

CHAPTER 6: RODENT MANAGEMENT

OANRP has managed MIP and OIP species that are subject to rodent predation with various strategies since 1997. This chapter discusses rodent control methods utilized over the past reporting year and also highlights recent changes. Specifically, this chapter has five main sections: Section 6.1 provides an overview of the current rodent control program and discusses recent changes, Section 6.2 reports on the status of the large-scale trapping grids at Kahanahaiki, Palikea, and Ekahanui, Section 6.3 provides results of an investigation into data quality for trapping grids, Section 6.4 highlights recent bait trials for traps, and Section 6.5 discusses the new Goodnature® A24 automatic rat traps.

6.1 OANRP Rodent Control Program Summary

OANRP manages some species only seasonally (e.g., *Chasiempis ibidis* or ‘Oahu Elepaio’ during the nesting season), while other species are protected year-round (e.g., *Achatinella* spp.). The methods of rodent control that OANRP currently utilizes for rodent control are limited to using kill-traps (Victor® traps, Ka Mate™ traps, and Goodnature® A24 traps) and predator exclosures. The use of bait stations with the rodenticide Ramik® (0.005% diphacinone) was utilized prior to June 8, 2013, when the Ramik® pesticide label expired.

Rat control in 2013 consisted of deploying small Victor® snap trap grids around resources, maintaining large-scale trapping grids consisting of Victor® or Ka Mate™ traps, constructing predator exclusion fences, and until August, collecting data from a Goodnature® A24 trap temporary research grid (Table 1). More Goodnature® traps will be installed across MUs over the next year. OANRP contracts Pono Pacific to conduct rat control during Elepaio nesting season (December – June) at Ekahanui, Kahanahaiki, Moanalua, Palehua, and Schofield Barracks West Range (SBW).

Table 1. Current rat control strategies utilized by OANRP as of October 2013.

MU/Area	Primary Spp. Protected	Control Method	Description	# Traps	Trap Type	Deployment	Interval
Ekahanui	<i>A. mustelina</i>	Trapping Grid	Many small grids	47	Victor w/out boxes	Year-round	4-6 weeks
Ekahanui†	<i>C. ibidis</i>	Trapping Grid	Large-scale grid	620	Victor w/ & w/out boxes ⁱ	Annual: Dec-June	2 weeks
Kahanahaiki	<i>A. mustelina</i>	Predator Exclosure	Constructed 1998	--	--	Year-round	--
Kahanahaiki†	<i>A. mustelina</i> , <i>C. superba</i>	Trapping Grid	Large-scale grid	464	Victor w/ boxes	Year-round	2 weeks
Kamaohanui	<i>A. mustelina</i>	Trapping Grid	One small grid	60	Ka Mate	Year-round	6 weeks
Koloa***	<i>A. livida</i>	Trapping Grid	Three small grids	76	Victor w/ boxes	Year-round	--
Makaha	<i>A. mustelina</i>	Trapping Grid	One small grid	30	Victor w/out boxes	Year-round	6 weeks
Moanalua†	<i>C. ibidis</i>	Trapping Grid	Many small grids*	312	Victor w/out boxes	Annual: Dec-June	2 weeks
Ohikilolo	<i>A. mustelina</i> , <i>P. kaalae</i>	Trapping Grid	Many small grids	47	Victor w/ boxes	Year-round	6 weeks
Opaeula***	<i>A. sowerbyana</i>	Trapping Grid	Many small grids	91	Victor w/ boxes	Year-round	--
Pahole	<i>C. superba</i>	Trapping	A24 Automatic	45**	Automatic	Oct '12 -	Varied

		Grid**	traps		traps	Aug '13	
Palehua†	<i>C. ibidis</i>	Trapping Grid	Many small grids*	180	Victor w/out boxes	Annual: Dec-June	2 weeks
Palikea	<i>A. mustelina</i>	Predator Exclosure	Constructed 2012	--	--	Year-round	--
Palikea-Mauna Kapu	<i>A. mustelina</i>	Trapping Grid	One small grid	15	Victor w/ boxes	Year-round	6 weeks
Palikea†	<i>A. mustelina</i>	Trapping Grid	Large-scale grid	189	Ka Mate	Year-round	2 weeks
Poamoho	<i>A. sowerbyana</i>	Predator Exclosure	Under Construction	16	Victor w/ boxes	Year-round	6 weeks
Poamoho***	<i>A. sowerbyana</i>	Trapping Grid	One small grid	16	Victor w/ boxes	Year-round	--
SBW- N. Haleauau‡	<i>A. mustelina</i>	Trapping Grid	One small grid	28	Victor w/out boxes	Year-round	6 weeks
SBW†	<i>C. ibidis</i>	Trapping Grid	Many small grids*	372	Victor w/out boxes	Annual: Dec-June	2 weeks
W. Makaleha	<i>C. grimesiana</i>	Trapping Grid	One small grid	28	Victor w/out boxes	Year-round	6 weeks
Waieli-Hapapa	<i>A. mustelina</i>	Trapping Grid	One small grid	38	Victor w/out boxes	Year-round	6 weeks
Waieli-Hapapa	<i>A. mustelina</i>	Predator Exclosure	Constructed 2011	--	--	Year-round	--

* Each managed Elepaio (*C. ibidis*) territory has 12 traps installed ~12 m apart in trees.

** Temporary grid designed to investigate traps; a new grid of A24s will be installed in November 2013

*** Beginning in October 2013, OANRP will discontinue maintenance of these grids due to lack of funding for Tier 2 and Tier 3 species. The Oahu Snail Extinction Prevention Program will conduct rodent control at these sites.

† Contracted Pono Pacific to maintain rat grids during Elepaio nesting season.

‡ N. Haleauau snail sites are included during Elepaio nesting season.

i The majority of traps have been removed from the wooden boxes and placed in trees.

Over the past two years, OANRP has phased out the use of bait stations due primarily to concerns related to bait efficiency/dynamics, bait longevity, and expense. Please refer to Chapter 6 of the 2012 OANRP Status Report for more details about these issues. As a result of many discussions within OANRP and with the US Fish and Wildlife Services, in 2012 OANRP removed 76% of the total number of bait stations deployed across MUs and replaced them with small snap trap grids (OANRP 2012). Over the past year, OANRP continued this process and removed the last remaining bait station grids, replacing them with snap trap grids.

Primarily, the changes in 2013 consisted of modifying the rodent control method in Elepaio territories from using grids that combined bait stations and snap traps to small grids of 12 snap traps centered on the core area used for nesting. Many territories are adjacent to one another; therefore, the small grids are somewhat continuous in some areas (see Elepaio Management Chapter for more information). The remaining MUs with bait station grids were replaced with snap traps over the course of the year; the last MUs to have their bait stations removed were Ekahanui and Ohikilolo.

