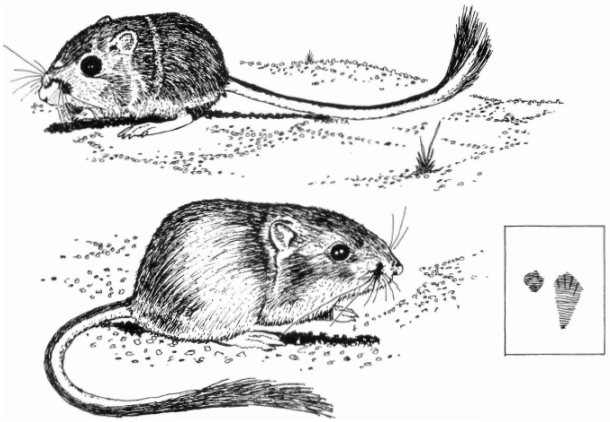
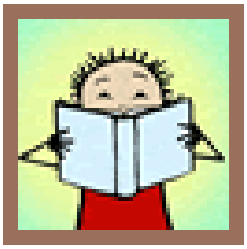
BIOLOGY, LEGAL STATUS, CONTROL MATERIALS AND DIRECTIONS FOR USE

Kangaroo Rats

***Dipodomys* spp.**

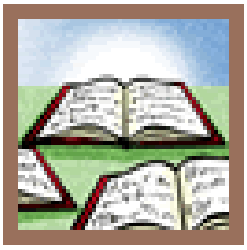
Family: Heteromyidae





Introduction: 23 species of kangaroo rat occur in North America. Some species are federally protected, and at state level some receive special threatened or endangered species classification. Always consult local authorities to determine status before applying any form of control.

Identification: Kangaroo rats are distinctive. They have a long tufted tail, small forelegs, and long powerful hind legs. Distinctive fur lined cheek pouches are visible. Their coloring varies from pale cinnamon to dark gray on the back, pure white under parts, dark markings on the face and tail. Size is 6 inches with a tail up to 8 inches.



Legal Status: Kangaroo rats are classified as nongame mammals by the California Fish and Game Code.** Nongame mammals which are found to be injuring growing crops or other property may be taken at any time or in any manner by the owner or tenant of the premises. They may also be taken by officers or employees of the Department of Food and Agriculture or by federal or county officers or employees when acting in their official capacities pursuant to the provisions of the Food and Agriculture Code pertaining to pests.

Important:**The following kangaroo rats have been designated as threatened or endangered species by the California Department of Fish and Game. They are the Morro Bay Kangaroo Rat (*Dipodomys heermanni*

morroensis) -- Endangered; Giant Kangaroo Rat (*Dipodomys ingens*), -- Endangered; Stephens' Kangaroo rat (*Dipodomys stephensi*) -- Threatened; the Fresno Kangaroo Rat (*Dipodomys nitratoides exilis*) -- Endangered; and the Tipton Kangaroo Rat (*Dipodomys nitratoides nitratoides*) -- Endangered. Before implementing rodent control within the range of these endangered and threatened species, contact the Department of Fish and Game or the Department of Pesticide Regulation.

Damage: Kangaroo rats may damage grain crops grown next to desert or semi-desert wild lands. Kangaroo rats harvest and store large quantities of grass and other seeds in the dry months, and they consume some green vegetation in winter and spring. This competition for forage and reduction of seed stock can reduce grazing capacity of drier range in drought periods.

Range: The 12 *Dipodomys* species cover most of the noncultivated desert and dry foothill regions of the state.

California Kangaroo Rat

Chisel-toothed Kangaroo Rat

Desert Kangaroo Rat

Giant Kangaroo Rat

Heermann's Kangaroo Rat

Fresno Kangaroo Rat

Merriam's Kangaroo Rat

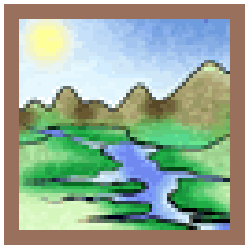
Narrow-faced Kangaroo Rat

Ord's Kangaroo Rat

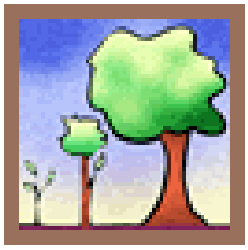
Pacific Kangaroo Rat

Panamint Kangaroo Rat

Stephens' Kangaroo Rat



Habitat: Kangaroo rats prefer dry open areas with sandy or gravelly soil and sparse vegetation.

