An Evaluation of the Effectiveness of Potential Norway Rat Attractants

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Abstract: Commensal rats cause significant damage to human food supplies and property around the world. They also cause severe ecosystem disruption, and even species endangerment, when introduced to islands. Effective attractants could help manage rat populations by increasing the probability of getting rats to detection stations, traps, and bait stations. Bait stations may contain a rodenticide, a fertility control agent, a disease vaccine, or an ecto-parasite control chemical. Effective rat attractants have not been made commercially available, although a few candidates have been identified over the years. We investigated 18 commercially-available materials for their attractiveness to groups of wild Norway rats in a pen study. The most promising candidate attractants, based on the number of station visits, were almond, ginger, and lemon extracts. However, a subsequent, brief field trial at a livestock feedlot with a resident Norway rat population did not result in greater rat capture numbers with any of the 3 attractants over traps only containing water. It appears that additional testing of these and other materials will be necessary before an effective attractant can be discovered and made available for Norway rat population management.

Key Words: attractants, commensal rodents, invasive species, lures, *Rattus norvegicus*, *Rattus rattus*

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INTRODUCTION

Introduced, invasive rats (*Rattus* spp.) have become widely established around the world. They cause substantial damage to crops, stored foods, and property (Timm 1994). Rats can be very prolific when introduced to islands where they have few, if any, predators, and their omnivorous foraging has lead to the endangerment or extinction of numerous island species (Moors and Atkinson 1984). Most seabirds that nest on islands have not evolved to deal with predation and are very vulnerable to introduced rats and other species introductions. There has been a concerted worldwide effort to eradicate introduced rats from islands with numerous successes (Howald et al. 2007, Veitch and Clout 2002). On mainland settings, there has been heavy reliance on rodenticides to control rat populations, although other methods such as traps and exclusion are also used (Timm 1994). In addition to control efforts, the presence of rats must be monitored to assess the success of control and eradication efforts and to provide an early-alert system should rats again re-colonize or gain access to a new area or island. Depending on the setting, monitoring can be done with traps, chew blocks, track stations, or remote cameras. Each of these approaches requires effective attractants especially when rat densities are very low. Rats have a good sense of smell, and attractants based on odors would be very useful for rodent management (Howard 1988, Timm and Salmon 1988). Effective attractants would allow managers to attract rodents to remote detection devices, bait stations, or traps. The bait stations, in turn, might have oral baits containing rodenticides, fertility control materials (where non-target hazards preclude lethal control), or disease control materials such as vaccines. Most research along these lines, however, has been on food flavor additives to enhance palatability and the amount of time spent feeding on toxic baits (Marsh 1988, Meehan 1984). Unfortunately, identification of effective rat attractants has eluded researchers to date (Marsh 1988, Meehan 1984). For example, Bullard (1985) reported that rats were more interested in familiar foods than in a wide array of odors tested. Additionally, much more effort has been put into research on rodent repellents than on attractants (Meehan 1984). Researchers have shown that rodents will respond to the biologically-derived odors (semioichemicals) of conspecifics, but the responses are variable depending on the age, sex, social dominance, and breeding condition of the animal (e.g., Drickamer 1997, Salmon and Marsh 1989). Hence, rodent semiochemicals may act as an attractant, repellent, or may do neither depending on the specifics of the situation. Consequently, in terms of management tools, we cannot expect rodents to respond reflexively and consistently to phermones as do some insects (Howard 1988). One of the few odors that some researchers have found to be attractive to rodents is carbon disulphide (Galef et al. 1988, Shumake et al. 2002); however, other researchers did not find this material to be particularly attractive (Koehler et al. 1994).

The pen study investigated 18 natural and synthetic materials as attractants, using wild-caught Norway rats (*Rattus norvegicus*) in a semi-natural pen setting. This research built upon earlier work that found that carbon disulfide increased capture rates and bait uptake, but used individual, white (Wistar) laboratory rats for trials in small, indoor arenas (Shumake et al. 2002). The second study was a brief field trial using the best 3 attractants identified in the pen trials.

METHODS

Pen Trials

Wild Norway rats, live-trapped near Fort Collins, CO, and their offspring were maintained in individual rack cages within an outdoor rodent building at the NWRC in Fort Collins. Rats were checked for general health and dusted with an insecticide (DeltaDust®; 0.05% deltamethrin, active ingredient) to kill ectoparasites. The rats were provided with rat chow, an apple slice daily, and

water *ad libitum*. A piece of burlap and chew sticks were also provided. The rats were allowed at least 2 weeks to acclimate to the cages before trials began. The rats were also weighed and sexed before the trial began. A small number of wild roof rats (*R. rattus*) were obtained from Wildlife Services operations personnel in Phoenix, AZ. They were maintained in the same way and were used for 1 trial (no replication with this species).

