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Roof Rats

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ROOF RATS

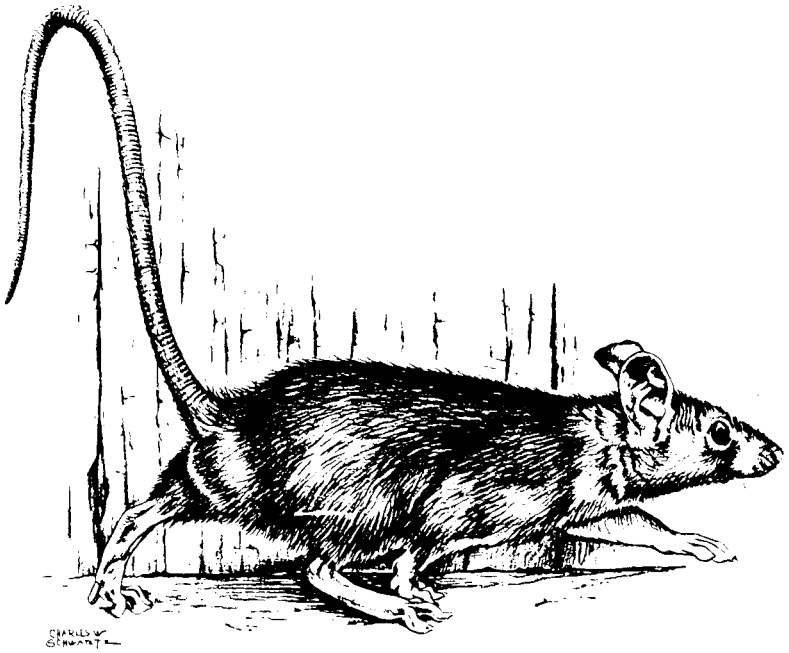


Fig. 1. Roof rat, *Rattus rattus*

Damage Prevention and Control Methods

Many control methods are essentially the same for roof rats as for Norway rats.

Exclusion and Rodent-proofing

Seal all openings that provide entry to structures.

Rat guards (for overhead utility lines).

Habitat Modification and Sanitation

Practice good housekeeping and facility sanitation.

Contain and dispose of garbage and refuse properly.

Reduce vegetative cover (for example, trim vines from buildings and fences).

Cultural practices in agriculture (weed and brush control, pruning).

Frightening

Ultrasonic devices have not been proven to provide rat control.

Lights and other sounds are of limited value.

Visual devices such as model owls, snakes, and cats are of no value.

Repellents

None are effective.

Toxicants

Anticoagulant rodenticides (slow-acting chronic-type poisons)
Brodifacoum (Talon®, Havoc®).
Bromadiolone (Maki®, Contrac®).
Chlorophacinone (RoZol®).
Diphacinone (Ramik®, Ditrac®).
Pindone (Pival®, Pivalyn®).
Warfarin (Co-Rax®).

Toxicants other than anticoagulants (may be acute or chronic poisons)
Bromethalin (Assault®, Vengeance®).
Cholecalciferol (Vitamin D_3) (Quintox®, Rampage®).
Zinc phosphide (Ridall Zinc®, ZP® Rodent Bait).

Fumigants

Structure or commodity fumigation.

Burrow fumigants are of limited use.

Trapping

Snap traps.

Box-type kill traps.

Live traps.

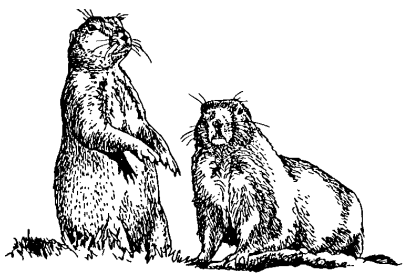
Glue boards.

Shooting

Limited usefulness where legal and not hazardous.

Predators

Cats may occasionally catch roof rats, as will barn owls. Predators are of little, if any, value in controlling roof rats.



