Journal of Animal & Plant Sciences, 36(2): 2026, Page: 341-347
ISSN (print): 1018-7081; ISSN (online): 2309-8694
https://doi.org/10.36899/JAPS.2026.2.0029

ECO-FRIENDLY STRATEGIES FOR CONTROLLING HOUSE MICE AND OVERCOMING TRAP-SHYNESS

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ABSTRACT

House mice (*Mus musculus*) are invasive rodents that pose serious challenges in urban and rural environments by contaminating food, transmitting diseases, and disrupting ecosystems. One of the major obstacles to effective control is trap-shyness, a learned behavioral avoidance following initial trap exposure. This study evaluated eco-friendly strategies to control house mouse populations while mitigating trap-shyness through improved trap design, bait selection, optimized placement, and behavioral camouflage. A novel approach involved camouflaging traps with mud to reduce visual and tactile detection by mice. Following the onset of trap-shyness, capture rates increased markedly after trap camouflaging, rising from 5–11 to 67–98 mice per store. Rodent activity, assessed via food consumption, declined substantially by over 90% in store 1 (from 735 to 40 g) and store 2 (from 398 to 34 g), and by 86.5% in store 3 (from 549 to 74 g). Statistical analysis confirmed that trap camouflaging significantly reduced trap-shyness ($P < 0.05$). By integrating behavioral ecology with sustainable pest management techniques, this study demonstrates an effective, non-chemical approach for house mouse control. The findings provide practical and environmentally responsible solutions for pest management professionals and researchers.

Keywords: *Mus musculus*, Camouflage techniques, Wildlife management, Rodent control, Trap-shyness.

Published first online December 25, 2025 Published final February 28, 2026

INTRODUCTION

House mice (*Mus musculus*) are adaptable rodents found worldwide in diverse environments, including urban, suburban, and rural areas. Their ability to thrive near humans makes them common in homes and food storage areas, but their presence can lead to serious problems. These mice contaminate food supplies by gnawing and leaving droppings, creating health and hygiene risks (Brown and Henry 2022). They are also carriers of diseases that can harm both humans and animals, making their presence a serious health concern (Rabiee *et al*., 2018). Their close association with human habitats increases the likelihood of disease transmission through direct contact or contamination of living spaces and food supplies. Consequently, controlling house mouse populations and mitigating their impact on humans and domestic animals' health and well-being is paramount for maintaining sanitary and preventing the spread of infectious diseases (Badan 1986, Singleton *et al*., 2003, Himsworth *et al*., 2013).

Traditional methods like snap traps, glue boards, and chemical rodenticides are commonly used for mouse control. However, these approaches can lead to "trap-shyness," where mice avoid traps after an initial encounter, reducing their effectiveness (Meerburg *et al*., 2009). Innovative solutions like the Faragir trap, a chemical-free live trap, offer safer alternatives for households with children or pets (Banazadeh *et al*., 2018). These traps also have minimal environmental impact and attract other mice, making them more efficient than conventional methods (Hamidi 2015). Trap efficiency is influenced by factors such as design, bait type, placement, and the behavioral traits of individual mice (Crowcroft and Jeffers 1961, Meerburg *et al*., 2009).

In recent years, there has been increasing interest in alternative methods for mouse control aimed at overcoming trap shyness and reducing environmental risks (Eason *et al*., 2017). Integrated pest management (IPM) strategies, incorporating diverse controls in a coordinated approach, have demonstrated effectiveness in reducing rodent populations and addressing trap shyness (Tripathi 2014). By combining multiple techniques, such as habitat modification, sanitation measures, and targeted trapping, IPM offers a comprehensive solution to rodent

infestations while minimizing environmental impacts (Motro *et al*., 2019, Innes *et al*., 2024).