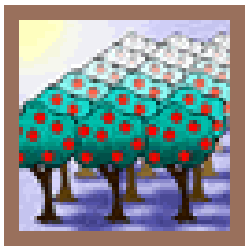


Biology: Kangaroo rats have very efficient kidneys and are well adapted to semi-arid areas. They derive much of their water from food and do not need drinking water. Equally important for survival are their nocturnal habits; they rest in their burrows during the day and come out at night when there is less evaporation and the humidity is higher. Kangaroo rats have external fur-lined cheek pouches used for carrying food. Soil around the burrow includes many hulls of harvested seeds.

Most kangaroo rats are solitary animals with home ranges of a little less than half an acre. These home ranges are often territories from which other individuals are excluded. Each rat has an extensive underground burrow system with nest chambers and storage areas for seeds. The amount of seeds stored, commonly several pounds for some species, varies greatly among species. The burrows of desert species are generally centered about a shrub or bush and are usually marked by a low mound. In some areas, ground squirrel burrows are often used. The burrows are generally shallow and of various lengths, depending on soil type and species. Burrows have one or several openings. Besides its home burrow, some kangaroo rats use a number of outlying burrows which serve as emergency shelters when the animal is foraging. Burrow entrances are usually closed with earth during the day.

The breeding season is from February to October. From one to three litters of two to five young are produced in a season. The gestation period is three to four weeks, depending upon the species, and the young probably begin to forage for themselves and seek new burrows at about four weeks of age. Females of *D. heermanni* have been observed in heat at approximately six weeks, but the males were not mature until 10 to 12 weeks of age (Fitch, 1948). Females born early in the breeding season may produce two litters in the remainder of the same breeding season.

Trapping records indicate that the usual life span is short, less than six months young. Death comes from unfavorable winter weather, poor forage yields in dry years, and from predation by rattlesnakes, coyotes, owls, foxes, and others.



Damage Prevention and Control Methods

Exclusion: If the area to be protected is small , a sheet-metal barrier 18 inches tall may be used to exclude kangaroo rats. Bury the barrier about 6 inches to prevent kangaroo rats from burrowing under it. Exclusion is impractical and too expensive for larger areas.

Habitat Modification: Kangaroo rats like open areas but removing dense cover by burning, mowing,

plowing, or the use of herbicides, where permissible, can help in detecting rat populations. Habitat modification is best as a preventive measure, since this control method will have little effect on the ensuing damage once a population reaches its peak.

Kangaroo rats are often found on rangeland areas which have been overused by livestock, and thus there is little grass cover.

Frightening: None are registered for repelling kangaroo rats.

Fumigants: There are no fumigants useful for kangaroo rats because their burrows are small, closed during the day, and difficult to find.

Repellents: There are no registered repellents for kangaroo rats

Toxic Bait: None registered.

Trapping: Small rodent live traps or rat-sized snap traps are effective for catching a small number of animals, including kangaroo rats. The traps should be baited with a mixture of peanut butter and oatmeal or oatmeal paste. The trap should be set in the runways at a right angle to the direction of travel. If live captured do not re-release in a different location as this is illegal in California. Trapping kangaroo rats requires a trapping license issued by the Department of Fish and Game (see ground squirrel section for details).

REFERENCES AND ADDITIONAL READING

Baker, Rex O., 1990. Native Heteromyid Rodents as Pests of Commercial Jojoba. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp.124-128.

Koehler, Ann E., R.E. Marsh, T.P. Salmon, 1990. Frightening Methods And Devices/Stimuli to Prevent Mammal Damage- A Review. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp. 168-173.

Sterner, Ray T., 1994. Zinc Phosphide: Implications of Optimal Foraging Theory and Particle-Dose Analysis to Efficacy, Acceptance, Bait Shyness, and Non-Target Hazards. Proc. 16th Vertebrate Pest Conf. (W.S. Halverson & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 152-159.

Tobin, Mark E., R.T. Sugihara, R.M. Engeman, 1994. Effects of Initial Rat Capture on Subsequent Capture Success Of Traps. Proc. 16th Vertebrate Pest Conf. (W.S. Halverson & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 101-105.

