Comparing House Mouse Management Programs in Apartments

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ABSTRACT: The house mouse is a common indoor pest found in the urban environment. Low-income communities often have the highest house mouse infestation rates due to inadequate pest management practices. We conducted an 18-month long study evaluating the effectiveness of three house mouse management strategies in a low-income community in New Jersey, U.S. Six buildings containing 156 apartments were divided into three groups, T&B, T&B+E, and control. The T&B treatment included the installment of traps and rodenticide baits. The T&B+E treatment included using traps and rodenticide baits, plus interior and exterior exclusion of the buildings. Researchers applied baits and traps inside apartments, crawl spaces, and basements and followed up until no mouse activity was found. Exclusion was completed by contracted vendors with oversight from researchers. The apartments in the control group were serviced by an existing contractor which used rodenticides and glue boards for mouse control and their treatment was offered only to residents who complained about mouse infestations. Building-wide inspections were conducted at 0, 6, 12, and 18 months to evaluate the effectiveness of the programs. T&B and T&B+E were more effective than the control in reducing house mouse infestations. The infestation rate in T&B, T&B+E, and control at 12 months (May 2023) was 2, 2, and 44%, respectively. The infestation rate rebounded in all groups from 12 to 18 months, which was probably related to lower temperatures in winter. T&B+E treatment caused faster reduction of mouse infestations than T&B treatment, but did not result in lower new infestations than T&B. The palatability of different rodenticides varied significantly. Kitchens had a higher amount of mouse activity than living rooms. A median number of three mice were caught by snap traps per infested apartment. Additional studies are suggested to determine the benefit of rodent exclusion.

KEY WORDS: exclusion, *Mus musculus domesticus,* rodent control, rodenticides, traps

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INTRODUCTION

The house mouse (*Mus musculus domesticus* Schwarz and Schwarz) (Rodentia: Muridae) is one of the most prevalent urban pests (Corrigan 2011). House mouse harbor pathogens, contaminate food, produce allergens, and can cause significant property damage (Bonnefoy et al. 2008, Ahluwalia et al. 2013, Williams et al. 2018a,b). Although effective rodenticides and trapping devices are available, urban mice remain a common pest in residential buildings, mostly due to the complexity of large apartment complexes and ineffective pest management programs. (Wang et al. 2008) reported that 36% of the surveyed apartments in Gary, Indiana were infested with rodents. A recent survey of 1,753 apartments from four low-income communities in four cities in New Jersey found 20% of the apartments were infested with house mice (Abbar et al. 2022). It is evident that more effective mouse management strategies need to be adopted to reduce the current high mouse infestation rates, especially in low-income communities.

Current mouse control methods often rely on rodent baits, glue boards, and snap traps (Almeida et al. 2013), among which glue boards are the most widely used, even though they are not effective for controlling mouse infestations (Frantz and Padula 1983, Corrigan 1998). While rodent baits and mechanical traps are effective, they are often used reactively, based on complaints from clients instead of proactively. Lack of proactive monitoring and prompt treatment allows mice to be prevalent in multi-unit dwellings. Sealing holes and cracks to prevent mice entry and spread, or "rodent-proofing" of the structure, is recognized as a critical method for sustainable rodent management. However, Corrigan (2011) found proper rodent exclusion was rarely utilized by property managers to control mice in infested structures. Most apartment buildings are not properly sealed, allowing mice to enter buildings or move between apartments in multi-dwelling buildings.

In light of the high prevalence of rodent infestations and ineffective mouse management practices, we designed a study to evaluate three mouse control programs for managing infestations in apartment buildings. The three programs are: contractor's existing service (using bait and/or glue boards), trapping and baiting (T&B); trapping, baiting, and rodent exclusion (T&B+E). We hypothesize that both T&B and T&B+E will be more effective than the control in reducing house mouse infestations; 2) T&B+E-treated buildings will have lower new infestations than the buildings received T&B treatment.