Rodents like mice and rats have complex behaviors that help them sense and avoid danger. Trap shyness happens when rodents connect traps with danger, causing them to be cautious and harder to catch. Traditional trapping methods may not work well with trap-shy rodents, so new strategies are needed (Crowcroft and Jeffers 1961, Stephens and Anderson 2014, Lorica *et al*., 2022). A potential solution involves camouflaging traps to make them less visible to rodents. Studies have shown that camouflage is important for reducing detection and increasing hunting success (Stevens 2013). It was observed that the camouflaging traps with mud mimics natural elements, making them less threatening and more acceptable to rodents. While direct research on mud camouflage for trap shyness is limited, similar techniques in wildlife management have shown promise (Stevens and Merilaita 2009, Lane *et al*., 2010, Stevens 2013, Troscianko *et al*., 2018).

Although camouflaging traps has been effective in wildlife management, its application in rodent control remains underexplored (Singleton 1987, Cameron *et al*., 2005). However, the use and effectiveness of camouflage techniques in rodent control settings require more investigation and testing, highlighting the need for additional research and validation (Troscianko *et al*., 2018). This study examines the effectiveness of camouflaging traps with mud to reduce trap-shyness and improve mouse capture rates in three food stores in Mashhad, Iran. By integrating traditional and innovative methods, this research offers practical insights for pest control professionals, homeowners, and researchers aiming to develop sustainable rodent management strategies.

MATERIALS AND METHODS

Study Locations: The study was conducted in three large chain stores in Mashhad, Iran, each covering 1500 m². These stores were selected based on reports of house mouse activity and accessibility for research. The stores sold a variety of food products, including meat, groceries, fruits, vegetables, and daily essentials.

Estimating Mice Population: The bait-box method is an effective technique for estimating rodent populations, based on precise measurement of food consumption over a specific period. In this method, the amount of food remaining after 24 hours is examined, and the number of rodents is estimated using the following formula:

$$\frac{H}{n \times h} = N$$

- **N**: Estimated number of rodents
- **H**: Total food consumed (in grams)
- **h**: Daily food consumption rate of the specific rodent species (for house mice, 6 grams per day)
- **n**: Number of days the food was available to the rodents

For this purpose, 20 plastic bait boxes, each measuring 20 × 20 cm, were randomly installed in various locations. Each box was provided with 100 grams of bait, consisting of a mixture of grains, daily. The daily consumption was recorded over a period of seven days. Subsequently, the average daily consumption was calculated, and the abundance of mice was estimated using the food consumption method (Desoky 2015, Abdel-Gawad and Desoky 2012).

Trap and Bait: In the present study, Faragir traps were employed, provided by "Asa Gostaran Faragir Company (Iran)", featuring plastic bait boxes (25 × 7 × 7 cm) for bait placement (Fig. 1A-C). Two types of bait were tested: peanuts (dry bait) and cucumber (wet bait). The bait formulations were as follows: the dry bait consisted of whole, unsalted peanuts, while the wet bait was made of freshly sliced cucumber.

Trap Setup and Placement: Traps were strategically positioned in areas with high mouse activity, such as entry points, nesting sites, and feeding spots. Each week, trap locations were changed to prevent mice from getting used to them quickly, reduce territorial effects, and ensure all mice had access to traps. Traps were checked twice weekly, with captured mice counted, bait replenished, and traps washed and dried weekly (Motro *et al*., 2019, Singleton *et al*., 1999).

Experimental Design: Various experiments were conducted to evaluate different methods for controlling house mouse populations and addressing trap shyness. The study was divided into four key phases:

- **Pre-Control:** The period before any control measures were implemented, serving as a baseline to assess changes in the mouse population.
- **Pre-Trap Shyness:** The initial phase after trap placement, during which mice actively interacted with the traps but had not yet developed avoidance behavior. This phase reflects the initial effectiveness of the traps before any learned avoidance occurred.
- **Post-Trap Shyness:** The phase after mice became familiar with the traps and exhibited avoidance behavior, reducing trap effectiveness.
- **Post-Camouflage Trap:** The phase in which camouflaged traps were introduced to minimize avoidance behavior and improve trapping success.

