Design of a Self-Resetting, Low-Maintenance, Long-Term Bait Station for Rodent Control

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ABSTRACT: A low-maintenance, long-term bait station that resets itself after being triggered would be a very useful tool for controlling Richardson's ground squirrels, or other problem rodent species, in remote locations. With collaborators, we developed and tested two such devices using lab rats in pen settings. The devices can be left *in-situ* for long periods of time without servicing, and requires only occasional bait and/or battery replacement. Squirrels would be unable to cache bait due to the integrated time-out mechanism. The devices use capacitive sensor or strain gauge systems for animal identification, making it very unlikely that smaller non-target species would be able to trigger the systems while the design precludes entry by larger non-target species. Further refinement and testing will be needed before a viable, commercial product can go into production. These refinements include increasing reliability, reducing power requirements, design features and triggering mechanisms tightly linked to the attributes of the targeted pest species, and reduction of production costs. The devices will also need to be tested in field settings for extended periods of time.

Key Words: bait station, remote locations, rodent, rodenticide, wildlife damage

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INTRODUCTION

Approximately 42% of all mammalian species in the world are rodents; this amounts to about 2,277 species rodents (Wilson and Reeder 2005). They occur on all continents with the possible exception of Antarctica. However, even there, commensal rodents may have been accidently introduced to the inhabited research stations. Rodent species have adapted to all life-styles: terrestrial, aquatic, arboreal, and fossorial (underground). Most rodent species are small, secretive, nocturnal, adaptable, and have keen senses of touch, taste, and smell. For most species of rodents, the incisors continually grow throughout their lifespan, requiring constant gnawing to keep the incisors sharp and at an appropriate length. Rodents have ecological, scientific, social, and economic values (Dickman 1999, Witmer et al. 1995). Rodents are important in seed and spore dispersal, pollination, seed predation, energy and nutrient cycling, the modification of plant succession and species composition, and as a food source for many predators. Additionally, some species provide food and fur for human uses, and can provide an ecosystem service for smallholder farmers through consuming pests of their crops.

Rodents cause many types of damage to human resources. The types of agricultural damage inflicted by rodents include the direct feeding on seeds and plants at all stages of the cropping cycle (i.e., planting, vegetative growth, maturation, and pre- and post-harvest). Additionally, rodents cause damage from their burrowing activities which can result in levee failures, flooding of fields, loss of water resources, and the undermining of structures and foundations (Joshi et al. 2000, Stuart et al.

2008). Burrows and burrow openings can result in damage to farm equipment and injury to workers or livestock. Through their gnawing activity, rodents can damage equipment, irrigation tubing, and buildings. For example, house mice cause significant damage to insulation in confined livestock operations (Hygnstrom et al. 1996). Chewing through wiring can result in power failure or devastating fires (Caughley et al. 1994). Rodents also compete with livestock for feed whether in confined operations or open rangeland. They also contaminate stored food with their feces and urine.

Many methods exist to reduce rodent populations and/or damage (Hyngstrom et al. 1994, Buckle and Smith 2015, Witmer and Singleton 2010). However, rodenticides (and to a lesser extent traps) are heavily relied upon (Witmer et al. 2007). While in some situations, rodenticide baits are broadcast by hand or machine over large areas, in or near buildings rodenticides are often placed in bait stations. This reduces the risk of poisoning of children, pets, livestock, and non-target animals. However, current bait stations are passive device which must be checked and refilled periodically. Rodents will often cache or hoard the bait by making repeated trips to take bait to their burrows or nests; thus, requiring frequent refilled of the bait station. This poses issues for widely scattered, remote and unmanned facilities such as power substations and many military sites such as intercontinental ballistic missile (ICBM) silos (e.g., Witmer et al. 2012). In some of these situations, self-resetting, long-term, low-maintenance baits stations would be a valuable addition to the rodent control toolbox.