OANRP does not plan on returning to the use of bait stations when the new label is approved due to the aforementioned concerns. Additionally, when the new Ramik® label is approved, it will have stricter stipulations and grid design requirements (Swift, pers. comm. 2013) that will likely preclude the use of Ramik® at most sites (i.e., the grid design and maintenance requirements may be impractical to meet).

A new tool for rat control recently became available from New Zealand: self-resetting rat traps called A24s created by Goodnature® Ltd. A24s are useful for rat control at more remote sites because the traps are designed to be set out for months without servicing, resulting in cheaper maintenance costs (see Appendix 6-1 for details). Remote sites that require access by helicopter may be especially ideal for A24s. OANRP is planning on installing A24s in the near future at several MUs and at many sites in the Koolau mountain range for protection of Kahuli tree snails.¹ These plans are discussed in Section 6.5. Having a new tool available for rat control in Hawaii is especially helpful since the use of bait stations is not an available or feasible option.

OANRP is continually researching and assessing rat control methods to determine the most effective strategies for the protection of natural resources.

6.2 Large-Scale Trapping Grid Updates

OANRP maintains three large-scale trapping grids in three management units (MUs) in the Waianae mountain range. The first grid at Kahanahaiki was installed in May 2009, the second grid at Palikea was installed in September 2010, and the third grid was installed at Ekahanui in January 2011. These grids are designed for large-scale lethal trapping for rats (*Rattus* sp.) across MUs. The overall goal is to reduce rat activity within an MU to a level that benefits the endangered plants, *A. mustelina* (Oahu tree snail), *C. ibidis* (Oahu Elepaio), native insects, and the native ecosystem as a whole. The grids are designed to target rats because they are the largest rodent threat to the natural resources OANRP protects (Mosher 2010, Shiels 2010). Mice have a much smaller home-range size than rats and the grids are not designed for effective trapping of mice. Consequently, this section discusses rat kills and rat activity only, although mice and mongooses are periodically killed in the trapping grids as well. The trapping grids follow the New Zealand Department of Conservation's (DOC) current best practices for kill trapping rats (NZ DOC 2005), however the grids vary in design, size, maintenance protocols, and trap type (discussed below). For more information about how these three trapping grids are designed, maintained, and monitored, refer to the 2011 Status Report (OANRP 2011).

Rat activity was monitored using tracking tunnels at least once a quarter inside each grid as well as outside (at a control site) for two years. OANRP determined that sufficient data had been collected to determine any differences inside and outside of the trapping grids after two years. In the Kahanahaiki grid, there was consistently less rat activity inside the trapping grid than outside the grid (control site was Pahole NAR). At Palikea, two years of rat activity data consistently showed less rat activity inside the trapping grid than in the control area (Kaaikukai). However, at Ekahanui, the tracking tunnel data did not show any clear trends or differences in rat activity inside the trapping grid versus outside (North Ekahanui). One reason for this may be that inside the Ekahanui grid there were 59 tunnels and in North Ekahanui there were only 16. This difference in sampling size is not ideal for comparison. Another factor is that the habitat in North Ekahanui is very different than the habitat inside the trapping grid. Rat activity is still monitored using tracking tunnels every quarter at each grid. However, there does not seem to be a clear correlation between trapping data and rat activity in tracking tunnels. Shiels (2010) also found no correlation between rat activity in tracking tunnels and estimates of rat abundances. Additionally, there was no correlation between rat activity in tracking tunnels and rat kills by automatic rat traps (see Appendix 6-1 for more information). OANRP continues to monitor rat activity with tracking tunnels on a quarterly basis inside each trapping grid. The utility of tracking tunnels for ongoing

¹ OANRP will not be actively managing Koolau snail sites beginning October 2013 due to a loss of funding for the management of Tier 2 and Tier 3 species. The Oahu Snail Extinction Prevention Program is taking over rodent control actions and snail management at these sites.

monitoring is uncertain; however, it has been recommended to continue to monitor rat activity using tracking tunnels (Peters, pers. comm.). According to Blackwell et al. (2002), using multiple methods for assessing rat densities increases the confidence in observed population trends and the overall quality and quantity of information gained. There have been no significant correlations found in trapping data and tracking tunnel data at any of OANRP's grids; however, OANRP plans to geographically assess tracking tunnel data in conjunction with trapping data to determine trends or "hotspots" across the grids.

In New Zealand, DOC uses tracking tunnels inside and outside of large trapping areas (> 200 ha) to assess efficacy of rodent control. They have also defined a 'damage threshold' at which rat activity in tracking tunnels must remain below in order to achieve management goals for a species (Hill pers. comm. 2011). OANRP has not been able to determine a damage threshold for rat activity in tracking tunnels that corresponds to management goals. Perhaps the trapping grids OANRP installed are too small or are otherwise unable to maintain a reduced population of rats inside the grid. Consequently, the tracking tunnel data likely reflects rat activity from new rats that are constantly moving into the trapping area, causing large fluctuations in tracking tunnel data. Additionally, the ability of a single rat to track multiple tracking tunnels makes the index susceptible to changes in activity and rodent abundance (Blackwell et al. 2002).

Instead of using rat activity in tracking tunnels to determine a 'damage threshold,' OANRP relies on trap catch data to indicate when increased trapping effort is necessary. The 'threshold' number of rat kills was selected for each grid by observing the number of rats killed in a two week period when seasonal high spikes occurred. Typically, rat catches remain below the threshold number; but when the threshold number is exceeded, the traps are baited and checked weekly until two consecutive weekly checks are completed with rat catches below the threshold number. Thereafter, twice monthly baiting resumes. The threshold number is used as a rough guideline for current management strategies. Each trapping grid is assessed separately for trends in the data and for determining the threshold number.

OANRP has looked at resource response since the trapping grids have been installed in a number of projects; thus far, all of these projects indicate a positive response overall (discussed in OANRP 2011). However, each grid has unique characteristics/successes/issues that spark questions and allow for testing and trialing of baits, trap types, and trap deployment techniques in order to improve rodent control efficacy and be more efficient with staff time. Because rat ecology is likely very different in Hawaii than in New Zealand, OANRP needs to tailor DOC's best practice guidelines to suit Hawaii's conditions.

OANRP has experienced difficulties and conditions that are not shared in New Zealand. For example, bait removal by slugs and other invertebrates is a major issue that is not experienced to the same degree in New Zealand. Additionally, it is possible that black rats (*R. rattus*) in Hawaii spend more time in trees than black rats in New Zealand (Peters, pers. comm. 2013). One question OANRP asked over the past year is whether or not rat control is improved by housing snap traps inside a protective box (typically placed on the ground) or whether uncovered snap traps mounted directly to trees is just as effective, if not more effective. Perhaps the rats would encounter the traps more easily if they were in trees and slugs would not encounter them as easily. DOC's best practice includes housing Victor[®] traps inside wooden boxes placed on the ground in order to exclude non-target species, guide target species, prevent accidental triggering, and maintain the integrity of the trap from weather (NZ DOC 2005). Recent trials in Ekahanui indicate that catch-rates may increase if traps are removed from the boxes and mounted off the ground in trees (discussed below in Ekahanui Trapping Grid section). OANRP is investigating this question further in Ekahanui over the next year and will use the results to help inform a best practice guide for OANRP's trapping grids.

