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# Rat Control for the Protection of Endangered Birds, Plants, and Tree Snails on the Island of Oahu, Hawaii

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**ABSTRACT:** Since 1997, the Oahu Army Natural Resource Program has been controlling rats using diphacinone rodenticide in small-scale bait station grids in combination with rat traps for the protection of one endangered forest bird species, 5 species of endangered Oahu tree snails, and 9 species of endangered plants in 2 mountain ranges on the island of Oahu. Endangered tree snail and some plant populations are protected year-round. Other plants are only protected during their flowering/fruited season, with small-scale baiting grids in combination with rat traps; and the Oahu Elepaio is only protected during its breeding season, with small-scale bait station grids in combination with rat traps centered on territories. In May 2009, year-round rat control was initiated over a 26-ha forested management unit on Oahu with 440 snap traps. The New Zealand Department of Conservation current best practice rat kill-trapping technology is being utilized for the first time in Hawaii with this large-scale trapping effort. Rat activity within the management unit will be monitored through the use of tracking tunnels. Forest health (seed rain and seedling germination), endangered plant recruitment, endangered tree snail survival, and native invertebrate abundance will be monitored closely to determine the effectiveness of this large-scale trapping effort. The Oahu Army Natural Resource Program is working towards integrating multiple control methods (bait station grids, large-scale rat trap grids, predator-proof fencing, hand and targeted aerial application of rodenticide) over large-scale areas in an effort to determine the most effective means to control rats in Army-managed areas on Oahu.

**KEY WORDS:** bait stations, diphacinone, endangered species, hand and aerial broadcast, Hawaii, predator-proof fencing, rat control, rodenticides, trapping

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## INTRODUCTION

The Oahu Army Natural Resource Program (OANRP) manages 52 endangered plant species, 6 endangered Oahu tree snail (*Achatinella* spp.) species, and 1 species of endangered forest bird, the Oahu Elepaio (*Chasiempis ibidis*). Resource management by OANRP has been occurring in 2 mountain ranges (Koolau and Waianae Mountains) with forest types ranging from rare dry forest to short stature rainforest since 1995. Introduced rats (*Rattus* spp.) in Hawaii are known predators of forest birds, tree snails, and plants (Stone 1985). One of the main reasons for decline in Elepaio populations on Oahu is nest predation and adult mortality of females caused by black rats, *Rattus rattus* (VanderWerf and Smith 2002). Black rats have also been implicated in declines of endemic tree snails in the Waianae Mountains of Oahu and elsewhere in Hawaii (Hadfield and Mountain 1980, Hadfield et al. 1993, Hadfield and Saufler 2009). Of the 52 endangered plant species managed by the OANRP, direct evidence of rat predation has been observed in 11 species (*Alectryon macrococcus* var. *macrococcus*, *Cyanea acuminata*, *C. grimesiana* subsp. *obatae*, *C. longiflora*, *C. superba* subsp. *superba*, *Cyrtandra viridiflora*, *Delissea waianaeensis*, *Euphorbia haeleeleana*, *Lobordia cyrtandrae*, *Plantago princeps* var. *princeps*, *Pritchardia kaalae*) that represent 7 plant families.

Since 1997, the OANRP has primarily controlled rats through the use of diphacinone bait blocks in bait stations in combination with rat traps in close proximity to the bait stations. This method of combining bait stations and rat

traps was adapted from results by Nelson et al. (2002), which showed that black rats readily consumed diphacinone rodenticide from bait stations and Polynesian rats (*Rattus exulans*) were primarily removed with rat traps. Small-scale bait station grids in combination with rat traps have been the standard method for rat control by the OANRP. With the continual need for rat control to aid in achieving stability for managed endangered species, the OANRP is working towards integrating multiple control methods over landscape-scale areas in an effort to determine the most effective means to control rats in Army-managed areas on Oahu.

## RAT CONTROL METHODS

Diphacinone is the only rodenticide registered in Hawaii for conservation purposes in natural areas. Currently, only HACCO Inc.'s Ramik<sup>®</sup> Mini Bars All-Weather Rat and Mouse Killer (SLN HI-980005) is registered in Hawaii for bait station use in natural areas for conservation purposes. In 2007, the label for Diphacinone-50 (EPA 56228-35) pelleted rodenticide bait was approved for conservation purposes in the control and eradication of invasive rodents on islands in the U.S. This label allows for bait station, burrow-baiting, canopy baiting, and targeted aerial and hand application of this formulation. These two rodenticide registrations and conventional snap trapping are the only measures in use in Hawaii today for conservation purposes. Ramik<sup>®</sup> Mini Bars in bait stations are widely used as a control tool for the protection and management of native and endangered

species in natural areas in Hawaii. Diphacinone-50 has only been used twice in aerial applications on offshore islands in Hawaii. We present a summary of the current and future rat control methods/techniques used by the OANRP.