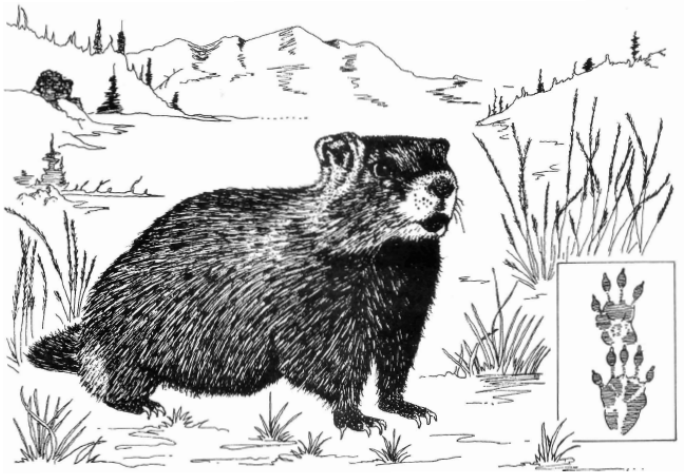
Whisson, Desley A., 1998. Modified Bait Stations For California Ground Squirrel Control in Endangered Kangaroo Rat Habitat. Proc. 18th Vertebrate Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 233-235.

BIOLOGY, LEGAL STATUS, CONTROL MATERIALS, AND DIRECTIONS FOR USE

Marmot

Marmota flaviventris

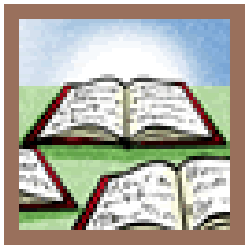
Family: Sciuridae



Introduction: Marmots are rodents, closely related to both ground squirrels and prairie dogs. There are currently 14 recognized species of marmot; these include woodchucks (groundhogs), each species have broad similarities. In the Western United States the most commonly found marmot is the yellow bellied marmot.

Identification: Marmots are large rodents about the size of the average housecat. Their fur is long and coarse. Their total body length ranges from 20 to 30 in. Male marmots are slightly larger and heavier than females. Tail length ranges 5 to 9in They also have a thumb stump with a nail.

Yellow bellied marmots have distinct yellow speckles on the sides of their necks, white between the eyes, and yellow to red-yellow bellies, and yellow-brown to tan, straight hair with white tips.

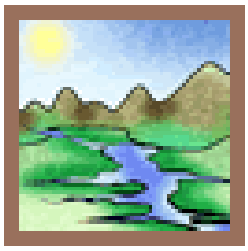


Legal Status: Marmots are classified as nongame mammals by the California Fish and Game Code. Nongame mammals which are found to be injuring growing crops or other property may be taken at any time or in any manner by the owner or tenant of the premises. They may also be taken by officers or employees of the Department of Food and Agriculture or by federal or county officers or employees when acting in their official capacities pursuant to the provisions of the Food and Agricultural Code pertaining to pests.

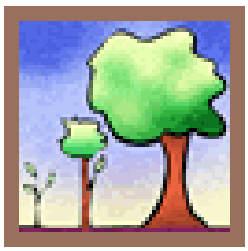
Damage: Alfalfa, legumes, grasses. It hosts the tick that carries Rocky Mountain spotted fever.

Range: Sierra Nevada and northeastern California.

Marmot



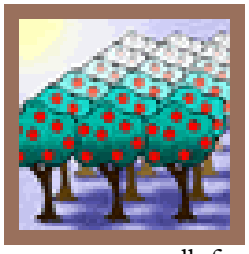
Habitat: Rocky situations, talus slopes, valleys and foothills, up to 12,000 feet elevation



Biology: Marmots are chiefly active by day (diurnal). They seem to enjoy lying on flat rocks in the sun. Most of the yellow-bellied marmots live in rock slides bordering green meadows where they are protected from badgers and wolverines which might dig them out. The den is usually near a large boulder which is used as a lookout post. Individuals spend most of their lives in a burrow with several entrances, which they excavate in well drained soil. The burrows are approximately 3 ft in depth, but hibernation burrows may be 16-22 feet deep. Tunnels may be 30 to 200 feet in length. Marmots accumulate layers of fat instead of making food caches before they become dormant. The time spent in dormancy depends on the location and elevation. Some of them go into estivation in late June, while others remain active until early October. Hibernation is apparently similar to that described by Ingles for the Mojave ground squirrel; the animal may awaken and become active for a few hours or days, but even in the presence of food, it will again soon become inactive. The animal may emerge from hibernation from late February to April.

Marmots breed soon after emerging from hibernation. The gestation period is about a month. The single litter per year may have from three to eight young, usually four to six. The young emerge from the den at about 30 days of age.

