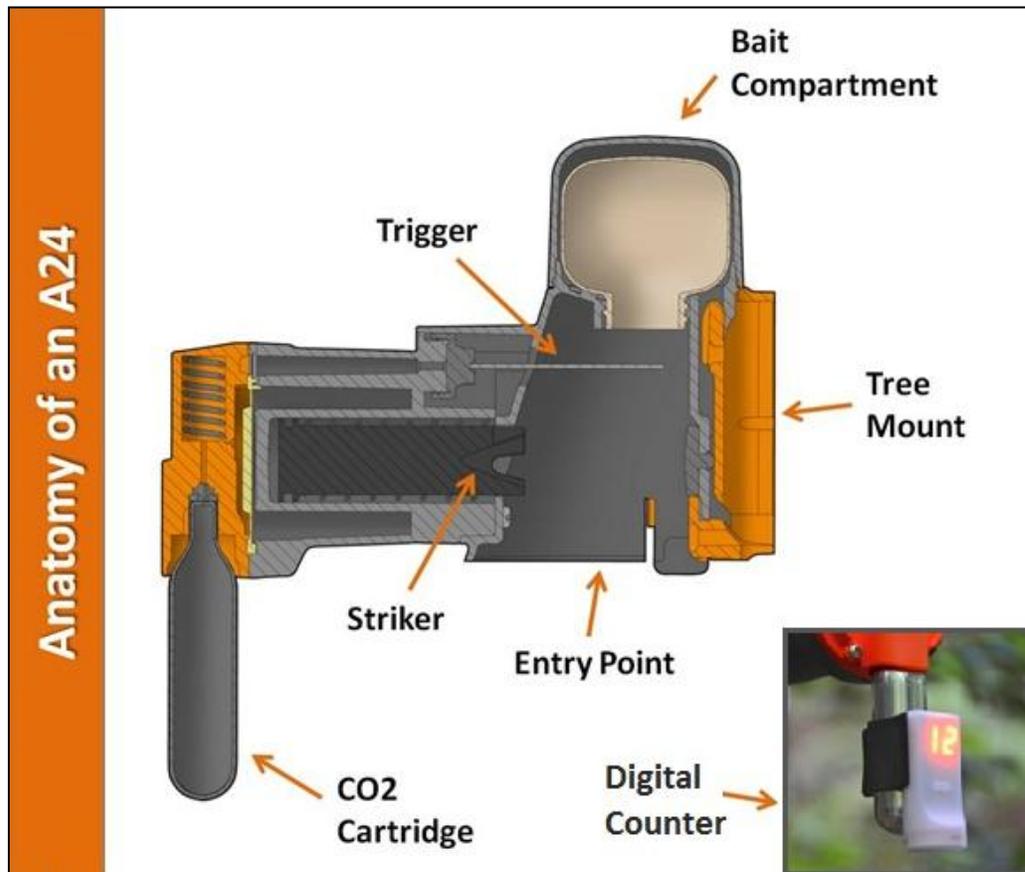


Figure 1. Goodnature® A24 Rat Trap and Digital Counter.  
Diagram and photo courtesy of Goodnature® Ltd.

### **A24 Humaneness**

A field evaluation of the lethality of A24s was conducted in New Zealand and found that ten consecutive rats were rendered irreversibly unconscious in less than 30 seconds. This time includes the lag between the trap triggering and the ability of the assessor to travel to the trap and conduct a reflex test (Jansen 2011). These results meet the New Zealand National Animal Welfare Advisory Committee kill trap testing guidelines; there is neither a comparable committee nor similar guidelines in the United States regarding the humaneness of rodent traps.

In Pahole NAR, OANRP observed a total of 125 rat carcasses that were killed by A24s; all had obvious trauma to the head indicating proper trap functioning and quick death. The only exception was one rat

that was found alive and injured near a trap. It appeared to have been struck on the head by the trap and sustained an obvious injury to its skull. Staff quickly dispatched the rat. This was the only time that a live injured animal was observed. It is assumed that the trap did not fire at full capacity, however it was observed to function normally otherwise. The incident was reported to Goodnature® and they responded that it was the first time they had heard of such an occurrence. Despite this incident, OANRP remains confident that A24s are a more humane alternative than other methods.

## CONSIDERATION OF RAT CONTROL METHODS

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### ***Utility of Various Methods***

All methods of rat control have advantages and disadvantages. Over the years, OANRP has seen evidence of successfully protecting some species, such as the endangered palm *Pritchardia kaalae*, using bait stations with Ramik® rat bait and snap traps together (unpublished data). Bait stations may be a good option in drier habitats and in areas that have a rat density low enough to be reduced by intermittent doses of Ramik®. Rat bait, however, is expensive, controversial, heavily regulated, and highly variable in efficacy. OANRP has often found the bait to be moldy, eaten by slugs, or otherwise untouched by rodents. As a result, there is concern that rats often consume sub-lethal doses of bait and may be left unharmed to prey upon vulnerable resources. Furthermore, the Ramik® label has expired so using bait stations is not currently legal. It is also likely that the new label will have stricter stipulations and grid design requirements (Swift, pers. comm.) that will preclude the use Ramik® at many sites because the new grid design requirements may be impossible or impractical to meet.

Both small and large snap-trap-only grids are known to have positive impacts on resources (Krushelnycky 2011; Mosher *et al.* 2010; Pender *et al.* 2012; Shiels, unpublished data). Snap traps are also the cheapest tool available for killing a rat. Snap traps may be ideal when there is a limited initial budget for a project or at a site that is relatively easy to access. Disadvantages to using snap traps are: trapping grids can be labor intensive to maintain, create heavy foot traffic in fragile ecosystems, and can be inefficient as bait is often quickly removed by slugs, ants, or other insects. The peanut butter bait has been observed to be eaten off half of all snap traps within a 24 hour period. Snap traps are only good for one kill each and must be cleaned, baited, and set before they can function again. There is also a risk of non-target species being harmed by a snap trap.