### **Small-Scale Bait Station Grids with Rat Traps**

The tools that have been used over the years for small-scale bait station grids with rat traps have consisted of Protecta® Tamper-Resistant Bait Stations (Bell Laboratories, Inc., Madison, WI) and Victor® Professional Rat Traps (Woodstream Corp., Lititz, PA). Bait stations and rat traps are mounted in trees (in areas without ungulate fencing) to prevent access to bait stations by feral pigs (*Sus scrofa*) and dogs. In areas with ungulate fencing, bait stations and rat traps are typically placed on the ground. Rat traps are placed out uncovered. Distance between bait stations follows the Hawaii SLN label of 25 to 50 m between stations and 4 to 16 ounces (113-454 g) of diphacinone bait per station.

### **Rare Plant Management**

Rat damage observed on endangered plants managed by the OANRP has consisted of chewing of stems, leaves, and fruit/seed predation. Nine species of endangered plants managed by the OANRP are protected with small-scale bait stations grids in combination with rat traps, either year-round or only during the flowering/fruited season. Eight sites have year-round rat control for the protection of 5 rare plant species (*C. grimesiana* subsp. *obatae*, *D. waianaeensis*, *E. haeleleana*, *P. princeps* var. *princeps*, *P. kaalae*). These sites were chosen for year-round rat control based on the degree of plant endangerment and/or degree of forest community continuity. Bait station grids in combination with rat traps for year-round rat control range in size from 6 bait stations with 8 rat traps to 39 bait stations with 32 rat traps. The number of bait stations at a site can vary depending on plant distribution and terrain. Year-round control grids are usually spread across the landscape when possible to encompass the majority of plants. Bait stations and rat traps are serviced every 4 to 6 weeks during the year. Over the years, 10 sites have had seasonal rat control during the flowering/fruited season to protect 5 species (*A. macrococcus* var. *macrococcus*, *C. grimesiana* subsp. *obatae*, *C. superba* subsp. *superba*, *G. manii*, *H. arbuscula*). The protection of these 5 species was based on the need to collect genetic storage material (seeds). Bait station grids with rat traps for seasonal rat control range in size from 2 bait stations with 4 rat traps to 6 bait stations with 12 rat traps. These seasonal grids are most often centered around individual plants or small groupings of plants. During seasonal rat control, bait station and rat trap servicing intervals vary depending on individual species phenology.

### **Rare Oahu Tree Snail Management**

The OANRP manages 5 species of Oahu tree snails (*A. byronii*, *A. lila*, *A. livida*, *A. mustelina*, *A. sowerbyana*) through year-round rat control at 16 locations. *Achatinella mustelina* only occurs in the Waianae Mountains. For this species, rat control is conducted at 6

sites with grids ranging in size from 2 bait stations with 2 rat traps to 12 bait stations with 24 rat traps. There are usually multiple grids at each *A. mustelina* site; grids surround discrete groupings of trees in which the snails are located, with one management site having as many as 47 bait stations and 87 rat traps spread out over 12 discrete grids. The 6 rat control sites were based on 6 recognized evolutionarily significant units (ESU) for *A. mustelina*. Within each ESU, rat control sites were located in areas with the highest number of snails and accessible terrain. All sites are accessible by foot within a few hours.

There are 8 discrete sites in the Koolau Mountains to control rats around the 4 remaining tree snail species (*A. byronii*, *A. lila*, *A. livida*, *A. sowerbyana*). These 4 tree snail species only occur in the Koolau mountain range. Bait stations grids with rat traps range in size from 5 to 8 bait stations and 10 to 12 rat traps each. All rat control locations in the Koolau Mountains are very remote, taking up to half a day or more by foot on semi-maintained trails; therefore, access to these sites is facilitated by the use of helicopter.

The Waianae Mountains rat control sites are serviced on a consistent 4 to 6-week interval because of the relative ease of access, whereas the Koolau Mountains rat control sites are attempted on 6-week intervals, but because of the variable weather over the Koolau Mountains access is not always consistent.

