



Introduction

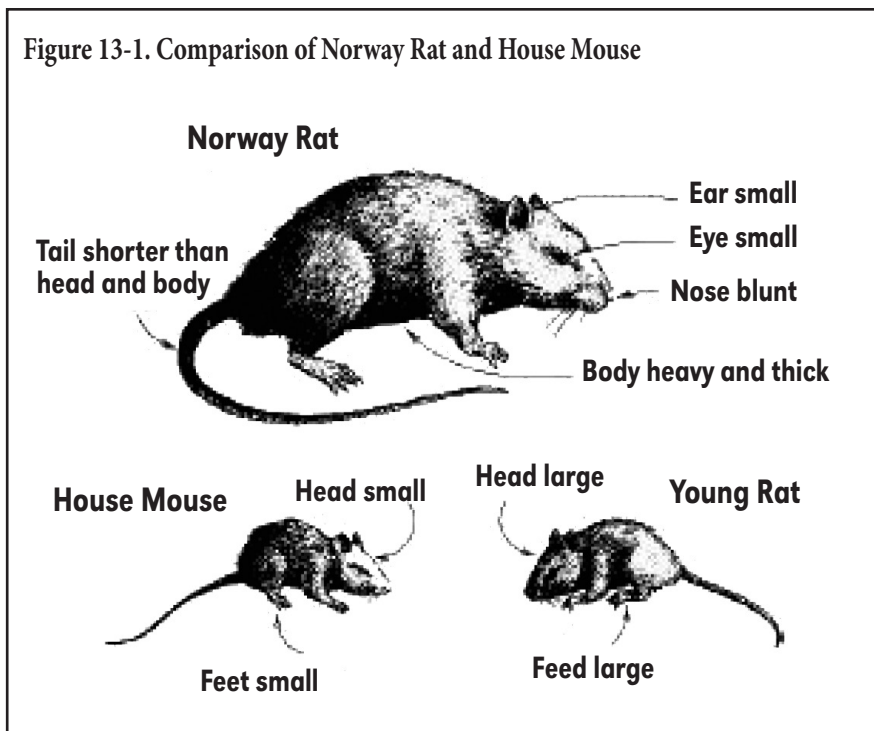
Although toxic baits are widely used to control rodents, their use can result in several problems. First, use of toxic baits creates the possibility that children or pet animals will inadvertently come in contact with the bait. Second, poisoned rodents frequently die in inaccessible places where their decomposing bodies create unpleasant odors and feed pest insects such as flesh flies and carpet beetles. Finally, inappropriate use of rodenticides raises the risk of rodents developing resistance and/or avoidance behaviors to toxic baits.

A better approach to effective rodent control combines careful inspection, regular monitoring, sanitation, garbage management, rodent-proofing, trapping, and, if necessary, baiting with toxicants. Unless the conditions that encouraged rodent presence are removed, new mice and rats will reoccupy the area vacated by the dead ones, and thereby continue the pest cycle.

Identification and Biology

Effective control of rodents requires knowledge of their biology, physical characteristics and abilities, and signs of their activities. Several tables and figures follow to provide you with a quick way to distinguish between the Norway rat (*Rattus norvegicus*) and the house mouse (*Mus musculus*) (Figure 13-1, Figure 13-2, Figure 13-3

Figure 13-1. Comparison of Norway Rat and House Mouse



and Table 13-1) and several species of native mice (Table 13-2).

Rats

We have included identification information on roof rats because their range is expanding. However, our discussion on the control of rats will focus on the Norway rat as it has the largest geographical distribution and

with some modifications, control of Norway rats would be very similar to the control of roof rats.

The Norway rat (*Rattus norvegicus*), also known as the brown, wharf, house, gray, or sewer rat, was brought to North America from Europe in the 1700s and today resides throughout the United States. Norway rats have a stocky build, with a blunt nose,

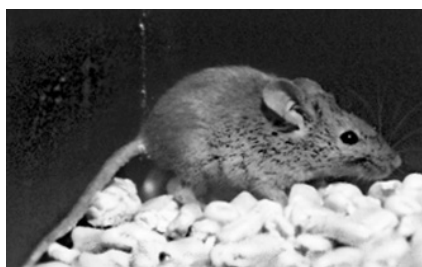


Figure 13-2. House Mouse



Figure 13-3. Norway Rat

Table 13-1. Differences Between the Roof Rat, Norway Rat, and House Mouse

	Roof Rat	Norway Rat	House Mouse
Scientific name	<i>Rattus rattus</i>	<i>Rattus norvegicus</i>	<i>Mus musculus</i>
Adult weight	6 to 12 ounces	3 to 16 ounces	1/2 ounce
Snout	pointed	blunt	pointed
Ears	Large enough to cover eyes	small and thick with short hairs	large, some hair
Tail coloration	uniform color	dark above, pale underneath	all dark
Fur	variable; black to brownish-gray	brown with black; shaggy	gray to light brown
Droppings	Capsule-shaped, pointed, 1/2-inch	capsule-shaped, pointed, 3/4-inch	1/4-inch rod-shaped, pointed
Food requirement	1/2 to 1 ounce/day	about 1 ounce/day	about 1/10 ounce/day
Water source	free water*	free water*	water from food; also need free water if diet is dry or high in protein
Climbing ability	excellent climber	can climb	good climber
Nest locations	mainly in elevated locations (e.g. trees, roofs,	mainly in burrows	walls, attics, basements near/in stored material
Swimming ability	Able but avoids water	excellent	can swim

*Water present by itself and not simply a constituent of the food eaten by the rodent. Free water is unnecessary when feeding on succulent foods but needed if diet is dry and/or high in protein.

Table 13-2. Distinguishing the House Mouse from Other Similar Species. Common Name Scientific Name Description

House Mouse	<i>Mus musculus</i>	small feet and head in proportion to body; long ears for body size; relatively small eyes; tail nearly hairless and equal or longer than the head and body combined; tail is uniformly dark
Deer Mouse or White-footed Mouse	<i>Peromyscus</i> spp.	same size or slightly larger than house mouse; distinctive bicolor coat, pale gray to reddish brown above white belly; tail brown or gray on top and white underneath; large eyes; invades buildings near fields or wooded areas
Vole or Meadow Mouse	<i>Microtus</i> spp.	large, robust body; weighs about twice as much as the house mouse; smaller, heavily furred ears; short tail; sometimes invades buildings, but commonly found outdoors under boards, boxes, etc.

Table 13-3. Reproductive Ability of Norway Rats

Breeding (estrous) cycle	polyestrous, every 4-5 days; in subtropical climates, rats can reproduce year around; in cooler climates, populations peak in spring & autumn
Litter size	average of 5 to 12
Litters per year	up to 9, depending on food availability (average - 4)
Age at weaning	around 30 days
Gestation period	20 to 25 day
Sexual Maturity	75-90 days
Life span in the wild	less than 1 year

hairless tail, and small ears. They weigh less than 16 ounces at maturity. They are prolific breeders (Table 13-3) and therefore, control must be aggressive or the remaining rats will simply repopulate.

Rats utilize a variety of nesting sites. Outdoor nests are typically ground burrows that are less than 18 inches deep and less than 3 feet long, but some can be quite complex. Burrow openings range from 2 to 4 inches in diameter and have smooth or worn openings when actively used. Rats also can take up residence in sewers and storm drains. Indoor nesting sites (usually in the lower floors of the building) are often found in wall voids and crawl spaces that have plenty of clutter and low human traffic.