METHODS

This study was carried out in a low-income community at Trenton, New Jersey. It contained eight buildings and 219 units. Each building had three stories and each apartment had 1-4 bedrooms (most had 2-4 bedrooms). A community-wide mouse monitoring was conducted in April 2022 to identify buildings with a high number of house mouse infested apartments. A Protecta® EVO® Mouse station (Bell Laboratories, Inc., Madison, WI) with a Liphatech® Rat & Mouse Attractant (Liphatech, Inc., Milwaukee, WI) and three ~1 g dollops of chocolate spread (The

Hershey's Company, Hershey, PA) were placed in the kitchen of each apartment for one week to identify infestations. If an apartment was missed during inspection (no key, refused, only minor at home, etc.), it was visited within a month to determine the infestation status. Consumption of blank rodent bait was considered as having rodent activity. Six buildings (156 units) with high mouse activity were selected. They were divided and assigned to one of the three treatment groups: T&B, T&B+E, and control. The T&B and T&B+E groups consisted of 51 apartments each, and the control group consisted of 54 apartments.

Trapping and Baiting (T&B treatment)

After five weeks (May 23, 2022) of identification of apartments with rodent activity, Rutgers University researchers placed two TrapRite® cardboard boxes (Anstar Products, Inc., Niles, IL) that containing four Victor® Easy Set™ Mouse snap traps (Woodstream Corporation, Lancaster, PA) and two mouse bait stations (Protecta® EVO® Mouse bait stations) with rodenticides to all apartments without mouse activities as a preventative measure to detect and control new infestations. One set was placed in the kitchen and the other set was placed in the living room. Four kinds of rodenticide baits were used in this study: FirstStrike (0.0025% difethialone) and TakeDown (0.01% bromethalin) from Liphatech, Inc. (Milwaukee, WI), Fastrac (0.01% bromethalin) and Ditrac (0.005% diphacinone) from Bell Laboratories (Madison, WI). TakeDown and Ditrac were the most used baits (80% of the bait used). They represent different modes of action, bait matrices, and texture. Two different kinds of rodenticide baits were placed in each mouse station.

In the mice-infested apartments, two TrapRite boxes and two Sherman live traps (H. B. Sherman Inc., Tallahassee, FL) were installed to control and to collect mice for studying mouse ectoparasites as part of a grant program. In most apartments, one set, including a TrapRite box and a Sherman trap was placed in the kitchen and another set was placed in the living room. In six apartments, the number of TrapRite boxes varied from 1-3. In seven apartments, the number of Sherman traps varied from 1-4. The extra boxes or traps were either placed in bedrooms or kitchens. A 1-page flyer about the importance of house mice along with prevention and control methods was given to residents in each apartment. Traps were examined every 1-2 days between May 24, 2022 and June 10, 2022. Mice caught by traps were removed and triggered traps were reset or replaced with new traps. Afterwards, two mouse bait stations with rodenticides were added and Sherman traps were removed. Researchers visited all mouse infested apartments every four weeks. During follow-up visits, rodenticide baits and snap traps were checked. The rodenticides were replaced with new ones if there was any consumption. Some rodenticides were consumed by American cockroaches (*Periplaneta americana*) or German cockroaches (*Blattella germanica*). They were easily distinguished from mice feeding based on feeding marks or presence of cockroach feces. The dead mice from the snap traps were discarded and the traps were reset or replaced. If there was no mouse activity based on bait stations and snap traps over the 4-week period, the apartments were no longer visited until the next building-wide inspection.

Building-wide inspection was conducted at 6, 12, and 18 months after the installation of traps and rodenticide baits using the same method as for the 0 month inspection. In all T&B and T&B+E apartments, new TrapRite boxes and mouse stations with rodenticides were installed if they were missing or damaged. Triggered snap traps were reset and rodenticides with consumption were replaced.