### **Elepaio (Hawaiian Flycatcher) Management**

The OANRP manages 75 pairs of the endangered Oahu Elepaio through rat control across 5 locations in both mountain ranges on Oahu. Rat control is only conducted during the Elepaio breeding season (late December through June). During this time of year, female Elepaio are very vulnerable to rat predation, since only females are known to incubate through the night. Elepaio territories are approximately 1 ha in size and are most often associated with forested gulch/stream bottoms. The number of bait stations and snap traps deployed in each territory ranges from 2 to 6 for bait stations with 4 to 12 rat traps, depending on territory size and closeness of neighboring pairs. Bait stations and traps are checked every week for approximately the first 6 weeks, then every 2 weeks through the remainder of the breeding season.

### **Measures to Prevent Non-Target Exposure from Bait Station Use**

In some of the managed areas, public pig hunting with dogs and hiking occurs. With the use of bait stations in areas in which feral pigs and dogs have access, there is always the concern for non-target disturbance and potential consumption of rodenticide. To address these concerns, the OANRP has instituted using the manufacturer-supplied (Protecta® Tamper-Resistant Bait Station) insert rods for holding bait blocks and locking bait station lid screws. Securing the rodenticide bait blocks to the rods inside a station and locking the lid eliminates the potential removal and caching of bait blocks from stations by rats or mongoose (*Herpestes javanicus*). The use of these bait-securing devices also

reduces the potential removal of bait blocks in cases of direct disturbance of bait stations by feral pigs or dogs.

### Large-Scale Rat Trap Grids

In May 2009, year-round rat control was initiated over a 26-ha forested management unit with 400 rat traps in wooden boxes, later expanded to 440 traps. This large-scale trapping grid is based on the New Zealand Department of Conservation current best practice rat kill trapping technology (NZ DOC 2005). This technology consists of a Victor® Professional rat trap set inside a wooden box. The wooden box is designed to exclude non-target species, guide target species, and maintain the integrity of the trap from weather. This technology is being utilized for the first time in Hawaii with this large-scale trapping effort. The trapping grid is directly benefiting 11 endangered plant species and 1 species of endangered Oahu tree snail.

Trap layout consists of perimeter traps (234) maintained at a distance of 12.5 m with interior traps (206) set at 25-m intervals along trails and transects. In interior areas with critical resources, additional traps have been deployed along the trail and transects at 12.5-m spacing. Traps are baited with peanut butter or FeraFeed® paste (non-toxic possum pre-feed, Connovation Ltd., Auckland, New Zealand) and half a macadamia nut. Traps were initially checked daily for the first week-and-a-half, then maintained every 2 weeks thereafter. Tracking tunnels are run monthly to index rat activity within the grid and quarterly at an adjacent plot with no rat control.

Several components of forest health (seed rain, seedling germination, endangered plant recruitment, endangered tree snail survival, and native invertebrate abundance) are being monitored closely to determine the effectiveness of this large-scale trapping effort

### Predator-Proof Fencing

Predator-proof fencing technology (Xcluder® Pest Proof Fencing, Rotorua, New Zealand; PestProof Fences, Hastings, New Zealand) has proved successful in New Zealand in protecting rare vertebrate species by excluding invasive rats. The OANRP has initiated design trials to retrofit an excluding device(s) for the highly invasive predatory rosy wolf snail (*Euglandina rosea*). This snail-excluding device(s) will be retrofitted to New Zealand-designed predator-proof fencing. Rosy wolf snails are predators of native tree snails in Hawaii and on other Pacific Islands (Hadfield et al. 1993, Coote et al. 2004). Oahu tree snails are impacted by rats, rosy wolf snails, and potentially invasive predator flatworms *Platydemus manokwari* (USFWS 1992). On Oahu, tree snails are restricted to upper elevations in both mountain ranges (USFWS 1992). These upper-elevation tree snail locations are often in remote areas on steep terrain with limited access. As Oahu tree snail populations continue to decline, the OANRP is planning to construct 3 predator-proof fences to eliminate rats and *Euglandina*. The 3 fences will each be approximately 300 m in length or 5,625 m<sup>2</sup> (75 × 75 m). Two sites will be located in mesic forest in the Waianae Mountain Range and 1 site in wet forest of the Koolau Mountain Range. Once

constructed, the enclosures will need routine inspection for breaches, as well as continuous maintenance and rat control (bait stations and/or rat trap boxes) outside the fences. The rat control will help to reduce rat pressure on the fences in the event that a breach occurs.