Rats have diverse diets and research has shown their nutritional needs mirror those of humans except that rats only need 110 calories a day. They enjoy foods high in protein, such as fish, meat, nuts, grains, pet food, and insects. Rats do require free-standing water unless their diet is unusually succulent, such as ripe fruit. Rats usually search for food between dusk and dawn but when hungry or living under crowded

conditions may be seen in the daylight. They have been known to travel several hundred feet from their nests in search of food.

Rats have amazing sensory abilities. They have acute sense of taste, smell, and hearing. Interestingly, human odors do not frighten them. Their eye sight is poor but is able to see contrasts, patterns, and movement.

Norway rats also have exceptional physical prowess, including the ability to:

- pass through any opening as small as 3/4-inch in diameter
- walk along horizontal wires and climb vertical wires
- climb inside vertical pipes from 1 1/2 to 4 inches in diameter
- climb outside of vertical pipes that are up to 3 inches in diameter
- climb the outside of vertical pipes and conduits of any size if within 3 inches of a wall
- crawl horizontally on any type of pipe or conduit
- jump vertically (from a standstill) at least 24 inches above a flat surface and at least 4 feet horizontally

- reach about 13 inches above a flat surface
- fall more than 50 feet and survive
- dive and swim underwater for as long as 30 seconds and tread water for up to 3 days
- swim up through the water seal, or trap, of toilets
- swim as far as 1/2-mile in open water
- gnaw and leave marks on almost anything, including wood, chip board, lead pipes, cinder blocks, asbestos, aluminum, sheet metal, sun-dried adobe, and an exposed edge of a piece of glass.

Their secretive behavior also allows them to establish a residence in and around human dwellings. Often rats are only discovered when their numbers reach a level to leave significant signs. Given their reproductive capacity (Table 13-3), rats only need a few months to achieve abundant numbers.

Behaviors of rats that have impact on management:

- require access to free water or succulent foods like fruit.

Table 13-4. The Reproduction of the House Mouse

Breeding (estrous) cycle	polyestrous, every 4 days all year
Litter size	4 to 8
Litters per year	6 to 8, depending on food available
Age at weaning	21 to 28 days
Gestation period	18 to 21 days
Sexual Maturity	5 to 9 weeks
Life span in the wild	less than one year, perhaps up to 2 years under excellent conditions

Table 13-5. Zoonotic diseases of house mice and Norway rats

Disease	Agent	Transmission
bubonic plague (Black Death)	<i>Yersinia pestis</i>	bites of infective fleas
salmonellosis	<i>Salmonella</i> spp.	ingestion of feces-contaminated food and water
lymphocytic choriomeningitis urine, or saliva	LCM virus	ingestion of contaminated food; inhalation of dust from feces
rickettsialpox (or vesicular rickettsiosis)	<i>Rickettsia akaria</i>	bite of infective house mouse mite <i>Liponyssoides (Allodermanyssus) sanguineus</i>
leptospirosis or infectious jaundice	<i>Leptospira icterohaemorrhagiae</i>	ingestion of or contact with urine contaminated food, water, etc.
rat bite fever (Haverhill fever, Sodoku)	<i>Streptobacillus moniliformis</i>	rat bite, ingestion of contaminated food
tapeworms	<i>Hymenolepis nana</i> , <i>H. diminuta</i>	ingestion of droppings, contaminated food
murine typhus or endemic typhus	<i>Rickettsia typhi</i>	infective flea feces that contaminate broken skin, or are inhaled, or eaten
Hantavirus Pulmonary Syndrome (HPS)	Sin Nombre Virus (SNV)	most common route of transmission is through breathing in the virus on/in aerosolized, infective rodent urine, saliva, and feces; mucous membranes can also be infected after one handles infective/ contaminated materials (dirt, dust, rodent excreta, etc.); a rodent bite is another, though less common route

- prefer to travel along edges, e.g., the edge of the floor next to the wall or along the outside or inside of a foundation so their whiskers can maintain contact with surfaces. It is rare for rats to venture into the middle of rooms or fields as this exposes them to predation.
- avoid new objects, a condition called neophobia. It is not unusual for rats to wait 2 weeks before approaching traps or bait stations.
- will follow the same travel routes established by urine trails.
- run up almost any vertical surface, including wood, brick, metal pipes and girders, wire mesh, and cables
- run along suspended electric wires and ropes of most common sizes
- squeeze through a 3/16-inch diameter hole
- travel upside down, clinging to 1/4-inch hardware mesh
- swim well but tend not to dive below the surface
- survive at 24°F for many generations.

Mice

The house mouse (*Mus musculus*) is the most common vertebrate species to invade structures, but native species of mice, such as meadow voles and deer mice, are occasionally found in buildings, especially when temperatures drop in the autumn. Usually native mice can be trapped easily and removed and rarely become chronic problems. Since deer mice are known vectors of hantavirus, consult Box 13-A before initiating any trapping or cleanup activities.

Invasions of the house mouse can occur at any time of the year, and once inside, they will continue to reproduce, generation after generation, without leaving the confines of the building. The reproductive potential of house mice is high (Table 13-4), and their physical abilities, like those of the Norway rat, are remarkable. They have the ability to:

- jump up to 10 inches from the floor, use vertical surfaces as a spring board to gain additional height, and jump downward 8 feet to the floor
- can generally obtain all the water they need from food; if dependent on dry food, they need some free water
- travel over their entire home range daily (about 33 feet), investigating changes and new objects
- prefer to travel along edges and are wary of crossing open spaces
- poor eyesight, but sensitive to motion; navigate using their whiskers
- indoors — often live in false ceilings, seek warmth in continuously operating appliances such as stoves, refrigerators, air conditioners, and coolers; in wall and floor voids; and in similar enclosed spaces
- outdoors — prefer thickly vegetated level areas

Behaviors of mice that have impact on management:

Indoors, populations of mice are limited by the availability of food, by competition from other animals, and by disease. The amount of available

shelter inside can limit the number of mice to a certain extent; however, in spring, summer, and fall, mice can establish themselves outdoors. They need to live inside only during the severe conditions of winter. Rats prey on mice and compete for the same food and shelter; therefore, removing the rats often results in higher and more visible populations of house mice.

Damage

Rodents damage food, clothing, documents, and structures through gnawing, urination, defecation, and nesting activities. Their activities can significantly reduce the value of structural insulation leading to increased energy bills. The damage to food from contamination is probably 10 times greater than the damage by direct feeding. Feces and urine raise the humidity of enclosed spaces, promote wood deterioration, and provide a medium for the proliferation of microorganisms. Mouse urine has also been implicated in causing allergies in 15% of children. Rodents cause fires by chewing through the insulation on electrical wires, and they are involved in spreading human pathogens (Table 13-5). Hantavirus is transmitted by mice and is a cause for cautionary measures when entering mouse contaminated areas (Box 13-A).

Detection and Monitoring

Inspection for the presence of rodents involves the careful and systematic investigation of an area searching for and identifying rodent habitat, signs, entry points, and damage in order to determine where control is needed.

Since rodents prefer dark, cramped, out of the way spaces, inspection requires proper illumination and personal protective equipment. Choose a flashlight with a powerful beam (at least 75,000 lumens). Ideally, flashlights with adjustable beams offer more flexibility. Other equipment needs include inspection mirror, binoculars (8x magnification), and personal protection equipment (PPE), such as gloves (preferably leather), work clothes, goggles, and NIOSH N100 or P100 rated respirator (depending on the environment). Respirators should be worn whenever entering an attic, crawl space, or other confined spaces not frequented by humans on a daily basis. Note that only individuals trained in fitting the respirator and who are medically cleared should wear a respirator. Finally, you will need a way to record findings.

