CHAPTER 12
IPM FOR RATS AND MICE IN SCHOOLS

INTRODUCTION

Although setting out poison baits is the common response to rodent problems, this tactic has been overused, and strains of rats and mice have developed that are no longer affected by the poison. Even when baits remain effective, 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. Moreover, on school grounds, there is always a risk that children or pet animals will inadvertently come in contact with the bait.

A better approach combines careful inspection, regular monitoring, sanitation, garbage management, rodent-proofing, trapping, and, if necessary, baiting with toxicants. Unless the conditions that attracted rodents in the first place are changed, new mice and rats often move into the habitat vacated by the dead ones, and the cycle will continue.

IDENTIFICATION AND BIOLOGY

It is important to identify which rodent species is present. Table 12-1 and Figure 12-1 describe the differences among Norway rats, roof rats, and house mice. Table 12-2 describes how to distinguish a house mouse from other similar species. After trapping a rodent, you can use information from these tables to identify it.

Rats

The two most common pest rat species in the United States, both introduced from Europe, are the Norway rat, Rattus norvegicus, and the roof rat, Rattus rattus. Table 12-3 summarizes the biology of these two rats. The Norway rat, considered the most important pest rat in the U.S., is also known as the brown, wharf, house, gray, or sewer rat. It occurs in every state. The roof rat, also known as the ship, black, or Alexandrine rat, occurs mainly along the coastal U.S., including the Pacific coast states, the Gulf states, and the southern and Atlantic states.

Characteristics of rats that can have an impact on management

- will feed on a wide variety of materials (see Table 12-4 for more specific information)

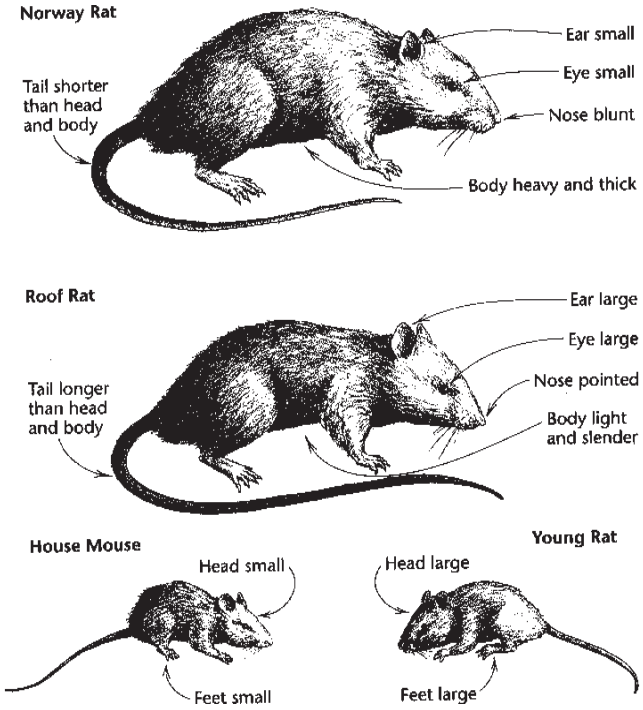

Figure 12-1.

- usually search for food between dusk and dawn, but when hungry or living under crowded conditions, may be seen in the daylight
- require water daily, unless food items are succulent
- can travel several hundred feet from their nests in search of food, depending on the relationship of food to nesting resources.
- prefer traveling along edges, e.g., the edge of the floor next to the wall, along the outside or inside of a foundation
- also travel along pipes, rafters, and for roof rats, overhead utility lines
- wary of crossing open spaces that provide no cover
- have poor visual acuity, but are quite sensitive to patterns and contrasts
- have acute senses of smell, taste, touch, and hearing; navigate using their whiskers and guard hairs
- tend to be extremely wary (though temporarily) of new objects in their environment

In general, Norway rats build their nests in underground burrows or in ground level areas in buildings while roof

Table 12-1. Differences Among the Norway Rat, Roof Rat, and House Mouse

Please find this table at end of chapter.

rats prefer living in elevated areas. Table 12-4 provides more specific information.

Rats have amazing physical abilities. Understanding what they can and cannot do is very important when planning ways to prevent rat problems or to reduce the number of rats present. These abilities are summarized in Box 12-A.

Mice

The house mouse is the most common species to invade structures, but "wild" mouse species such as meadow voles and deer mice are also occasional problems, especially when temperatures drop in the autumn. Usually these mice can be easily trapped and removed, and rarely become chronic problems.

Invasions of the house mouse can occur at any time of the year, and once inside, house mice will continue to reproduce, generation after generation, without leaving the confines of the building. Biological information for the house mouse is summarized in Table 12-5, and its physical abilities are summarized in Box 12-B.

Characteristics of mice that can have an impact on management

- can generally get all the water they need from food; if dependent on dry food, will need some free water
- travel over their entire home range daily (about 33 feet), investigating changes and new objects
- like rats, prefer to travel along edges and are wary of crossing open spaces
- have poor visual acuity; navigate using their whiskers
- indoors, often live in false ceilings; in appliances such as stoves, refrigerators, air conditioners, and coolers; in wall and floor voids; and in similar enclosed spaces
- outdoors, prefer thickly vegetated ground level areas

Indoors, mice populations 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. Because rats prey on mice

Table 12-2. Distinguishing the House Mouse from Other Similar Species

Please find this table at end of chapter.