Marmots are generally plant feeders although caterpillars and other invertebrates are eaten. Their native food is green vegetation and it includes tender grasses, clovers, vetch and sedum. Marmots relish alfalfa and they are serious pests when they live nearby. Badgers, coyotes, eagles, horned owls, large hawks, and wolverines are known to feed on marmots. The marmot signals danger by emitting a loud whistle.



Damage Prevention and Control Methods

Exclusion: The use of fencing where marmots are living adjacent to orchards, gardens, and agricultural fields (alfalfa) can help reduce damage. However, marmots are good climbers so any fencing needs to be used in conjunction with electric wire.

Fencing needs to be a minimum of 3 feet high, 2 inch mesh wire. Since marmots burrow very well, fencing should be buried 10 to 12 inches with the bottom edge bent 1 to 2 inches in an 'L' shape. The top edge of the fence should be bent outward at approximately 45 to prevent climbing. Keep the area immediately close to the fence clear of vegetation to enhance inspection.

Frightening: Not recommended.

Toxicants: None registered.

Fumigants: The use of fumigants to control Marmot is effective. Two forms of control exist; the use of aluminum phosphide tablets (Restricted Use Material) and gas cartridges (carbon monoxide).

Aluminum Phosphide

Place 2 to 4 tablets per burrow opening

Directions for Use

Various forms of tablet are available commercially.

Aluminum Phosphide tablets interact with moisture in burrows creating hydrogen phosphide gas.

Place the label recommended amount (usually 2 to 4 tablets) as far in each active burrow opening as possible. Seal tightly by shoveling dirt over the entrance after first packing the opening with crumpled newspaper. This will prevent soil from covering the tablets. Use lower rates in small burrows or under moist soil conditions and higher rates in large burrows or when soil moisture is low. Check treatment area after 48-72 hours and re-treat as before all opened burrows.

Follow all labeled directions for use closely. Do not use within 15 feet of occupied buildings or where gases could escape into areas occupied by other animals or humans.

Gas Cartridges (carbon monoxide)
Gas cartridges are mixtures of active ingredients and sawdust compressed into a tube. When ignited by a fuse, they give off smoke and toxic gases that are effective if confined in burrows.

With a nail or sharp object about the diameter of a pencil, puncture cartridge cap end at marked points. Rotate nail to loosen material inside. Insert fuse in one end using one of the center holes. Light fuse and insert cartridge into active burrow entrance as far back as possible. Quickly seal burrow opening with earth and tamp tightly. Close nearby connected burrows where smoke is seen escaping. Well established burrows usually require two cartridges.

CAUTION: Smoke coming from cartridges occasionally ignites. Do not use where a fire hazard exists.

NOTE: Cartridges absorb moisture readily so they must be kept dry at all times. Do not store in damp places.

These are commercially available and are specially designed cylinders filled with slow-burning chemicals. Ignite after placing in burrow systems. Once the cartridge starts to smoke, push it down into the burrow with a shovel handle or stick. All burrow entrances should be sealed, as the cartridges burn they release toxic gas lethal to marmot.

Always read and follow specific label instruction carefully. Be especially careful not to use them in burrows located near or under buildings or other combustible material because of fire hazard. The cartridges are usually ignited by lighting a fuse and if handled correctly should not explode. Have firefighting equipment (water, blanket) nearby should they become necessary.

Treatment of burrows can be conducted at any time although it will be most effective in the spring before young emerge and when soil moisture is relatively high.

To treat a burrow system with gas cartridges:

1. Locate main entrance and other associated secondary entrances.

2. Dig a square of nearby sod or loose soil and place over each entrance, leaving one spare next to the main entrance.

3. Prepare and ignite the gas cartridge and place as far as possible inside the main entrance. Immediately seal the main entrance and check area for smoke leaks from entrances. Seal these with loose soil.

4. Observe site for about 5 minutes.

5. Repeat these steps for other burrow systems. Identification of burrows where marmots have dug out is necessary when using fumigants. Check treatment area after 48-72 hours and retreat as before all opened burrows.

Dig outs by marmots have been reduced by placing a crumpled wad of newspaper into the burrow immediately after dispensing the fumigant and before sealing the burrow entrance with earth.

Fumigants are most effective when soil contains enough moisture to hold the gas within the burrow system.

As with all pesticides, follow label directions for use, storage and disposal.

Acrolein - Magnicide "H"

No information on this material is available for marmot control. This is a Restricted Use Material and requires specific use practices.