Begin your inspection on the property surrounding the structure. Look for tall grass, water sources, bird feeders, debris, woodpiles, and other kinds of rodent harborage and sources of food.

Next, focus on the structure's exterior, inspecting as much of the structure you can without using a ladder. The following process will focus on inspection for mouse entry as their smaller size makes them more difficult to find. Check the foundation (particularly the sill plate), pipes, wires, and vents that enter a building for openings capable of allowing a mouse to enter (3/8-inch wide). Look carefully through ground ivy for the presence of rat holes.

While avoiding electrical lines, use a ladder rated for your weight to allow visual access of soffits, gables, vents (including ridge vents), gaps,

and other possible entry areas that were not easily investigated from the ground. Make notes on your findings. Fall protection equipment may be required when walking on the roof.

Interior inspections are more complicated as walls, construction practices, and furnishings all interfere with gaining access to signs. Access to a floor plan aids in documenting your findings. As you inspect, don't neglect to wear your PPE as conditions warrant. Respirators should always be worn when entering attics and investigating drop ceilings. Look for signs of droppings along walls, above drop ceilings, and underneath insulation. Trails and tracks may be seen in areas with a lot of dust or high rodent traffic.

The following tips will help improve the quality of your interior inspection.

1. Look for droppings along the edges of walls, especially walls behind objects that prevent easy view.
2. Rodents seek heat. Pay close attention to areas around hot water heaters, appliances with pilot lights, or compressors that are regularly working such as refrigerators and freezers.
3. Look under insulation.
4. Inspect pipes, particularly those that travel between floors as these can be highways for rodents.
5. Spend time in areas with food, including pet food.

Box 13-B, Box 13-C, and Box 13-D, highlight previously mentioned tips. Remember to inspect any outbuildings on the property.

- Collect fecal pellets and gnawed wood shavings and remove any nests. Re-inspect for new rodent signs in a day or two. The use of a vacuum is not advised because of the risks associated with Hantavirus (Box 13-A);
- Close suspected rodent burrows or holes temporarily with soil or crumpled paper. Inspect 24 hours later to see if the holes have been opened, or the paper chewed or moved.

Management Options

Ideally, rodent management should be performed simultaneously throughout the structure, employing all the techniques and strategies applicable to your situation. If resources (time, money, etc) are limited, concentrate control efforts in the high risk/high priority areas, such as the kitchen, the cafeteria, loading docks, and storage rooms. Your inspection will reveal the areas you must concentrate on in your own facility. After you have improved sanitation in these areas, worked on rodent exclusion, and trapped most of the offending animals, move on to the other areas noted in your inspection, being mindful that rodents can reinvade controlled areas and migrate to new ones.

Habitat Modification

It is very important to change the physical environment that is supporting rodents. As mentioned before, killing rodents without removing the conditions that allowed them to thrive will simply result in rodents outside the zone of control to reinvade and replace the dead ones. Initially, the task of instituting the recommendations below can feel

Box 13-A. Hantavirus

Hantavirus pulmonary syndrome (HPS) is a serious, often deadly, respiratory disease that has been found mostly in the rural areas of the western United States where there is an abundant population of deer mice (*Peromyscus* spp.), the primary vector (see Table 13-2 for description). Other rodent vectors may be involved also.

The most common route of transmission is through breathing in the virus on or in aerosolized, infective rodent urine, saliva, and feces. Mucous membranes can also be infected by touching them with fingers that have been contaminated by handling infective or contaminated materials such as dirt, dust, and rodent excreta. Rodent bites also can spread the virus, but this is less common. Organisms such as ticks, lice, or fleas are not involved, and as of this writing, no human-to-human transmission has been observed.

Human exposures have been mostly associated with agricultural activities such as planting and harvesting field crops, but several exposures have come from contaminated dwellings. Infections have occurred from staying in previously vacant cabins, from cleaning barns and other outbuildings, and from hiking and camping. Any time the rodent population becomes large enough to incubate large quantities of the virus, disease outbreaks can result. At room temperatures, Hantavirus can remain infectious for up to 3 days. Sunlight will reduce its viability and freezing will extend it.

Symptoms of Hantavirus usually appear within 2 weeks of infection but can appear as early as 3 days to as late as 6 weeks after infection. The primary symptom of this disease is difficulty breathing, but other symptoms may include fever (101°-104°F), headache, abdominal and lower back pain, and sometimes nausea and vomiting. If any combination of these symptoms—especially difficulty in breathing—appear after direct or indirect exposure to rodents, contact your doctor immediately and be sure to mention your exposure to rodents.

In areas of known infection, a trained health department representative or pest control operator should do trapping and cleanup.

At present, the best means of protection against the virus is by excluding deer mice from buildings. Since the types of mice that carry Hantavirus are difficult to identify, all wild rodents should be considered potentially infectious and should be avoided. Methods for excluding deer mice are identical for the house mouse. See the section on excluding rodents under Management Options for directions on rodent-proofing your sensitive environment building.

When cleaning, you can minimize contamination by following these precautions:

- Thoroughly air out crawl spaces and infrequently used areas where rodents have likely resided prior to entry. Avoid disturbing materials or stirring up dust before treating with disinfectant. Wear protective equipment described below.
- Since the virus can enter by breathing contaminated air or through broken skin and conjunctive tissues, wearing protective clothing is imperative. Minimum protective equipment no matter how slight the contamination includes gloves (e.g. latex, rubber, vinyl, or nitrile). Eye protection and a dust mask are recommended. For cleanup in heavily contaminated areas, one should wear a Tyvek® suit and a full-face particulate respirator rated N100 (if oil is not present) and P100 (if oil is present). Medical evaluation and fit-training is required to use respirators safely and correctly.
- Mix a solution of 1 1/2 cups of bleach to 1 gallon of water or use a household disinfectant and spray contaminated areas until damp BEFORE cleaning. In particular, spray or soak any dead mice, droppings, traps with captured mice, or nesting areas with disinfectant or the 10 percent bleach solution.
- Wipe down counter tops, cabinets, and drawers. Mop floors and baseboards.
- Do not vacuum, sweep, or dust as this may spread the virus throughout the air. Use rags, sponges, and mops that have been soaked in the disinfectant solution.
- Steam-clean carpets, rugs, and upholstered furniture.
- Wash clothes and bedding in hot water and detergent. Transfer to a dryer set on high.
- Wrap contaminated items, including dead mice, in double-plastic bags before disposal.
- Disinfect gloves before taking them off and throw them away.
- When you are done, thoroughly wash your hands with soap and hot water.
- If you develop flu-like symptoms within 6 weeks of your cleaning activities, inform your doctor that you were working in a rodent contaminated area.

overwhelming. Avoid the trap of thinking that small habitat modifications will not help. The fact is every reduction in rodent friendly habitat, no matter how small, increases the stress of the remaining rodents. Rodents under stress have lower reproductive rates and are more susceptible to other control techniques.

Reducing Food Availability

- Store foods such as grains, pet foods, snacks, etc. in metal, glass, or heavy plastic containers with tight fitting lids.
- Food stored in classrooms, meeting rooms, or worker lounges should be in tightly closed containers. Do not leave food out overnight.
- Do not allow students or staff to store food in their lockers overnight unless it is in rodent-proof containers.
- Explain to them why this is important to help improve compliance.
- Store fresh fruits and vegetables in refrigerators or in open-air coolers that are screened with 1/4-inch, heavy wire mesh.