Adapted from Olkowski, et al. 1991

and compete for the same food and shelter, removing the rats often results in higher and more visible mouse populations.

Damage

Rodents damage food, clothing, documents, and structures through gnawing, urination, defecation, and nesting activities. The damage to food from contamination is probably ten 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 proliferation of microorganisms (Frantz 1988). Rodents cause fires by chewing through the insulation on electrical wires, and they are involved in spreading human pathogens (see Table 12-6). The hantavirus is cause for concern in many parts of the country; see Box 12-C for more information.

Detection and Monitoring

Make a thorough inspection to find as many of the active infestations as possible. At the same time note all possible harborage sites, sources of food and water, and holes that provide access to the building. Box 12-D details the signs of rodent infestation, and Boxes 12-E and 12-F summarize the areas to inspect inside and out. Make detailed notes about problem areas on a map of the building. Do not neglect to inspect any outbuildings on the property.

To help you monitor effectively, do the following:

- Make a site plan of the school with separate drawings of each floor so you can accurately record information.
- Lightly dust smooth surfaces near suspected harborage, runs, or entry points with unscented talcum powder or powdered chalk to gain further information. Footprints and drag lines (made by tails) across powdered surfaces indicate rodent traffic. The powder can also be dusted onto a heavy, smooth material such as a piece of floor tile that can be moved around. Holding a flashlight at a low angle helps to illuminate tracks on dusty surfaces.
- Inspect at night with a strong flashlight. Look for movement and listen for squeaking, scrambling, and gnawing sounds.
- Vacuum up fecal pellets and gnawed wood shavings and remove any nests. Re-inspect for new rodent signs in a day or two. In areas where hantavirus is suspected, vacuuming is not advised. See Box 12-C for precautions to take when cleaning.

Table 12-3.
The Biology of Norway and Roof Rats

Please find this table at end of chapter.

Source: Frantz & Davis 1991

Table 12-4. Nesting and Eating Habits of Norway Rats and Roof Rats

Please find this table at end of chapter.

Sources: Meehan 1984 and Ingles 1965

- You can temporarily place a piece of gray paper or cardboard in dark or hard-to-reach areas and inspect them later for fecal pellets. Remember that rats, especially Norway rats, are fearful of new things, so it may take several days before they even come near the paper. For this reason, darker colors of paper will work better than bright white.
- Temporarily close suspected rodent burrows or holes with soil, crumpled paper, aluminum foil, or sawdust. Inspect 24 hours later to see if the holes have been opened or the paper chewed or moved.

Monitoring Blocks/Monitoring Stations

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 blocks:

- 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, bird seed, etc.
- outdoors in dense vegetation and along buildings and fences

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 rodent presence.

Box 12-A. Physical Abilities of Rats

Rats have the ability to:

- pass through any opening as small as 3/4 inch in diameter
- walk along horizontal wires and climb vertical wires (especially roof rats)
- 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; Norway rats are not likely to climb vertical wires unless they are close to 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 horizontally at least 4 feet
- 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.

Sources: Caslick and Decker 1980, and Howard and Marsh 1967

The low risk areas can be inspected once every quarter. It is important to pay attention to seasonal and other changes. Is there a wheat or cornfield next to the school? If so, at harvest time, field mice will often leave the field and seek shelter in the nearest building. Is new construction or demolition starting next door to the school? Rats will be displaced and could invade the school yard and buildings. These are times for renewed vigilance.

Management Options

Initially, concentrate control efforts in the high risk/high priority areas, such as the kitchen, the cafeteria, locker rooms, and perhaps various storage rooms. Your inspection will reveal the precise areas you must concentrate on in your own school. 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 you noted in your inspection. You need not tackle the entire school at once.

Habitat Modification

It is very important to change the physical environment that is supporting rodents. As mentioned before, if rodents are killed but habitat and food are still available, it is very likely that new rodents will move in to replace the dead ones.

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 or teachers' lounges should be in tightly closed containers. Do not leave food out overnight.
- Do not allow students to store food in their lockers overnight unless it is in rodent-proof containers. Explaining to them why this is important will help with compliance.
- Store fresh fruits and vegetables in refrigerators or in open air coolers that are screened with 1/4-inch, heavy wire mesh.
- Store bags of grass seed, dry pet food, and other similar items in rodent-proof containers, or at the very least, inspect them frequently for any signs of chewing.
- Promptly clean up any spilled bird seed around feeders.

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 the pests.

Table 12-5.
The Biology of the House Mouse

Please find this table at end of chapter.