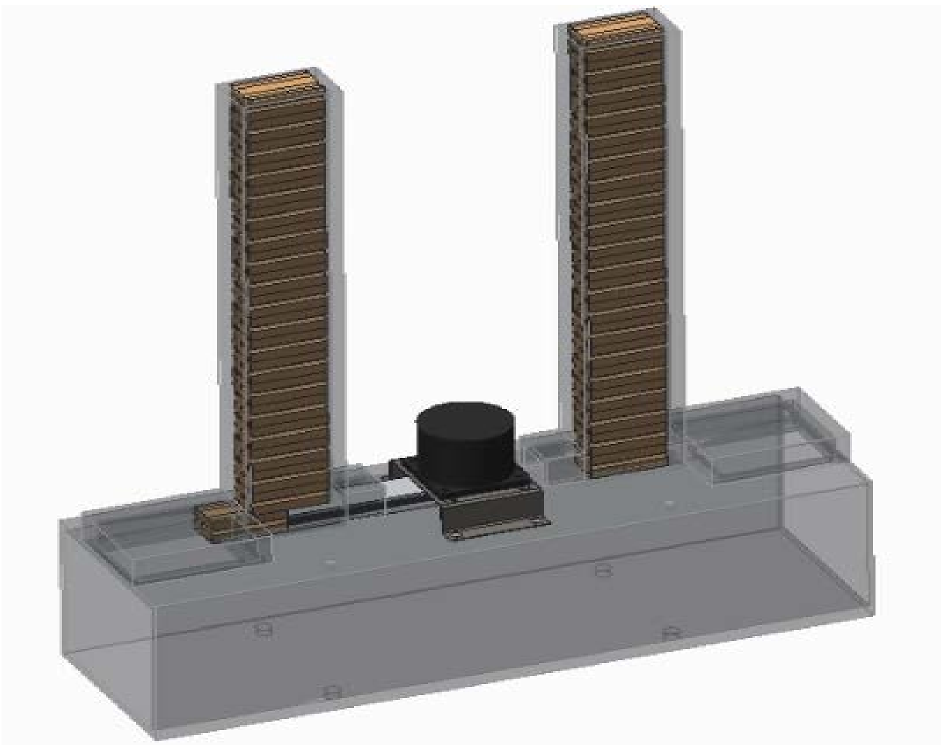
The features and characteristics we sought were:

- High durability
- Low-maintenance
- Capable of storing substantial amounts of bait
- Environmentally robust with bait protected from weathering
- Predetermined lethal dose of bait delivered upon triggering
- Incorporated "time out" (i.e., the bait station would re-set itself after delivering a bait, but will not deliver another dose for a predetermined period of time to prevent bait caching/hoarding)
- Capable of continued operation over long timeframes without staff visits

COLORADO STATE UNIVERSITY PROTOTYPE

Engineering seniors at Colorado State University (CSU), Fort Collins CO, are required to complete a special project in their senior year. We formed a team to design and build a self-resetting bait station to meet that academic requirement. The students designed and built a prototype meeting most of the desired features and we tested it with lab rats, using non-toxic rodent chow blocks. The lower structure was a tunnel-like design that was open at both ends so that rodents could see all the way through the device, thus feeling more at ease in entering the device. The structure was made of hard, clear plastic and had two tall towers to hold rodenticide bait blocks (Figure 1). There was a circuit board to control the 12 volt unipolar stepper motor, timer, strain gauge sensor, and the horizontal rack and pinion track. The linear action of the rack pushed a plunger to drop a bait block from one tower and the next time activated, it would move in the reverse direction to drop a block from the other tower. On the central floor area of the device was the strain gauge sensor which, based on the animal's weight, would activate the plunger. We had the gauge set to activate if it detected an animal weight of about 400 g (roughly the weight of a ground squirrel) so that mice or small birds would not trigger the device. For the trial with lab rats, the dispense interval was programmed at one hour. Motion sensitive and video cameras were used to record rat use/entries and bait drops of the station. The device performed as designed, dispensing all the bait blocks over the course of 3 days. In a field application, the device would be programmed to only drop a bait every eight hours or so when triggered by an animal. Some redesign was needed to lower the power demand. Additionally, debris tended to accumulate under the strain gauge sensor, affecting its ability to detect the correct animal weight. To remedy that, force sensitive resistors were tried, but they were not suitable substitutes for the strain gauge sensors. The device is powered by a 12 volt battery. Additional efforts were made to reduce the cost of the device. We estimated that if the parts were purchased in bulk, the price of one device would be about $120-130. One of the main upfront costs would be in having the body of the device made through plastic injection molding with a high cost in the production of the mold.