Box 13-B. Signs of Rodent Presence

Live or Dead Rodents

- Seeing live rodents is the most obvious and certain sign of their presence. Observation of live rodents in the daytime frequently suggests a heavy infestation, that their harborage has been disturbed, or that new rodents are moving into the area and have not found any harborage yet.
- Discovery of intact dead rodents signifies an active infestation, but this is not necessarily true with an old, dried body, which may merely indicate a previous infestation.

Droppings

- Most droppings will be in feeding areas, travel routes, and near harborage.
- Rat droppings may be up to 3/4-inch long and 1/4-inch in diameter. Mouse droppings are much smaller, about 1/4-inch long but can reach 1/2-inch. To distinguish from cockroach droppings, look for longitudinal ridges; rodent droppings will be smooth.
- Fresh droppings are moist, soft, black or nearly black, and they glisten or look wet. After a few days to a week, the droppings dry, become hard, and appear dull rather than shiny. In warm, dry atmospheres, the droppings can lose their shine after only a few hours. After a few weeks, rat droppings become gray, dusty and crumbly, and mouse dropping become hard, dry, and dull or whitish.
- If very old droppings are moistened, they may look like new ones, but they will still be crumbly instead of soft.
- Sometimes bat droppings can be confused with rodent droppings. But bat droppings contain insect fragments that can easily be seen with a hand magnifying glass (look for sparkles) when the droppings are crushed.
- Monitor for current rodent activity by removing droppings so that fresh droppings are apparent during future inspections.

Damage to Goods and Structures

- Rodents gnaw to get at food in packaging or containers and to obtain nesting material.

- When rodents gnaw, their front teeth leave two parallel marks, about 1/8-inch across for rats and about 1/16-inch across for mice.
- Gnaw marks on doors or ledges, in corners, in wall material, or on stored materials as well as bits of gnawed wood, paper, cloth, and packaging materials are good indications of the presence of rodents.
- Rats can gnaw through rusty sheet metal and sheet aluminum.

Grease Marks or Rub Marks

- Smudge marks on beams, rafters, walls, pipes, and other fixtures are the result of oil and dirt rubbing off rodents' fur along frequently traveled routes.

Runs or Burrows

- Trails or burrows of rats may be found outside along foundations, walls, fences, and under bushes or debris. Runs will look like tiny paths and burrows are open holes.

Tracks

- Look for tracks in dust, mud, or snow. Rats and mice have 4 toes on the front feet and 5 on the hind. Rat tracks range in size from 3/4 to 1 1/4 inch in length versus 3/8 to 3/4-inch of mice. Sign of tail dragging is rare but when found may suggest an older rodent.

Noises

- Rats make noise as they gnaw, claw, fight, and scramble around inside walls, which is particularly audible at night when they are most active. A stethoscope may be used to pinpoint the activity. Mice are harder to hear, but you can sometimes hear them scurrying and skittering around. Squirrels and other animals can make similar noises so you should confirm the presence of rats and mice with other signs.

Urine

- Fresh rodent urine will fluoresce blue-white under ultraviolet light, but many other substances also fluoresce so recognizing rodent urine takes skill. Since droppings are more easily recognized and just as effective in identifying rodent activity, we do not recommend the use of ultraviolet (UV) lights for inspections.

- Store bags of grass seed, dry pet food, and other similar items in rodent-proof containers.
- If birdfeeders are not removed, reduce seed waste by using one seed per feeder. Install a new feeder for each seed type you wish to use. Install catch-plates under bird feeder to reduce the volume

of seed reaching the ground. Promptly clean up any spilled bird seed around feeders. Make sure the feeders are squirrel proofed (Information can be found at <http://icwdm.org>).

Limiting Areas for Eating

If you expect to contain and limit pest problems (cockroaches and ants

as well as rodents), it is very important to designate appropriate areas for eating and to enforce these rules. The fewer designated areas, the easier it will be to limit pests.

Managing Garbage Properly

In most areas, garbage is the main source of food for rats. An electric garbage disposal unit in the sink can

Box 13-C. How to Conduct a Rodent Inspection Outside

- Try to identify as many of the areas as possible that provide rodents with harborage, food, water, and access to buildings.
- Make detailed notes on your map of the exterior of the building and the sensitive environment grounds.
- Take note of how garbage is dealt with, what condition dumpsters and garbage cans are in, and whether rodents have easy access to garbage.
- Check doorways for gaps or holes and note windows without screens or glass.
- Look for other openings in the structure — holes, vents without screens, holes around plumbing, and electrical wire entry points.
- Note any power lines that run into the upper portions of buildings and any trees that brush up against the structure; these give rodents access to the roof.
- Note any bird or bat problems because rats may not be far behind. Rodents will feed on bird eggs, chicks, and young bats.
- What kind of vegetation is growing near the building? Does it give rodents cover for runways or nesting sites? Are there any fruit- or nut-bearing trees?
- Inspect all planters, piles of waste wood, portable storage containers, and outbuildings. Are there signs of rodent infestation in or around any of these areas?
- Take into account any adjacent field or lot, as well as any supermarket or fast food establishment that may attract rodents. Rodents that start to invade a structure may be an overflow from adjacent properties. If a vacant building next door to a sensitive environment is going to be renovated or an empty field or lot prepared for construction, the rodent population will be displaced to the surrounding areas.
- Pay attention to seasonal occurrences. For example, field mice often migrate to the nearest structure when corn or wheat fields are harvested in the fall.
- Check for irrigation leaks and any standing water such as irrigation or drainage ditches, stagnant pools, ornamental ponds, and fountains.
- Check air conditioning units that might provide water and harborage for rats.

Box 13-D. How to Conduct a Rodent Inspection Inside

- Begin in the basement or substructure. Remember that you are trying to find as many areas as you can that might provide harborage, food, water, or access to the building.
- Make detailed notes on your schematic of the building.
- Try to locate all entry points and nesting areas. “Starter holes” for rodents to enlarge can be openings as small as 1/4-inch in diameter in walls, around pipe entries, sewer outlets, and under doors. Unscreened sewer outlets and even toilets can give rats access to buildings. Nests are often composed of shredded paper, pieces of plastic, and bits of fabric gathered together into a 5-inch diameter mass for mice and 8 to 12 inch diameter for rats. If you find clothing or paper that looks torn or shredded but doesn't look like a nest, you will most likely find the nest nearby.
- Look for water leaks and rooms where water condenses on the walls.
- Always be on the lookout for piles of trash, clutter, or other debris.
- Note where the custodians, staff, residents, and students take their breaks or eat lunch. These areas can present a sanitation problem.
- Rodents like to follow edges; inspect these areas for feces, rub marks, urine, or other indications of activity.
- Move to the main floors of the building and inspect locker rooms, home economics rooms, art rooms, child care facilities, lower-grade areas, cafeteria, kitchen, and teachers' lounges. Think broadly as some rooms (like Science classrooms) can have food for rodents.
- Continue into the attic to look for holes, nests, feces, and rub marks. Inspect vents, especially those you were not able to inspect properly during your outside inspection.

make rat problems worse by providing them with food in the sewer system. Proper disposal of organic garbage (food waste, garden waste, pet waste) is essential.

- All food waste from the kitchen, cafeteria, and other areas should be separated from other garbage, drained so it will be as dry as possible, and then stored in sealed

plastic bags. These bags must be placed in rodent-proof containers at the end of each day because plastic bags are not rodent-proof.

- In food preparation areas, thoroughly rinse all cans, bottles, and plastic containers before recycling or discarding.
- Make sure garbage cans and dumpster lids seal tightly when

closed and remain closed when not in use, especially at night. Repair or replace garbage cans with holes or with lids that do not close tightly. Use stretchy fasteners over garbage can lids, if necessary.