Goodnature® A24 rat traps may be the best choice for sites that are remote or otherwise difficult to access. These traps are designed to be baited with a long-lasting attractant and set out for months without servicing, resulting in cheaper maintenance costs (discussed further in next section). Remote sites that require access by helicopter may be especially ideal for A24s. Additionally, because A24s are multi-kill devices, they should be able to kill more rats than snap trap grids; OANRP found that in Pahole NAR, the A24s killed more rats per unit area than a nearby snap trap grid. Risks to staff may also be reduced as there is less handling of rat carcasses compared to snap traps. A24s may also be the most humane option for rat control. Downsides to using A24s include the upfront cost of purchasing them, limited research indicating their effectiveness, finding a long-lasting attractant (see “Bait Considerations,” page 10), and troubleshooting mechanical issues (see “Mechanical Malfunctions,” page 14).

### ***A24s vs. Snap Traps: Cost Analysis & Effectiveness***

Essentially, the total cost for rat control is equal to the sum of the cost of traps, labor, transportation, and maintenance/replacement. Even with the relatively high cost of A24s, they appear to be more cost effective over time in comparison to maintaining a snap trap grid.

OANRP currently maintains a grid of 464 Victor® snap traps that are housed in wooden boxes across 26 hectares (~18 traps per hectare) located in Kahanahaiki Valley in the Northern Waianae range. The initial cost of 464 Victor® traps housed in boxes was approximately \$6,900. With the helicopter time necessary to deploy the traps and boxes, the total start up cost of the trapping grid was at least \$8,100. All 464 traps are normally checked and re-baited every two weeks by four people. For simplicity, in this example it is estimated that labor costs are \$12,000 per year to maintain the grid. If automatic traps were deployed instead of snap traps in a 100 m by 50 m grid as used in Pahole (see “Grid Layout Considerations,” below), there would be a total of 54 A24s at Kahanahaiki. Each A24 (with a counter) costs approximately \$180; therefore 54 A24s and counters would cost around \$9,720. No helicopter time would be required as the gear would be easy to carry and deploy. Therefore, the total cost for the A24 grid (including CO<sub>2</sub> canisters) would be around \$10,000. This grid would probably be checked and re-baited at least quarterly by a couple of people, thereby resulting in *less than 20%* of the total labor now required to maintain the snap trap grid.

A comparison of the cumulative theoretical cost of maintaining the current snap trap grid at Kahanahaiki versus a grid of 54 A24s shows that the “break-even point” between the two methods would occur before the end of the first year (Fig. 2). In year 0, the cost of purchasing A24s is slightly higher than the cost of starting a snap trap grid, however, when labor costs are factored into the cumulative cost of the grids over time, it is clear that the A24 grid quickly makes up for the additional upfront cost with a reduction in labor (calculated at 20% of the labor for the snap trap grid). By the end of year 2, the cumulative cost of maintaining the snap trap grid is approximately twice as much as the cost of maintaining the A24 grid.

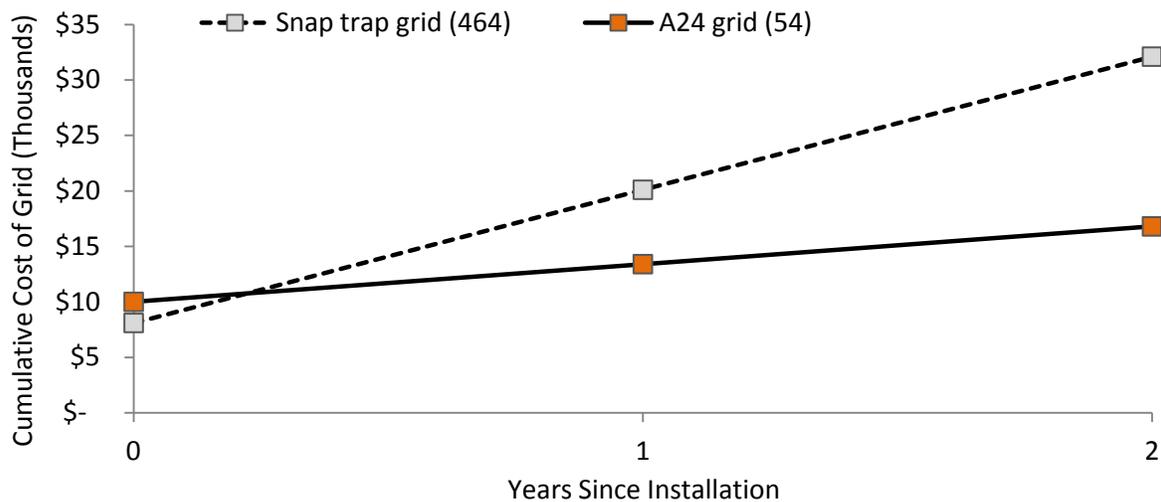


Figure 2. Theoretical cumulative cost of protecting natural resources at Kahanahaiki using a 464 snap traps (current method used by OANRP) versus a grid of 54 A24s. Year 0 represents the initial cost of purchasing supplies. Subsequent years include the cost of labor. An additional \$1,000 has been incorporated into the yearly budget for the A24 grid for replacement traps and CO<sub>2</sub> canisters.

This example shows that maintaining a grid of A24s could be a more cost effective option at Kahanahaiki. Furthermore, using Kahanahaiki as an example to compare cost effectiveness of the two methods does not consider the additional cost of helicopter flights that are necessary to access other remote sites.

Data from this study indicate that A24s are more effective than snap traps at killing rats. A comparison of the effectiveness of the snap trap grid at Kahanahaiki (464 traps; 26 hectares) versus the grid of A24s (45 traps spaced 100 m by 50 m; 12.6 hectares) at Pahole shows that the A24 grid caught more rats per hectare (51 rats/ha) than the snap trap grid (34 rats/ha; Fig. 3, A). Moreover, the Pahole A24 grid was maintained with roughly 35% of labor required for the Kahanahaiki snap trap grid (Fig. 3, B). A24s appear to give “more bang for the buck.”