Another question is whether Victor[®] traps are the best trap or if there are other types of traps that may prove to be more effective. The Palikea grid consists of metal Ka Mate[™] snap traps that were deployed in

order to experiment with that style of trap and compare the trapping efficacy to Victor[®] snap traps; they are deployed without wooden boxes because they have less risk of being accidentally triggered. More experimentation with Ka Mate[™] traps will occur over the next year. Automatic rat traps are a new type of trap that OANRP has recently tested and appears to be very promising; OANRP will expand the use of these traps to investigate their utility.

Additionally, OANRP will assess trapping data using GIS to ascertain any geographical trends and identify areas in need of more traps or areas where traps can be removed. Essentially, the reason for the differences between the grids and the objective for conducting these trials is to synthesize the data in order to define OANRP's best practice protocols for trapping grids. Adaptive management is essential and the best practice protocols will continue to evolve and employ varied methodologies.

In the sections below, summaries of recent trends in trapping data for each grid are assessed, the current management practices are discussed, and management considerations and changes for the coming year are highlighted. The data presented for each grid represent data collected since installation of the grid, unless otherwise stated.

6.2.1 Kahanahaiki Trapping Grid

The Kahanahaiki grid covers 65 acres (26 ha) of the Kahanahaiki MU. The grid is composed of 464 Victor[®] snap traps that are housed in protective wooden boxes on the ground; the perimeter consists of 234 traps spaced 12.5 meters apart and the interior contains 246 traps on transects and trails at a spacing of 25 meters apart. Since January 2012, Pono Pacific has maintained the grid from January to June and for the rest of the year OANRP staff resumes maintenance. All traps are typically checked and rebaited every two weeks unless more than 30 rats are caught on a single check; this number correlates to approximately 6.5% of the total number of traps and is used as the 'threshold' number.

As of October 3, 2013, the entire grid has been checked a total of 151 times and has killed 3,961 rats and 1,029 mice (Fig. 1). On average, 75 rat-kills have been recorded each month; the seasonal high spikes throughout the year are likely the reason the monthly average is so high. The average number of rats killed in a check is 24. Over the years, some annual trends have emerged. Catch rates in mid to late summer are typically the lowest of the year and catch rates are typically the highest in early winter. One possible explanation for this trend is that during the summer months, rats may not have to scavenge as much due to an abundant food source from strawberry guava fruits and therefore are not as inclined to visit the bait on snap traps. After the fruiting season ends in the fall, there is a boom in rat activity (possibly due to higher birth rates as a consequence of increased food consumption) and increased scavenging for food. This increase in the rat population without the supply of strawberry guava fruit causes more rats to be caught in snap traps. A second spike in catch rates has also been observed in March/April. These fluctuations correspond to previously documented trends; Shiels (2010) found that April-May and October-December tended to be the months with the greatest numbers of black rats at three study sites in the same region (including Kahanahaiki). Tomich (1981) also documented two seasonal peaks in reproduction: August to November and February to June. As seen in the Palikea grid, there were more high spikes in 2011 than in any other years. Rat population densities likely vary from year to year based on a variety of environmental factors.

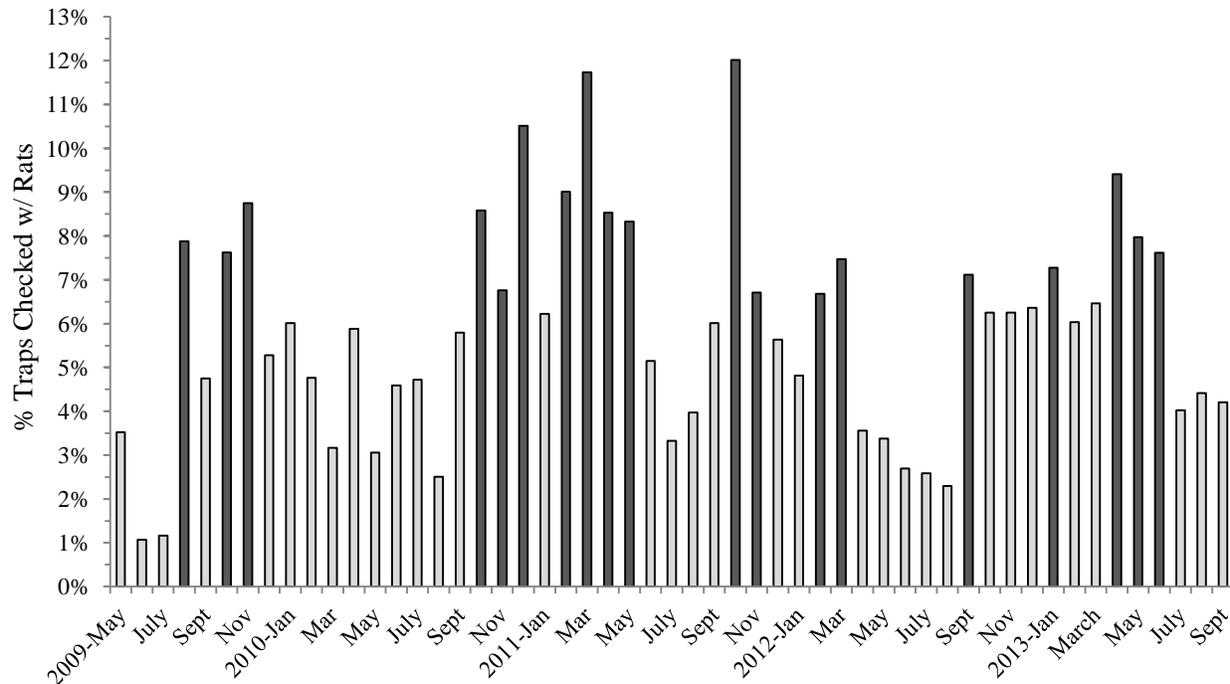


Figure 1. Percent of total traps checked each month at Kahanahaiki with rat catches. Dark gray bars represent months when the ‘threshold’ number of rats was exceeded.

OANRP continues to monitor rat activity with tracking tunnels on a quarterly basis inside the trapping grid. The tracking tunnels have been run 36 times total and the average rat activity in tunnels is 23.3% ($\pm 12.2\%$). The average rat activity each year has ranged from 17.8% to 29.9%.

