# Science-Based Rodent Solutions for Rodents
# The Outside-In Approach

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## INTRODUCTION

Commensal rodents are defined as rodents living in close association with humans. These animals often depend on humans for their food, water and harborage. There are three species of rodent that are considered commensal: the house mouse (*Mus musculus*), the roof rat or black rat (*Rattus rattus*), and the Norway rat or ship rat (*Rattus norvegicus*). These rodents are global pests that contribute to millions of dollars of damage annually to human food and structures[1].

Commensal rodents have also been associated with the spread of disease in humans and their mere presence is usually associated with filth, decay and unsanitary conditions. These animals are not welcome in the places we live, work, play and heal in.

Rodent management in and around commercial structures is best managed using an **Outside-In Approach**. This is done by establishing three layers of protection:

1) **Exterior** - reduce rodent pressure on the outside
2) **Barrier** - minimize rodent entry into the structure
3) **Interior** - rapidly remove rodents from within the structure

An Integrated Pest Management (IPM) strategy should be used in each of these layers to maintain rodent-free facilities. An emphasis on solving rodent issues on the exterior of a structure before any activity is seen inside is the basis of the Ecolab Outside-In Approach to rodent elimination.

## OBJECTIVES

The objective of this paper is to review current knowledge and science regarding rodents and their behavior in and around commercial structures. Science-based recommendations and procedures to minimize rodent activity will also be provided.

Rodent control efforts can be traced back to the origin of the pest control industry[2]. Over the years many approaches have been used to combat these persistent pests. New rodent control products and equipment continue to emerge, with some being more effective than others. This paper will compare and contrast current approaches to rodent control and provide expert recommendations on the protocols and services available to minimize rodent activity inside commercial structures.

[1] Mallis 2011; Corrigan 2001
[2] Snetsinger 1983

## BIOLOGY AND BEHAVIOR

Rodents are small, rapidly reproducing mammals, that spend most of their lives reproducing and searching for suitable harborage, food and water. Understanding the behavior of rodents in and around commercial structures is an important step towards identifying management strategies. Rats and mice share many behaviors with one another[1]. A good general guide to commensal rodent behavior can be found in the book, Rodent Control: A Practical Guide for Pest Management Professionals, by Dr. Bobby Corrigan.

### *Common Rodent Pest Species*

Rodents have long been associated with humans. Not all rodents will readily breed inside commercial structures, so identifying the species is a critical step in managing rodent activity.

House Mouse

***Mus musculus***

Adults are 6-10 cm in length with a tail about the same length as the body, pointed snout, light brown to gray fur, and rod shaped droppings 3-6 mm in length.

Roof Rat

***Rattus rattus***

Adults are 16-20 cm in length with a tail longer than the body, pointed snout, gray to black fur on the back and lighter underneath, and spindle shaped droppings about 1 cm in length.

Norway Rat

***Rattus norvegicus***

Adults are 18-25 cm in length with a tail shorter than the body, blunt snout, brown shaggy fur on the back and lighter underneath, and capsule shaped droppings 2.0-2.5 cm in length.

Other Rodents

**Variety of non-commensal species including deer mice, field mice, vole's shrews, cotton rats, wood rats and others**

A variety of sizes and shapes but not fitting the descriptions above. These animals are usually caught by doors and do not nest inside in most instances.

[1] Drai et.al. 2001

### *Rodent Learning*

Rats and mice have been used for decades as research models in learning and memory studies. Learning begins at a very young age as rodents watch and mimic behaviors of their mother and other adult rats in their environment. The first bites of solid food taken by young rodents are from food being fed by other adults[1]. As such, food preferences and other behaviors are conservative and passed across generations. Some food preference learning may also occur prior to birth according to the diet the mother rodent is eating[2]. Some persistent behaviors may also have a genetic component, such as behavioral resistant strains of mice found in the UK[3].

Like food preferences, behavior around objects in their environment including traps and other devices can be learned. Young rats have been observed watching adult rats interact with traps, and then perform the same exploratory behaviors themselves. Video observations also indicate that there is behavioral variation in populations of rodents[4]. Some rodents in a population do not respond to traps or are more cautious than others. Rodent learning and population variation leads to the need to use multiple-tactics or an IPM approach in management efforts.

### *Rodent Vision*

Vision is a critical sense for rodents and they rely on it as they navigate through their environment. Visual cues play a critical role in rodent learning[5]. Contrary to common statements in literature, rodent sight is excellent – at least in dark environments. Poor daylight vision is the trade-off for excellent night vision[6].