To monitor mouse numbers before and after control efforts, the Bait-take method was used. This method provides an indirect yet effective measure of mouse activity and population levels by tracking bait consumption. In each store, 50 bait boxes were randomly

placed in different locations, and daily bait consumption was measured over three days. The data collected helped evaluate changes in mouse presence and assess the effectiveness of the control methods.

Data Analysis: The results were analyzed using the General Linear Model (GLM) method. The data were analyzed using Minitab ver. 21 software, and the main effects and interactions of factors were evaluated through a Two-Way ANOVA test. Prior to analysis, the data were organized and prepared in Excel 2013.

Ethical Considerations: All experiments followed ethical guidelines for animal research and pest management, in accordance with the AVMA Guidelines for the Euthanasia of Animals (2020). Measures were taken to minimize animal suffering and ensure humane treatment of captured mice.

- Live-capture traps were used to avoid causing physical harm or unnecessary stress to the mice.
- Captured mice were euthanized humanely using carbon dioxide (CO_2), following AVMA guidelines
- Traps were placed in quiet, low-traffic areas to reduce stress caused by human activity or noise.
- Mice were handled gently and for the shortest duration possible during inspections and data collection.
- Any injured or visibly distressed mice were immediately euthanized to prevent prolonged suffering.
- Traps were designed to prevent injuries, such as sharp edges or mechanisms that could harm the mice.