Source: Frantz & Davis 1991

Box 12-B.
Physical Abilities of the House Mouse

Mice have the ability to

- jump up to 12 inches from the floor, use vertical surfaces as a spring board to gain additional height, and jump downward 8 feet to the floor
- run up almost any vertical surface, including wood, brick, metal pipes and girders, sheet metal, wire mesh, and cables
- easily run along suspended electric wires and ropes of most common sizes
- squeeze through a 1/2 inch diameter hole
- travel upside down, clinging from 1/4 inch hardware mesh
- swim well, but tend not to dive below the surface
- survive at 24°F for many generations

Adapted from Pinto 1992

Managing Garbage Properly

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

- Trim trees, vines, bushes, grass, and weeds at least 12 to 18 inches from all buildings to decrease cover for rodent runways and prevent hidden access to buildings.
- Break up dense plantings with pathways, stretches of lawn, or very low groundcover. Rats don't like to move across areas where they can be easily seen.
- Avoid large plantings of a single groundcover that could allow rats to run for long distances without being seen.
- Thin out dense bushes to reduce rat habitat.
- Avoid planting date palms or Algerian ivy (Hedera canariensis) on the school grounds because rats can live in and feed on these plants.

Excluding Rodents

Exclusion must be the basis of any reliable management program. Rodent-proofing will take time and should begin simultaneously with trapping and/or poison baiting. 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. Make supports or frames for the screen and make sure they are secured solidly to the building.
- If maintenance staff needs access to the opening, install a lockable door with a heavy-duty spring hinge that will automatically close the door if someone forgets.
- 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.
- Make sure all vents are screened with 1/4-inch hardware cloth and that existing screen is not ripped.
- Cover vent pipes with a square of 1/4-inch hardware cloth bent around the pipe and secured with a wire.

Small Openings in the Structure, Inside or Out

- Depending on the material in which you find these openings, holes as small as 3/16 inch in diameter should be sealed. These holes are very important and are often difficult to find. If the holes are in materials that rats can gnaw, they can enlarge these holes until they can eventually squeeze through them.
- Seal small holes with steel or copper wool (copper will not rust) or with caulk.
- Check for gaps around exterior doors and seal with weather stripping. Metal kickplates 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

Table 12-6. Selected Pathogens Associated with the House Mouse, Roof Rat, and Norway Rat

Please find this table at end of chapter.

Sources: Frantz 1988, Harwood and James 1979, Olkowski 1991, and Quarles 1995

Box 12-C. 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 overpopulation of deer mice, Peromyscus maniculatus, the primary vector (see Table 12-2 for description). Other rodent vectors include the piñon mouse, P. truei; brush mouse, P. boylii; and various western chipmunks, Tamias spp.

The most common route of transmission is through breathing in the virus on or in aerosilized, 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, rodent excreta, etc. Rodent bites can also 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 a number of 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 can result.

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.

To determine if deer mice are a problem in your area, call the local Cooperative Extension. In areas of known infection, trapping and cleanup should be done by a trained health department representative or pest control operator.

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 exclusion for deer mice are the same as for any rodent. See the section on excluding rodents under Management Options for directions on rodent-proofing your school building.

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

- Wear latex or rubber gloves.
- Mix a solution of 1 cup bleach to 10 cups water or use a household disinfectant.
- Wipe down counter tops, cabinets, and drawers. Mop floors and baseboards.
- Thoroughly spray or soak any dead mice, droppings, or nesting areas with disinfectant or the 10% bleach solution.
- Do not vacuum, sweep or dust. 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.
- Dispose of contaminated items, including dead mice, in a double plastic bag.
- Disinfect or throw away the gloves you used.
- When you are done, wash your hands with soap and hot water.

Source: Centers for Disease Control and Prevention 1993

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 caulk or with steel or copper wool.

Air Conditioners

- These units can provide rodents with water, harborage, and access to the structure. Make sure each unit is well-sealed, especially those on the roof.

Sewer Pipes

- Repair broken sewer pipes. Rats can dig into broken sewer lines and swim up the trap in a toilet to get into a building.
- Toilet drains can be rat-proofed by feeding the pipe from the toilet bowl into a pipe section of larger diameter (Frantz and Davis 1991).

Drains

- Cap the drains in basement floors so rats cannot enter through them.
- Install a brass drain cover or a perforated metal cap held in place by a hinge so it can be opened for cleaning. Make sure the unhinged type of cover is

Box 12-D. Signs of Rodent Presence

Live or Dead Rodents

- Seeing live rodents is the most obvious and certain sign of their presence. Seeing live rodents in the daytime usually means there is a heavy infestation, that their harborage has been disturbed, or that new rodents are moving into the area and haven't found any harborage yet.
- A freshly dead rodent is a sign of infestation, but this is not necessarily true with an old, dried body which may merely indicate a previous infestation.

Droppings

- The largest number of droppings will be in feeding areas and near harborage.
- Rat droppings may be as large as 3/4 inch long and 1/4 inch in diameter. Mouse droppings are much smaller, about 1/4 inch long.
- 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 lizard or bat droppings can be confused with rodents droppings, but both lizard and bat droppings contain many insect fragments that can easily be seen when the droppings are crushed.
- In order to monitor for current rodent activity, remove the 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, packaging, etc. are good indications of rodent presence.
- Rats can gnaw through rusty sheet metal and sheet aluminum.

Grease Marks or Rub Marks

- These 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

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

Tracks

- Footprints and long, thin marks indicating a tail being dragged or rested can easily be seen on dusty surfaces, in mud, or in snow.