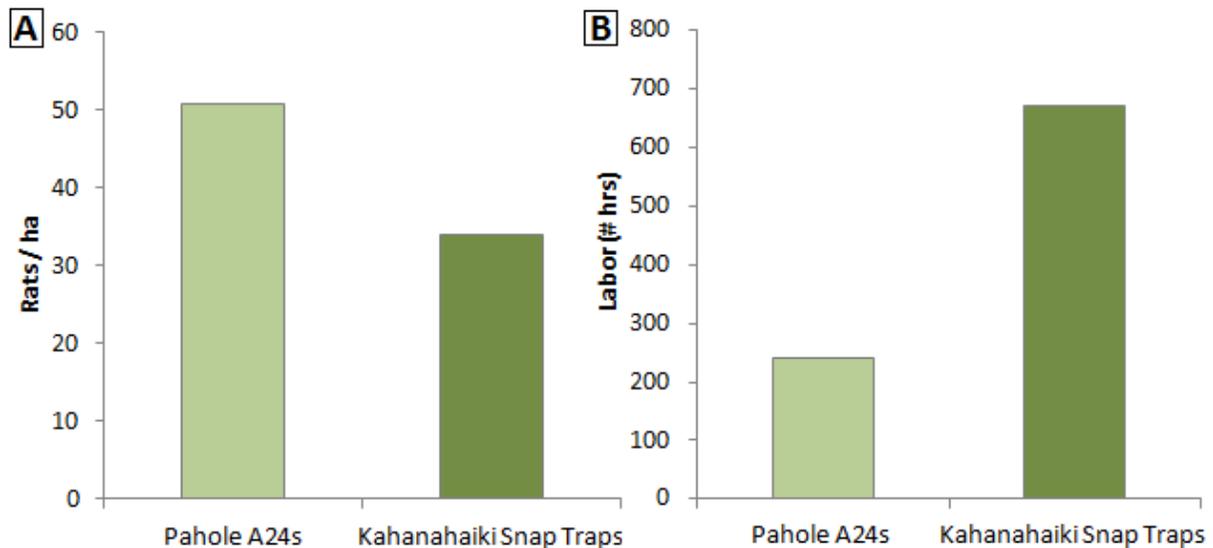


Figure 3. Comparison of the Pahole A24 grid versus the Kahanahaiki snap trap grid for: A) rats per hectare killed; and B) estimated number of hours of labor invested.

*The Pahole grid consisted of 45 A24s across 12.6 hectares; the Kahanahaiki grid consisted of 464 snap traps across 26 hectares. Data collected from October 26, 2012 to August 12, 2013. The Pahole grid was checked 24 times; the Kahanahaiki grid was checked 28 times.*

## PURCHASING & SHIPPING

### **Purchasing**

Over the past year several kinks have been worked out regarding the logistics of purchasing traps. Goodnature® has complied with US regulations and is now officially approved by the Environmental Protection Agency to sell their traps in the US. Putting in an order with Goodnature® is now relatively straight forward. Government-affiliated agencies, such as the National Park Service, may require that a “Sole Source Justification” document be submitted to approve the international order. The document essentially states why the traps are an important purchase and that Goodnature® is the only distributor of the traps in the world.

### **Shipping**

Goodnature® will ship the order using the best method in compliance with US regulations. It is important to learn whether or not the shipment will be received by US Customs and Border Protection (CBP) and require clearance. International shipments go through CBP for a number of reasons and the purchaser should check with Goodnature® to discover whether or not to expect this situation. If the order will be held by CBP, be prepared in advance by arranging to have a broker handle the customs clearance. Additional fees are incurred in this process.

## DEPLOYING A24S

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### ***Grid Layout Considerations***

In Pahole NAR, the grid design was selected by reviewing literature, conferring with New Zealand experts, and assessing site specifics such as topography and resource locations. Goodnature® recommended at least one trap per rat home-range size for the minimum trap density (pers. comm.). The Department of Conservation (DOC) in New Zealand suggested installing the traps more densely on transects spaced 100 m apart with traps 50 m apart on the transects (D. Peters, pers. comm.). With rat home-range sizes of approximately four hectares in the northern Waianae Mountains (Shiels 2010), a grid of 50 m by 100 m yielded up to 15 traps per rat home-range. For the purposes of the Pahole NAR project, that density seemed adequate to begin to assess the utility of the traps.

Five transects were installed in Pahole, spaced 100 m apart from each other as measured from the gulch bottom. Traps were installed 50 m apart on each transect with additional traps in between each transect on the perimeter. This method of creating a denser spacing of traps around the perimeter of a trapping area is the current best practice for snap trap grids by the New Zealand Department of Conservation (DOC 2005). The grid was centered on an outplanting of *C. superba* and extended approximately 200 m in all directions from the outplanting (Fig. 4). This layout needed 45 traps total: 37 on transects and eight additional perimeter traps. The buffer of rat protection measured approximately 12.6 hectares (31.1 acres). This buffer was comparable in size to the buffer protecting the nearby *C. superba* at Kahanahaiki where there is a large snap trap grid. Twenty-nine tracking tunnels were also deployed at Pahole for monitoring rat activity.



**Map removed to  
protect rare resources**

Figure 4. A24 grid at Pahole NAR.

*Each black symbol represents one trap. The orange circle represents the 200 m buffer of rat control around the *C. superba* plants; the pink squares represent the size of a black rat's home-range (~4 ha, Shiels 2010).*

The mesic forest of Pahole provides ideal habitat for black rats in Hawaii because the forest structure is diverse with many tall trees, contains ample food sources such as strawberry guava (*Psidium cattleianum*), is located at a moderate elevation (1,800-2,000 ft), and has varied and moderate topography creating many habitat niches.

The grid design at Pahole provided valuable information regarding the utility of the traps, yet the optimal layout of traps that would minimize the number of traps needed while maximizing the desired resource response was not determined. The grid likely reduced predation on the *C. superba*, however predation was still unacceptably high by management standards (73% predation of monitored fruit). For ten consecutive months, rat activity in tracking tunnels was suppressed inside the Pahole grid relative to a control site (six months were significant at  $p < 0.05$ ). See “Monitoring” (page 15) for more information about these results.

The ideal trap density and number of traps necessary will vary according to site-specific details and ultimate goals. To protect a particular species that is highly vulnerable to rats and located in areas with high rat densities (such as *C. superba* at Pahole) a tighter, denser grid will be necessary. Saturating the area with A24s spaced 25 m apart and extending approximately 50 m from the perimeter of the population may be a more appropriate layout for this species. To reduce rat populations over a larger area and to provide benefits throughout the ecosystem (not for single species protection), the grid spacing of 100 m by 50 m was adequate at Pahole. Rat densities may be significantly lower in other ecosystems, such as those in Kalaupapa National Historical Park. Therefore, it may be easier to control rats at other sites with fewer traps or a less dense spacing.