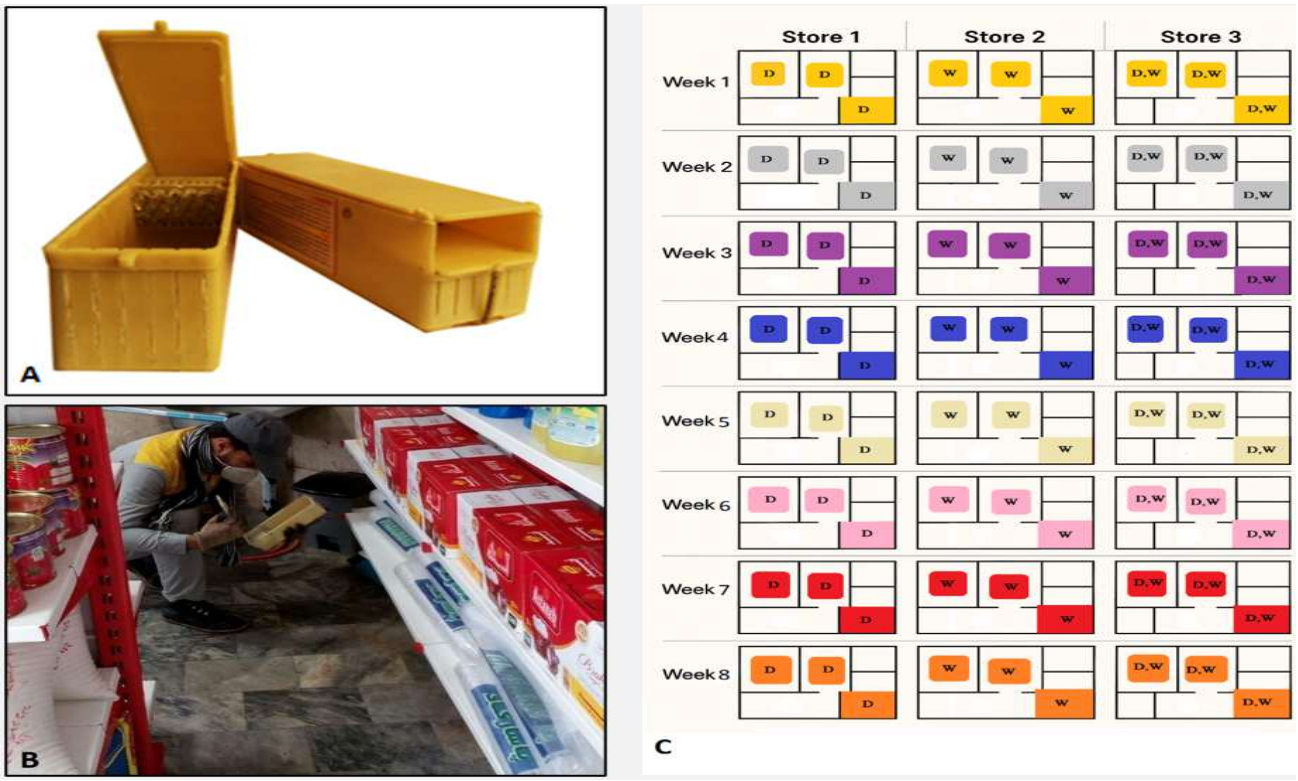

Fig. 1. (A-B) The Faragir Trap used for controlling house mouse (*Mus musculus*) populations, (C) The Faragir Trap placed in the selected stores (W, D= wet and dry bait, W= wet bait and D= dry bait.

RESULTS

Mouse Population and Activity: The study showed that store 1 had the highest mouse population density, with 301 mice captured, compared to 230 in store 2 and 260 in store 3. Food consumption data supported these findings, as store 1 had the highest mean daily food consumption before control efforts (735 g). The mouse population was lowest in store 2, which also showed the least trap-shyness (Table 1). The population density was estimated using the baiting method, which calculates the number of rodents, based on food consumption rates. This method was chosen for its non-invasive nature and reliability in estimating rodent populations in enclosed environments.

Food Consumption Changes: The average amount of food eaten daily dropped a lot during the experiment. Before traps setup**,** the mice ate the most amount of food (735 g in store 1, 398 g in store 2, and 549 g in store 3).

After trap-shyness tests**,** the amount of food eaten reduced sharply (113 g in store 1, 59 g in store 2, and 151 g in store 3), reaching to its lowest levels (40 g in store 1, 34 g in store 2, and 74 g in store 3) where the camouflaged traps were used (Table 1).

The results of the analysis of variance (ANOVA) indicated that the main effects of both factors -weeks and bait type- on the number of trapped mice were significant in all examined food stores ($P < 0.05$, data not shown)

Table 1. Evaluation of trap efficiency and trap-shyness on *Mus musculus* in three food stores.

Period	Store1 (Dry Bait)		Store2(Wet Bait)		Store3(Wet, Dry Bait)	
	Mean daily consumption of food (g)	Number of trapped mice	Mean daily consumption of food (g)	Number of trapped mice	Mean daily consumption of food (g)	Number of trapped mice
Pre-Control	735.02	_	398.34	_	548.71	_
Pre- Trap Shyness	346.45	192	108.41	155	263.20	171
Post- Trap Shyness	112.83	11	58.74	8	151.34	5
Post- Camouflage trap	40.23	98	33.67	67	73.56	84
Total	1234.53	301	599.16	230	1036.81	260

Effectiveness of Camouflaged Traps: Trap-shy behavior was a significant challenge, as evidenced by the sharp decline in mice captured after initial trapping efforts. This behavior was measured by several factors, including a significant drop in capture rates and indirect signs, such as a decrease in bait consumption near the traps, which confirmed the presence of trap-shyness. However, the use of camouflaged traps (+Mud) in week 5 dramatically improved trap efficiency, increasing captures in all stores. This method proved effective in overcoming trap-shyness and reducing rodent activity further (Fig. 2).

The results of the analysis showed the interaction effect between weeks and bait type was significant, suggesting that the effect of bait type on the number of house mice varied across different weeks. This particularly indicates that the combination of baits and the timing of their use had a differential impact on the house mouse population over the weeks (fig. 2). The P-values of less than 0.05 for all sources of variation (weeks, bait type, and their interaction) demonstrate that the observed changes in the number of house mice were significantly influenced by these two factors and their interaction.