A rodent visually searching for a place to hide will move towards dark areas or spots and will enter dark protected areas, if available. This behavior is especially true for rodents in unfamiliar environments[7]. This behavior helps explain why multi-catch traps work best near exterior doors and other rodent entrance points. Mice are more likely to enter these 'protection traps' when they first enter a structure compared to when they are familiar with their environment and have established foraging paths.

Rodent eyes are located on the rounded edges of the skull allowing for a wide perspective view of their surroundings. This increases their ability to avoid predators as they explore shadowy environments.

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[1] Bennett and Clark 1971; Bennett 2003; Bennett et. al. 2005; Chou et.al. 2000
[2] Nolte and Mason. 1995
[3] Humphries and Meehan 2000
[4] IR camera recordings of wild roof rats, Ecolab
[5] Zoladek and Roberts 1978
[6] Lashly 1932; Wiesenfeld and Branchek 1976; Powers and Green 1978
[7] Welker 1959

### *Rodent Tactile Sensing*

Rodents use the sense of touch instead of vision for close examination of their environment[1]. Rodents have specialized sensory hairs (vibrissae) throughout their fur with a high concentration on their heads. Head vibrissae, often called whiskers, are used not only as touch indicators[2], but can be used to determine shape and even texture of objects and surfaces contacted[3]. Whiskers are used for a broad range of other functions including communication with other rodents and monitoring environmental conditions such as wind direction[4] and vibration[5].

Vibrissae form a cone-shaped sensory field around the head of the rodent. This sensory field allows detailed examination (whisking) of objects up close with very little contact. Traps and other devices can be carefully examined without triggering. Once a rodent learns to avoid a specific device such as a snap trap, it will recognize and avoid direct contact with all devices having similar structures and design. Video monitoring of wild roof rats has shown that rats are not afraid or shy around trapping devices. They readily approach and 'whisk' snap traps but do not directly contact these traps, even when baited with foods they are known to be feeding on[6]. The highly developed tactile abilities of rodents also contribute to the need to use multiple-tactics or an IPM approach in rodent management efforts.

**Why aren't the rodent traps working anymore?**

Ecolab uses cameras to document rodent behavior in structures to study their interaction with traps. The following points have been learned from these clips:

- Rodents actively explore their environment and study new objects
- Rodents appear to learn from 'close calls' and change their behavior
- Young rodents follow their mothers and appear to learn her behavior
- There is variation within a population with some rodents being shyer than others and less likely to interact with specific types of traps

### *Rodents and Neophobia*

Neophobia is a fear of new objects. While it is commonly believed that rats are neophobic, and mice are neophilic (love of new objects – curious), both have been shown to exhibit an avoidance response to new objects placed in a familiar environment[7].

New food items will also be avoided by mice when placed in a familiar environment[8]. Studies show that mice can develop neophobic behaviors in the presence of trapping pressure[9]. Neophobic responses are much stronger with new objects than with new foods[10]. Rodents in a new environment do not exhibit neophobia due to everything being new. They will readily

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[1] Williams and Kramer 2010
[2] Lottem and Azouz 2009, O'Connor et.al. 2010, Metha and Kleinfeld 2004
[3] Diamond et.al. 2008a&b, Grant et. al. 2009, Kleinfeld et. al. 2006, Lottem and Azouz 2008, Nelson and McIver 2006
[4] Ahl 1986, Blanchard et. al. 1977, Crish et.al. 2003
[5] Shats and Christensen 2008
[6] IR camera recordings or wild roof rats, Ecolab
[7] Humphries et al. 2000, Inglis et.al. 1996, Misslin 1982, Misslin and Cigrang 1986, Misslin and Ropartz 1981
[8] Bedroy and Drickamer 2007
[9] Kronenberger and Medioni 1985
[10] Inglis et.al. 1996

approach traps and other devices looking for protection. Therefore, multi-catch traps work near entrances and not so well where there is an established infestation.

Population variation is also an important aspect in rodent response to new objects. Within a population there can be inherent individual variation in behavioral, physiological and life-history traits[1]. This variation can result in individual rodents being susceptible to single control measures such as snap traps, glue boards or specific rodenticides. This population variation is also why using multiple tactics, or an IPM approach, in rodent management works best.

### *Why do rodents enter structures?*

Commensal rodents will actively enter commercial structures and live inside if given the opportunity. Non-commensal rodents will also enter commercial structures but are less likely to nest within. There are several factors that increase the risk of rodent invasion into a structure.