A group of 4 Norway rats (3 females, 1 male) was established in an outdoor rodent building for a series of trials. The rodent building was 9.1 × 12.2 m and contained about 1 m of soil for burrow establishment. The rodent building contained 2 low wooden pallets for harborage, several piles of straw (for bedding), sticks and rocks, and segments of PVC piping along each wall. Two rodent chow troughs were provided along with a central water container; each was replenished as needed. The group of rats was allowed a week to acclimate to the building and to establish burrow systems.

The series of trials was replicated twice, using new groups of Norway rats. Then the trials were conducted with 1 group of roof rats; inadequate numbers of female roof rats prevented replication with this species.

Four-choice trials were conducted with potential attractants at 3 corner lure stations and water (control) at the fourth station. Each lure station consisted of a 0.3 × 0.3-m white vinyl floor tile. A metal tube was placed vertically into the soil through a hole in the center of each tile. During the late afternoon of a trial day, the stations each received a randomly-assigned potential attractant with 1 station always being water (control). The potential attractant (or water) was placed into a 2-ml disposable plastic centrifuge tube. The tube was pushed down into the metal tube such that the rats did not have direct access to the test materials, but could detect the odors dispersing from the tubes. An infra-red video camera system was mounted on ceiling braces above each lure station so that 24-hr recordings were made of rat visits to lure stations. When tapes were later viewed, the amount of activity at each station was recorded as 1) a pass– the rat did not go on the tile, 2) a near visit– the rat was on the tile, or 3) a direct sniff– the rat directly sniffed the centrally-located lure tube opening. For purposes of data analysis, we combined the latter 2 categories into the total number of visits to the lure station. An ANOVA test was used to determine if some potential attractants received significantly ($P \leq 0.05$) more visits than others or the control.

Potential attractants were added in the late afternoon and removed the next day by mid-morning. The open-air building was left without lures for a full 24 hrs to dissipate any lingering odors before the next trial with 3 new potential attractants. This process was repeated a total of 6 times with each group of rats, allowing 18 potential attractants to be tested with 3 replications. The materials tested were genaniol, eugenol, carbon disulphide (diluted to about 1 part in 1,000 parts water), almond extract, ginger extract, lemon extract, banana flavoring, anise oil, peanut oil, peppermint extract, chocolate (ground and added to water), cod liver oil, apple concentrate, bacon grease, fatty acid scent (FAS), fermented egg (Deer-Away), cheese spread, and coconut flavoring. Hence, all were in a liquid form (except the cheese spread, which was more like a paste) and the lure tubes were filled with about 1 ml of the potential attractant.

Once a group of rats was finished with their 6 trials, they were live-trapped and returned to their individual cages and put back on routine animal care. All straw was removed from the rodent building and the soil was raked before fresh straw was added. After a few days, the next group of rats was placed in the building and allowed to acclimate before beginning the series of 6 trials. All rats were euthanized and incinerated at the end of the study.

Field Trial

The field study was conducted at a livestock (cattle and sheep) feedlot near Ault, CO. Landowner permission to trap rats was obtained. Cage traps were placed at locations where rat sign was observed. The traps were set in the late afternoon and checked in the morning. Traps were operated from 6-7 consecutive nights, generally until no, or very few, daily captures occurred. Each trap was randomly assigned (by a roll of a die) to 1 of 4 treatment groups: almond extract, ginger extract, lemon extract, or water (control). An approximately equal number of traps were used in each treatment group. Traps were placed in 2 distinct areas of the feedlot (north-side and south-side) that were separated by a 2-lane highway. Each trap had a unique number assigned, and the number was attached to the trap.

The assigned attractant (about 2 ml) was placed on a small piece of sponge in a small plastic weighing tray under the cage trap at about the treadle location. A small

Table 1. Total direct sniffs and near visits of lure stations by group of Norway rats, June-October 2005.