Management Considerations for 2014

OANRP has begun to assess individual trap catch data to determine which areas of the grid catch the most rats and which areas catch the least. The grid was designed with traps spaced more closely together on the perimeter of the grid with the intention to stop rats from outside the grid from reaching the interior; however, data indicate that the traps on the interior catch more rats than on the perimeter. One reason for this could be that the trapping grid is not successful enough at keeping rat numbers low enough inside the grid in order to observe the perimeter traps creating a barrier; in this case, the grid would have to be larger, be maintained more frequently to ensure there is fresh bait available, and/or have more traps added to increase rat control. Kahanahaiki is a relatively skinny MU and rats can likely cross from one side of the trapping grid to another in a day. Another reason more rats may be caught in the interior traps could simply be that there are far more interior traps than perimeter traps and the interior traps cover a large distance. More analysis is needed to optimize the grid and OANRP is discussing alternatives; a GIS layer will be created to synthesize trapping data in order find geographical trends and identify areas in need of more traps or areas where traps can be removed.

OANRP is considering installing a grid of Goodnature[®] A24 automatic rat traps across the MU instead of maintaining the snap trap grid. As discussed in Appendix 6-1, a grid of A24s across the MU will be more cost-effective because A24s require less frequent maintenance than snap traps. A24s may also prove to be a more effective method of rat control because they are multi-kill devices. Installing a grid of A24s would provide another opportunity to investigate the functionality of A24s. Tracking tunnels will also be monitored inside and outside of the A24 grid to monitor changes in rat activity.

OANRP continues to test new baits to use on snap traps that will minimize slug and ant consumption and render traps more effective (see “Bait Persistence Trials” section).

6.2.2 Palikea Trapping Grid

The Palikea grid covers an area of 21 acres (9 ha) (Fig. 11). The grid consists of 180 Ka Mate™ traps; there are 98 traps on the perimeter of the MU spaced 12.5 meters apart and 82 traps in the interior of the MU spaced 25 meters apart along trails. Unlike the Ekahanui and Kahanahaiki grids, the Palikea grid consists of Ka Mate™ traps without boxes instead of Victor® traps in boxes. Ka Mate™ traps were deployed in order to experiment with that style of trap and compare the trapping efficacy to Victor® snap traps. Ka Mate™ traps are set by wedging hard bait, such as coconut, underneath the trigger. The bait is held in place by tension and the trap cannot trigger until the bait is removed. The traps are deployed without wooden boxes because they have less risk of being accidentally triggered. This grid is run by the contractor Pono Pacific year-round. All traps are typically checked and rebaited every two weeks unless more than 30 rats are caught on a single check; this number correlates to approximately 16.6% of the total number of traps and is used as the ‘threshold’ number.

As of October 3, 2013, a total of 1,630 rats and 183 mice have been recorded in the grid (Fig. 2). On average, approximately 24 rat kills are recorded each time the grid is checked. Yearly trends are not as distinct in the Palikea grid as in the Kahanahaiki grid but the summer catch rates are still relatively low compared to fall/early winter catch rates. In October 2011 a record of 237 rats were recorded in the grid (the traps were baited and checked weekly). As seen at Kahanahaiki, there were more high spikes in 2011 than in any other years. Rat population densities likely vary from year to year based on a variety of environmental factors.

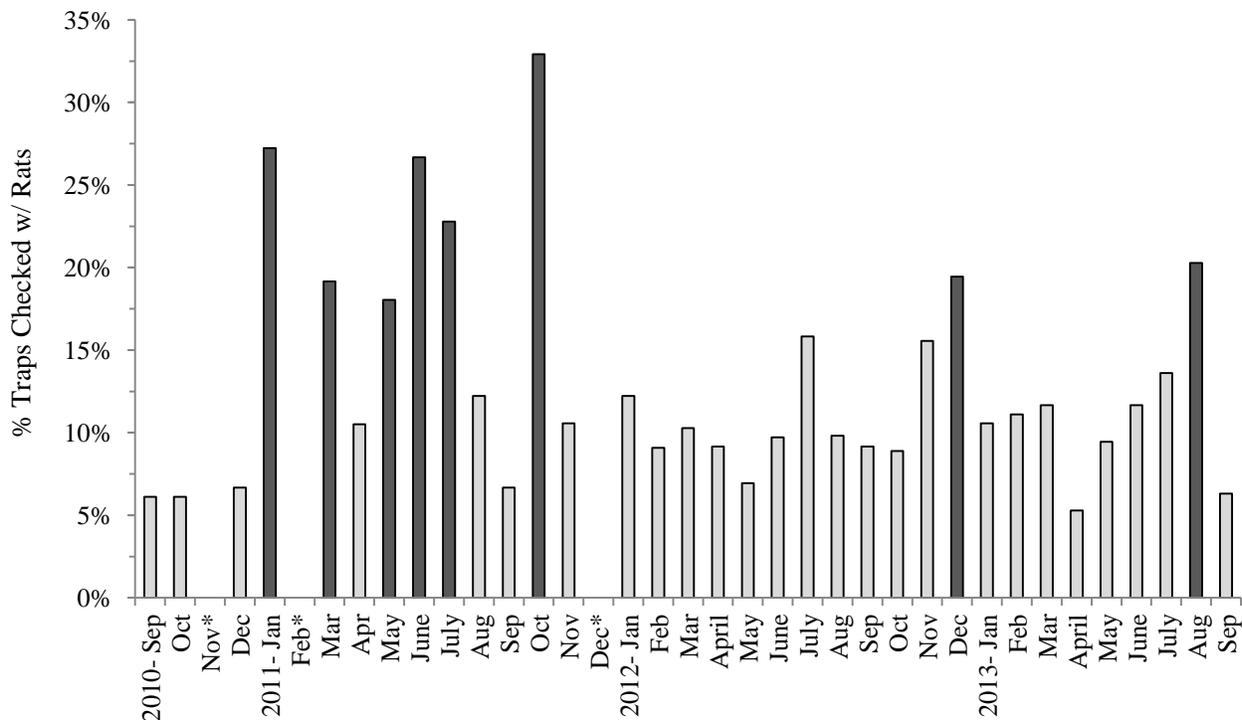


Figure 2. Percent of total traps checked each month at Palikea with rat catches.

*Dark gray bars represent months when the ‘threshold’ number of rats was exceeded. * indicate months that the grid was not checked.*

It is also remarkable that this grid catches more rats per trap (0.13 rats/trap) per check than the Kahanahaiki grid and Ekahanui grid (approximately 0.06 rats/trap and 0.09 rats/trap, respectively), although it is the smallest grid with the fewest traps. The Palikea grid is roughly a third the size of the grid at Kahanahaiki, yet the grids catch around the same number of rats in each check. Therefore, the threshold number to indicate spikes in rat numbers is the same at Palikea as it is at Kahanahaiki (30 rats caught in a two week period). Furthermore, the difference between the average tracking tunnel rat activity inside the trapping grid at Palikea versus the average rat activity at the control site (Kaaikukai) was greater than at any other trapping grid. Therefore, the Palikea grid appears to have the most noticeable effect on reducing rat activity relative to outside the grid.