PREVENTION AND CONTROL OF WILDLIFE DAMAGE — 1994

Cooperative Extension Division
Institute of Agriculture and Natural Resources
University of Nebraska - Lincoln

United States Department of Agriculture
Animal and Plant Health Inspection Service
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Identification

The roof rat (*Rattus rattus,* Fig. 1) is one of two introduced rats found in the contiguous 48 states. The Norway rat (*R. norvegicus*) is the other species and is better known because of its widespread distribution. A third rat species, the Polynesian rat (*R. exulans*) is present in the Hawaiian Islands but not on the mainland. *Rattus rattus* is commonly known as the roof rat, black rat, and ship rat. Roof rats were common on early sailing ships and apparently arrived in North America by that route. This rat has a long history as a carrier of plague.

Three subspecies have been named, and these are generally identified by their fur color: (1) the black rat (*R. rattus rattus* Linnaeus) is black with a gray belly; (2) the Alexandrine rat (*R. rattus alexandrinus* Geoffroy) has an agouti (brownish streaked with gray) back and gray belly; and (3) the fruit rat (*R. rattus frugivorus* Rafinesque), has an agouti back and white belly. The reliability of using coloration to identify the subspecies is questionable, and little significance can be attributed to subspecies differentiations. In some areas the subspecies are not distinct because more than one subspecies has probably been introduced and cross-breeding among them is a common occurrence. Roof rats cannot, however, cross with Norway rats or any native rodent species.

Fig. 2. Approximate distribution of roof rats (a) and Norway rats (b) in the United States.

Some of the key differences between roof and Norway rats are given in Table 1. An illustration of differences is provided in figure 2 of the chapter on Norway rats.

Range

Roof rats range along the lower half of the East Coast and throughout the Gulf States upward into Arkansas. They also exist all along the Pacific Coast and are found on the Hawaiian Islands (Fig. 2). The roof rat is more at home in warm climates, and apparently less adaptable, than the Norway rat, which is why it has not spread throughout the country. Its worldwide geographic distribution suggests that it is much more suited to tropical and semitropical climates. In rare instances, isolated populations are found in areas not within their normal distribution range in the United States. Most of the states in the US interior are free of roof rats, but isolated infestations, probably stemming from infested cargo shipments, can occur.

Habitat

Roof rats are more aerial than Norway rats in their habitat selection and often live in trees or on vine-covered fences. Landscaped residential or industrial areas provide good habitat, as does riparian vegetation of riverbanks and streams. Parks with natural and artificial ponds, or reservoirs may also be infested. Roof rats will often move into sugarcane and citrus groves. They are sometimes found living in rice fields or around poultry or other farm buildings as well as in industrial sites where food and shelter are available.

Table 1. Identifying characteristics of adult rats.

Item	Roof Rat (*Rattus rattus*)	Norway Rat (*Rattus norvegicus*)
General appearance	Sleek, graceful	Large, robust
Color of belly	Uniform: all white, all buff, or all gray	White with gray underfur
Body weight	5 to 10 ounces (150 to 250 g)	7 to 18 ounces (200 to 500 g)
Tail	4.3 inches (more than 11 cm), extends at least to snout; black, fine scales	4.3 inches (more than 11 cm), shorter than body; dark above, pale below
Head	Muzzle pointed	Muzzle blunt
Ears	Can be pulled over eyes	Do not reach eyes
Hind foot length	1.3 inches (3.5 cm)	1.7 inches (4.4 cm)
Number of teats on female	10	12

Roof rats frequently enter buildings from the roof or from accesses near overhead utility lines, which they use to travel from area to area. They are often found living on the second floor of a warehouse in which Norway rats occupy the first or basement floor. Once established, they readily breed and thrive within buildings, just as Norway rats do. They have also been found living in sewer systems, but this is not common.