Noises

- As rats gnaw, claw, fight, and scramble around inside walls they make noises. These are particularly audible at night when they are most active. A stethoscope may be used to pinpoint the activity. Mouse noises are harder to hear, but you can sometimes hear them scurrying and skittering around. Note that squirrels and other animals can make similar noises, so you should confirm rodent presence with other signs.

Urine

- Rodent urine will fluoresce blue-white under ultraviolet light, but many other substances also fluoresce, so recognizing rat urine takes skill.

Adapted from Meehan 1984

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's harder to detect rodent presence in such rooms and the clutter is attractive harborage.
- Outside, remove debris heaps, wood piles, or construction debris.

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.
- Fix leaking pipes, faucets, or broken irrigation systems.
- Eliminate condensation in places like boiler rooms.

Installing Barriers

- Make rat-proof barriers to separate landscaping from the foundations of buildings by digging a small trench 8 to 12 inches wide, 8 inches deep, and as long as the building. Fill this with pea gravel. Rats dislike burrowing in loose gravel and will be discouraged from trying to penetrate the foundation.
- Place barriers between and within walls to prevent rodent travel (see Figure 12-2). An open space between floor joists (as shown at A) gives rats free access to wall voids. Wood 2x4 stops (show at B) are sometimes used on upper floors, but an incombustible material 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, incombustible stops of a good grade 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.

Box 12-E. 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, under doors, etc. Unscreened sewer outlets and even toilets can give rats access to buildings. Nests are often composed of things like 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, teachers, 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 areas, lower-grade areas, cafeteria, kitchen, and teachers' lounge. Even science rooms can have food for rodents.
- Continue into the attic to look for holes, nests, feces, and rub marks.

Adapted from Harmon 1995

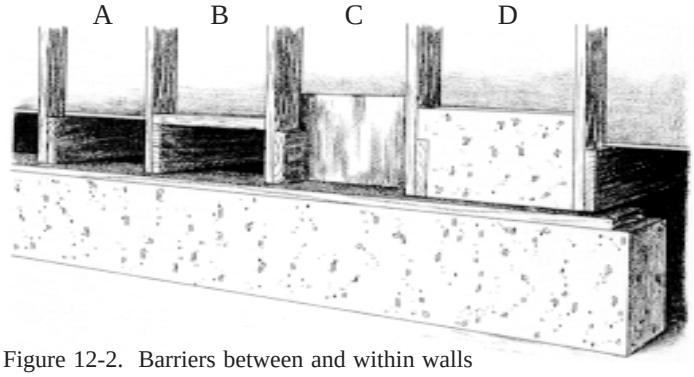

Figure 12-2. Barriers between and within walls

Trapping Rodents

Many schools have concerns about the ethical implications of killing rodents slowly by trapping. Snap traps are probably the most humane in that regard because they kill the animals swiftly. These concerns for the animals 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. Be sure to inspect the traps daily to remove and humanely kill any rodents that have been caught.

Killing trapped rodents

- Plunge live capture traps or glue boards into a 5 gallon bucket of soapy water and hold down until the rodents drown.
- Place a few traps into a large, heavy-duty garbage bag and tie the bag loosely to the exhaust pipe of a car. Open the car windows, start the car, and leave it running for a minute or two. After turning off the car, remove the bag from the exhaust pipe, seal the bag and leave it for several more minutes.

Tips for a successful trapping program

- Set traps in the correct locations, bait properly, and inspect frequently—sometimes this will mean daily.
- Use the map of the building and/or grounds to record the precise location of each trap and the date it was set. This record keeping 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.
- When handling traps, always wear gloves for protection from diseases.
- Rats will avoid traps for a few hours to several days after initial placement. "Pre-baiting" traps for rats (see below under Baits) can improve catches.
- For mice, set a large number of traps for a few days, then remove the traps and dispose of dead mice. Reset traps two weeks later. This will ensure that

Box 12-F. How to Conduct a Rodent Inspection Outside

- Try to identify as many of the areas as possible that provide rodents harborage, food, water, and access to the building.
- Make detailed notes on your map of the exterior of the building and the school 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 running into the upper portions of buildings and any trees which are brushing 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, wood waste piles, portable storage containers, and outbuildings. Are there signs of rodent infestation in or around any of these areas?
- Take into account any field or lot which may be next door, as well as any supermarket or fast food establishment which may attract rodents. Rodents that start to invade the school may be an overflow from adjoining properties. If a vacant building next door to a school 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, if there is a corn or wheat field near the school, when the grain is harvested in the fall, field mice often migrate to the nearest structure.
- Check for irrigation leaks and any standing water such as irrigation or drainage ditches, stagnant pools, ornamental ponds, and fountains.
- On the roof, check air conditioning units that might provide water and harborage for rats.

Adapted from Harmon 1995

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.

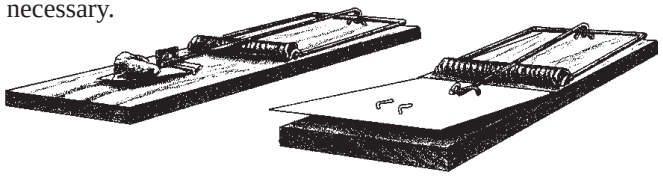

Figure 12-3. Rat traps

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.
- When most of the rats have been trapped, it can be hard to catch the last few because they may have become trap-shy and will avoid the traps. In such cases, the traps can be removed for a week, then set in new locations using the pre-baiting method described below. You can also 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 three general categories: snap traps, 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.