An alternative method for estimating how many A24s are needed at any given site is to think of A24s in the same manner as bait stations; both are multi-kill devices that are designed to have minimal maintenance. The expired Ramik® label specified that bait stations be spaced 25 m apart in a grid layout around the vulnerable resource. OANRP is using the number of bait stations that previously occurred at a site as a guideline to determine how many A24s should be ordered to replace the bait stations. OANRP is optimistic that the traps will perform better than bait stations, especially in wetter habitats.

To summarize this section discussing grid design, OANRP has found:

- A grid of 45 A24s spaced 100 m by 50 m was adequate to reduce rat activity across 12.6 hectares (31.1 acres) of mesic forest but not adequate to protect an extremely vulnerable species (*C. superba*) in the center of the grid
- For vulnerable species, a denser grid (traps placed 25 m apart) with a buffer of at least 50 m to increase protection will likely be necessary
- The larger the buffer of rat control around a vulnerable resource, the better
- When unsure of how many A24s to deploy at a site, referring to past experience at that site using bait stations (if applicable) is helpful to give a starting point

Monitoring the effects of a trapping effort is crucial for effective management (refer to “Monitoring” section, page 15).

### **Mounting A24s**

The traps should ideally be mounted on sturdy, non-native trees that don't have too much vegetation that may block a rat's access to the trap. Goodnature® recommends installing them approximately 18 cm (roughly the height of a 'shaka'; Fig. 5, A) above the ground or above a branch jutting out horizontally from the tree. If there are ground nesting birds or other species of concern in the area, the

trap should be mounted higher off the ground, perhaps above a horizontal branch. Shiels (2010) found that black rats spend a significant amount of time in trees so installing some traps higher up on trees may be beneficial. In Pahole NAR, most traps were mounted about a shaka height from the ground but a few were higher up on trees or on fallen logs.

A24s come with square-headed screws; however it is worth considering supplying one's own screws if another type of screw is preferred. Use a cordless drill for ease. Be careful not to over-tighten the tabs on the tree mount because as the tree grows and swells over time, the mount becomes harder to remove and the tabs that the trap clips into can become warped. Note: Strawberry guava trees seem to swell more than other species which can make it particularly difficult to unscrew the mount.

Alternatively, if there are not many suitable trees in the area, the traps can be mounted onto pointed stakes that are pounded into the ground (Fig. 5). Stakes can be constructed from "trex decking" or another durable material and should measure approximately 30 inches long by 2 inches wide. The National Tropical Botanical Garden has used this method in Upper Limahuli Preserve on Kauai (M. Lucas, pers. comm.). OANRP will be utilizing this method for sites in the Koolau range on Oahu.



Figure 5. Mounting A24s on stakes.

A) Mount attached a 'shaka' height above ground; B) A24 mounted on stake in Upper Limahuli Preserve. Photos courtesy of Matt Lucas, National Tropical Botanical Garden.

Consider making signs to display in the area that warn of the dangers of tampering with the traps. Stickers printed on waterproof mailing labels can also be made that fit onto the top of the trap (Fig. 6).



Figure 6. Safety signage used in Pahole NAR.

A) Durable sign that was mounted on trees at access points to trapping area; B) Stickers made from mailing labels to adhere to trap; C) A24 with sticker

### CO<sub>2</sub> Canisters: Installing & Removing

Each Goodnature® A24 trap comes with one 16 gram threaded CO<sub>2</sub> canister. This type of canister is also available at bicycle shops (such as The Bike Factory), but Goodnature® is concerned that other canisters may not be ideal and could damage the trap. OANRP has found that canisters can become stuck and damage the trap by causing the entire regulator that the canister screws into to come out. Many traps have been returned to Goodnature® for repairs that have been damaged in this way. Goodnature® recently announced a new policy stating for new orders of A24s, the warranty on the traps will be voided if other sources of CO<sub>2</sub> are used besides their own (pers. comm.).

If it is not feasible to purchase additional CO<sub>2</sub> from Goodnature®, preferably purchase gold-colored canisters because the threads are less likely to adhere to the metal of the regulator (Goodnature®, pers. comm.; Fig. 7). For these canisters, apply a tiny smear of silicone grease (available in the plumbing section of a hardware store) to the tip of the canister. It may also be helpful to also apply some silicone to the threads of the canister to prevent it from getting stuck.



Figure 7. 16 gram threaded gold-colored CO<sub>2</sub> canister.

When installing a CO<sub>2</sub> canister, make sure there is no debris or dirt on the tip or threads. Gently screw the canister into the trap until an obvious stop is felt. Do not over-tighten as this can damage the trap.

Steps for installing a Goodnature® counter onto a canister are as follows:

- It is helpful to slide the counter onto the canister before screwing in the canister
- The counter must be pushed as far onto the canister as possible (the bottom of the canister fits into the curve on the back of the canister)
- The counter must face directly out from the trap (adjust by spinning in the direction of tightening the canister)

To remove a CO<sub>2</sub> canister, first relieve the majority of gas pressure inside the trap by holding down the trigger from the top (where the bait sits) until the gas runs out. This causes the canister to become very cold and frosty. Try to gently unscrew the canister but stop if it does not turn or if the whole regulator it is screwed into begins to turn. There are a few tricks that seem to help in the removal when the canister does not easily unscrew:

- Let the canister come back to ambient temperature and verify that there is no residual gas pressure inside the trap by firing the trap or holding down the trigger – *try to unscrew again*
- If it is still stuck, try holding down trigger from top with one hand while attempting to unscrew the canister with the other hand
- If *still* stuck, bring trap with canister attached out of field to try again in office
- When all else fails or the regulator comes out, mail the trap back to Goodnature® for repairs

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## **BAIT SELECTION, DATA COLLECTION & MAINTENANCE**

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### ***Bait Considerations***

Peanut butter has consistently been found by OANRP to be the most attractive bait to rats (unpublished data); therefore, it is the most commonly used bait in the Kahanahaiki snap trap grid. In the Pahole A24 project, peanut butter was used exclusively in the A24s from the start of the project in October, 2012 to February, 2013 to determine the effectiveness of A24s at both attracting rats and killing them. The peanut butter in the A24s was refreshed approximately every two weeks, which was roughly the same interval that the snap trap grid at Kahanahaiki was maintained in order to allow for comparison. Using bait that is known to be highly attractive to rats limited possible confounding data regarding the effectiveness of A24s. Additionally, using peanut butter allowed for comparison of effectiveness between snap traps and A24s.