Trapping, Baiting, and Exclusion (T&B+E treatment)

This treatment used same trapping and baiting methods as in the T&B group but also included rodent exclusion around the exterior perimeter of the buildings and inside the apartments. Exclusion was done by an experienced pest control contractor selected by the researchers and was oversight from researchers. Exclusion to the exterior of buildings included entry doors, basement/crawl space windows, utility line penetrations, holes in walls, and any other gaps ¼ inch or larger that had been identified. Exclusion inside apartments included all vertical and horizontal utility penetrations, gaps along baseboards, holes in walls, and any other gaps ¼ inch or larger that had been identified. Due to high labor cost, the interior exclusion was conducted only in the 20 units identified with existing house mouse infestations at 0 month. Materials used included Xcluder door sweeps (Global Material Technologies, Inc., Buffalo Grove, IL), Xcluder rodent fill fabric (Global Material Technologies, Inc., Buffalo Grove, IL), BASF master seal, ¼ inch stainless steel mesh, fast-setting concrete mix (Rapid Set Mortar Mix, CTS Cement Manufacturing Corp., Cypress, CA), and metal flashing. The exclusion work was completed during June 20-29, 2022 (10 weeks after initial identification of the infestations). Rutgers University researchers checked the quality of the exclusion and asked contractors to seal missed rodent entry points. Additional exclusion work was conducted in 12 of the 20 apartments and exterior of the two buildings on July 29, 2022.

Control Group

Apartments in the control group continued to receive monthly pest control services offered by an existing pest control contractor. To our knowledge, the contractor used FirstStrike rodenticide bait and/or glue boards for mouse control. However, the contractor only visited the apartments when complaints were received from residents or housing staff. For this reason, most apartments with mouse infestations did not receive treatments.

Statistical Analyses

The rodenticide consumption in the kitchen and the living room was analyzed by student *t*-test or signed rank test. The consumption by weight was calculated as the consumed volume (%) multiplied by the average weight per rodenticide pouch or block. The Chi-square test was used to compare the number of mice caught between kitchens and living rooms, between trap catch and rodenticide consumption. All analysis was done using SAS 9.4 software (SAS Institute 2019).

RESULTS

Dynamics of Mouse Infestations

During the four inspection periods, we accessed 73-85% of the apartments. The non-accessed units were due to refusal to access by residents, or the apartments were boarded for repair. Both T&B and T&B+E treatments were very effective in reducing the infestation rate to a very low level (2%) after 12 months. Whereas the percent of homes with mouse infestations in the control increased from 30% to 44% over the same period (Figure 1). T&B+E caused faster reduction in infestation rate than T&B from 0 to 12 months.

From 12 (May 2023) to 18 months (December 2023), all three treatment groups experienced an increase in mouse infestations, which was probably caused by new invasions related to seasonal differences in outdoor temperatures. The mean monthly temperature in May 2023 and January 2024 recorded by the nearest weather station was 16.1 and 1.5℃, respectively. T&B+E had higher number of new infestations than T&B from 12 to 18 months, which is contrary to our hypothesis about the role of exclusion, suggesting that hidden rodent entry points that were not visible to us still existed. Residents letting the exterior doors of the buildings remained partially open also affected the effectiveness of exclusion.

From 0 to 18 months, the percent of apartments with house mouse activity increased by 24% (from 30% to 54%), indicating the lack of effectiveness of the pest control service from the contractor. In contrast, the percent of apartments with mouse activity in T&B and T&B+E groups decreased by 22% and 27%, respectively. Besides those mice infested units identified by blank baits during periodic building-wide inspections, there were 18 and 10 infested apartments detected by traps or rodenticide baits in T&B and T&B+E groups, respectively. They accounted for 55% and 26% of the identified infestations in T&B and T&B+E treatments, respectively. Therefore, placing traps and baits in all units helped detect and control missed or new infestations between building-wide inspections. Over the 18 months period, 72, 65, and 78% of the accessed apartments experienced house mouse infestations in the control, T&B, and T&B+E groups.

Bait Consumption

Among 95 observations in 41 apartments where mouse consumption occurred and both stations in the kitchen and the living room were present, mean consumption of bait in kitchens and living rooms was 1.0 ± 0.1, and 0.5 ± 0.1 pouch (block), respectively. Consumption in kitchens was significantly higher than that in living rooms ($t = 4.37$, $df = 94$, $P < 0.0001$), indicating greater mouse activity in kitchens than in living rooms. Rodenticide bait acceptance varied significantly. FirstStrike was consumed significantly more than Ditrac based on weight ($t = 3.06$, $df = 10$, $P = 0.01$). TakeDown was also consumed significantly more than Ditrac based on weight ($S = 189$, $P < 0.0001$). There was no significant difference in palatability between FirstStrike and Fastrac ($t = 1.46$, $df = 7$, $P = 0.18$) and between FirstStrike and TakeDown ($t = -1.05$, $df = 17$, $P = 0.31$).