Snap Traps. These traps are widely available and can be made more effective by expanding the trigger (see Figure 12-3) so that it can be tripped by a mouse or rat simply running over the trap. Do not place them where human toes might accidentally get caught, unless the traps are protected inside a bait station (see below). These traps work well in dusty places, but do not use a snap trap in an area with standing water or high humidity because the mechanism will rust and the trap will be useless.

Live Capture Traps. Live traps are available for rats and mice, but the rodents must be killed once they are trapped. When mouse populations are high, multiple-catch live traps may be more efficient than snap traps. Multiple catch traps can capture several mice at a time without needing to be reset. Some models have wind-up 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. These are boards 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 in order 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 nail or wire. Boards should always be secured when you are trapping rats so that if the rats are only partially caught they cannot drag the traps away. Baiting glue boards is not necessary but will improve the chances of success.

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.
- 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 nailed 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, it may be useful to secure the trap so that if a rat is only partially caught, it cannot drag the trap away to an inaccessible area.
- A trap can be camouflaged by sinking it just below ground level on dirt surfaces. This is done by positioning the trap and then completely 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

- Baits for Norway rats include pieces of hot dog, bacon, liver, peanut butter, or nut meats. Suggested baits for roof rats include nuts, dried fruits, or fresh fruits such as bananas or apples. You can also try other baits such as candy, marshmallows, raisins, or peanut butter mixed with rolled oats or bacon grease. Many of these baits don't last long because they dry up or become rancid. If rats are feeding on other foods, try them as baits also.
- For catching mice try raisins, gumdrops, or a mixture of peanut butter and 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, will not spoil, and is less likely to attract new pests such as flies, cockroaches, etc.
- 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. This may not be necessary for mice, unless you find them avoiding 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. Once you see signs of feeding on the bait, refill the bait and set the traps.
- Alternatively, pre-bait the traps with a large piece of peanut butter, hot dog, liver, or fruit. When you are ready to set the traps, remove the large piece of bait and smear a small bit on the underside of the trigger. The animals will have become used to taking the bait from the trigger and will now try to manipulate the trigger to find the bait they know should be there.
- Cereal (like oatmeal) can be sprinkled around the traps to make them more attractive.
- Remember that you will probably have to experiment to find the bait that works best in your situation.

Number of Traps to Use

- It is difficult to give a formula for the number of traps to use because the appropriate number will depend on the situation; however, it is better to err on the side of too many traps than too few. Place traps where you see activity and try using traps every 2 to 3 feet along a wall. You may need 3 to 6 traps around each hole or burrow opening.
- Concentrate the traps in one area at a time. When you have finished trapping in that area, move the traps to your next target.

Protecting Snap Traps

- If safety or tampering is a concern, you can place a snap trap inside a cardboard rat bait station that has been assembled inside-out to hide the poison warnings. 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 can be used inside professional cardboard rat or mouse bait stations. This extends the life of the board by protecting it from dust, dirt, children, and tampering. This method also hides the catch from view. The following points will help you set up the traps:

- Assemble the cardboard bait station inside-out to conceal the rodenticide warnings.
- 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.

Glue Boards in Multiple Catch Mouse Traps

This combination allows the multiple catch trap to be serviced quickly, prevents mice from leaping out of the trap at service time, keeps the trap cleaner, protects the glue board, and contains hairs, droppings, and ectoparasites.

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, scrub them with a stiff brush, soak them in detergent and water, dry them carefully, and coat the metal parts with a thin layer of oil.

Repellent Sound Devices

There is no evidence to show that these devices either kill rodents or prevent them from entering buildings. The Federal Trade Commission has ruled that these devices are ineffective in controlling rodents and insects, that they do not prevent pests from entering an area, and that the sound does not cover the area advertised.

Biological Controls

Some institutions maintain cats for protection against rodents. Cats can "prune" a mouse population but seldom eliminate it. They can be a deterrent to new mouse immigration, although it is entirely possible to have alert cats and still have mice present.

Cats can kill rats as well, especially young rats; however, as with mice, cats are not a guaranteed rat deterrent. Owls and snakes are rat predators, so when considering the use of chemical control techniques, remember that depending on the toxicant used, these predators can be killed by consuming poisoned rats.

Chemical Controls

If non-chemical methods alone prove insufficient to solve the problem, then integrating a rodenticide into your management program may be warranted. For information on the hazards of various rodenticides and on how to select an appropriate rodenticide for your situation, consult Appendix G for a list of resources.

Rodenticides must be used in accordance with their EPA-approved label directions. Applicators must be certified to apply rodenticides and should always wear protective gear during applications. All labels and Material Safety Data Sheets (MSDS) for the rodenticide products authorized for use in the IPM program should be maintained on file.

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. If a rat nibbles on a bit of poison bait that later makes it sick without killing it, the rat will avoid similar baits in the future, and, if female, may teach her young to do the same.