There are several factors that may be influencing these trends. First, there may be a higher density of rats at Palikea than at the other two sites. Another explanation is that because Palikea is the only MU where the grid consists entirely of Ka Mate™ traps, it may indicate Ka Mate™ traps are more effective at killing rats than Victor® traps (see OANRP 2011 for results of a trial comparing trap types).

OANRP continues to monitor rat activity with tracking tunnels on a quarterly basis inside the trapping grid. The tracking tunnels have been run 20 times and the average rat activity in tunnels is 15.7% ($\pm 12.1\%$). The average rat activity in 2011 was 20.3%, 14.5% in 2012, and 9.4% to date in 2013.

Management Considerations for 2014

As with the other grids previously discussed, OANRP will create a GIS layer to synthesize trap catch data is needed to determine which areas are consistently catching higher numbers of rats in order to optimize grid design and ensure greater protection for rare resources. Ka Mate™ traps will continue to be used at Palikea but there will be continued investigation on the performance of Ka Mate™ traps relative to Victor® traps. Alternative baits to coconut will also be trialed. Pono Pacific will continue to run the grid through 2014.

6.2.3 Ekahanui Trapping Grid

The Ekahanui grid covers an area of 177 acres (72 ha). The grid consists of 620 Victor® snap traps that are housed in protective wooden boxes on the ground or placed in trees without boxes; there are 225 traps on the perimeter of the MU and 394 traps in the interior of the MU, all spaced 25 meters apart. All traps are checked twice per month until the end of the nesting season (June). The off-season is from July to November each year. In the 2011 off-season, the entire grid was baited once a month and then a subset of the traps (150) was baited a second time each month to control rodents around populations of *Achatinella mustelina*. In the 2012 and 2013 off-season, the subset of traps was baited only once a month; it was determined that running the entire grid once a month was not necessary during the off-season. In 2013, the subset of traps was modified to include areas with traps that were previously maintained by OANRP in order to be more efficient with staff time. The grid is maintained by the contractor Pono Pacific. There are no clear trends to indicate a ‘threshold’ number of rats caught that would signal the need to increase effort.

As of October 3, 2013, approximately 2,524 rats and 22 mice have been recorded in the grid (Fig. 3). On average, 106 rat-kills are recorded each month during the Elepaio nesting season (December – June) when the entire grid is checked twice monthly. Trapping data in months where only the subset of traps are baited is not meaningful to examine as OANRP maintained bait stations with Ramik® bait in those areas as well (until the label expired). Only 5.8 rats were caught per check of the 150 traps in 2012. In the summer of 2013, most of the traps were removed from the wooden boxes and placed in trees, which seemed to increase the number of rats killed; these changes are discussed below. The trapping data overall do not

show any clear yearly trends. It should be noted that the number of traps checked in a month varies widely from 1,500 to fewer than 150 depending on whether or not it is the nesting season.

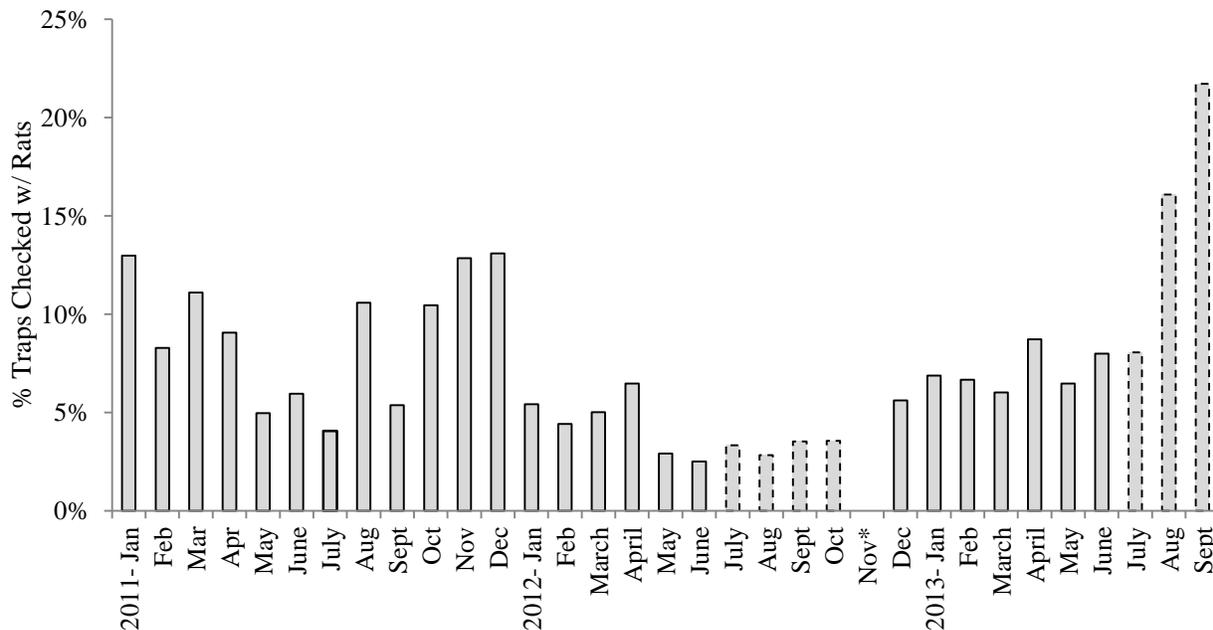


Figure 3. Percent of total traps checked each month at Ekahanui with rat catches.

*Bars with solid outlines represent data collected when the entire grid is checked; bars with dashed outlines indicate 'off-season' trapping when only 150 traps are checked monthly. In 2011, the entire grid was baited during the off-season one time a month plus the additional 150 traps a second time each month. * indicate that the grid was not checked that month. The high percentages of traps with rats in August and September of 2013 are likely related to recent modifications made to the grid.*

Over the past year, OANRP began to ask whether or not the traps in wooden boxes on the ground were more effective than traps uncovered in trees. This question arose because catch-rates at Ekahanui and at Kahanahaiki (also has traps in boxes) are overall lower than catch-rates at Palikea (Ka Mate™ traps uncovered) and are also lower than catch-rates in the small trapping grids in Elepaio territories (consisting of 12 uncovered Victor® traps in trees). It was also discussed that perhaps rats would encounter the traps more often and slugs would encounter the traps less often (to eat the bait) if they were in trees. The boxes add to the overall cost of installing grids and also add considerable difficulty when deploying or even checking the traps. It is possible that boxes placed in trees might be the most beneficial, but because the boxes are bulky and relatively heavy, it can be very difficult to find suitable trees in which to mount them. There are a small number of boxes with traps in trees scattered opportunistically throughout the Ekahanui grid, however, there is limited data to conduct analyses on whether or not this method is more effective. OANRP would like to test whether or not covering traps that are mounted in trees is beneficial in order to test all variations of trap deployment, but is first going to trial traps in trees uncovered.