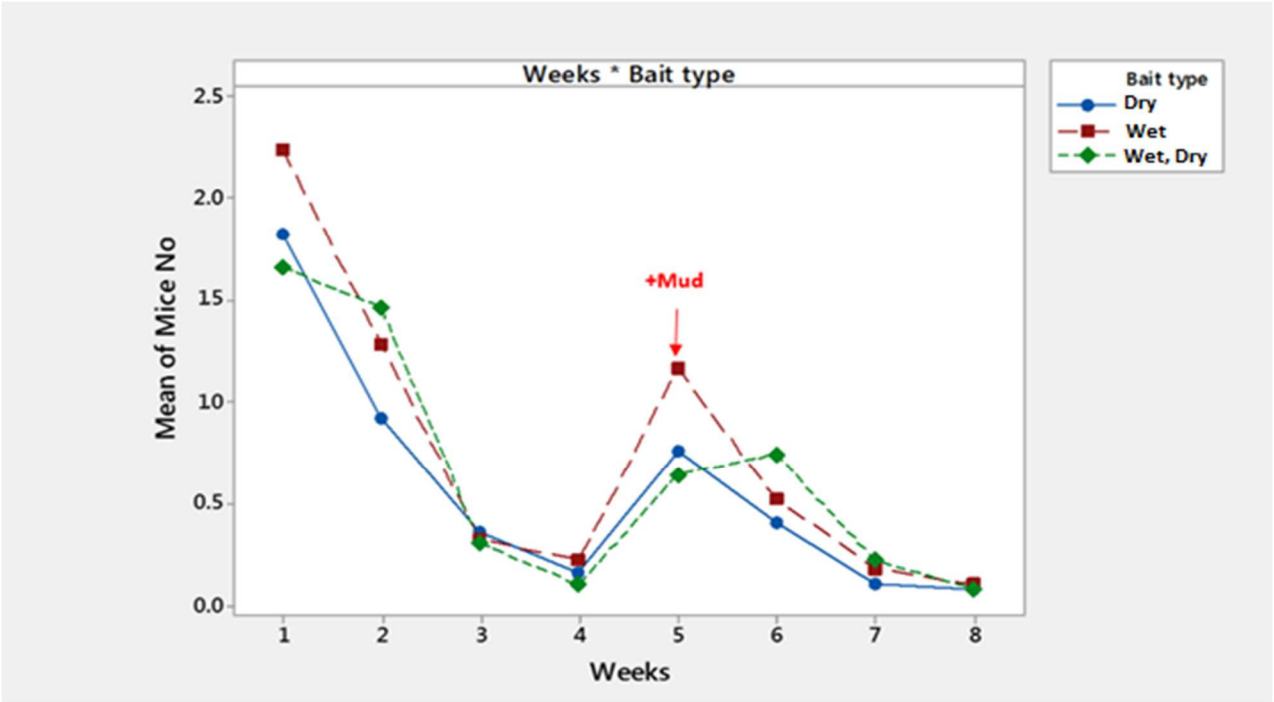

Fig. 2. The number of trapped mice over eight-week period based on bait type (data in three food stores were pooled).

Bait Performance: Dry bait (peanuts) was the most effective overall, particularly in the early weeks and after camouflaged traps were introduced. Wet bait (cucumber) worked well initially but was less consistent. Mixed bait provided average results but did not outperform dry bait alone. These results highlight the importance of choosing the right bait for successful pest control.

Reduction in Rodent Activity: Throughout the study, food consumption decreased significantly, showing a direct link between trapping efforts and rodent activity reduction. By the end of the experiment, mean daily food consumption dropped from 735 g to 40 g in store 1, 398 g to 34 g in store 2, and 549 g to 74 g in store 3. This reflects the success of combined strategies in reducing the mouse population.