Attractant	Group 1	Group 2	Group 3	Totals
Almond	6	11	15	**32**
Lemon	7	7	1	**15**
Ginger	3	6	3	**12**
Geraniol	1	11	0	**12**
Peppermint	4	4	0	**8**
Anise	1	5	1	**7**
Carbon disulphide	3	3	0	**6**
Banana	4	2	0	**6**
Fermented eggs	0	6	0	**6**
Eugenol	5	0	0	**5**
Apple concentrate	2	2	0	**4**
Bacon grease	2	2	0	**4**
Cheese spread	0	2	2	**4**
Coconut	2	1	0	**3**
Fatty acid scent (FAS)	2	0	0	**2**
Peanut oil	0	1	0	**1**
Chocolate	1	0	0	**1**
Cod liver oil	0	0	1	**1**
Water (control)*	1	1	0	**2**
Total sniffs/ visits	**47**	**71**	**24**	**142**

*Note that each entry for water is the average of 6 values, as water was presented during each trial run of 3 potential attractants.

amount of soil was removed from under the trap to create a depression for the tray. Traps were re-treated every-other day or as needed (depending on evaporation rate, being covered with soil, etc.). Control traps were set in the same way except that distilled water was used instead of a potential attractant. Each trap used in the study was at least 2 m from any other trap.

Beginning the day after treatment, the traps were monitored daily. Captures were recorded by date, location, trap number, and treatment. The sex and weight of each rat captured was also recorded after euthanasia. All non-target captures were recorded and the animal was released, unharmed, nearby. These data were used to determine whether or not attractants being tested for Norway rats were also attractive to non-target animals. All rats captured were euthanized and buried on site.

RESULTS

Pen Trials

The combined number of direct sniffs and tile visits (henceforth called "visits") by attractant and trial are presented in Table 1. There was considerable variation in the total number of visits between trial groups of rats: Group 1 = 47, Group 2 = 71, and Group 3 = 24 (Table 1). The 4 attractants that were visited most often were almond, lemon, ginger, and geraniol. Note, however, that almost all (11 of 12) visits to geraniol were by rats in Group 2. An ANOVA test revealed a significant difference in number of visits by attractant ($F = 2.83$, $DF = 18$, $P = 0.0035$), however, only almond extract received a significantly greater number of visits than all other attractants. Besides almond, lemon, and ginger, the only attractant to receive at least 1 visit by a rat in each of the 3 series of trials was anise (Table 1). The number of visits to an attractant varied considerably by trial with almond and ginger showing the most consistency across trials (Table 1).

The roof rats showed very different responses to the potential attractants in the pen study than the Norway rats with the exception of lemon, which was visited most often (13 visits) by the 1 group of roof rats tested. Next most frequently-visited attractants by roof rats were peppermint and eugenol (10 visits each), anise (9 visits), and almond and FAS (8 visits each). Interestingly, the roof rats visited the water (control) station more often (average of 4.5 visits per trial) than the Norway rats (average of 0.7 visits per trial). Because we could not replicate the attractant trials with the roof rats, statistical analysis was not possible.

Field Trial

Thirty-six Norway rats were captured at the feedlot from May 17-25, 2006 (Table 2). Because there were 312 trap-nights, this equates to a capture success rate of about 12%. Somewhat more males (58%) were captured than females (42%). This was not unexpected, as males tend to be more exploratory than females.

None of the 3 potential attractants proved effective in improving rat capture rates. Roughly equal numbers were caught with the 3 test materials, and each caught fewer rats than the control (water-only) traps (Table 2). An ANOVA test revealed no significant difference between captures by attractant type ($F = 0.48$, $DF = 3$, $P = 0.71$).

Table 2. Norway rat live-captures by area and lure type, Ault, CO, May 2006.

Area	Lure Type			
	Almond	Ginger	Lemon	Control (water)
Northside	2	1	5	4
Southside	5	6	5	8
Total (both areas)	**7**	**7**	**10**	**12**

Only 5 non-target animals were captured: 4 ground squirrels (*Spermophilus* spp.) and 1 striped skunk (*Mephitis mephitis*).

DISCUSSION

Introduced, invasive rodents have been extremely detrimental to mainland and island resources worldwide. A variety of methods are used to control rodent populations and to reduce their damage (Witmer et al. 1995). That being said, new methods continue to be investigated (e.g., fertility control, disease agents, barriers; Howard 1988). Effective odor attractants would be a great addition to the "tool box" of options for commensal rodent control. They would allow managers to attract rodents to remote detection devices, bait stations, or traps. The bait stations, in turn, might have oral baits containing rodenticides, fertility control materials, or disease control materials such as vaccines. In this pen study, we identified 3 odor attractants that appear to have potential for effectively attracting Norway rats: almond, lemon, and ginger.

In the preliminary field study, we tested the 3 odor attractants (almond, lemon, and ginger) that had effectively attracted Norway rats in the pen trials. None of the 3 potential attractants were effective at the one site tested; hence, we cannot recommend further testing of these materials. Apparently, the effort to identify an effective odor attractant for Norway rats has once again been elusive. Additional pen trails will be needed to identify additional candidates for field testing.

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