As a first step to investigate the question, in May of 2013 a subset of traps (41 traps or 6.6% of total traps) in one area of the grid were removed from the wooden boxes on the ground and mounted above the ground directly on trees or logs to test whether or not the bait lasted longer and to discover if it would increase rat catches. The results from this trial indicate that placing traps off the ground uncovered may improve rat control: previously, the 41 traps in this trial typically caught three or fewer rats but after being hung in trees they caught 8-18 rats in the months of May and June which represented 17-45% of all rats caught in the entire grid. If this trend holds true over time and across the entire grid, the number of rats

caught could dramatically increase if more traps were hung on trees. Bait longevity, however, did not seem to be affected by moving the traps into trees. Based on this initial trial, OANRP moved the majority of traps inside the interior of the grid from boxes on the ground into trees. OANRP will continue to monitor trapping data but believe this is likely why there were high spikes in rat catches in August and September of 2013. In order to collect data for traps in boxes on the ground to compare with the traps in trees, the traps on the perimeter of the grid will remain in the wooden boxes on the ground for the time being. Finding suitable trees to install traps along the fenceline on the perimeter of the grid will likely be more challenging. Theoretically, the new placement of traps will be more accessible and attractive to rats traveling within the forest canopy and will improve overall trapping efficacy and efficiency.

OANRP continues to monitor rat activity with tracking tunnels on a quarterly basis inside the trapping grid during the nesting season. The tracking tunnels have been run 17 times and the average rat activity is 11.6% ($\pm 5.8\%$). The average rat activity each year has ranged from 10.5% to 12.4%.

Management Considerations for 2014

During the 2014 Elepaio nesting season, OANRP will assess trapping data to determine whether or not there has been a significant increase in trapping efficacy with the traps in trees in comparison to past data and to the traps that remain in the wooden boxes on the perimeter of the grid. Further analysis of individual trap catch data is needed to determine which areas are consistently catching higher numbers of rats in order to optimize the grid design. OANRP continues to test new baits to use on snap traps that will minimize slug and ant consumption and render traps more effective (see “Bait Persistence Trials” section 6.4). Pono Pacific will continue to run the grid through 2014.

6.3 Trapping Data Quality Analysis

OANRP conducted an interesting investigation on the quality of data reported by the contractor, Pono Pacific, who maintains all trapping grids in managed Elepaio territories. Pono Pacific staff record data, rebait, and reset all traps (over 860) every two weeks. All trapping grids maintained by Pono are Victor[®] rat traps. OANRP staff monitor Elepaio nesting success during this period and often opportunistically rebait and reset traps when necessary. Starting in February, OANRP staff began to record detailed notes when there was evidence of a kill: when a carcass or any hair was observed on a trap (sometimes only a few hairs), the data was recorded but the trap was not reset. This data was later compared to the data received from Pono Pacific after they had visited the site in order to quality control their performance and to assess the overall accuracy of the kill data. The interval between OANRP staff recording data and Pono visiting the site varied widely across the study period (from 1 – 30 days with an average interval of approximately 11 days); the wide range in intervals between checks was primarily due to the fact that access to SBW was limited to one to two weekends a month. Although this analysis has only been conducted this one time, it would be useful to conduct the same study on OANRP staff.

Results from this informal study indicate that Pono Pacific reported 65.0% of the rat kills that OANRP staff observed (147 out of 226). The majority of the kills missed by Pono Pacific staff were recorded as ‘sprung’ traps with no signs of a kill. On only six occasions did Pono make a detectable error in reporting the data (recording a trap as ‘unsprung’ when OANRP staff observed it sprung with a kill). These six errors are likely a mistake in recording or entering the data; however with the total number of traps checked each month (over 1,720), the error rate in data reporting appears to be very low.

The implications of this project indicate that many more rats are being killed in trapping grids than are indicated by the data (in this study 35% of rat kills were missed). Indeed, there are many predators and scavengers in Oahu’s forests that have been documented to remove 50% of observed rat carcasses after two to three days (see Appendix 6-1 for more information about scavenging). It is interesting to note that

theoretically, all rat kill data from OANRP's trapping grids could actually be increased by 35% to more accurately represent the number of rats killed.

Most importantly, the results of this project reiterate the need for careful inspection of traps for signs of kills and then ensuring that any sign of a kill is cleaned off the trap before setting again so as not to make the mistake of recording the kill a second time (Fig. 4).



Figure 4. An 'unsprung' trap with rat hair present on the 'kill bar'.

When traps are not adequately cleaned prior to resetting, the quality of future data may be affected. Photo courtesy of Pono Pacific, Ltd.

6.4 Bait Persistence Trials for Victor[®] Traps

One issue that needs to be overcome in order to improve rodent control using Victor[®] traps (or any type of trap) is bait persistence in the field. The bait in Goodnature[®] A24s seems to persist longer than in snap traps due to the fact that a larger quantity of bait is used and because the bait compartment is less accessible to slugs (especially larger slugs) than the bait on a snap trap. In trapping grids, bait can be removed from Victor[®] traps within 24 hours, typically by slugs (Fig. 5). Finding bait that persists in the field and is attractive to rats for a longer duration is crucial, especially with the increased reliance of OANRP on trapping grids alone for rat control. Finding a longer lasting bait could also greatly increase the efficacy of rat control efforts and increase benefits to natural resources.



Figure 5. Slugs (*Limax maximus*) consuming peanut butter on Victor® traps.

Many types of potential baits have been trialed in the past including: peanut butter, Nutella®, liquid scents on sponges, dog treats, tootsie rolls, nuts, homemade scented wax concoctions, peanut butter inside plastic tubing, peanut butter wrapped in metal mesh, coconut, chocolate chips, fish oil, cinnamon paste, various scented waxes, commercial baits for squirrels, and more. OANRP has had very little success in deterring slugs with zinc tape, salt or by elevating traps (OANRP 2010). Ants are also very problematic. Bait trials for some substances were discontinued for reasons such as lack of persistence in the field, attractiveness to rats, and difficulty of use. Several trials are ongoing; finding better bait is a never-ending endeavor.

Other types of lures for rats currently being investigated in New Zealand include audio tones, visual cues, and various scents including rat odors and pheromones. The development of such tools is in the preliminary stages; nevertheless, it is promising that such alternative and high-tech attractants are being investigated.

In 2012, OANRP experimented with a peanut butter-scented wax product from Pest Control Research (PCR), a New Zealand company (www.pestcontrolresearch.co.nz). The company molded the wax to fit Victor® snap traps perfectly (Fig. 6).



Figure 6. Peanut butter scented wax bait purchased from PCR (New Zealand) for Victor[®] rat traps.