Food Habits

The food habits of roof rats outdoors in some respects resemble those of tree squirrels, since they prefer a wide variety of fruit and nuts. They also feed on a variety of vegetative parts of ornamental and native plant materials. Like Norway rats, they are omnivorous and, if necessary, will feed on almost anything. In food-processing and storage facilities, they will feed on nearly all food items, though their food preferences may differ from those of Norway rats. They do very well on feed provided for domestic animals such as swine, dairy cows, and chickens, as well as on dog and cat food. There is often a correlation between rat problems and the keeping of dogs, especially where dogs are fed outdoors. Roof rats usually require water daily, though their local diet may provide an adequate amount if it is high in water content.

General Biology

Control methods must reflect an understanding of the roof rat's habitat requirements, reproductive capabilities, food habits, life history, behavior, senses, movements, and the dynamics of its population structure. Without this knowledge, both time and money are wasted, and the chances of failure are increased.

Unfortunately, the rat's great adaptability to varying environmental conditions can sometimes make this information elusive.

Reproduction and Development

The young are born in a nest about 21 to 23 days after conception. At birth they are hairless, and their eyes are closed. The 5 to 8 young in the litter develop rapidly, growing hair within a week. Between 9 and 14 days, their eyes open, and they begin to explore for food and move about near their nest. In the third week they begin to take solid food. The number of litters depends on the area and varies with nearness to the limit of their climatic range, availability of nutritious food, density of the local rat population, and the age of the rat. Typically, 3 or more litters are produced annually.

The young may continue to nurse until 4 or 5 weeks old. By this time they have learned what is good to eat by experimenting with potential food items and by imitating their mother.

Young rats generally cannot be trapped until about 1 month old. At about 3 months of age they are completely independent of the mother and are reproductively mature.

Breeding seasons vary in different areas. In tropical or semitropical regions, the season may be nearly year-round. Usually the peaks in breeding occur in the spring and fall. Roof rats prefer to nest in locations off of the ground and rarely dig burrows for living quarters if off-the-ground sites exist.

Feeding Behavior

Rats usually begin searching for food shortly after sunset. If the food is in an exposed area and too large to be eaten quickly, but not too large to be moved, they will usually carry it to a hiding place before eating it. Many rats may cache or hoard considerable amounts of solid food, which they eat later. Such caches may be found in a dismantled wood pile, attic, or behind boxes in a garage.

When necessary, roof rats will travel considerable distances (100 to 300 feet [30 to 90 m]) for food. They may live in the landscaping of one residence and feed at another. They can often be seen at night running along overhead utility lines or fences. They may live in trees, such as palm, or in attics, and climb down to a food source. Traditional baiting or trapping on the ground or floor may intercept very few roof rats unless bait and/or traps are placed at the very points that rats traverse from above to a food resource. Roof rats have a strong tendency to avoid new objects in their environment and this neophobia can influence control efforts, for it may take several days before they will approach a bait station or trap. Neophobia is more pronounced in roof rats than in Norway rats. Some roof rat populations are skittish and will modify their travel routes and feeding locations if severely and frequently disturbed. Disturbances such as habitat modifications should be avoided until the population is under control.

Senses

Rats rely more on their keen senses of smell, taste, touch, and hearing than on vision. They are considered to be color-blind, responding only to the degree of lightness and darkness of color.

They use their keen sense of smell to locate and select food items, identify territories and travel routes, and recognize other rats, especially those of the opposite sex. Taste perception of rats is good; once rats locate food, the taste will determine their food preferences.

Touch is an important sense in rats. The long, sensitive whiskers (vibrissae) near their nose and the guard hairs on their body are used as tactile sensors. The whiskers and guard hairs enable the animals to travel adjacent to walls in the dark and in burrows.

Roof rats also have an excellent sense of balance. They use their tails for balance while traveling along overhead utility lines. They move faster than Norway rats and are very agile climbers, which enables them to quickly escape predators. Their keen sense of hearing also aids in their ability to detect and escape danger.

Social Behavior

The social behavior of free-living roof rats is very difficult to study and, as a result, has received less attention than that of Norway rats. Most information on this subject comes from populations confined in cages or outdoor pens.

Rats tend to segregate themselves socially in both space and time. The more dominant individuals occupy the better habitats and feed whenever they like, whereas the less fortunate individuals may have to occupy marginal habitat and feed when the more dominant rats are not present.