- Clean garbage cans and dumpsters frequently to prevent the build-up of food waste. Dirty garbage cans not only attract pests but also

repel people who want to use the garbage cans so that trash ends up outside the can. Use a high-pressure stream of water or a brush and soapy water if necessary. If possible, dumpsters should be fitted with drains so dirty water can be drained. The plug should be snugly in place, except when hosing out the dumpster; otherwise, rodents can enter the dumpster, and it becomes a huge feeding station. Another option is to require the refuse company to clean the dumpster or replace it with a clean one more frequently.

- Do not store extra garbage in cardboard, plastic, or paper outside the garbage cans because they can be torn open by rats, dogs, raccoons, or other animals.
- Inspect dumpsters and other outdoor trash receptacles at the end of the day and pick up any wastes lying on the ground.
- Garbage cans on the facility's grounds should have removable, domed tops with vertical, spring-loaded swinging doors. Line these cans with plastic bags that can be tightly sealed and emptied into rat-proof garbage containers every evening.
- Inform students, residents, and staff of the importance of placing garbage inside the proper containers.
- Pick up cat and dog feces daily (rats will feed on these).
- Shovel, rake, or sweep up fallen fruit, nuts, and similar foods that may be feeding rats in the yard. Dispose of the foods in rat-proof garbage containers. Sometimes it may be necessary to strip trees of their fruits or nuts to get a rat problem under control.

- Store excess garden produce away from rats or dispose of it in rat-proof garbage containers.

Removing Vegetation

- Create a plant-free perimeter at least 12- to 18-inches around the building to decrease cover for rodent burrows and runways and prevent hidden access to buildings. Trim trees branches 6 feet from structures. Prune vines, bushes, grass, and weeds away from the structure.
- Break up dense plantings with pathways, stretches of lawn, or very low groundcover. Rodents don't like to move across barren areas where they can be easily seen.
- Avoid large plantings of a single groundcover that provide cover for rodents to move for long distances without being noticed.
- Thin out dense bushes, cut long grass, and trim weeds to reduce rodent cover and food sources.

Excluding Rodents

Exclusion is the basis of any reliable management program. Since rodent-proofing takes time, begin simultaneously with population control techniques. The following procedures are recommended.

Large Openings in the Exterior of the Structure

- Seal holes larger than 3 inches in diameter with 1/4-inch hardware cloth, 19-gauge or thicker sheet metal, plaster, or mortar. Attach supports or frames for the screen solidly to the building. Never seal holes unless you are certain they are no longer being used by rodents. If in doubt, cork the hole

with crumpled newspaper and monitor for several days.

- If access to the opening is needed, install a lockable door with a heavy-duty spring hinge that will close the door automatically.
- Look for holes in the building not only in the first 3 feet above the ground but also at the roof line, in the eaves, and in attic and roof vents.
- Install 1/4-inch hardware cloth over all vents and ensure that no existing door and window screens are ripped. Note that 1/4-inch mesh will reduce airflow. Separate control measures should be used with dryer exhaust vents. Consider using floating shuttle type dryer vent covers such as Lambro Ultraseal Dryer Vent. Louvered vents frequently become jammed with lint so unless they are regularly cleaned, they will not provide significant protection.
- Cover vent pipes with manufactured covers and screens that meet building codes. Installation of 1/4-inch hardware cloth over exhaust could be a safety hazard if moisture freezes and blocks escaping vapors and gasses.

Small Openings in the Structure, Inside or Out

- Seal all holes less than 1/2 inch in diameter with caulk or other sealant (be sure to choose the type suitable for the substrate and setting).
- Holes 1/2-inch or larger should be filled with backing, such as wool made of stainless steel (e.g. Xcluder™) or copper mesh to provide backing for the caulk or sealant.
- Check for gaps around exterior doors and seal with metal-clad weather stripping. Metal kick

plates can be used to prevent rodent entry. Use raised metal door sills when necessary.

- Some doors have vents or louvers in them as part of the ventilation system. It may be necessary to screen these. Sometimes pipes have been installed through the vents or louvers; make sure to seal any gaps around the pipes.
- Check areas where pipes and wiring enter buildings and close any gaps with wire mesh, sheet metal, or mortar.

Air Conditioners

- Cooling units can provide rodents with water, harborage, and access to the structure. Seal each unit to eliminate access.

Overhead Cables and Electrical Lines

- Rodents sometimes use overhead lines. In these situations, consult your electrical company. NEVER tamper with or work in proximity of electrical lines. CritterGuard® is a product employed by power companies to prevent rodents from climbing wires. Non-electrical lines can be protected by installing 18-inch discs and PVC pipe overlays.

Sewer Pipes

- Repair broken sewer pipes. Rats can dig into broken sewer lines and swim up the toilet trap and enter the building.
- Toilet drains can be rat-proofed by installing a toilet flap or feeding the pipe from the toilet bowl into a pipe with an internal diameter greater than 4 inches.

Drains

- Install 1/2-inch galvanized wire mesh in the drains in basement floors so rats cannot enter through them.
- Install a brass drain cover or perforated metal cap held in place by a hinge so it can be opened for cleaning. The unhinged type of cover should be threaded so it screws in place; otherwise, a rat can push it open.
- Place 1/4-inch galvanized hardware cloth under existing drain covers with holes larger than 1/2-inch.

Debris and Clutter

- Clean up and organize storage rooms to eliminate as much clutter as possible. It is more difficult to detect the presence of rodents in such rooms, and the clutter is attractive harborage.
- Outside, remove heaps of debris, wood piles, or construction debris. Cut grass frequently enough to prevent seeding to remove a food source for mice.

Water

- Free-standing water in stagnant pools, ditches, ornamental pools, or fountains can provide rats with their daily ration of water. Drain or eliminate these sources where possible. Fountains and ornamental pools will pose a problem, but during severe rat infestations, they may need to be temporarily drained. Do not neglect standing water that may be present on the roof of the building.
- Fix leaking pipes, faucets, or broken irrigation systems.
- Eliminate condensation in places like boiler rooms or under air conditioner units.

Installing Barriers

- Install rodent-proof barriers to separate landscaping from the foundations of buildings by digging a small trench at least 12 inches wide, 8 inches deep, adjacent to the foundation and as long as the building. Place 1/4-inch galvanized hardware cloth along the structural and floor sides of the trench. Secure top of mesh to building. Then fill with gravel. These weed-free zones discourage rodents from digging and approaching the structure.
- Place barriers between and within walls to prevent rodent travel (Figure 13-4). An open space between floor joists (as shown at A) gives rats free access to wall voids. Wood 2x4 stops (shown at B) are sometimes used on upper floors, but noncombustible materials should be employed on lower floors. In old buildings, galvanized sheet metal (shown at C) can be cut to fit and nailed between studs, joists, floor, and sill. In new construction, noncombustible stops of cement are recommended (shown at D).
- Vertical barriers of galvanized sheet metal 18 to 24 inches high placed around stored flour or grain will exclude mice. Pallets containing stored food and paper supplies can be mouse-proofed by elevating the pallet on 12-inch cinder blocks, then covering the pallet with a layer of sheet metal so that the edges of the sheet metal extend 4 to 6 inches beyond the edges of the pallet. The edges should then be bent down toward the floor at a 45° angle.