DISCUSSION

Several studies demonstrated that the enclosed spaces, trap usage is crucial for controlling mice, especially where poison is not an option (Singleton 1987, Torre *et al*., 2010). However, our findings showed that the traps alone may not significantly reduce mouse populations in high-infestation areas, prompting the exploration of camouflage techniques. Using mud to disguise traps leverages rodents' reliance on visual cues, potentially reducing trap shyness (Sherman *et al*., 1979). Camouflaging traps with mud blends them into the environment, making them less noticeable and increasing capture rates. This innovative approach aligns with principles of predator-prey interactions and wildlife management.

This study highlights how combining simple yet effective strategies, such as using the right bait and camouflaging traps, can significantly reduce mouse populations in urban food stores. Store 1 had the highest mouse density and food consumption, yet after introducing camouflaged traps, both the number of trapped mice and the amount of food consumed sharply decreased. In fact, by the end of the study, store 1's food consumption dropped from 735 g to just 40 g, demonstrating the power of the trapping methods.

One major challenge faced was trap-shyness, where mice avoided traps after the initial captures. However, using mud to camouflage the traps made a huge difference. This simple modification made the traps less visible and helped to overcome the mice's hesitation. The increase in trapped mice after camouflage was introduced shows how small changes in trapping techniques can have a big impact. Camouflaged traps effectively blended into the environment, reducing mice's ability to detect them, and this led to more successful captures.

Food consumption data clearly shows the link between trapping efforts and a decrease in rodent activity. As traps became more efficient, the amount of food eaten by mice sharply dropped. For example, in store 2, where the food consumption was initially 398 g, it fell to just 34 g after using camouflaged traps. This drop in food consumption directly reflects the success of the trapping strategy.

The choice of bait also played a key role in the results. Dry bait (peanuts) proved to be the most effective throughout the study, especially in the early stages and after camouflaged traps were introduced. This supports earlier findings that dry bait tends to attract rodents more consistently. Wet bait, like cucumber, worked well initially but wasn't as reliable in the long term. This shows that selecting the right bait is crucial for successful rodent control.

Previous research has shown that trapping is an essential method for controlling mice in spaces where poisons can't be used (Singleton, 1987; Torre *et al*., 2010). However, our study suggests that just using traps may not be enough, especially in areas with high mouse populations. This is where the camouflage technique becomes vital. Camouflaging traps with mud, an idea grounded in predator-prey dynamics, helped to reduce the mice's ability to detect the traps. This approach worked because mice rely heavily on visual cues, and blending the traps into their surroundings made them less wary. The results from this study show how a small but clever modification can drastically improve trapping success (Sherman *et al*., 1979, Awoniyi *et al*., 2024).

Conclusion: The study shows that combining effective bait, adaptive trapping strategies, and camouflaged traps significantly reduces mouse populations in urban environments. The use of mud camouflage helps mitigate trap shyness, making traps more effective by blending them into the surroundings. This approach aligns with predator-prey dynamics, where camouflage reduces the likelihood of rodents avoiding traps. The research highlights the need for adaptable baiting strategies, as the interaction between bait types and trapping duration influences success. By continuously adjusting these strategies, long-term rodent control can be achieved. The methods also emphasize environmentally friendly and humane pest control, reducing reliance on harmful chemicals. The study suggests that refining these techniques through ongoing research can enhance trapping efficiency. Ultimately, the findings offer a sustainable, ethical solution to urban pest management. Continuous monitoring and adaptation are key to maintaining effectiveness. This approach holds promise for elevating pest management standards in urban settings.

Acknowledgments: We extend our foremost thanks to Prof. Dr Mehdi Nasiri Mahallati (Ferdowsi University of Mashhad) for his valuable help in data analyses. We express our gratitude to the management of Ferdowsi

Organization within the Mashhad Municipality for granting us permission to conduct our work at the Behesht Reza Cemetery stores. We would like to thank two anonymous reviewers for providing constructive comments on earlier manuscript drafts. This work was financially supported in the framework of the Ph.D. project of the first author by Ferdowsi University of Mashhad, Iran (No. 3/57968), which is sincerely appreciated.

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