Knowledge is limited on interspecific competition between the different genera and species of rats. At least in some parts of the United States and elsewhere in the world, the methods used to control rats have reduced Norway rat populations but have permitted roof rats to become more prominent, apparently because they are more difficult to control. Elsewhere, reports indicate that roof rats are slowly disappearing from localized areas for no apparent reason.

It has often been said that Norway rats will displace roof rats whenever they come together, but the evidence is not altogether convincing.

Population Dynamics

Rat densities (numbers of rats in a given area) are determined primarily by the suitability of the habitat—the amount of available nutritional and palatable food and nearby protective cover (shelter or harborage).

The great adaptability of rats to human-created environments and the high fertility rate of rats make for quick recuperation of their populations. A control operation, therefore, must reduce numbers to a very low level; otherwise, rats will not only reproduce rapidly, but often quickly exceed their former density for a short period of time.

Unless the suitability of the rat's habitat is destroyed by modifying the landscaping, improving sanitation, and rat-proofing, control methods must be unrelenting if they are to be effective.

Damage and Damage Identification

Nature of Damage

In food-processing and food-storage facilities, roof rats do about the same type of damage as Norway rats, and damage is visually hard to differentiate. In residences where rats may be living in the attic and feeding outdoors, the damage may be restricted to tearing up insulation for nesting or gnawing electrical wiring. Sometimes rats get into the kitchen area and feed on stored foods. If living under a refrigerator or freezer, they may disable the unit by gnawing the electrical wires. In landscaped yards they often live in overgrown shrubbery or vines, feeding on ornamentals, vegetables, fruits, and nuts. Snails are a favorite food, but don't expect roof rats to eliminate a garden snail problem. In some situations, pet food and poorly managed garbage may represent a major food resource.

In some agricultural areas, roof rats cause significant losses of tree crops such as citrus and avocados and, to a lesser extent, walnuts, almonds, and other nuts. They often eat all the pulp from oranges while the fruit is still hanging on the tree, leaving only the empty rind. With lemons they may eat only the rind and leave the hanging fruit intact. They may eat the bark of smaller citrus branches and girdle them. In sugarcane, they move into the field as the cane matures and feed on the cane stalks. While they may not kill the stalk outright, secondary organisms generally invade and reduce the sugar quality. Norway rats are a common mammalian pest of rice, but sometimes roof rats also feed on newly planted seed or the seedling as it emerges. Other vegetable, melon, berry, and fruit crops occasionally suffer relatively minor damage when adjacent to infested habitat such as riparian vegetation.

Like the Norway rat, the roof rat is implicated in the transmission of a number of diseases to humans, including murine typhus, leptospirosis, salmonellosis (food poisoning), rat-bite fever, and plague. It is also capable of transmitting a number of diseases to domestic animals and is suspected in the transference of ectoparasites from one place to another.

Rat Sign

The nature of damage to outdoor vegetation can often provide clues as to whether it is caused by the roof or Norway rat. Other rat signs may also assist, but be aware that both species may be present. Setting a trap to collect a few specimens may be the only sure way to identify the rat or rats involved. Out-of-doors, roof rats may be present in low to moderate numbers with little sign in the way of tracks or droppings or runs and burrows.

There is less tendency to see droppings, urine, or tracks on the floor in buildings because rats may live overhead between floors, above false ceilings, or in utility spaces, and venture down to feed or obtain food. In food-storage facilities, the most prominent sign may be smudge marks, the result of oil and dirt rubbing off of their fur as they travel along their aerial routes.

The adequate inspection of a large facility for the presence and location of roof rats often requires a nighttime search when the facility is normally shut down. Use a powerful flashlight to spot rats and to determine travel routes for the best locations to set baits and traps. Sounds in the attic are often the first indication of the presence of roof rats in a residence. When everyone is asleep and the house is quiet, the rats can be heard scurrying about.