Methods of Direct Population Reduction

Trapping Rodents

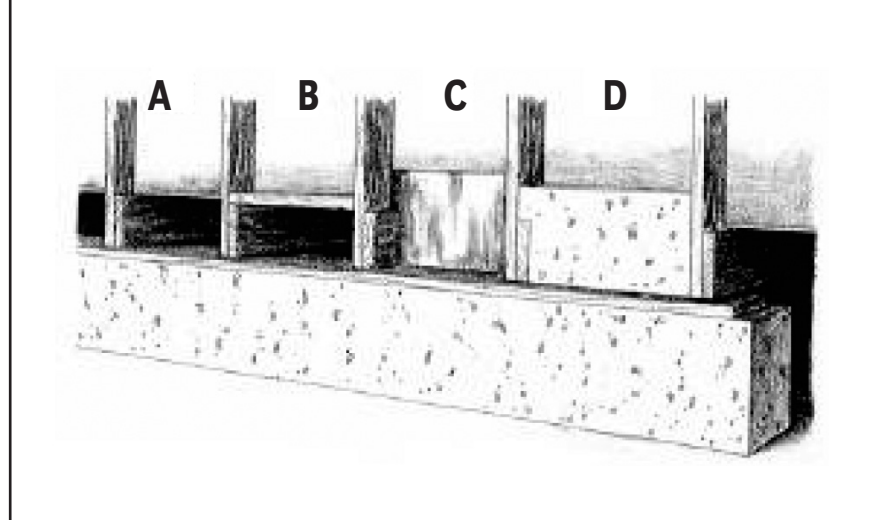
Rodent trapping, especially for mice, is an important component of an integrated pest management program in sensitive environments. Some people have concerns about the ethical implications of killing rodents by trapping. Remember that house mice and Norway rats are invasive species and do not belong in the United States. Relocation is not necessarily humane (and in some areas is illegal) because you will have separated the animal from its familiar surroundings and forced it to find food and shelter while avoiding predators in an unfamiliar environment. Some research shows that rodents released into the backyard simply reenter the structure from which they were evicted.

The following are direct population control methods in descending order of humaneness to the animal; electric shock traps, anti-coagulant toxicants, non-anti-coagulant toxicants, specially designed snap traps (e.g. Victor® Quick Kill Mouse Trap) traditional snap traps, multiple catch traps, and glue boards. Animal welfare concerns can be turned into motivation for habitat modification and other strategies that exclude rodents and eliminate their food supply, thus reducing the numbers that have to be directly killed. Inspect traps daily to remove and humanely kill any rodents that have been caught.

Killing trapped rodents

- Mice found alive in traps should be killed by a swift blow to the head or by asphyxiation with carbon dioxide gas. Insert a hose attached to a regulator connected to a cylinder of CO₂ (available

Figure 13-4. Barriers between and within walls



at bottled gas companies) into a 5-gallon pail. Place the traps in the pail, rest the cover on the pail. The cover does not need to seal because CO₂ is heavier than air. As the CO₂ enters the pail, it will push out the oxygenated air. Turn on the gas for 15-20 seconds at a rate of 10 liters/minute, turn down the flow to 1 liter/minute and leave the pail for 5 minutes. Upon returning, carefully lift the lid and check the trapped mice for signs of life. If you notice respiration or movement, replace the lid and continue the gas flow at the 1 liter/minute rate for another 5 minutes.

- Place the dead mice in two plastic bags (double-wrapped) and dispose of them in a sealed dumpster or garbage can.

Tips for a successful trapping program

- Place baited but unset traps in areas where rodent activity has been noted and/or is likely. Check and rebait (if needed) for 3 consecutive days. Set traps on the third day. Check traps daily, removing captures and rebaiting as neces-

sary. As captures begin to decline, checks can be extended to every other day or every few days.

- Use the map of the building and/or grounds to record the precise location of each trap and the date it was set. This recordkeeping is the key to preventing lost and forgotten traps. If dead and decomposing rodents are left in the traps, the results can be very unpleasant.
- Always wear gloves when handling traps for protection from diseases.
- Trapped rodents provide you with the opportunity to identify the species. Take the opportunity to confirm the species of rodent you are controlling.
- For mice, set a large number of traps for a few days (1 every 6-10 feet). One of the greatest errors in mouse trapping is the failure to use enough traps. Continue to monitor.
- If trapping success ends, set snap traps and leave them in place. Reset traps two weeks later to ensure that mice too small for capture during the first trapping are caught in the second round.

- If catches are poor, try moving the traps to new locations or place new traps in new locations.
- Most rats are trap-shy and have been known to avoid traps for up to two weeks. Rat traps can be pre-baited in the unsprung position to improve their effectiveness. You also can leave out food in shallow pans until the rats readily eat it, and then camouflage the trap by burying it under the food in the pan.

Trap choices

Rodent traps fall into four general categories: electric shock traps, snap traps, box traps (a.k.a. live) traps, and glue boards. Each kind of trap is better suited to some situations than others. The information below will help you decide where to best use each of the traps.

Electric Shock Traps. These traps use battery power to kill rodents when they complete the electrical circuit.

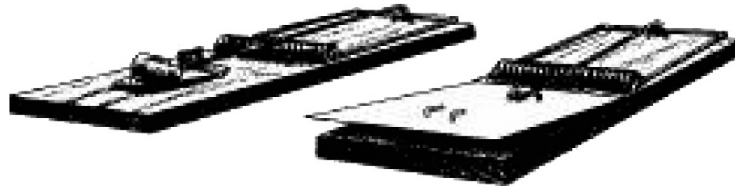
Snap Traps. Snap traps are widely available and fall into two types. The first is the traditional snap trap that uses a striking bar to kill the rodent. Those lacking wide triggers can be made more effective by expanding the trigger (see Figure 13-5) so they can be tripped by a mouse or rat that is running over the trap. Do not place them where human toes might accidentally get caught unless the traps are protected inside a tamper proof bait station (Figure 13-6). Clamshell type is the second trap variety. It uses jaws to kill the rodent. While more expensive, the design of the trap allows for easy (one hand) removal of the rodent.

Box Traps. Box traps (a.k.a. Live traps, Figure 13-7) are available for rats and mice, but the rodents must

Figure 13-5. Rat traps

Making an Expanded Rat Trap Trigger

Rat traps with expanded triggers are available commercially, but you can also make your own. Cut a 1 1/2 in (3.8 cm) square piece of stiff cardboard or 1/8 in (0.3 cm) thick wood and attach it to the existing trap trigger with wire or strong glue. Expanded triggers often catch rats without bait if the traps are placed well and are moved when necessary.



be killed once they are trapped. When mouse populations are high, multiple-catch live traps may be more efficient than snap traps. They are not as effective on rats.

Multiple catch traps can capture several mice at a time without needing to be reset. Some models have windup mechanisms that “kick” the mice into another compartment. Others use a treadle door. Although these traps can work without baits because mice are curious and attracted to the small entrances designed into the traps, they are more effective when baited.

Glue Boards. Glue boards are covered with a sticky material that will catch mice and rats. Glue boards provide the advantage of catching and retaining rodent hairs, droppings, and ectoparasites coming from the trapped animal. Glue board traps should be inspected daily to prevent unnecessary suffering by the trapped animals.

If glue boards are used in areas where they might fall and get stuck to something, secure the traps with a staple or wire. Glue boards should always

be secured when trapping rats so that the rats cannot drag the traps away. Baiting glue boards is not necessary but will improve the chances of success. Never apply peanut butter or other greasy bait on the glue as the oils will decrease the glue’s effectiveness. Place baits in a plastic soda bottle cap and set in the middle of the board. Research suggests that glue boards are less effective in capturing rodents (particularly rats) than other capture methods. Dust will reduce the glue board’s stickiness over time.