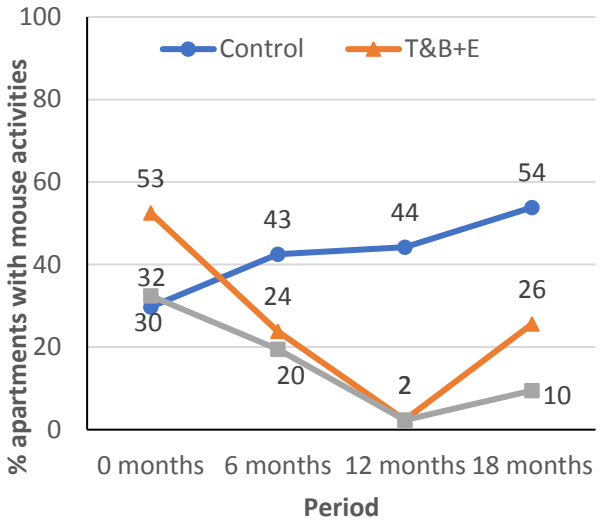

Figure 1. Effect of three mouse control programs on mouse infestations over 18 months period.
"Control": monthly service by existing pest control operator using glue boards and rodenticide, only when complaints received; "T&B+E": trapping, baiting, and exclusion; "T&B": trapping and baiting.

Mice Caught by Mechanical Traps

Before rodenticides were installed (May 24-June 10, 2022), a total of 120 mice were caught by snap traps and 39 mice were caught by Sherman traps from 35 infested apartments (4.5 mice per apartment). When both snap traps and Sherman traps were present and not disturbed, there were 70 observations where mice were caught by snap traps, but not by Sherman traps. In contrast, there were only 12 observations where more mice were caught by Sherman traps, but not by snap traps. Snap traps were more effective in catching mice than Sherman traps, even though more snap traps were present in each apartment (average four snap traps and two Sherman traps per apartment) ($\chi^2 = 28.8$, $df = 1$, $P < 0.0001$). After adjusting for the number of traps, each snap trap caught 0.28 ± 0.02 mice compared to 0.19 ± 0.03 mice by Sherman traps when mice were caught in apartments.

During the 18 months period, 290 mice were caught in 52 apartments. Snap traps caught a median number of three mice and maximum number of 38 mice per apartment. In addition, there were 18 apartments with traps but no mice were caught. The apartment with 38 mice was visited 20 times over 367 days period. In addition to the 38 mice caught by snap traps, 4 mice were caught by Sherman traps in that apartment. During each visit to that apartment, 1-3 mice were found on snap traps until April 26, 2023. Based on 138 observations where mice were caught by snap traps in apartments, mice were more likely to be caught in kitchens than in living rooms ($\chi^2 = 62.6$, $df = 1$, $P < 0.0001$). There were 24 cases where mice were caught both in kitchens and living rooms, 87 cases where mice were only caught in kitchens, and 27 cases where mice were only caught in living rooms, illustrating the importance of not limiting the use of rodent control devices to kitchens.

Comparison between Rodenticides and Snap Traps

There were 175 observations where mouse activity was detected (either with mice caught by snap traps and/or with rodenticide consumption) in apartments. Among them, there were 144 observations of bait consumption, and 97 cases of mice caught by traps. Placing rodenticide bait is more likely to detect mouse activities ($\chi^2 = 30.29$, df = 1, $P < 0.0001$). There were 78 cases where only rodenticide bait consumption was observed, and there were 31 cases where mice were only detected by snap traps.

DISCUSSION

This study revealed the existing pest control service adopted by the housing authority failed to reduce mouse infestations. Many infested apartments were left untreated based on our observations during our building-wide inspections. In those that were treated, the contractor only placed rodenticides behind stoves or only used glue boards when they received complaints. The result underscores the need to modify the pest control contracts that commonly adopted by low-income communities.