Legal Status

Roof rats are not protected by law and can be controlled any time with mechanical or chemical methods. Pesticides must be registered for rat control by federal and/or state authorities and used in accordance with label directions.

Damage Prevention and Control Methods

The damage control methods used for roof rats are essentially the same as for Norway rats. However, a few differences must be taken into account.

Exclusion or Rodent-proofing

When rodent-proofing against roof rats, pay close attention to the roof and roof line areas to assure all accesses are closed. Plug or seal all openings of greater than 1/2 inch (1.3 cm) diameter with concrete mortar, steel wool, or metal flashing. Rodent-proofing against roof rats usually requires more time to find entry points than for Norway rats because of their greater climbing ability. Eliminate vines growing on buildings and, when feasible, overhanging tree limbs that may be used as travel routes. For more detailed information, see **Rodent-proof Construction and Exclusion Methods.**

Attach rat guards to overhead utility wires and maintain them regularly. Rat guards are not without problems, however, because they may fray the insulation and cause short circuits.

Habitat Modification and Sanitation

The elimination of food and water through good warehouse sanitation can do much to reduce rodent infestation. Store pet food in sealed containers and do not leave it out at night. Use proper garbage and refuse disposal containers and implement exterior sanitation programs. Emphasis should be placed on the removal of as much harborage as is practical. For further information see **Norway Rats.**

Dense shrubbery, vine-covered trees and fences, and vine ground cover make ideal harborage for roof rats. Severe pruning and/or removal of certain ornamentals are often required to obtain a degree of lasting rat control. Remove preharvest fruits or nuts that drop in backyards. Strip and destroy all unwanted fruit when the harvest period is over.

In tree crops, some cultural practices can be helpful. When practical, remove extraneous vegetation adjacent to the crop that may provide shelter for rats. Citrus trees, having very low hanging skirts, are more prone to damage because they provide rats with protection. Prune to raise the skirts and remove any nests constructed in the trees. A vegetation-free margin around the grove will slow rat invasions because rats are more susceptible to predation when crossing unfamiliar open areas.

Frightening

Rats have acute hearing and can readily detect noises. They may be frightened by sound-producing devices for awhile but they become accustomed to constant and frequently repeated sounds quickly. High-frequency sound-producing devices are advertised for frightening rats, but almost no research exists on their effects specifically on roof rats. It is unlikely, however, they will be any more effective for roof rats than for Norway rats. These devices must be viewed with considerable skepticism, because research has not proven them effective.

Lights (flashing or continuously on) may repel rats at first, but rats will quickly acclimate to them.

Repellents

Products sold as general animal repellents, based on taste and/or odor, are sometimes advertised to repel animals, including rats, from garbage bags. The efficacy of such products for rats is generally lacking. No chemical repellents are specifically registered for rat control.

Toxicants

Rodenticides were once categorized as acute (single-dose) or chronic (multiple-dose) toxicants. However, the complexity in mode of action of newer materials makes these classifications outdated. A preferred categorization would be "anticoagulants" and "non-anticoagulants" or "other rodenticides."

Anticoagulants (slow-acting, chronic toxicants). Roof rats are susceptible to all of the various anticoagulant rodenticides, but less so than Norway rats. Generally, a few more feedings are necessary to produce death with the first-generation anticoagulants (warfarin, pindone, diphacinone, and chlorophacinone) but this is less significant with the second-generation anticoagulants (bromadiolone and brodifacoum). All anticoagulants provide excellent roof rat control when prepared in acceptable baits. A new second-generation anticoagulant, difethialone, is presently being developed and EPA registration is anticipated in the near future. For the characteristics of the various anticoagulant rodenticides see **Norway Rats.**

A few instances of first-generation anticoagulant resistance have been reported in roof rats; although not common, it may be underestimated because so few resistance studies have been conducted on this species. Resistance is of little consequence in the control of roof rats, especially with the newer rodenticides presently available. Where anticoagulant resistance is known or suspected, the use of first-generation anticoagulants should be avoided in favor of the second-generation anticoagulants or one of the nonanticoagulant rodenticides like bromethalin or cholecalciferol.