The major downside to peanut butter is that it is often eaten by slugs or ants within days, or goes rancid after a few weeks. For the Pahole project, this was not as much of a concern initially because the objective was to learn as much about the performance of A24s relative to snap traps so the traps were checked frequently. However, finding a bait that is highly attractive over months will be essential to maximizing the utility of A24s. In May, 2013, the trap check/bait refreshing intervals were lengthened to monthly at Pahole. One reason for this change was that sufficient data had been collected regarding trap performance at a two-week interval, and the goal for using A24s is to stretch the interval as long as possible for on-going rat control. Another reason to lengthen the time between checks was to test the attractiveness of various baits in the traps over a longer period.

Experimenting with new baits to investigate their relative attractiveness and longevity in the field began on February 26, 2013. Various attractants were tested. These included:

- Regular creamy peanut butter (PB)
- Goodnature® cinnamon lure that came with the traps
- PB and coconut oil infused bee's wax chunks (Fig. 8), with or without a preservative (potassium sorbate)
- Fish oil
- PB with a preservative (silica) from Goodnature® (now comes as the standard bait with A24s)



Figure 8. Peanut butter, coconut, and preservative infused bee's wax chunks.

*The wax chunks were used in the A24 in place of the bait jar. They were homemade in cupcake tins or ice cube trays.*

Different quantities of the baits were available at different times and were deployed for various lengths of time. This method of testing baits was to troubleshoot and to broadly assess attractiveness relative to regular peanut butter, with the ultimate goal of identifying a lure that lasted longer and was equally as attractive.

The three types of peanut butter baits clearly caught more rats per trap night (TN) than the other two baits (Fig. 9). Regular creamy peanut butter was used the most throughout the trial period (2507 TN) and also killed the most rats (132 rats); however, it tied for rats per trap night with the preservative peanut butter bait (0.053 rats/TN). Peanut butter and coconut oil infused bee's wax chunks, also with a preservative (potassium sorbate), were also successful at attracting rats (0.051 rats/TN). The Goodnature® cinnamon lure was marginal in its attractiveness; despite being used fairly frequently (1444 TN), it had less than half of the rats/TN than the peanut butter based lures did. However, this bait was very long-lasting and may have potential use at sites that are not accessed frequently. The fish oil used in this trial was not promising.

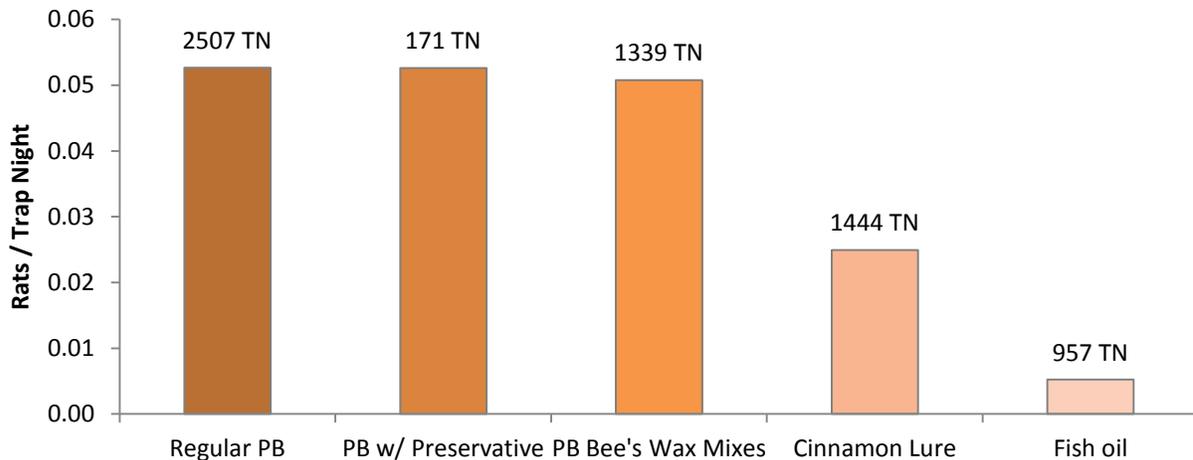


Figure 9. Results from bait trials conducted in Pahole NAR.

*Various baits were deployed at different times and in different quantities from February 26 to August 12, 2013. The number of trap nights (TN) was calculated by multiplying the number of traps with each bait by the number of nights it was available; data shown in rats/trap night in order to normalize the variance between the number of trap nights each bait was available.*

The recommendation derived from these investigations is to use a peanut butter-based lure that has some sort of preservative in it for longevity. Regular peanut butter went rancid after two to four weeks in the mesic forest of Pahole but the peanut butter with preservative appeared to stay fresh for over two months. OANRP is pleased that the preservative peanut butter is now shipped with new orders of A24s as the standard bait. Wax concoctions may be more resistant to slugs/ants but perhaps are not necessary with a good supply of preservative-infused peanut butter. More testing is necessary.

A useful tip for filling the Goodnature® bait jars with peanut butter (or any other cream/paste) is to cut the jar in half, fill the top half, then use the bottom half of the jar to squish out peanut butter through the mesh (Fig. 10). Use the bottom half as a cap. In the field, fresh bait can easily be added and then squished out. This method may be easier than trying to fill the whole jar through the opening in the top.



Figure 10. Cut bait jars for easy filling and dispensing of peanut butter. *Idea and photo courtesy of Goodnature® Ltd.*

**Pre-Baiting for Rat “Knockdown”**

The Department of Conservation recommends pre-baiting all traps in the field before the traps are set in order to promote trap familiarity and allow the rats to communicate information to other rats about

their new food source (D. Peters, pers. comm.). This way, a larger “knockdown” of the rat population will occur more quickly. It is also advisable to smear peanut butter (or other bait) on the tree below each trap to encourage rats to investigate the trap. All 45 A24s in the Pahole grid were pre-baited with peanut butter in this manner at least four days prior to becoming active. The traps may need to be serviced more frequently during the initial knockdown period to ensure that the bait is still present and fresh.