When to Use a Poison-Baiting Program

It is appropriate to use poison-baits when trapping and physical changes to the building and to food and waste storage have been clearly documented to be ineffective. In emergency situations when there are very high numbers of rodents or when rat fleas have been identified as transmitting bubonic plague, it may be appropriate to use poison baits, but trapping and habitat modification must also be used at the same time.

Be aware that overuse of some rodenticides has produced rodent populations resistant to the poisons. Rodenticides should be used only if absolutely necessary. This approach preserves their effectiveness when they are needed to handle emergency situations.

Safety Precautions

- All rodenticides must be placed inside tamper-resistant bait stations. These are metal or heavy plastic boxes that lock with a metal screw and can be filled with poison bait. They protect bait from humans and pets, and can be easily inspected to determine how much bait is being consumed. Bait stations should always be secured to the floor, a wall, or some other surface and be clearly labeled with a warning.
- Use poison baits over long holidays when students are not in the building.
- Use only in locked storerooms, basements, attics, or other areas not accessible to children or escaped classroom pets.
- Rats may cache (hide) food that may or may not be eaten later. This is very important to remember when using poison baits because rats may take the poison bait to a place where children and animals can find it, or to other locations the label does not allow, or may hide it without eating it. Some forms of baits, such

as grain or meal, paraffin blocks, and water baits, are not as readily distributed by rats.

- 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 one so the bait will not absorb odors that may impair its effectiveness.)

Rodenticide 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.
- Meal formulations, e.g., cornmeal or oatmeal mixed with a poison, are a good choice because mice or rats are less likely to drop and/or take away much of the meal. Canarygrass seed bait is particularly attractive to mice.
- Parafinized 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.

Types of Rodenticides

In general, the older anticoagulant rodenticides such as warfarin, chlorophacinone, and pindone are recommended over the newly developed anticoagulants. The older anticoagulants last for only a few days in a dead rodent body so that they pose less of a hazard to non-target organisms than some other rodenticides such as brodifacoum, which can last for many months. Zinc phosphide, an acute poison, can be useful for burrow baiting in its wax pellet formulation.

Anticoagulants work by preventing blood from clotting. Rodents eat small doses of these chemicals over several days and eventually die from internal bleeding.

Resistance Problems

Many rats and mice have become resistant to some anticoagulants. This means that the rodents can eat the anticoagulant and not sicken or die. Resistance to a chemical should be suspected if the bait is eaten regularly but the same or a greater number of rodents, holes, droppings, etc. continue to be seen. Research has shown that even rats that are classified as "resistant" to warfarin eventually succumb to the poison if enough time (at least 30 days) is allowed to lapse between exposures (Frantz and Padula 1990). This seems to indicate that it may not be necessary to resort to the newer and more problematic rodenticides if the rodenticide producing resistance can be withdrawn from use for a period of time. During that time, focus on eliminating food and harborage.

Instituting a Poison Baiting Program

Before beginning a baiting program, use monitoring blocks or stations (see the discussion under Detection and Monitoring, above) to determine the locations where rodents are most likely to accept poison bait.

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

- Bait stations must always be secured in place and clearly labeled "RODENT BAIT—POISON—DO NOT TOUCH."
- Set out bait stations only where rodents are most active and have previously gnawed on monitoring blocks. Place bait stations along walls and, whenever possible, between shelter and the source of food. In the case of roof rats, bait stations should be placed above the ground in areas such as attics, roofs, or trees.
- For rats, bait stations should be placed 15 to 30 feet apart, for mice, 6 to 8 feet apart.
- Mark the location of each bait station on your building map.
- Check each bait station daily to make sure there is enough bait (this is extremely important), the bait is in good condition (not moldy or rancid), and the bait station is not being tampered with.
- 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 4 or more days for the rats to try the bait.
- Multi-dose anticoagulants take from 4 to 9 days to kill rodents if the bait is the only food source.
- Rats have an excellent sense of taste, enabling them to detect extremely small amounts of rat poison very quickly. For this reason, poisoned baits must be more attractive to rats than the other foods that are available to them in the area.
- Remove and securely store all bait stations when the baiting program is over.

BIBLIOGRAPHY

Bio-Integral Resource Center (BIRC). 1996. 1997 directory of least-toxic pest control products. IPM Practitioner 18(11/12):1-39.

Baker, R.O., G.R. Bodman, and R.M. Timm. 1994. Rodent-proof construction and exclusion methods. In: Prevention and Control of Wildlife Damage, pp. B137-B150. University of Nebraska, Lincoln.

Caslick, J.W. and D.J. Decker. 1980. Rat and mouse control. Cornell Cooperative Extension, Ithaca, NY, Bulletin 163.

Centers for Disease Control and Prevention. 1993. Hantavirus infection—Southwestern United States. Interim recommendations for risk reduction. Morbidity and Mortality Weekly Report 42(No. R-11):1-20.

Corrigan, R.M. 1994. Managing field mice. Pest Management 13(7):8-12.

Dodds, W.J., S.C. Frantz, and K. Story. 1986. The Professional's Guide to Managing Poisoning by Anticoagulant Rodenticides. Chempa Products Div., Lipha Chemicals, Inc., New York. 10 pp.