Other rodenticides. The older rodenticides, formerly referred to as acute toxicants, such as arsenic, phosphorus, red squill, and ANTU, are either no longer registered or of little importance in rat control. The latter two were ineffective for roof rats. Newer rodenticides are much more efficacious and have resulted in the phasing out of these older materials over the last 20 years.

At present there are three rodenticides—zinc phosphide, cholecalciferol (vitamin D_3), and bromethalin—registered and available for roof rat control. Since none of these are anticoagulants, all can be used to control anticoagulant-resistant populations of roof rats.

Roof rats can be controlled with the same baits used for Norway rats. Most commercial baits are registered for both species of rats and for house mice, but often they are less acceptable to roof rats than to the other species. For best results, try several baits to find out which one rats consume most. No rat bait ingredient is universally highly acceptable, and regional differences are the rule rather than the exception.

Pelleted or loose cereal anticoagulant baits are used extensively in tamper-resistant bait boxes or stations for a permanent baiting program for Norway rats and house mice. They may not be effective on roof rats, however, because of their usual placement. Bait stations are sometimes difficult to place for roof rat control because of the rodents' overhead traveling characteristics. Anticoagulant paraffin-type bait blocks provide an alternative to bait stations containing pelleted or loose cereal bait. Bait blocks are easy to place in small areas and difficult-to-reach locations out of the way of children, pets, and nontarget species. Where label instructions permit, small blocks can be placed or fastened on rafters, ledges, or even attached to tree limbs, where they are readily accessible to the arboreal rats.

Some of the first-generation anticoagulants (pindone and warfarin) are available as soluble rodenticides from which water baits can be prepared. Liquid baits may be an effective alternative in situations where normal baits are not readily accepted, especially where water is scarce or where rats must travel some distance to reach water.

In controlling roof rats with rodenticides, a sharp distinction must be made between control in and around buildings and control away from buildings such as in landfills and dumps, along drainage ditches and streams, in sewer water evaporation ponds, and in parks. Control of roof rat damage in agriculture represents yet another scenario. Distinctions must be made as to which rodenticide (registered product) to use, the method of application or placement, and the amount of bait to apply. For example, only zinc phosphide can be applied on the ground to control rats in sugarcane or macadamia orchards, and the second-generation anticoagulants, cholecalciferol and bromethalin, can be used only in and around buildings, not around crops or away from buildings even in noncrop situations. Selection of rodenticides and bait products must be done according to label instructions. Labels will specify where and under what conditions the bait can be used. Specifications may vary depending on bait manufacturer even though the active ingredient may be the same. The product label is the law and dictates the product's location of use and use patterns.

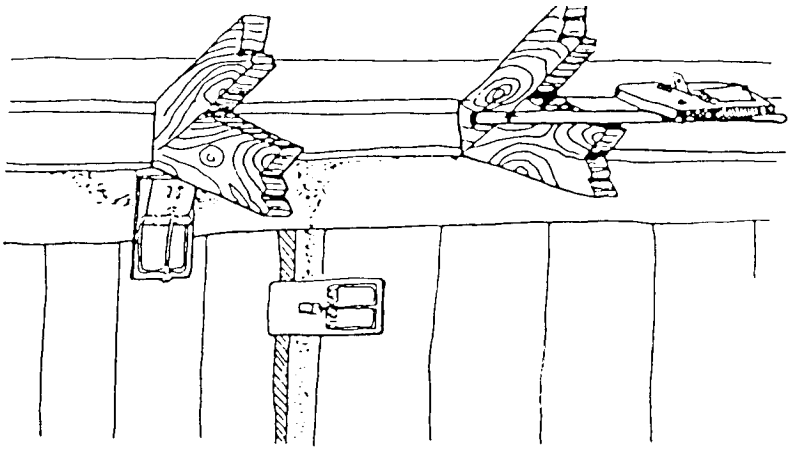

Fig. 3. Overhead trap sets are particularly useful for roof rats. Trap at left is modified by fastening a piece of cardboard to expand its trigger size (traps with expanded treadles can also be purchased from several manufacturers). Traps may be nailed to beams or studs and secured to pipes with wires.