Place nozzle applicator device as far into the active burrow entrance as possible. Shovel soil onto the applicator device and the burrow entrance to create a seal that will prevent loss of gas. Dispense fumigant at the rate of 20 cc per burrow. Withdraw application device and seal burrow opening by tamping it tightly.

Repellents: Not applicable

Trapping: In California body grip trapping (steel or padded leg hold traps etc) in nearly all circumstances are illegal. Very specific guidelines exist in the California Fish and Game Code Section 3003.1. For those cases where trapping is allowed check carefully to comply with laws and regulations. Be aware that should a protected animal be trapped inadvertently this may render you liable to prosecution.

Live trapping may be acceptable if the animal is euthanized in a humane manner. However it can sometimes prove difficult. Live traps can be self built, or purchased from commercial sources. Place the traps at main entrances to the burrows. 'Funnel' the pathway from the burrow entrance to the trap by placing several logs on either side of the marmot travel lane. This will help guide the marmot to the trap bait. Bait the traps with sliced apple or carrots and lettuce. Check traps twice a day and replace bait daily.

Other Methods

Shooting: Rifles with telescopic sights are effective in the control of marmots where shooting can be accomplished safely. Landowners and hunters should agree on hunting arrangements prior to initiating any shooting activities. Always check with your local Fish and Game authority for compliance issues with local as well as State and Federal ordinances.

REFERENCES AND ADDITIONAL READING

Atwill, Edward R., R. Phillips, F. Rulofson, 2002. Environmental Loading Rates of the Waterborne Pathogenic Protozoa Cryptosporidium Parvum in Certain Domestic and Wildlife Species in California. Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp. 241-243.

Atwill, Edward R., R. Phillips, F. Rulofson, 2002. Environmental Loading Rates of the Waterbourne Pathogenic Protozoa Cryptosporidium parvum in Certain Domestic and Wildlife Species in California. Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp. 241-243.

Borrecco, John E., H.C. Black, 1990. Animal Damage Problems and Control Activities on National Forest System Lands. Proc.!4th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis. Pp. 192-198.

Koehler, Ann E., R.E. Marsh, T.P. Salmon, 1990. Frightening Methods And Devices/Stimuli to Prevent Mammal Damage- A Review. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp. 168-173.

La Combe, Jonathan, 2006. Reno "Live Trap" Loaning Program. Proc. 22nd Vertebrate Pest Conf. (R.M. Timm and J.M. O'Brien, Eds.) Published at Univ. of Calif., Davis. Pp. 402-405.

Sterner, Ray T., 1994. Zinc Phosphide: Implications of Optimal Foraging Theory and Particle-Dose Analyses to Efficacy, Acceptance, Bait Shyness, and Non-Target Hazards. Proc. 16th Vertebrate Pest Conf. (W.S. Halverson & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 152-159.

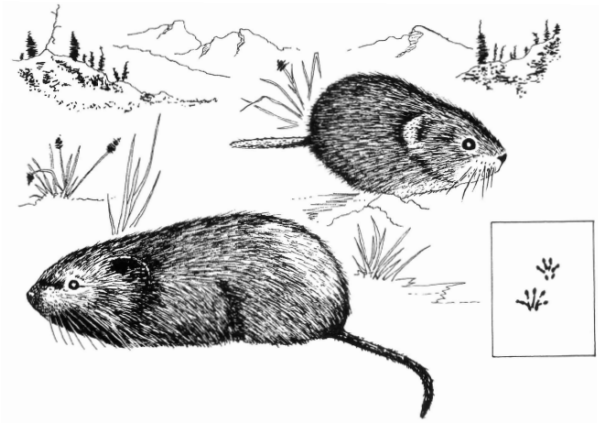
Sullins, Monty, D. Sullivan, 1992. Observations of A Gas Exploding Device for Controlling Burrowing Rodents. Proc. 15th Vertebrate Pest Conf. (J.E. Borrecco & R. E. Marsh, Eds.) Published at Univ. of Calif., Davis. Pp. 308-311.

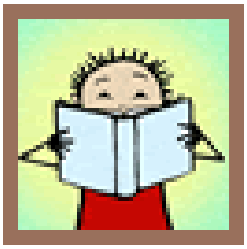
BIOLOGY, LEGAL STATUS, CONTROL MATERIALS, AND DIRECTIONS FOR USE

Meadow Voles

Microtus californicus, M. montanus

Family: Cricetidae

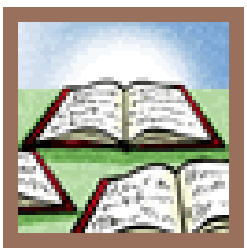




Introduction: Meadow voles are intriguing small mammals. Their population growth often fluctuates dramatically, causing sudden increases. This Often catches landowners by surprise which is when their presence usually becomes problematic whether to the individual or commercial landowner. After vole populations peak they generally subside even if no control has taken place. A low population may exist for 4 – 8 years before another resurgence.