### ***Carcass Scavenging & Digital Counter Utility***

Counters are a necessary purchase if data collection regarding number of rats killed is important because scavenging of rat carcasses by other predators is a frequent occurrence. In Pahole, none of the traps had counters for the first three weeks because they were not yet available from Goodnature®. It was therefore necessary to frequently check all 45 traps to search for signs of rat kills in order to estimate how many rats were killed. From October 26 to November 16, 2012, the traps were checked every two to three days for a total of eight times. This intensive checking of the traps and refreshing of the bait also served to assess overall trap function and ensure that the traps would attract rats. Rat carcasses were sprayed with blue dye or spray paint in order to avoid mistakenly counting them again the next time. The number of previously observed “blue” carcasses at each trap was recorded in order to estimate scavenging rate by other predators (i.e. cats or mongooses). The data indicate that *after two to three days, 48%* of previously observed carcasses were missing.

Digital counters were received on November 14. From that time forward, data regarding number of kills at each trap for the remainder of the Pahole project was recorded from the counters instead of visual observations. Additionally, the trap check/bait refreshing interval transitioned to bi-monthly to be comparable to the snap trap grid at Kahanahaiki. Data from these bi-monthly checks indicate that only 10% of “counts” registered on the counters had rat carcasses present at the trap. When the trap check interval transitioned to monthly in May, only 2% of “counts” had rat carcasses present.

Clearly, frequent scavenging of rat carcasses occurs by predators such as cats, mongooses, other rats, or owls (pueo seen in Upper Limahuli Preserve, Kauai; M. Lucas, pers. comm.; Fig. 11). Indeed, tracking tunnels from Pahole indicate a high presence of cats in the trapping area and many of the traps were marked with urine.



Figure 11. Two pueo (*Asio flammeus sandwichensis*) staking out an A24 in Upper Limahuli Preserve. Photo courtesy of Matt Lucas, National Tropical Botanical Garden.

It should be noted that the counters are not 100% accurate representations of the number of rats killed. Large slugs such as *Limax maximus* can trigger the trap. Also, globs of peanut butter can fall onto the trigger and cause the trap to fire or in some cases deplete the trap from all gas; this seems to occur most frequently with bait jars that do not have a plastic mesh screen over the opening. On two occasions, there was a rat carcass present at a trap but no count on the counter.

Because the technology of automatic traps is new and there is limited research to indicate a true “best practice” for their use, it is recommended to purchase at least some counters initially in a project in order to approximate the number of rats killed and gauge rat control efficacy. Note: it is important to also conduct monitoring in order to gauge efficacy of rat control (see “Monitoring”). Counters are also a necessary tool for collecting data to determine relative attractiveness of various baits.

**Checking Traps & Recording Data**

After the pre-baiting and initial knockdown of rats has occurred, the necessary interval for checking traps is highly variable and dependent on the longevity of the bait used. If bait longevity is a concern, A24s should be checked and bait refreshed each month. However, the traps are not intended to be serviced so frequently; each can kill up to 24 rats which likely means it could be active for several months without servicing. Again, finding a bait that maintains its palatability over three months is the key to maximizing the utility of the A24s and reducing long-term rat control costs.

When checking an A24, first examine the area for signs of a kill, especially downhill from the trap. Keep in mind that there will likely not be any signs of a kill due to scavenging; however, during the frequent checks in Pahole, rat carcasses were often detected by smell or a blood spot before being visually observed. In addition to the number of rat carcasses present, other data that can be recorded include the number indicated on the counter (if applicable), notes regarding bait, whether or not the CO<sub>2</sub> or entire trap was replaced, and any other relevant notes (Fig. 12). Because the technology of A24s is still new and there have been some mechanical malfunctions (discussed in next section), it is currently recommended to test-fire each trap by triggering it from above (where the bait container screws into the trap) to ensure that there is still CO<sub>2</sub> present and that the trap is functioning properly. If there is a counter installed on the trap, ensure that the counter records the test-fire. Counters can be reset to avoid counting the test-fire.

Trap	Counter #	Trap Test	Ctr Test	# New Bodies	Bait Notes	Co2 Changed?	New Trap?	Functioning on Departure? Comments?
A1								
A2								
A3								
A4								
A5								

Figure 12. Sample of data sheet used in Pahole NAR.

**Mechanical Malfunctions**

OANRP received one of the first models of A24s that Goodnature® had on the market. Because OANRP initially assumed that the new traps would function for months without servicing, the gas canisters were not replaced in the 45 A24s in Pahole for the first three months nor were any of the traps test-fired. Upon first attempt to replace gas canisters on February 1, 2013, five traps were suspiciously out of CO<sub>2</sub>, indicating a slow leak. Two weeks later, six additional traps showed signs of leaking gas. Over time, 25 out of the 66 traps in OANRP’s possession had mechanical failures, most of them leaking gas. The National Tropical Botanical Garden (M. Lucas, pers. comm.) and the New Zealand Department of

Conservation (Gillies *et al.*, 2012) independently found similar results with early models of A24s. All faulty traps were sent to Goodnature® for fault diagnoses and repair. In April, all of OANRP's traps received mechanical updates (new type of o-ring and diaphragm) which greatly improved their reliability and performance. Nevertheless, it is still recommended to test-fire each trap periodically to ensure it is functioning properly.

Additionally, the batteries on the digital counters have been unreliable. According to Goodnature®, even with frequent checks they are supposed to last five years, but 12 out of 59 counters have died over the past ten months. Like the A24s, all faulty counters were returned and replaced by Goodnature®. The company recently found a new manufacturer for the counters so hopefully the unreliable battery life won't continue to be an issue.

Based on the responsiveness of Goodnature® to these issues, OANRP is optimistic that the trap design will continue to improve and become more reliable.

## MONITORING

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### **Monitoring Rat Activity**

Footprint tracking tunnels are used to index rat activity levels. They are used to compare relative abundances of rodents within similar habitat types and are best when coupled with another sampling method, e.g. monitoring fruit predation (Blackwell 2002). OANRP has found them to be most useful in detecting a difference in rat activity inside a rat control area relative to an adjacent "non-treatment" area (OANRP, unpublished data). The set-up consists of paper cards with ink-pads placed inside plastic tunnels that record rodent tracks when the animal walks through the tunnel. The tracks are analyzed by rodent type and counted as either present or absent; no inference on the number of rodents of each species is made. Tracking tunnel cards are typically baited with peanut butter, set out for one night, and collected the next day (Fig. 13).