Ebeling, W. 1975. Urban Entomology. University of California, Los Angeles. 695 pp.

Fehrenbach, P. 1994. Are PCO's at risk? Pest Control Technology 22(8):32-34,108.

Frantz, S.C. 1979. Rodent Control—A Case for Integrated Pest Management (IPM). U.S. Public Health Service, Center for Disease Control, Preventive Health Services Conference, Ellenville, NY. May 7-11, 1979. 29 pp.

Frantz, S.C. 1980. Integrated Pest Management: Philosophy and Basic Guidelines. National Association of Housing and Redevelopment Officials, Albany, NY. Sept. 3 -4, 1980. 20 pp.

Frantz, S.C. 1988. Architecture and commensal vertebrate pest management. In: Architectural Design and Indoor Microbial Pollution, R.B. Kundsin, ed., Oxford University Press, New York, NY.

Frantz, S.C. and D.E. Davis. 1991. Bionomics and integrated pest management of commensal rodents, pp. 243-313. In: Gorman, Ecology and Management of Food-Industry Pests. Association of Official Analytical Chemists, Arlington, VA.

Frantz, S.C. and C.M. Padula. 1990. Recent developments in anticoagulant rodenticide resistance studies: surveillance and application in the United States. In Proceedings of the 9th Vertebrate Pest Conference. J.P. Clark, ed. University of California Press, Davis, CA. pp. 80-88.

Goldstein, M.M. 1995. Teaching old pro's new tricks: utilizing existent rodent IPM tools in new ways can result in greater rodent catch and time savings. Pest Control Technology 23(8):48,50,52.

Gorman, J.R., ed. Ecology and Management of Food-Industry Pests. FDA Tech. Bulletin 4. Association of Official Analytical Chemists, Arlington, VA. 595 pp.

Gunther, R., et al. 1988, Toxicity of vitamin D3 rodenticides to dogs. Journal of the American Veterinary Medical Association 193(2):211-214.

Harmon, J. 1995. Classy vermin: controlling rodents in schools. Pest Control Technology 23(9):38,40,49,52,54,112.

Harwood, R.F. and M.T. James. 1979. Entomology in Human and Animal Health, Seventh Edition. Macmillan, New York, NY. 548 pp.

Howard, W.E. and R.E. Marsh. 1967. The rat: its biology and control. University of California, Davis. Division of Biological Science, Cooperative Extension Service (Leaflet 2896). 22 pp.

Hygnstrom, S.E., R.M. Timm and G.E. Larson. 1994. Prevention and Control of Wildlife Damage. University of Nebraska, Lincoln.

Ingles, L.G. 1965. Mammals of the Pacific States, California, Oregon, and Washington. Stanford University Press, Stanford, CA. 506 pp.

Kundsin, R.B., ed. 1988. Architectural Design and Indoor Microbial Pollution. Oxford University Press, New York, NY.

Marsh, R.E. 1994. Roof rats. In: Prevention and Control of Wildlife Damage, pp. B125-B132. University of Nebraska, Lincoln.

Meehan, A.P. 1984. Rats and Mice: their biology and control. Rentokil Ltd., East Grinstead, England. 383 pp.

Moore, F., et al. 1988. Hypercalcemia associated with rodenticide poisoning in three cats. Journal of the American Veterinary Medical Association 193(9):1099-1100.

Olkowski, W., S. Daar, and H. Olkowski. 1991. Common-Sense Pest Control: Least-toxic solutions for your home, garden, pets and community. Taunton Press, Newtown, CT. 715 pp.

Pinto, L. 1992. Module III, vertebrates. In: Urban Integrated Pest Management: a guide for commercial applicators, Chapter 3, pp. 1-7. Dual & Associates Inc., Arlington, VA.

Quarles, W. 1995. Deer mice spread new hantavirus. Common Sense Pest Control Quarterly 11(1):13-15.

Scott, H.G. 1991. Design and construction: building out pests, pp. 331-343. In: Gorman, Ecology and Management of Food-Industry Pests. Association of Official Analytical Chemists, Arlington, VA.

Timm, R.M. 1983. House mouse. In: Hygnstrom, Timm and Larson, Prevention and Control of Wildlife Damage, pp. B17-B44. University of Nebraska, Lincoln.

Timm, R.M. 1994. Norway rats. In: Hygnstrom, Timm and Larson, Prevention and Control of Wildlife Damage, pp. B105-B120. University of Nebraska, Lincoln.

Timm, R.M. 1991. Chemical control of rodent pests in bulk-stored grains, pp. 419-426. In: Gorman, Ecology and Management of Food-Industry Pests. Association of Official Analytical Chemists, Arlington, VA.

Timm, R.M. and G.R. Bodman. 1983. Rodent-proof construction. In: Prevention and Control of Wildlife Damage, pp. B125-B131. University of Nebraska, Lincoln.

This document was produced for USEPA (Document #909-B-97-001) by the Bio-Integral Resource Center, P.O. Box 7414, Berkeley, CA 94707, March 1997.