Six species of Meadow voles of the genus *Microtus* occur in California. Two species of voles are responsible for the majority of damage in California. The California vole (*Microtus californicus*) and the Montane vole (*M. montanus*). Voles do not normally invade homes and should not be confused with the common house mouse.

Identification: Meadow voles are small rodents with stocky bodies, short legs and tails, and short rounded ears. Their long, coarse fur is black-brown- to gray. Adults are 4 to 5 inches long. They are larger than a house mouse but smaller than a rat. Meadow voles are active night and day, all year, and are found in areas of dense, grassy ground cover. They are relatively poor climbers and do not usually enter buildings. They dig short, shallow burrows with numerous openings about 2 inches across.



Legal Status: Meadow voles are classified as nongame mammals by the California

Fish and Game Code. Nongame mammals which are found to be injuring growing crops or other property may be taken at any time or in any manner by the owner or tenant of the premises. They may also be taken by officers or employees of the Department of Food and Agriculture or by federal or county officers or employees when acting in their official capacities pursuant to the provisions of the Food and Agricultural Code pertaining to pests.

Damage: Permanent pasture, hay, alfalfa, artichokes, brussel sprouts, carrots, cauliflower, potatoes, sugar beets, tomatoes, grains, nursery stock and the bark of apple, avocado, citrus, cherry and olive trees.

Range: Of the five species of *Microtus* found in California, only *M. californicus* and *M. montanus* are economically important. *M. californicus* is found in the Owens and lowland valleys and the Coast Range areas; *M. montanus* inhabits northeastern California and the eastern Sierra slope. *M. longicaudus*' range approximates montanus' range plus an extension into northwestern California; *M. oregoni* and *M. townsendi* are found only in northwestern California.

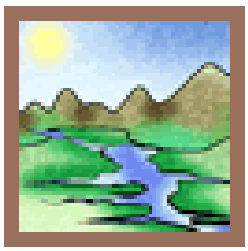
California Vole

Creeping Vole

Long-Tailed Vole

Montane Vole

Townsend's Vole



Habitat: Meadow voles are likely to be found where there is good vegetative cover. They generally do not invade cultivated crops until the crop is tall enough to provide food and shelter. *M. californicus*: marshy ground, saltwater and fresh wet meadows, and dry grassy hillsides. *M. montanus*: near springs and in wet grassy meadows of the yellow pine, red fir, Engelman spruce, hemlock and lodgepole forests. *M. longicaudus*: stream banks and mountain meadows, occasionally in dry situations, brushy areas in winter. *M. oregoni*: Forests, brush, grassy areas, usually on dry slopes. *M. townsendi*: moist fields, sedges, tules and meadows, usually near water.

Biology: Meadow voles are active all year round, irrespective of weather. They

forage at any time during the day or night but are chiefly diurnal. They are usually found in colonies marked by numerous 1 to 2 inch wide surface runways through matted grass. Small piles of brownish feces and short pieces of grass stems along the runways are evidence of activity. In areas of winter snow, their round burrow openings to the surface of the snow also reveal their presence. The burrows consist of shallow underground tunnels, nest chambers, and storage chambers. *Microtus montanus* females are territorial and, except during the short period of heat, all strangers of either sex are driven away from the home range around the burrow. Home range is small, less than a 60-foot radius in the case of *M. californicus*. All meadow voles swim well.

There has been disagreement as to feeding habits, but observations of *M. montanus* indicate that meadow voles do forage beyond the sheltered runways. Food consists of tubers, roots, seeds, grain, and succulent stems and leaves; *M. californicus* subsists largely on grasses and sedges, whereas *M. montanus* prefers forbs.

Females of *M. californicus* were reported to have bred at 22 days of age, but males attain sexual maturity at 6 weeks (Hall, 1959). White concluded that females breed at from 4 to 6 weeks of age. The average litter size for *M. californicus* is 4.2 (range 1 to 9), and the litter size is usually 5 to 8 for *M. montanus* and *M. townsendi*. Size of the litter correlates directly with protein content of the food eaten, i.e., the largest litters are born in the spring (Hoffman, 1958). The gestation period is 21 days and the young are weaned at about 2 weeks of age.