Figure 13. Tracking tunnel and ink card with tracks at Pahole NAR.

In the Pahole A24 project, 29 tunnels were placed inside the rat control area. An additional 24 tunnels were placed in a management area to the east known as Kapuna (also part of Pahole NAR) for comparison. All tunnels were run prior to the A24s becoming active in October 2012 to determine pre-treatment rat activity levels. Thereafter, all tunnels were run on a monthly basis.

As would be expected in comparable habitat types, rat activity in October (prior to trapping) was similar in Pahole and Kapuna (Fig. 14). After trapping began, rat activity in Pahole was consistently lower than in Kapuna. The difference between the two sites, however, did not become statistically significant until February (chi square test,  $p < 0.05$ ). The rat levels in Pahole remained significantly lower than in Kapuna for the remainder of the project, with the exception of May. In April, all 45 traps were removed from the field for the mechanical updates previously mentioned so it is assumed that this break gave the rat population a chance to rebound. From June to August, rat activity was again significantly less in Pahole than in Kapuna.

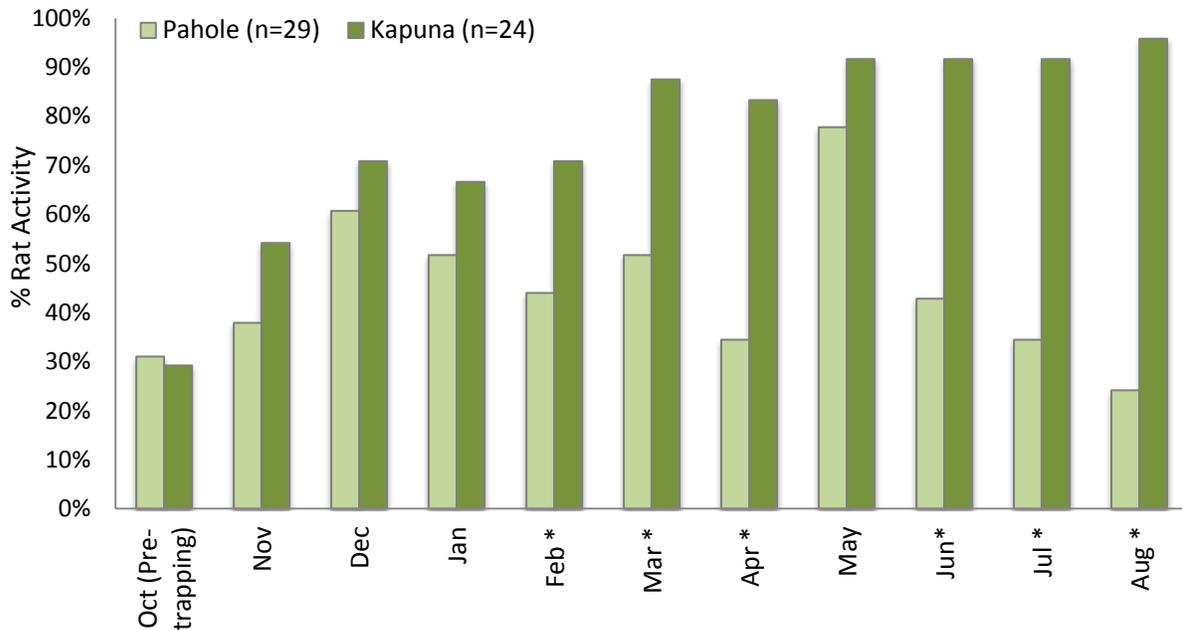


Figure 14. Rat activity at Pahole (A24 grid) and at Kapuna (non-treatment site). Data collected from October 2012 to August 2013 using tracking tunnels. The \* indicates months that had significantly less rat activity at Pahole than Kapuna (chi test,  $p < 0.05$ ).

The data from the tracking tunnels indicate that the 100 m by 50 m layout was sufficient at reducing overall rat activity inside the managed area. However, it is perhaps even more important to directly monitor resource response to a rat control effort, as discussed below.

**Monitoring Rat Predation on Resources**

Rat control programs in natural areas are typically designed to protect a particular rare species, but can also be implemented across an ecosystem to benefit all species that are directly or indirectly affected by rats. This section focuses on monitoring a single species for rat predation to gauge the effectiveness of rat control.

In Pahole, the A24 grid was arranged around an outplanting of *Cyanea superba* subspecies *superba*, an endemic Hawaiian tree which has fruit that are highly attractive to rats. Rat control is considered essential for managing the species. The A24 grid created a buffer of rat control for the plants that was comparable to the buffer of protection the *C. superba* received from the snap trap grid in Kahanahaiki (refer to “Grid Layout Considerations,” page 6, for more information). All traps were deployed six weeks before the fruit became mature (early December).

In 2010, Pender et al. (2012) found that predation by rats on *C. superba* fruit from December 2009 – January 2010 was higher in Pahole where there was no rat control at the time than in Kahanahaiki where the snap trap grid had been running since May 2009. This difference was assumed to be due to the lack of rat control in Pahole and the effectiveness of the Kahanahaiki snap trap grid at controlling rats. The results from Pender *et al.* (2012) provided a unique opportunity to test the effectiveness of the A24 grid at Pahole.

Using their dataset, the change in fruit predation after the installation of A24s in Pahole could be detected. It was assumed that if the percentage of fruit predated at Kahanahaiki and Pahole changed similarly over time (either positively or negatively), then it would indicate that installing A24s in Pahole had *no effect* on fruit predation (e.g. rats not adequately controlled). If the change in the amount of fruit consumed by rats between the 2009 fruiting season and the 2012 fruiting season was significantly reduced in Pahole relative to Kahanahaiki, then it could be asserted that the A24s had an effect on predation.

The methods for monitoring rat predation on *C. superba* in this study were identical to those outlined in Pender et al. (2012); however only a subset of the total number of plants in the 2009 study were monitored. To summarize the methods, when the fruit became mature (December 6, 2012), individual plants were monitored for rodent damage every 2-3 days at Kahanahaiki (N = 13) and at Pahole (N = 11). On each visit, the number of predated fruit on each infructescence was recorded in order to calculate the total proportion of fruit predated at each site (Fig. 15). The monitoring concluded on January 22, 2013. For comparison between years, the 2009 dataset was reduced to only include the subset of plants that were monitored in 2012.