Both T&B and T&B+E programs were effective in reducing the number of house mouse infestations to very low levels after 12 months. None of the infested apartments identified in T&B and T&B+E at 0 month had mouse activity at 18 months. T&B+E caused faster reduction in infestation rate than T&B from 0 to 6 months. Thus, the exclusion work was helpful in mouse elimination even though the exclusion work was conducted about two months after initial identification of the infestations. However, rodent proofing of buildings and in some of the apartments did not lead to lower number of new infestations from the 12 to 18 months period compared to the T&B group. All nine new infestations from 12 to 18 months in T&B+E occurred in one building. Ineffectiveness of exclusion might be due to: 1) only those units with mouse activity identified at 0 month received rodent exclusion; 2) residents often left the exterior doors of the building partially open.

We selected the rodent exclusion provider based on a combination of the bid price and reputation. The labor cost for rodent exclusion was US$150 per unit and $2,500 for exterior exclusion of two buildings (total 51 apartments). The exclusion materials for apartments (door sweeps, rodent fill fabric, caulking materials, etc.) were approximately $44 per apartment. The materials needed for exterior exclusion were approximately $208 for two buildings. Total exclusion cost was estimated $247 per apartment. Whereas mouse control materials (mouse stations, TrapRite boxes, rodenticides, snap traps) were only $16 per apartment. In spite of the high labor cost charged by the exclusion contractor, 13 out of the 20 units where the contractor performed interior exclusion needed to be revisited to seal missed potential rodent entry points based on our inspections. There were also missed rodent entry points around the exterior of each of the two buildings. The very high exclusion cost will be a limiting factor affecting future adoption in sustainable mouse management programs in apartment buildings.

We found installing both snap traps and rodenticides in all apartments, regardless of the presence or absence of mouse activities helped detect and control new infestations that occurred between the periodic building-wide inspections. This approach does not fit the traditional integrated pest management (IPM) principle which recommends pesticide application as a last resort. However, we felt it is important to have rodenticide bait stations present in each apartment in buildings with a high percentage of infested units, as shown in the results. There were 78 observations where baits were consumed, but the traps placed in the apartments did not catch mice. Thus, placing both traps and baits were important for fast control. Since rodenticide baits were in mouse stations, they could be easily removed from the apartments if needed. Results also show that in family style apartment buildings, not limiting placement of traps and bait in kitchens alone, is necessary to achieve fast elimination. We only placed two TrapRite boxes (four snap traps) per apartment to minimize the cost and labor. The high number of trapped mice in some apartments indicate the number of TrapRite boxes could be increased for faster mouse elimination. Besides kitchen and living room, placing traps or bait stations in other rooms where activities are suspected is recommended. Rodenticide baits varied in their palatability. It is necessary to use a combination of rodenticides or rotate among different baits in each apartment to increase the likelihood of consumption and avoid resistance development which has been reported in the U.S. and other countries (Jackson and Ashton 1986, Pelz and Prescott 2015, Díaz and Kohn 2021, Krijger et al. 2023).

American cockroach and German cockroach feeding on baits placed on snap traps might have affected the speed of mouse elimination in apartments with cockroach activity. Future studies should consider implementing cockroach control at the same time when conducting mouse control. In this study, rodenticides and snap traps were also placed in basements and areas behind crawl space doors of the buildings. However, most consumption was due to American cockroach or Oriental cockroach (*Blatta orientalis* L.) feeding, rather than mouse feeding.

We encountered several challenges in implementing the mouse control programs including resident refusal to access apartments, residents throwing away traps and bait stations, and poor sanitation, which likely had a negative impact upon the success of the treatments. There was also a general lack of structural repair such as large holes in walls or ceilings, and gaps associated with crawl space access points. Another challenge was the loss of access to some apartments due to vandalism or major repair needs. Those apartments were boarded and might have mouse activity. The structural defects compromised the effectiveness of rodent exclusion and the building-wide treatments.

While rodent exclusion is recognized as a long-term rodent management procedure, the high cost to fully and properly exclude rodents in every apartment may be prohibitive to many low-income communities. The effectiveness of rodent exclusion needs to be further studied to confirm its benefit and increase the adoption of this procedure. Sustainable control of house mouse infestations will need to incorporate resident education and cooperation, using traps and baits, periodic building-wide monitoring, and proper structural maintenance of the buildings.

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