Trap Placement

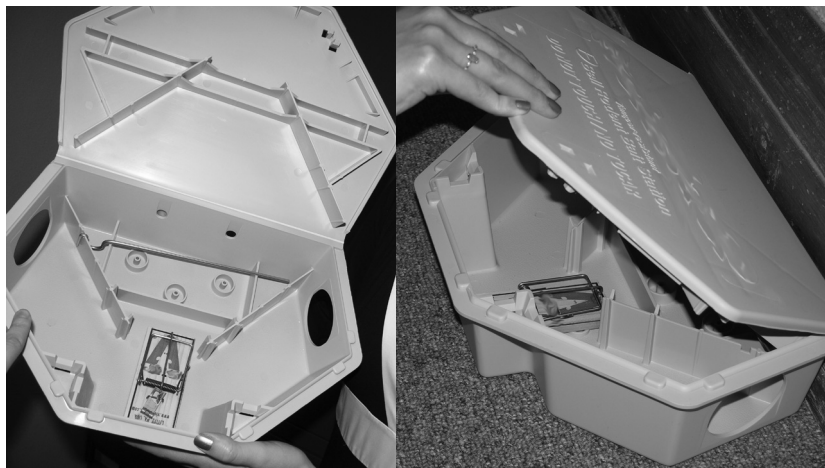
- Check the monitoring map to locate active rodent holes, and set traps along walls or other runways leading to the holes. Other good trap locations include areas near droppings, gnawing marks, or other signs of rodent damage; under and behind objects likely to harbor rats or mice; in dark corners; and along rafters or other protected areas where rodents are likely to travel.
- Changing the location of furnishings will produce new pathways

that mice will quickly investigate. Traps can be placed along these new pathways. For rats, move objects around to funnel them into the traps.

- Set traps at right angles to the wall with the trigger facing the wall (Figure 13-8).
- Place traps flush with the wall so that rodents traveling along the edge of the wall will encounter the traps.
- Two traps, side by side with their triggers facing the wall, can increase the chances of success. Alternatively, the two traps can be placed parallel to the wall, back to back with their triggers facing away from each other. Three traps in a row will make it difficult for a rat to jump over the traps without being caught.
- Traps can also be screwed to a wall or rafter or wired to a pipe. Make sure the trigger side of the trap is projecting into the rodents' runway.
- When trapping rats with snap traps, secure them to prevent rats from moving traps to inaccessible areas.
- Traps can be camouflaged on dirt surfaces by sinking it just below



Figure 13-7. Box trap



Photos: Erin Bauer

Figure 13-6. Snap trap in tamper proof bait station

ground level and covering it with a fine layer of sand or sawdust. Traps can also be set in shallow pans filled with sawdust, grain, or meal. It may be necessary to place a small piece of cloth over the trigger to keep it from jamming.

Baiting the Traps

- Peanut butter is attractive bait for rodents, particularly house mice. Given that some people are seriously allergic to peanut butter, it may be prudent to avoid its use at least in more public areas. Other baits include raisins, chocolate, gumdrops, chicken fat, caramel, rolled oats, or bacon grease. A small piece of cotton can be attached to the trigger instead of food. The cotton makes attractive

nesting material, does not spoil, and is less likely to attract new pests such as flies, ants, and cockroaches.

- Baits for Norway rats include pieces of chocolate, pepperoni, hot dog, bacon, liver, peanut butter, or nut meats. If rats are feeding on other foods, try them as baits also.
- Place the bait in the center of the trigger. Baits that do not stick to the trigger can be tied on with string or dental floss so the rodent cannot steal the bait without tripping the trigger.
- To catch rats, you will probably have to “pre-bait” the traps. Place the traps out with bait but do not set the traps. Check them daily to see if the bait has been taken and move them to a new location if the bait remains undisturbed for three or four days. Once you see signs of feeding on the bait, apply fresh bait and set the traps. Remember, snap and clam-style traps can be set in blind, meaning without bait. Simply placing traps the trigger end abutting the wall will be close enough to catch a rat walking along the wall.



Figure 13-8. Proper placement of traps

Number of Traps to Use

- For house mice, place one trap every 6 to 10 feet along a wall and more in areas where there are many signs of mice. Remember to think in three dimensions. Mice signs on one floor mean you should set traps not only on that floor but also the adjoining rooms/ areas beside, below, and above.

Protecting Snap Traps

- If safety or tampering is a concern, you can place a snap trap inside a rat bait station. Use only rat bait stations; a mouse station is not large enough to allow traps to fire. Place the bait station on its side against the wall with the entry holes closest to the floor. Set and insert a baited rat or mouse snap trap with its trigger facing the entry hole. By placing two of these bait station traps back to back, the rodent will be caught traveling in either direction.
- Mouse snap traps can also be placed inside PVC pipe. Use pipe that is at least 3 1/4 inches in diameter so the traps have room to fire. Place two traps end to end inside the pipe with the triggers facing the cut ends of the pipe.

PVC piping is available at plumbing supply stores and can easily be cut to the desired length.

Protecting Glue Boards

Glue boards should be placed inside professional rat or mouse bait stations to extend the life of the board by protecting it from dust, dirt, and tampering. This method also hides the catch from view. The following points will help you set up the traps:

- For mouse bait stations, you will need to cut or fold the glue board to fit inside the station before you remove the protective release paper from the board.
- Remove the glue board from the bait station to dispose of the rodent and replace with a new board. Glue boards can also be placed inside a length of PVC pipe along exterior foundations or indoor walls. Curl the glue board inside the pipe, making sure that the curve of the board matches the contour of the pipe.

Miscellaneous Points

- Do not spray insecticides on the traps and do not store them with insecticides, rodenticides, or application equipment. The traps

will smell of these substances, and rats will avoid them.

- To prepare snap traps for storage, treat with disinfectant, scrub them with a stiff brush, soak them in detergent and water, and dry them. Be sure to wear your PPE.

Repellent Sound Devices

A number of sonic, ultrasonic, magnetic, and electronic devices are marketed as effective tools in preventing and/or evicting rodents from structures. None of these products have been demonstrated to be effective in the long-term control of rodents in real-world situations. The reasons for their lack of efficacy are quite simple. Rodents exploit the inevitable sound shadows that arise from their use or simply tolerate the noise while foraging.

Biological Controls

Some institutions maintain cats for protection against rodents. While cats can and do kill rodents, they typically only “prune” the population. Rodents in areas with cats quickly learn to avoid their presence. It should also be apparent that no matter how good a cat is at catching rodents, they cannot enter walls where rodents live. Free-ranging cats also can transmit diseases acquired outdoors to their owners, such as toxoplasmosis.

Rodenticides

If non-chemical methods alone prove insufficient to solve the problem, then integrating rodenticides into your management program may be warranted. However, rodents weakened by toxicants can poison the animals that eat them, such as owls and snakes. This phenomenon is known as secondary poisoning. So when considering the use of chemical

control techniques, remember that depending on the toxicant used, these predators can be killed by consuming poisoned rodents.

Rodenticides must be used in accordance with their EPA-approved label directions. Applicators that are hired by an institution must be certified to apply rodenticides and should always wear protective clothing during applications. Copies of all labels and Material Safety Data Sheets (MSDS) for the rodenticide products authorized for use in the IPM program should be maintained on file.

Patience is necessary when using rodenticides. Baits and bait stations will be avoided for a few hours to several days after initial placement. Even after this period, rats will be very cautious about approaching them. Depending on the type and amount of rodenticide eaten, rodents will begin dying in 3 days but have been known to live up to 3 weeks before succumbing to the poison.