Figure 15. *C. superba* fruit that has been marked with an 'X' after being recorded as predated.

The results of the monitoring effort indicate that overall, predation was unacceptably high by OANRP management standards at both sites (Fig. 16). The percent of total fruit predated at Kahanahaiki increased from 5% (2009) to 43% (2012) and at Pahole it increased from 60% (2009) to 73% (2012). However, because the increase in predation at Kahanahaiki was far greater than the increase in predation at Pahole, it is assumed that the A24s likely prevented a worse increase in predation at Pahole. If the addition of A24s had made no difference, theoretically, there would have been the same magnitude of change in predation at both sites.

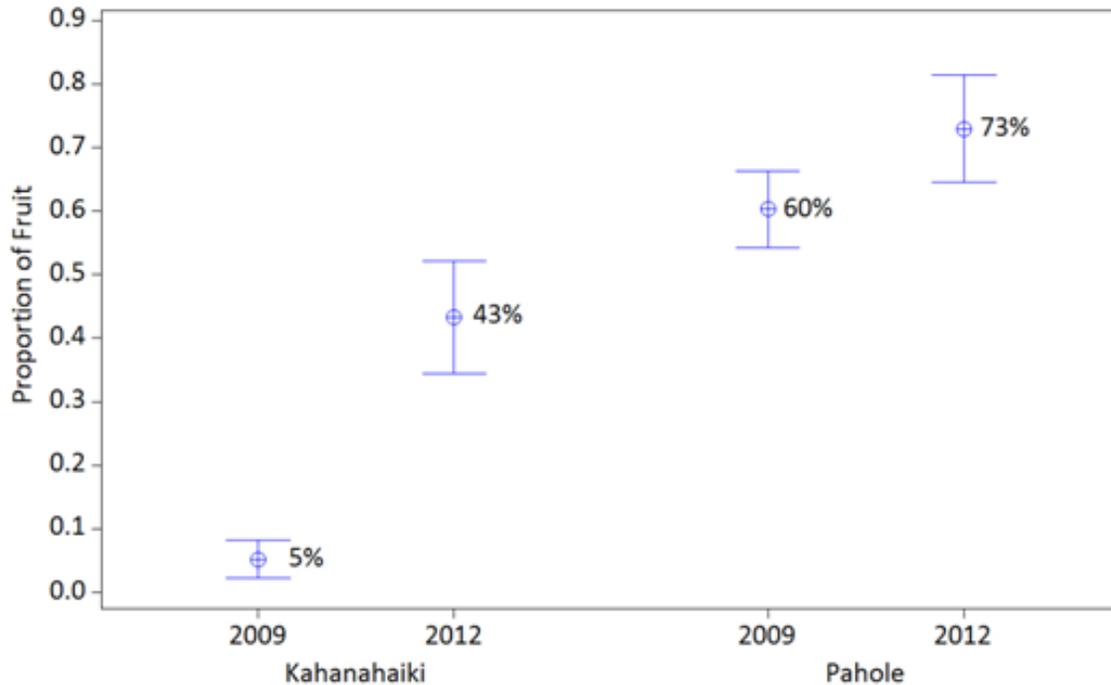


Figure 16. Proportion of *C. superba* fruits predated over time. Bars are one standard error from the mean.

These results illustrate the need for direct monitoring of resources to gauge whether rat control goals are achieved. In the future, OANRP will likely employ a smaller and denser grid of A24s closer to the *C. superba*.

Other methods of monitoring efficacy of rat control include sampling predation on seeds found on ground (such as guava seeds) before, during, and after a rat control method is employed. Sampling seedling diversity (species abundance and richness) is another way to detect change over time that may be a result of rat control. Attractive fruits (such as lama) can also be placed in tracking tunnels on ink cards (instead of peanut butter) to detect rat predation on resources. Invertebrates have also been shown to respond to rat control efforts (Krushelnycky 2011), however, this method of monitoring is highly labor intensive. Combining multiple monitoring methods will yield the most comprehensive information regarding the effectiveness of rat control and guide in the creation of adaptive management protocols.

## CONCLUSIONS & IMPLICATIONS

The results of this study indicate that a grid of Goodnature® A24 traps may be more effective and efficient for rat control than a large-scale snap trap grid. At Pahole NAR, the grid of A24s killed more rats per hectare than the large-scale snap trap grid at Kahanahaiki. Moreover, 65% less labor was required to conduct the monitoring and maintenance of the A24 grid than the snap trap grid. In actual management practice, even less labor would be required to maintain an A24 grid than the labor invested in this project because the A24s were checked frequently to collect data. Changing a grid of snap traps to A24s is predicted to be more cost-effective due to reduced labor costs.

To maximize the utility and cost-effectiveness of A24s, the goal is to install them at priority sites and check them every few months. To be confident in the rat control efficacy of a grid of A24s, consider the following objectives and recommendations:

- 1) The grid design should correspond to management goals.
  - *Recommendation:* A large-scale grid of traps spaced 100 m by 50 m may be adequate for overall reduction in rat control across an ecosystem. A tighter grid of traps spaced 25 m by 25 m may be necessary to protect a particularly vulnerable species. The larger the buffer of traps around a resource, the better (ideally at least 50 m).
- 2) The bait should persist for months and maintain palatability.
  - *Recommendation:* Use a peanut butter-based bait with an added preservative.
- 3) The traps should be mechanically sound; no leaking gas or other malfunctions.
  - *Recommendation:* Test-fire A24s every check until sufficient confidence in trap performance is obtained. Only use gas canisters purchased from Goodnature®.
- 4) Monitor the efficacy of grid design and overall rat control.
  - *Recommendation:* Run tracking tunnels periodically inside and outside of the rat control area to detect changes in rat activity. Also monitor predation on resources to ensure management goals are met.

Gaining a new tool for rat control is especially valuable in Hawaii because there are limited options available and all methods have limitations or restrictions. OANRP considers the utility of A24s to be the greatest at remote sites that require helicopter access or are otherwise difficult to access.

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