Tracking powders. Tracking powders play an important role in structural rodent control. They are particularly useful for house mouse control in situations where other methods seem less appropriate. Certain first-generation anticoagulants are registered as tracking powders for roof rat control; however, none of the second generation materials are so registered. Their use for roof rats is limited to control within structures because roof rats rarely produce burrows.

Tracking powders are used much less often for roof rats than for Norway rats because roof rats frequent overhead areas within buildings. It is difficult to find suitable places to lay the tracking powder that will not create a potential problem of contaminating food or materials below the placement sites.

Tracking powders can be placed in voids behind walls, near points of entry, and in well-defined trails. Tunnel boxes or bait boxes specially designed to expose a layer of toxic powder will reduce potential contamination problems and may actually increase effectiveness. Some type of clean food can be used to entice the rats to the boxes, or the tracking powders can be used in conjunction with an anticoagulant bait, with both placed in the same station.

Fumigants

Since roof rats rarely dig burrows, burrow fumigants are of limited use; however, if they have constructed burrows, then fumigants that are effective on Norway rats, such as aluminum phosphide and gas cartridges, will be effective on roof rats. Where an entire warehouse may be fumigated for insect control with a material such as methyl bromide, all rats and mice that are present will be killed. The fumigation of structures, truck trailers, or rail cars should only be done by a licensed pest control operator who is trained in fumigation techniques. Rodent-infested pallets of goods can be tarped and fumigated on an individual or collective basis.

Trapping

Trapping is an effective alternative to pesticides and recommended in some situations. It is recommended for use in homes because, unlike with poison baits, there is no risk of a rat dying in an inaccessible place and creating an odor problem.

The common wooden snap traps that are effective for Norway rats are effective for roof rats. Raisins, prunes, peanut butter, nutmeats, and gumdrops make good baits and are often better than meat or cat food baits. The commercially available, expanded plastic treadle traps, such as the Victor Professional Rat Trap, are particularly effective if properly located in well-traveled paths. They need not be baited. Place traps where they will intercept rats on their way to food, such as on overhead beams, pipes, ledges, or sills frequently used as travel routes (Fig. 3). Some traps should be placed on the floor, but more should be placed above floor level (for example, on top of stacked commodities). In homes, the attic and garage rafters close to the infestation are the best trapping sites.

Pocket gopher box-type traps (such as the DK-2 Gopher Getter) can be modified to catch rats by reversing the action of the trigger. Presently, only one such modified trap (Critter Control's Custom Squirrel & Rat Trap) is commercially available. These kill traps are often baited with whole nuts and are most useful in trapping rats in trees. Their design makes them more rat-specific when used out-of-doors than ordinary snap traps that sometimes take birds. Caution should be taken to avoid trapping nontarget species such as tree squirrels.

Wire-mesh, live traps (Tomahawk®, Havahart®) are available for trapping rats. Rats that are captured should be humanely destroyed and not released elsewhere because of their role in disease transmission, damage potential, and detrimental effect on native wildlife.

Glue boards will catch roof rats, but, like traps, they must be located on beams, rafters, and along other travel routes, making them more difficult to place effectively for roof rats than for Norway rats or house mice. In general, glue boards are more effective for house mice than for either of the rat species.

Shooting

Where legal and not hazardous, shooting of roof rats is effective at dusk as they travel along utility lines. Air rifles, pellet guns, and .22-caliber rifles loaded with bird shot are most often used. Shooting is rarely effective by itself and should be done in conjunction with trapping or baiting programs.

Predators

In urban settings, cats and owls prey on roof rats but have little if any effect on well-established populations. In some situations in which the rats have been eliminated, cats that are good hunters may prevent reinfestation.

In agricultural settings, weasels, foxes, coyotes, and other predators prey on roof rats, but their take is inconsequential as a population control factor. Because roof rats are fast and agile, they are not easy prey for mammalian or avian predators.