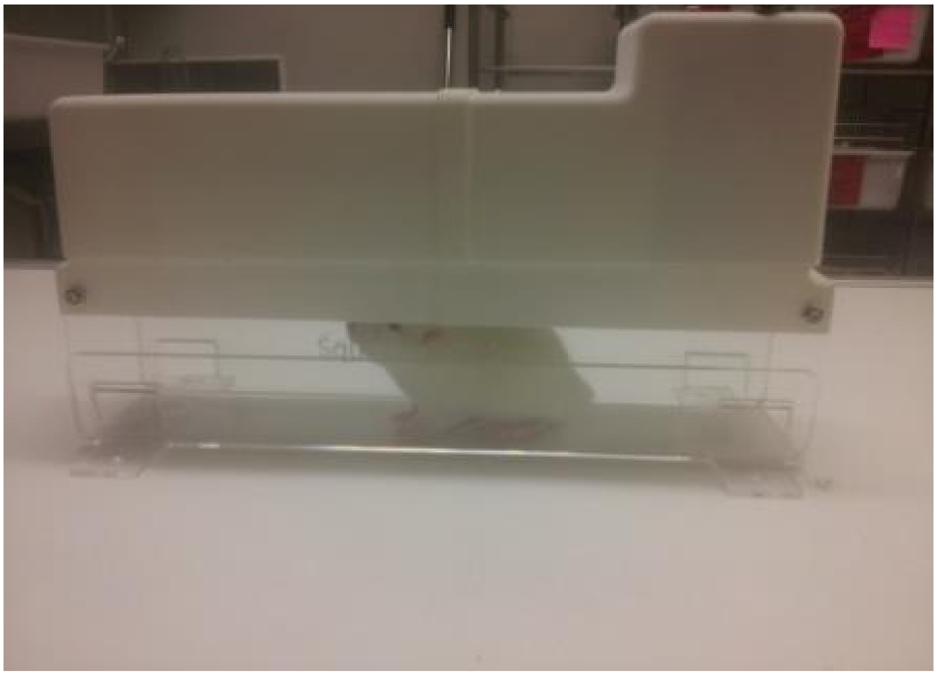
Figure 1. The Colorado State University self-resetting rodenticide bait station.



LINCOLN UNIVERSITY PROTOTYPE

Wildlife and engineering staff at Lincoln University, New Zealand, were subcontracted to design, build and test a prototype self-resetting bait station. They were contacted about the project, in part, because they had been working on similar devices for invasive stoat and weasel control in New Zealand (Blackie et al. 2012). Those devices were designed to detect the invasive animal and spray it with a toxic paste containing para-aminopropiophenone (PAPP). The animal consumes a lethal dose when it grooms the paste off its fur. For our rodent control project, they started out with a vertical device, but then switched to a lower, horizontal device profile that would suit the outdoor terrain better as well as the bait storage area (Figure 2). They used a vacuum-formed rodent-chewing resistant plastic housing which is lightweight, but very robust. Other aspects of the design varied considerably from the CSU prototype. They used a horizontally-oriented bait storage container and bait sachets which could contain, for example, zinc-phosphide coated grain. An acute toxicant would be preferable over an anticoagulant because the animal would be incapacitated or dead before it could take additional baits. While the sachets are housed in a cardboard container, that container resides within the plastic device above the ceiling of the rodent “tunnel”. Additionally, instead of using the animal’s weight as a triggering mechanism, they used two capacitive sensors an appropriate distance apart for the targeted species. Both sensors have to be triggered at the same time for the device to drop a bait sachet. This approach was found to be simpler and more reliable than a weight-activated platform. Like the CSU prototype, the device has a rodent tunnel that is open at both ends and also uses a "time out" mechanism so that the device will not drop another bait sachet before the programmed time has elapsed. The device has a low power drain, but is equipped with three 9 vole batteries that would last for years in the field. As with the CSU device, the Lincoln University device would be relatively expensive to produce unless they were produced in large numbers with bulk-priced components.

Figure 2. The Lincoln University self-resetting rodenticide bait station.



CONCLUSIONS AND FUTURE NEEDS

The continued development of rodent control technologies is essential to reduce the losses of human resources. This is especially true for remote locations, unmanned sites, and rodent control on distant, uninhabited islands. As stated by Blackie and others (2013): "With the integration of new technological and engineering advances, resetting control systems offer the potential to "set and forget" devices in the field for extended periods, allowing continued population suppression over longer timeframes, and an ultimate decrease in control costs."

We have designed, built, and tested two rodent control prototype devices that appear to meet those goals. The final reports with more details and diagrams than in this summary article are available from the senior author. Further refinement and testing will be needed before a viable, commercial product can go into production. These refinements include increasing reliability, reducing power requirements, design features and triggering mechanisms tightly linked to the attributes of the targeted pest species, and reduction of production costs. The devices will also need to be tested in field settings for extended periods of time.

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