- **Commensal rodents have adapted to life with humans –** These rodents will displace other rodent species near human dwellings[2]. Commensal rodents actively associate with humans taking advantage of food, water and harborage that humans provide.
- **Rodent pressure on the exterior of the structure –** Poor garbage handling practices, standing water and overgrown vegetation can invite rodents to live near structures. Increased rodent activity on the exterior will put pressure on the structure resulting in an increase of invasion attempts.
- **Gaps under doors and other openings –** Rodents take advantage of gaps under doors, pipe chase openings, sewer access points and other openings to enter commercial structures. In addition to their natural curiosity to explore new surroundings, environmental factors such as odors and temperature differences may cause rodents to explore openings in structures.
- **Historical presence of rodents –** Commensal rodents have been shown to respond to urine and other odors from their same species[3]. Past rodent activity inside a structure suggests that there is rodent access into the structure and communicative odors from past rodent inhabitants. Odors from previous rodent infestations create a signal to new rodents that this is a safe area and provides a hidden pathway through the structure.

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[1] Hurst 1987, Shilova and Tchabovsky 2009
[2] Garba et.al. 2014
[3] Volfova et.al 2010, Kazumi et.al 2009, Doty 1986

## RODENT MANAGEMENT STRATEGIES

Rodent management in and around commercial structures is best accomplished by using an **Outside-In Approach**. This is done by establishing three layers of protection:

1) **Exterior** - reduce rodent pressure on the outside
2) **Barrier** - minimize rodent entry into the structure
3) **Interior** - rapidly remove rodents from within the structure

### 1. *Exterior - Reducing Rodent Pressure on the Outside*

Reducing pest pressure on the exterior is the first line of defense against pest invasion and is often the most effective long-term solution of the Outside-In Approach. An IPM strategy on the exterior incorporates multiple methods to minimize the presence of rodents in the area. This combination of methods includes:

- **Eliminate rodent attractants –** Minimize spilled garbage, move dumpsters away from the structure whenever possible, remove standing water and have proper storm drainage.
- **Remove excess vegetation –** Keep grass and bushes trimmed. Tree branches should not be in contact with walls or overhang the roof. Remove ivy or other vegetative wall coverings.
- **No 'bone-yards' –** Exterior storage of old equipment, construction material or other large items should not be done near the structure. Storage containers should allow inspection and service between the container and the structure. Storage containers should be placed on cement or asphalt and not on bare ground.

### Rodent Risk Assessment

Food and beverage processing and other complex facilities should use a risk assessment strategy to manage and mitigate rodent risk.

- Determine the extent of rodent activity on the exterior
- Identify the rodent species in the area
- Assess the risk of structural invasion at potential rodent entrance points
- Correct or repair structural barriers wherever possible
- Adjust exterior protection program to protect vulnerable entry points where commensal rodent pressure has been verified
- Track rodent activity over time to identify high pressure areas and centers of activity
- Adjust the program as needed over time to focus efforts on active areas and reduce wasted resources

A risk assessment approach will result in a sustainable rodent program with focused protection at high risk locations.

### 2. *Barrier - Minimizing Rodent Entry into the Structure*

The rodent barrier of a facility is comprised of the physical structure between the exterior of the building and the interior, such as walls and doors. It also includes protected areas such as wall interiors, plenums, chases and tracks that lead to exterior access points. Rodents caught at introduction points inside the facility are evidence that the physical barrier of the structure has been compromised.

- **Repair doors –** Ensure that door sweeps, and thresholds allow for a tight fit when closed and there are no gaps. Make sure doors close tightly. Conduct scheduled inspections of door seals and respond immediately when failures are identified.
- **Find and close all possible entry points –** Holes and structural damage that allow rodents to enter the structure should be immediately repaired. Gaps in expansion joints and/or around pipes, un-sealed docks and other potential access points should be identified and corrected.

- **Inspect product deliveries –** The introduction of rodents on incoming deliveries is a possibility of rodents on incoming goods is a possibility, at-risk materials should be inspected for evidence of rodent presence before receiving.
- **Add additional barrier monitors/traps –** high-risk rodent introduction points should have additional monitoring equipment put in place to maximize detection and early warning efforts.

### 3. *Interior – Rapidly Remove Rodents from Within the Structure*

The presence of rodents on the interior of a facility indicates that there has been a breech across the other layers of protection. Interior rodent activity poses risks to human health, food safety and a risk to the brand. Immediate action with a sense of urgency is the only course of action.