### Targeted Aerial Application and Hand Application of Rodenticide

Only recently in Hawaii has hand and targeted aerial application of rodenticides become available as a tool for controlling rats. Hand application has only been conducted in experimental treatments on the main Hawaiian islands. Targeted aerial application has only been applied on 2 small offshore islands in Hawaii. One of the main restrictions for both hand and targeted aerial application use on the mainland Hawaiian Islands is the requirement of no ungulate (feral pigs) immigration or emigration from the application site. Since feral pigs are widespread on the main Hawaiian Islands, the most feasible locations will be within ungulate-free enclosures. The majority of fenced enclosures ( $n = \sim 33$ ) that the OANRP manage are less than 10 ha in size with two-thirds less than 5 ha. The OANRP manage 4 existing fenced enclosures ranging in size from 42 to 110 ha that are potential locations for hand broadcast application. In the near future, the OANRP will determine the feasibility of hand application within these 4 medium-size fenced enclosures, with the possibility of using large-scale rat trapping grids in conjunction with hand broadcast application. Accessibility to these sites, as well as habitat sensitivity, will play a major role in choosing application sites.

Currently, on Oahu there are no fenced areas large enough to accommodate a targeted aerial application of rodenticide. In 2011, the OANRP will start construction of a 714-ha fenced enclosure on Schofield Barracks. This fence will enclose approximately 16 endangered plant species, multiple small populations of *A. mustelina*, and 43 pairs and 18 single males of Oahu Elepaio. Construction will take approximately 1½ years with an additional 1½ - 2 years for ungulate removal before a targeted aerial application can be conducted. Public perception of targeted aerial application of rodenticide may play a major role in deciding whether this tool will become a viable option on the main Hawaiian Islands. The OANRP has partnered with other federal and state agencies to facilitate public awareness of the impacts of invasive rodents on Hawaii's native ecosystems, as well as attempting to alleviate public misconceptions about targeted aerial application of rodenticide.

### SUMMARY

Small-scale bait station grids in combination with rat traps have proven successful in reducing and/or eliminating predation on rare plant species by rats. *Pritchardia kaalae* and *E. haeleleana* are 2 tree species that are highly susceptible to seed predation by rats. Prior to rat control, there was no naturally occurring recruitment of either species, however within 1 - 2 years after rat control, recruitment was observed. Both species have had rat control for over 10 years with recruitment success for *E. haeleleana* with ~100 immature plants and *P. kaalae* with ~1,000 immature plants. Seasonal rat control around

plants to enable the collection of genetic material has been successful each time during the flowering/fruitlet periods. Determining the success of small-scale bait station grids in combination with rat traps in Oahu tree snail areas has proven difficult. Tree snails are very cryptic and sedentary, making them very difficult to detect in dense vegetation. In many locations, very steep terrain precludes snail surveys and ideal placement of bait stations and rat traps for snail protection. Ground shell plots have been installed in all managed tree snail areas to help assess the degree of rat predation. In most managed tree snail locations, some degree of rat predation has been detected.

Small-scale bait station grids in combination with rat traps has had similar success at some of the OANRP-managed Oahu Elepaio locations during the breeding season, as observed in southeastern Oahu (VanderWerf and Smith 2002, VanderWerf et al. 2011). Rat control has increased fledgling success and increased female survival at some locations. With the increasing reproductive success and adult survival of Oahu Elepaio at managed locations, the need for increased rat control at the landscape level to encompass a greater number of territories at a management location will be needed in the future. Large scale trapping grids and hand or targeted aerial application of rodenticides are potential control techniques to address the landscape level need of rat control. A combination of these techniques may be necessary to address terrain/topographic limitations.

After many years of using small-scale rodenticide bait station grids in combination with rat traps for the protection of endangered plant and animal resources, the OANRP has begun planning and integrating multiple rat control technologies.

The use of large-scale rat trap grids as an alternative tool to rodenticide use has proven successful in New Zealand. Preliminary results from the OANRP's first large-scale rat trap box grid has shown success in significantly reducing rat predation on fruits of *C. superba* subsp. *superba* a critically endangered species. Two additional large-scale trapping grids will be established in 2010. The second large-scale rat trap box grid will encompass a management area of ~70 ha with ~650 rat trap boxes for the protection of several endangered plants, Oahu tree snails, and Oahu Elepaio. The third large-scale trapping grid will consist of ~180 Ka Mate rat traps (Ka Mate Traps Ltd., Nelson, New Zealand) over a 16 ha area for the protection of Oahu tree snails.

Small-scale predator-proof exclosures are another tool that the OANRP will be implementing for the protection of Oahu tree snails. These small-scale barriers will protect tree snails and reduce the amount of rodenticide usage.

The OANRP is working towards integrating multiple control methods (bait station grids in combination with rat traps, large-scale rat trap grids, predator-proof fencing, hand and targeted aerial application of rodenticide) over large-scale areas in an effort to determine the most effective means to control rats in Army-managed areas on Oahu.

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