Economics of Damage and Control

Roof rats undoubtedly cause millions of dollars a year in losses of food and feed and from damaging structures and other gnawable materials. On a nationwide basis, roof rats cause far less economic loss than Norway rats because of their limited distribution.

There are approximately 30,000 professional structural pest control operators in the United States and about 70% of these are primarily involved in general pest control, which includes rodent control. It is difficult to estimate how much is spent in structural pest control specifically for roof rats because estimates generally group rodents together.

Sugarcane, citrus, avocados, and macadamia nuts are the agricultural crops that suffer the greatest losses. In Hawaii, annual macadamia loss has recently been estimated at between $2 million and $4 million.

Acknowledgments

I wish to acknowledge my colleague, Dr. Walter E. Howard, for information taken from his publication *The Rat: Its Biology and Control,* Division of Agricultural Sciences, University of California, Leaflet 2896 (30 pp.), coauthored with R. E. Marsh. I also wish to express my thanks to Dr. Robert Timm, who authored the chapter on Norway rats. To avoid duplication of information, this chapter relies on the more detailed control methods presented in the chapter **Norway Rats.**

Figure 1 from C. W. Schwartz and E. R. Schwartz (1981). *The Wild Mammals of Missouri,* rev. ed. Univ. Missouri Press, Columbia. 356 pp.

Figures 2 and 3 from Howard and Marsh (1980), adapted by David Thornhill.

For Additional Information

Dutson, V. J. 1974. The association of the roof rat (*Rattus rattus*) with the Himalayan blackberry (*Rubus discolor*) and Algerian ivy (*Hedera canariensis*) in California. Proc. Vertebr. Pest Conf. 6:41-48.

Frantz, S. C., and D. E. Davis. 1991. Bionomics and integrated pest management of commensal rodents. Pages 243-313 *in* J. R. Gorham, ed. Ecology and management of food-industry pests. US Food Drug Admin. Tech. Bull. Assoc. Official Analytical Chem. Arlington, Virginia.

Howard, W. E., and R. E. Marsh. 1980. The rat: its biology and control. Div. Agric. Sci., Publ. 2896, Univ. California. 30 pp.

Jackson, W. B. 1990. Rats and mice. Pages 9-85 *in* A. Mallis, ed. Handbook of pest control. Franzak & Foster Co., Cleveland, Ohio.

Kaukeinen, D. E. 1984. Resistance; what we need to know. Pest Manage. 3(3):26-30.

Khan, J. A. 1974. Laboratory experiments on the food preferences of the black rat (*Rattus rattus* L.). Zool. J. Linnean Soc. 54:167-184.

Lefebvre, L. W., R. M. Engeman, D. G. Decker, and N. R. Holler. 1989. Relationship of roof rat population indices with damage to sugarcane. Wildl. Soc. Bull. 17:41-45.

Marsh, R. E., and R. O. Baker. 1987. Roof rat control—a real challenge. Pest Manage. 6(8):16-18,20,29.

Meehan, A. P. 1984. Rats and mice: their biology and control. Rentokil Ltd. E. Grinstead, United Kingdom. 383 pp.

Recht, M. A., R. Geck, G. L. Challet, and J. P. Webb. 1988. The effect of habitat management and toxic bait placement on the movement and home range activities of telemetered *Rattus rattus* in Orange County, California. Bull. Soc. Vector Ecol. 13:248-279.

Thompson, P. H. 1984. Horsing around with roof rats in rural outbuildings. Pest Control 52(8):36-38,40.

Tobin, M. E. 1992. Rodent damage in Hawaiian macadamia orchards. Proc. Vertebr. Pest Conf. 15:272-276.

Weber, W. J. 1982. Diseases transmitted by rats and mice. Thomson Publ., Fresno, California. 182 pp.

Zdunowski, G. 1980. Environmental manipulation in roof rat control programs. Proc. Vertebr. Pest Conf. 9:74-79.

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