- **Identify the extent –** Inspect the facility to determine the extent of the activity, rodent harborage locations and travel paths. It is best to have a pest professional conduct a thorough inspection and create a plan of action to quickly eliminate interior rodent populations.
- **Find the root cause(s) –** A critical part of the elimination process is to determine and address root causes. How did the rodents get inside in the first place? What can be done to minimize future invasions?
- **Rapid reduction of interior populations –** In some instances, rapid removal of rodents through mass trapping and other means to quickly reduce the interior population is required. A controlled application of rodenticide on the interior may be necessary in some situations to quickly reduce numbers. Rodenticide should be secured, protected and removed when no longer needed.
- **Elimination –** The complete removal of all rodent activity from inside a facility is called 'rodent elimination.' Success is achieved only when the last rodent is found and removed from the inside of the structure. Finding and removing the last rodent can require skill and dedication.

During elimination efforts, more frequent service visits may be required to adjust placement of devices as elimination efforts are narrowed to remaining active areas. If increased service frequency is necessary during the elimination phase, a minimum of three days between visits is recommended except for emergency situations. This allows time for rodents to interact with traps and other devices.

## SUMMARY AND CALL TO ACTION

Commensal rodents continue to be serious pests globally. Adapted for life with humans they easily find ways to use our homes and businesses as their own. Creating a rodent free environment in commercial structures requires a partnership between the owner/manager of the property and the pest service provider. Both play a critical role in identifying conditions that may lead to rodent invasion and correcting those issues before problems arise.

An Outside-In Approach based on rodent biology and behavior is the best means to secure long-term protection against rodents. Rats and mice are considered ‘flashpoint pests.’ A single sighting on the interior can result in serious, long-lasting damage to brand and reputation. Rodent activity inside commercial structures cannot be tolerated. An aggressive elimination plan that uses the right tools, placed in the right locations by trained professionals should be followed.

### *What You Can Do*

1. Reduce rodent pressure on the exterior
   - Eliminate spillage of garbage
   - Close all garbage receptacles with tight-fitting covers
   - Move garbage receptacles away from the facility whenever possible
   - Eliminate standing water around the facility
   - Remove weeds, tall grass and other excessive vegetation
   - Remove clutter and items stored on the ground near the facility
   - Consider other sources of rodent pressure (adjoining structures, distribution centers, product vendors, etc.)
2. Minimize rodent entry opportunities
   - Seal all doors, inspect and repair entrances on a regular basis
   - Trim trees so that branches do not touch walls or over-hang the roof
   - Seal holes and gaps on the exterior of the facility
   - Seal openings and chases around pipes
   - Seal holes and gaps noted on the interior perimeter
   - Inspect incoming goods for evidence of rodent activity
3. Minimize conditions that support rodent activity on the inside of the structure
   - Minimize product spillage and regularly clean under shelves and gondolas
   - Eliminate all standing water and accumulated condensation
   - If present, remove all rodent droppings (after they have been documented by your pest service provider)
   - Seal potential access to hidden runways and harborages

### *What Ecolab Will Do*

- Provide a science-based, risk assessment approach to monitor and address commensal rodent activity in and around structures.
- Use an Outside-In Approach to provide layers of protection based on behavioral patterns of commensal rodents.
- Provide regular, visual inspections of the outside and inside of structures by trained professionals.
- Document sanitation and structural issues that are conducive to rodent activity and that may lead to interior infestation of commensal rodents.
- Meet with management to review findings and make recommendations on corrective actions.
- Respond to interior rodent activity aggressively using science-based methodology to quickly eliminate interior infestations.

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## ABOUT THE AUTHOR:

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*Douglas Gardner provides over 20 years of industry experience and 9 years of academic research to the Ecolab Pest Elimination team. His background as a biologist includes a B.S. degree in biochemistry from the University of Arizona and an M.S in Entomology from Texas Tech University. He has received the designation as a Board-Certified Entomologist from the Entomological Society of America and as a Registered Sanitarian from the National Environmental Health Association. He has held a variety of positions in his professional career from providing pest services as a service specialist to leading teams of experts in operations, technical support and research. Research focusing on large flies and rodents has been his passion although he has a broad understanding of the science of pest elimination. Douglas is currently a corporate scientist providing expertise and driving innovation for Ecolab Pest Elimination.*

ECOLAB PROPRIETARY

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