When to Use Rodenticides

It is appropriate to use rodenticides when trapping and physical changes to the building and to food and waste storage have been clearly documented to be insufficient to meet control requirements. In emergency situations when there are very high numbers of rodents or when rodent ectoparasites have been identified as a concern (e.g. bubonic plague), it may be appropriate to use toxicants, but trapping and habitat modification should be used at the same time. Understand, however, that control of rodents does not automatically constitute control of ectoparasites.

Safety Precautions

- Before purchasing a rodenticide, carefully read the instructions on

the label. Consider whether the label allows its use in the area where rodents need to be controlled. Remember, “The label is the law.” Different rodenticides may have different restrictions. So choose the one best suited for your situation.

- All rodenticide baits should be placed inside Tier 1 tamper-resistant bait stations. Tier 1 stations are resistant to weather and tampering by children and dogs. Bait stations should always be secured to the floor, a wall, or other surface. We also suggest that they be positioned out of the reach or access of children whenever possible. Bait stations should be clearly labeled with a warning.
- Use rodenticides over long holidays when residents, workers, and students are not in the building.
- Use only in locked storerooms, basements, attics, or other areas not accessible to children.
- Only use formulations of toxicants that cannot be moved by rats or mice, such as secured paraffin blocks.
- Handle rodent carcasses with gloves.
- Keep unused bait in its original container in a locked cabinet with appropriate warnings on the outside of the cabinet door. If baits are stored with other chemicals, put the original container into an airtight container so the bait will not absorb odors that may impair its effectiveness.

Types of Rodenticides

Rodenticides fall into two broad categories, anticoagulants and non-anticoagulants. Anticoagulants kill rodents by disrupting their capillaries and preventing the clotting of

their blood. Non-anticoagulants kill by disruption of the nervous system or other means. Rodents usually eat small amounts of the toxicant over several days and eventually die from internal bleeding. Anticoagulants present minimal hazards to humans because of the small amount of toxicant in the baits and an antidote (vitamin K) that is readily available. Anticoagulants are further categorized as first or second generation. First generation anticoagulants require multi-feedings before the rodent receives enough poison to reach lethal levels. Second generation anticoagulants can kill rodents in a single feeding, but rodents typically begin dying by the third day. The delay in the toxicant’s lethality is to prevent rodents from “learning” that the bait is actually dangerous. If rodents got sick immediately after a feeding, the few that survive would avoid the bait thereafter.

Three non-anticoagulant rodenticides are available: bromethalin, cholecalciferol, and zinc phosphide. All three can kill rodents with a single dose, but no antidote is available. Non-anticoagulants are recommended only if there is a need for a quick reduction of the rodent population and if access to the baits is completely restricted.

Recent changes in EPA regulations now designate second generation anticoagulants and above ground use of non-anticoagulants as Restricted Use Pesticides. This categorization means you must have a pesticide license in order to purchase and use these toxicants. First generation anticoagulants, however, are still considered General Use Pesticides and are available at supermarkets, hardware, and farm supply stores.

Rodenticide Formulations

- Parafinized and extruded bait blocks are useful in wet situations where dampness could spoil other baits. These blocks must be wired to the bait station so they cannot be dragged away. This formulation is available to the public.

Restricted Use Pesticide Formulations

- Liquid formulations are dispensed in special bait stations made especially for liquids and are most useful for rats in situations where water is very restricted and food is plentiful. Liquid bait must always be used where non-target animals and children have no access.
- Loose grain or meal formulations, e.g., cornmeal or oatmeal mixed with a toxicant, are extremely attractive to rodents. But rodents sometimes make caches of the bait to eat at another time.
- Tracking powders are used in wall voids and other locations inaccessible to humans. As rodents walk through the powder, they ingest the toxicant during their grooming.

Use of Toxic Baits

Before beginning a baiting program, inspect to determine the locations where rodents are most likely to accept poison bait.

Points to consider when instituting a baiting program include the following:

- bait stations (Use Tier 1 bait stations) should be secured in place and clearly labeled “RODENT BAIT — POISON — DO NOT TOUCH”

- place bait stations where rodents are most active. Place bait stations along walls and, whenever possible, between shelter and the source of food
- use one color of toxicant for indoor stations and another for outdoor stations. These colors will persist in rodent droppings and will tell you whether the rodent was feeding indoors or out.
- bait stations should be placed 15 to 30 feet apart in areas with high densities of rodents (but check toxicant label)
- number your bait stations and mark the location of each on your building map when beginning, check each bait station every 3 to 5 days ensure there is enough bait (this is extremely important in the early stages of a control program), the bait is in good condition (not moldy or wet), and the bait station is not being disturbed. Leave bait stations in place for the number of days recommended on the label. Mice will readily investigate new things in their territory, but it may take 2 weeks for rats to try the bait. Anticoagulants, whether first or second generation, require 5 days or more to kill rodents. Maintain bait stations by checking them at least monthly. Dispose of old bait according to the label. When cleaning stations wear protective clothing as suggested by CDC.gov. If you must use a cleaning agent, swap the station out with a new one
- remove and securely store all bait stations when the baiting program is over.

Vigilance

You cannot relax after finding and treating a rodent infestation. Mice and rats are always a potential problem. Designate areas of high and low risk and continue to monitor the high risk areas perhaps every other week. Use monitoring blocks to help detect the presence of rodents.

The low risk areas can be inspected once every quarter. It is important to pay attention to seasonal and other changes. Is there a vacant lot, or agricultural area adjacent to the sensitive environment? If so, the property will be regularly invaded by surplus or evicted rodents seeking shelter on your property. Is new construction or demolition starting next door to the sensitive environment? Rats will be displaced and could invade your facility's yard and/or buildings. These are times for renewed vigilance.

Monitoring Blocks/Monitoring Stations

Monitoring blocks provide an effective, convenient, and non-toxic way to maintain a vigilant outlook for rodents. Monitoring stations require several steps, including the following:

- make a site plan of the sensitive environment with separate drawings of each floor so you can accurately record information.
- Non-toxic, food attractant blocks are commercially available for monitoring rodents. You can also use bait stations filled with non-toxic baits such as rabbit food or grains. These monitoring blocks or stations can be placed anywhere indoors or out to locate or monitor a rodent population simply by noting whether animals have fed on the bait. Monitoring blocks or

stations can also help you gauge the effectiveness of your treatment efforts. The blocks or bait stations should be wired, staked, or glued down with caulk so they cannot be dragged away. Clearly mark the blocks or stations with a tag, alerting people that a non-toxic, rodent monitoring program is underway.

Number each block or station and note its location on your map. In 2 to 7 days, check for signs of rodent feeding and record the amount on a monitoring form.

The following are some of the best locations to place monitoring stations:

- food storage areas
- kitchens — in closets and food storage areas
- locker rooms, break rooms, and teachers' lounges
- attics
- basements
- under and behind cabinets, appliances, computers, and electrical boxes
- in storage sheds, especially any containing grass seed or bird seed
- outdoors in dense vegetation and along buildings and fences

Conclusion

While rats and mice will continue to thrive in and around human environments, the extent of their success depends entirely on us. Implementation of an integrated management program, involving habitat modification, exclusion, lethal control, and regular monitoring, will result in a rodent-free environment.

Resources

For Norway Rat, House Mouse and other pest vertebrate management practices, see the publications available from UNL Extension on-line at: <http://www.ianrpubs.unl.edu>.

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