From January - May, 2013, approximately half of all Victor[®] traps in managed Elepaio territories (over 860 traps in total) received a piece of New Zealand wax in addition to peanut butter (or other bait such as Nutella[®]) when they were baited (two times each month). The hypothesis was that the traps with both baits would kill more rats over time because after the first bait (e.g., peanut butter) was removed by something other than a rat and left unsprung with no bait, the traps would still have the wax bait and be more attractive to rats than traps that had no bait left. However, the results of the trial indicated that the presence of the wax on half the traps had no influence on overall catch-rates. Data were analyzed several different ways but the results were consistent: overall, the traps with wax did not catch more rats than traps with only peanut butter.

The results of the trial with the New Zealand wax were disappointing but spurred new experimentation with wax-based baits. OANRP began creating peanut butter infused beeswax cups (Fig. 7). Coconut oil was also an ingredient; however it was not consistently measured. A food preservative, potassium sorbate, was also added to the ‘wax cups’ to increase their resistance to mold and improve their overall longevity. The beeswax cups were experimented with in the Goodnature[®] A24 traps in Pahole (see Appendix 6-1) but also systematically tested in the Kahanahaiki snap trap grid on September 9 and September 23, 2013.



Figure 7. Peanut butter, coconut oil, and preservative infused beeswax cups.

Left: The wax chunks were homemade in cupcake tins or ice cube trays. Right: A black rat killed by a trap baited with peanut butter beeswax.

Qualitative observations clearly indicated that the preservative made a remarkable difference in increasing the longevity of the wax cups. Data from the bait trials in the A24s at Pahole showed that the wax cups were as attractive to rats as regular peanut butter (with or without an added preservative). See Appendix 6-1 for more information. On September 9 (Trial 1) and on September 23 (Trial 2), peanut butter beeswax chunks were placed on approximately every other trap in the Kahanahaiki trapping grid and regular peanut butter was used on the rest of the traps (consisting of 464 Victor[®] traps; Fig. 8). Results from these trials indicate that the longevity of the beeswax is significantly better over a two week period than peanut butter (Table 2). Longevity is indicated by the percent of traps that had bait present when checked. Furthermore, the peanut butter infused beeswax appears to be relatively attractive to rats. Trial 1 had proportionally more rats killed in traps with the beeswax bait than in traps baited with peanut butter

(PB). However, in the second trial, the reverse occurred with proportionally more rats being killed in traps baited with PB.

Table 2. Results from peanut butter beeswax versus peanut butter bait trials.

		Trial 1	Trial 2
BEESWAX	# Traps w/ bait	249	240
	# Rats	12	16
	% Traps w/ rats	4.8%	6.7%
	% Traps w/ bait present	50.6%	44.6%
PB	# Traps w/ bait	211	223
	# Rats	8	26
	% Traps w/ rats	3.8%	11.7%
	% Traps w/ bait present	6.2%	9.0%

Regular peanut butter has been found by OANRP to be the most attractive bait despite its persistence issues. However, the results from these bait trials are very promising in that the peanut butter beeswax is also attractive to rats and has much better longevity. It may be the most promising alternative bait discovered so far. More testing is occurring to confirm these results.

Over the next year, OANRP will begin using the peanut butter beeswax more extensively. To maximize bait attractiveness to rats and longevity, OANRP will experiment with using the peanut butter beeswax as supplemental bait; all traps will be baited with a piece of the wax and also a fresh dab of peanut butter or another bait, such as Nutella®. This way, the traps will be highly attractive to rats while the first bait (e.g., peanut butter) is present and will remain baited with the wax after the peanut butter has been removed by insects or slugs.

OANRP will also experiment more with adding food preservatives to peanut butter to increase longevity. Wax concoctions appear to be more resistant to slugs/ants but may not be necessary in trapping grids that are visited more frequently (e.g., traps in Elepaio territories during the nesting season) since more rats were caught at Kahanahaiki in a two week period with regular peanut butter.

Using peanut butter beeswax cups in combination with peanut butter on snap traps could greatly reduce labor costs since the majority of traps will remain baited for longer periods and re-baiting intervals could be stretched at some sites.

6.5 Goodnature® A24 Automatic Rat Trap Projects

The Goodnature® A24 self-resetting kill-trap from New Zealand is a new tool for rat control in natural areas (Fig. 8). These traps are powered by compressed CO₂ and can reset automatically up to 24 times before the CO₂ canister needs to be replaced. They are designed to be baited with a long-lasting attractant and set out for months without servicing. A24s appear to be a more effective, humane, and safe way to conduct rat control. Additionally, they may significantly reduce long-term costs because they are designed to be maintained less often than bait stations or traditional snap traps. The traps also kill stoats (*Mustela erminea*; not found in Hawaii) and mongooses (*Herpestes javanicus*).



Figure 8. Goodnature® A24 Automatic rat trap with CO₂ cartridge and digital counter.
Photo taken at Pahole NAR.

In partnership with Kalaupapa National Historical Park and collaboration with the State of Hawaii Department of Land and Natural Resources, OANRP maintained a grid of 45 Goodnature® A24 traps at Pahole Natural Area Reserve, from October 2012 to August 2013. The overall aim of this project was to investigate the utility of automatic traps in Hawaiian forest settings. Specific project objectives were: testing a specific grid layout, monitoring resource response to the effects of the A24 grid, monitoring changes in rat activity after installation of the grid, experimenting with various baits, and creating guidelines to help develop a best practice protocol.

A technical report that discusses the details of the project, a discussion of the results, and implications of the study is included as Appendix 6-1. There are also suggestions and tips included for use of traps.

OANRP also installed one A24 per Elepaio territory in North Haleauau gulch at Schofield Barracks West Range (SBW) in 15 consecutive territories. The primary reason for installing A24s at this site was that access to SBW was severely restricted during the past Elepaio nesting season. From January to March no access was permitted to SBW; from April-June access was granted one to two weekends per month. Installing A24s was an attempt to try to improve rat control efficacy during the nesting season.

In 13 territories at North Haleauau, one A24 trap was installed in the center of an existing grid of 12 snap traps. The snap traps ran throughout the length of each territory and were spaced approximately 12 meters apart. In two territories, A24s were placed in the center of the territory as the sole method of rat control (no snap traps).

The 15 A24s in North Haleauau did not kill as many rats per trap as the 45 A24s in Pahole. On average, the North Haleauau A24s killed 0.96 rats per trap each month. In contrast, the Pahole A24s killed 1.53 rats per trap per month. The number of traps with counters to record data varied each month from 12 to 14 at North Haleauau. When counters were not available to install on a trap, no data was collected. A

total of 53 rats were recorded in five checks from April to June (Fig. 9). One mongoose carcass was also found.