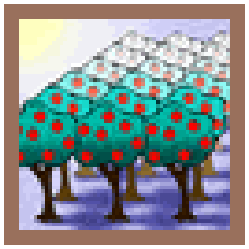
Under natural conditions, a female *Microtus* may produce from 5 to 10 litters a year. Within 15 hours after the young are born, breeding may occur again. White states that it is unlikely that many individuals survive an entire breeding season. Though a few individuals will breed in any season, the major breeding season corresponds with the season of forage growth. In *M. californicus*, there is a major peak in late winter and early spring, and a lull in summer. *M. montanus* ordinarily ceases breeding during the cold winter months and resumes with the return of warm weather in the spring.

Meadow vole populations generally build up to a peak every 3 or 4 years, followed by a rapid decline during the next breeding season. When an anticipated peak occurs in a dry year, it may be barely noticeable, but if it occurs during a wet year, it can be of serious proportions. The exact causes of the cycle of buildup and decline are not known, though disease, food shortages, physiological stress from overcrowding, and other factors may be involved.

It may be assumed that in cultivated areas meadow vole populations are permanently based in favorable habitat such as roadsides, canal banks, or adjacent non-cultivated land. Invasion into cultivated cropland occurs when the population builds up or when the wild habitat becomes unfavorable, as when range grasses dry up in summer. Serious invasions may be detected early by the use of strategically located drift fence pit traps or lines of snap traps.

Coyotes, badgers, weasels, snakes, hawks, owls, herons, and gulls are among the principal vole predators. It is generally believed that predators can neither prevent a population eruption nor control it after it occurs

because the birth rate of the predators is too low to keep pace with the fast-breeding voles.



Damage Prevention and Control Methods

Exclusion: Plastic, wire, or metal barriers that are at least 1 foot high, mesh size – ¼ inch will exclude meadow voles. Meadow voles rarely climb but they may dig beneath. To reduce this possibility, bury the bottom edge 6 to 10 inches below the soil surface. Plastic or hardware cloth cylinders surrounding the trunks can protect young trees, vines, or garden ornamentals. Again bury the bottom at least 6 inches in the soil.

Habitat Modification

Habitat modification can be very effective in deterring voles. Grassy weeds, heavy mulch, and other dense covers encourage voles by providing food and protection from predators. By removing the protection the area will be much less suitable to voles. For example, clearing grassy areas adjacent to gardens or crops can help reduce voles by removing their cover. A minimum width of 15 feet is recommended, but even that may not be enough if vole numbers are high. Clearing vegetation 2 feet from young trees or vines reduces damages because voles do not like to feed in the open. Voles often damage plants beneath thick mulches or bark chips.

Frightening

Frightening methods are ineffective and not recommended for vole control.

Fumigants

Fumigants are not usually effective because of the complexity and shallowness of vole burrow systems; the fumigant escapes. Aluminum phosphide can be effective in situations where the burrow openings are quite visible such as immediately after discing.

Repellents

Not recommended. Several commercial repellents are available, utilizing Thiram or capsaicin (the hot in chile) as an active ingredient are registered for protecting plants from meadow voles, although they have not been proven to be effective or practical in California. Voles usually damage plants at or just beneath the soil surface. This makes the use of repellents difficult as rain, sprinklers, or even heavy dew often washes repellents away. Repellents should not be applied to food crops unless this use is specified on the product label.

Toxic Bait

CDFA labels	0.005% Chlorophacinone grain bait

0.005% Diphacinone grain bait

2.0% Zinc Phosphide grain bait (grain and artichoke leaves)

2.0% Zinc Phosphide concentrate (artichoke bracht)

Whenever using poison baits always follow the product label carefully, and take care to ensure the safety of children, pets, and nontarget animals. Use only baits registered for voles.

Anticoagulant baits are slow acting and must be consumed over a period of several days to be effective. Pelleted or whole grain baits are commonly recommended. Because of the continuous feeding requirement the bait must be available to the voles until the population is controlled. Bait placement is very important. Place it in runways, next to burrows, or in burrow openings so voles will find it during their normal travel. If the label allows for broadcast baiting, follow the label instructions for application and reapplication. Remember baits are toxic so that care must be taken to prevent exposure to nontarget wildlife. Bait can be placed in bait stations, (1 foot) sections of plastic pipe 2 inch diameter which will reduce exposure to nontarget species and allows protection of the bait from weather.