Table 12-1. Differences Among the Norway Rat, Roof Rat, and House Mouse

	Norway Rat	Roof Rat	House Mouse
Scientific name	*Rattus norvegicus*	*Rattus rattus*	*Mus musculus*
Other common names	brown, wharf or sewer rat	black, ship or house rat	
Adult weight	3 to 21 ounces	3 to 12 ounces	1/2 ounce
Snout	blunt	pointed	pointed
Ears	small & thick with short hairs	large & thin without hair	large, some hair
Tail coloration	dark above, pale underneath	all dark	all dark
Fur	brown with black; shaggy	light brown, gray to black, smooth	light brown to gray
Droppings	capsule-shaped, pointed	pointed & curved	rod-shaped, pointed
Food requirement	about 1 ounce/day	1 ounce or less/day	1/10 ounce/day
Water source	free water*	free water*	water from food; also need free water if dependent on a diet that is dry or high in protein
Climbing ability	can climb	active climber	good climber
Nest locations	mainly in burrows	walls, attics, trees	near/in stored material
Swimming ability	excellent	can swim	can swim

** Waterpresent by itself and not simply a constituent of thefood eaten by the rodent. Free water unnecessary wben feeding on succulentfoods, but needed if diet is dry andlor bigh in protein.*

Sources: Frantz & Davis 1991, Olkowski et a]. 1991

Table 12-2. Distinguishing the House Mouse from Other Similar Species.

Common Name	Scientific Name	Description
House Mouse	*Mus musculus*	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	*Peromyscus* 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 with distinct line between the two colors; large eyes; invades buildings near fields or wooded areas
Meadow Mouse or Vole Mouse	*Microtus* spp.	larger, more robust body; weighs about twice as much as the house mouse; smaller, heavily furrcd cars; much shorter tail; sometimes invades buildings, but commonly found outdoors under boards, boxes, etc.

Adapted from Olkowski, et al. 1991

Table 12-3. The Biology of Norway and Roof 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
Littcr size	average of 5 to 12
Litters per year	up to 9, depending on food availability (average is approx. 4 for Norway rats and 5 for roof rats)
Age at weaning	around 30 days
Gestation period	20 to 25 days
Sexual Maturity	75-90 days (Norway); 68-90 days (Roof)
Life span in the wild	Less than 1 year

Source: Frantz & Davis 1991

Table 12-5. The Biology 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

Source: Frantz & Davis 1991

Table 12-4. Nesting and Eating Habits of Norway Rats and Roof Rats

	Norway Rats	Roof Rats
Nesting Sites Outdoors	• in the ground, in burrows that are less than 18 inches deep and less than 3 feet long; burrow openings are 2 to 4 inches in diameter • burrow system can be quite complex and interconnected • in unused sewers or storm drains	• usually above ground: in trees, especially untrimmed palm trees; in dense, overgrown vegetation, especially Algerian ivy *(Hedera canariensis);* and in piles of wood and debris • in the ground if there are few suitable above-ground sites and there are no Norway rats nesting in the area • in unused sewers or storm drains
Nesting Sites Indoors	Usually in the lower floors of the building • in wall voids and crawl spaces • in storage rooms under pallets or equipment • behind seldom-used stored materials at the corners and backs of rooms • in any cluttered area that is little used	Usually in the upper part of the building • in the attic • in ceiling and attic voids • can also nest in the lower floors of a building
Eating Habits	• more likely to cat garbage than roof rats • prefer foods that are high in protein, such as fish, meat, nuts, grains, pet food, and insects	• prefer fresh plant material, such as nuts and seeds, fruit and vegetables, and tree bark • sometimes cat garbage and meat

Sources: Meehan 1984 and Ingles 1965

Table 12-6. Selected Pathogens Associated with the House Mouse, Roof Rat, and Norway Rat

Disease	Causal Agent	Transmission (common routes)
bubonic plague (Black Death)	*Yersinia pestis*	infective flea bites
salmoncliosis	*Salmonella spp.*	feces-contaminated food and water
lymphocytic choriomeningitis	LCM virus	contaminated food; dust from feces, urine, or saliva
rickettsialpox (or vesicular rickettsiosis)	*Rickettsia aka?i*	bite of infective house mouse mite, *Liponylloides (=Allodermanyssus) sangui.neus*
leptospirosis, or infectious jaundice	*Leptospira icterobaemorrhagiae*	contaminated food, water, etc.
rat bite fcvcr (Haverhill fever, Sodoku)	*Spirillum minus, Streptobacillus moniliformis*	rat bite, contaminated food
tapeworms	*Hymenolepis* nana, H. diminuta	droppings, contaminated food
favus, ringworm	*Tricbopbyton scboe'nleini*	direct contact, mites
murinc typhus, or endcmic typhus	*Rickettsia typbi* (formerly R. *mooseri)*	infective flea feces that contaminate broken skin, or are inhalcd or eaten
Hantavirus Pulmonary Syndrome (HPS)	Sin Nombre Virus (SNV)	most common route of EransmissioniS through breathing in the virus on/in aerosolized, infective rodent urine, saliva, and feces I mucous membranes can also be infected after one handles infcctive/contaminated materials (dirt, dust, rodent excrcta, etc.) a rodent bite is another, though less common route

Sources: Frantz 1988, Harwood and James 1979, Olkowski 1991, and Quarles 1995