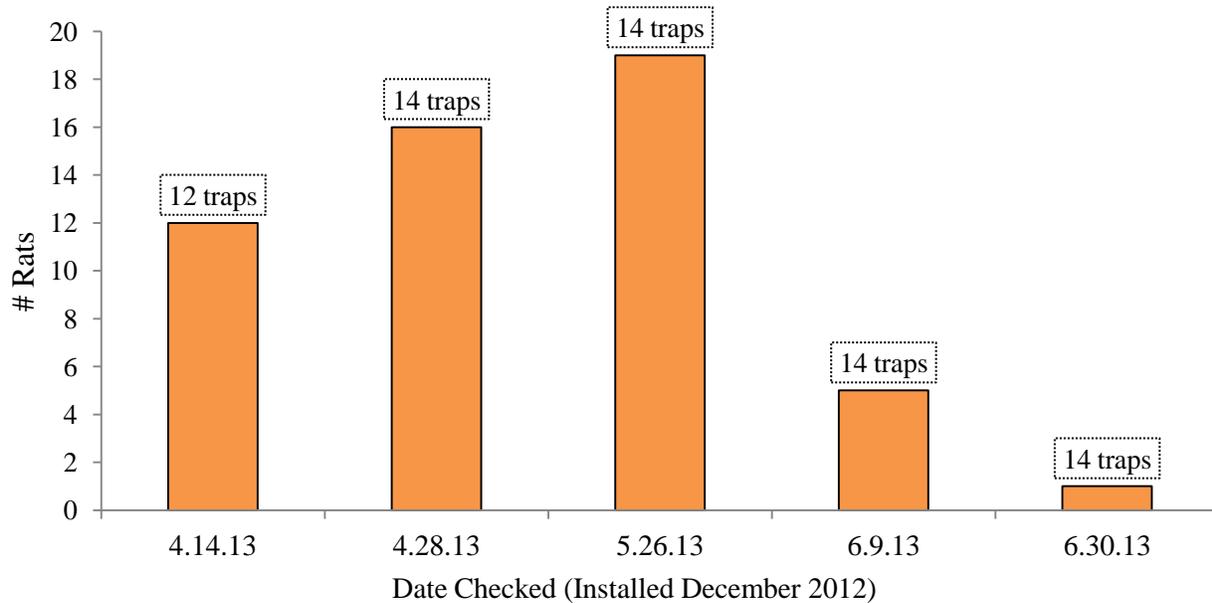


Figure 9. The number of rats killed by A24s in North Haleauau, Schofield Barracks West Range.

One possible reason the A24s did not perform as well in North Haleauau is that in the majority of Elepaio territories there were also snap traps grids. OANRP found the small snap trap grids to be effective for rat control in order to achieve Elepaio nesting success (see Elepaio chapter). Perhaps more rats would have been killed by A24s if they had been the sole device in those territories. There was no noticeable difference in the performance of the two traps that were the sole rat control method in their respective Elepaio territories. It possible that there are differences in the rat populations at Pahole versus North Haleauau, but the habitats of the two areas are similar (i.e., mesic forest, gulches, abundant strawberry guava) so it is assumed that any differences in rat populations or behavior are minimal. It is also possible that the relatively small number of A24s installed in North Haleauau limited the quality of data collected. Finally, the fact that the A24s in North Haleauau did not have their bait refreshed as often as the A24s in Pahole likely affected the overall attractiveness of the North Haleauau traps.

Overall, OANRP has learned a great deal about these new traps over the past year. OANRP considers the utility of A24s to be the greatest at remote sites that require helicopter access or are otherwise difficult to access. A24s will be installed in the near future at remote sites including Ohikilolo, East Makaleha, and at many sites in the Koolau mountain range for protection of Kahuli tree snails.² As mentioned, OANRP is also considering installing a grid of A24s in Kahanahaiki across the MU instead of maintaining the snap trap grid. Gaining a new tool for rat control in Hawaii is especially valuable because there are limited options available and OANRP is optimistic about the use of these new traps.

WORKS CITED

² As previously mentioned, OANRP will not be actively managing Koolau snail sites beginning October 2013 due to a loss of funding for the management of Tier 2 and Tier 3 species. The Oahu Snail Extinction Prevention Program is taking over rodent control actions and snail management at these sites.

- Blackwell, G., M. Potter, J. McLennan. 2002. Rodent density indices from tracking tunnels, snap-traps, and Fenn traps: do they tell the same story? *New Zealand Journal of Ecology* **26**(1): 43-51.
- Hill, G. 2011. Personal Communication. Department of Conservation, New Zealand.
- Mosher, S.M., J. L. Rohrer, V. Costello, M. D. Burt, M. Keir, J. Beachy. 2010. *Rat control for the protection of endangered birds, plants, and tree snails on the island of Oahu, Hawaii*. Proc. 24th Vertebr. Pest Conf. (R. M. Timm and K. A. Fagerstone, Eds.). Univ. of Calif., Davis. Pp. 14-17.
- NZ DOC (New Zealand Department of Conservation). 2005. *Kill trapping for rat control (Current best practice)*. Department of Conservation, Wellington, NZ.
(http://www.predatortraps.com/downloads/techniques_rat_trap.doc)
- OANRP. 2010. *Oahu Army Natural Resources Program 2010 Status Report for the Makua and Oahu Implementation Plans*. US Army Garrison, Hawaii and Pacific Cooperative Studies Unit, Schofield Barracks, Oahu, HI. Available online at:
http://manoa.hawaii.edu/hpicesu/DPW/2011_YER/2011_YER_Edited.pdf.
- OANRP. 2011. *Oahu Army Natural Resources Program 2011 Status Report for the Makua and Oahu Implementation Plans*. US Army Garrison, Hawaii and Pacific Cooperative Studies Unit, Schofield Barracks, Oahu, HI. Available online at:
http://manoa.hawaii.edu/hpicesu/DPW/2011_YER/2011_YER_Edited.pdf.
- OANRP. 2012. *Oahu Army Natural Resources Program 2012 Status Report for the Makua and Oahu Implementation Plans*. US Army Garrison, Hawaii and Pacific Cooperative Studies Unit, Schofield Barracks, Oahu, HI. Available online at:
http://manoa.hawaii.edu/hpicesu/DPW/2012_YER/2012_YER_edited.pdf.
- Peters, D. 2013. Personal Communication. National Predator Control, Research, Development and Improvement, Department of Conservation, New Zealand.
- Shiels, A. 2010. Ecology and impacts of introduced rodents (*Rattus* spp. and *Mus musculus*) in the Hawaiian Islands. Dissertation, Department of Botany, University of Hawaii at Manoa.
- Swift, K. 2013. Personal Communication. Predator Control/Toxicant Registration Specialist, US Fish and Wildlife Services.
- Tomich, P. Q. 1981. Community Structure of Introduced Rodents and Carnivores. Pp. 301-09 in *Island Ecosystems* ed. by D. Mueller-Dombois, D. W. Bridges, and H. L. Carson. US/Int. Biol. Prog. Synthesis Ser. 15. Univ. Hawaii Press, Honolulu.