Paraffin bait blocks may also be available for vole control. Place directly in runways or in tube stations. Exposed bait blocks can present a hazard to dogs if picked up and chewed. Replace bait as eaten and remove those that remain when feeding stops.

Zinc phosphide is a common vole control toxicant. It is a Restricted Use Pesticide and usually used where vole populations are high and occupy larger areas i.e. agricultural settings. Zinc phosphide is a single dose toxicant available as pellets or grain based bait. The bait is usually applied by broadcasting or spot baiting (placing small quantities close to burrow entrances). Care should be taken to always follow product label directions. Zinc phosphide baits are potentially hazardous to ground feeding birds, especially waterfowl, especially if applied to bare soil.

Trapping

Trapping is not an effective method of control where population numbers are high. Simple wooden mouse traps can be used to control low populations concentrated in small areas. Baiting can include peanut butter, oatmeal or apple slices. Often no bait is needed as voles operate the traps by passing right over them.

Trap placement is important. Meadow voles do not stray far from their ‘runs’. Traps should set at right angles with the trigger directly in the path of the vole. For additional placements, look for nests, burrow openings, runways in or around mulch or grass. Traps must be set in sufficient numbers to be effective. Examine traps daily. Remove and bury dead voles or place them in plastic bags in the trash. For health and safety reasons do not directly handle voles without wearing plastic or rubber gloves.

Other

Shooting is not practical or effective in controlling voles.

Predators do feed on voles but are not usually able to keep populations below acceptable levels. This is because of voles' high reproductive rate; allowing them to increase faster than predators.

Direction For Use

Spot Baiting (Zinc phosphide): Lightly scatter teaspoon quantities of bait (above 80 baits per pound) in runways near active burrows.

Broadcast Baiting (Zinc phosphide): Broadcast baiting using zinc phosphide baits: Spread bait evenly by hand, mechanical spreader, or aircraft through the infested area at the rate of 5 to 10 pounds per acre, depending on the density of the infestation.

Broadcast bait will fall through most vegetation to the ground surface. Do not apply bait when trees or grass are wet, or when rain is likely to occur within 24 hours.

Anticoagulants: Lightly scatter tablespoon amounts (1/4 to 1/2 ounce) of bait near active burrows or in runways. With first generation anticoagulants, repeat treatment every day for three treatments.

REFERENCES AND ADDITIONAL READINGS

Askham, Leonard R., 1990. Effect of Artificial Perches and Nests in Attracting Raptors to Orchards. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp.144-148.

Bryson, David T., 2004. Montane Vole Control with Rozol Paraffinized Pellets in Orchards of the Pacific Northwest. Proc. 21st Vertebrate Pest Conf. (R. M. Timm and W. P. Gorenzel, Eds.) Published at Univ. of Calif., Davis. Pp. 145-149.

Engman, Richard M., G.W. Witmer, 2000. IPM Strategies: Indexing Difficult to Monitor Populations of Pest Species. Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp. 183-189.

Everett, Richard, S. Monsen, 1990. Rodent Problems In Range Rehabilitation. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp. 186-191.

Giusti, Gregory A., D.A. Whisson, W.P. Gorenzel, 1996. Rodents And Cover Crops-A Review. Proc. 17th Vertebrate Pest Conf. (R.M. Timm & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 59-61.

Giusti, Gregory A., 2004. Assessment and Monitoring of California Vole (*Microtus californicus*) Feeding Damage to a Coastal Redwood (Sequoia sempervirens) Restoration Project. Proc. 21st Vertebrate Pest Conf. (R. M. Timm and W. P. Gorenzel, Eds.) Published at Univ. of Calif., Davis. Pp. 169-173.

Hueth, Brent, B. Cohen, D.Zilberman, 1998. Non-Predator Vertebrate Pest Damage in California Agriculture: An Assessment of Economic Impacts in Selected Crops. Proc. 18th Vertebrate Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 371-377.

Hygnstrom, Scott E., K.C. VerCauteren, J.D. Ekstein, 1996. Impacts of Field-Dwelling Rodents on Emerging Field Corn. Proc. 17th Vertebrate Pest Conf. (R.M. Timm & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 148-150.

Koehler, Ann E., R.E. Marsh, T.P. Salmon, 1990. Frightening Methods And Devices/Stimuli to Prevent Mammal Damage- A Review. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp. 168-173.

Lewis, Steven R., J.M. O'Brien, 1990. Survey of Rodent and Rabbit Damage to Alfalfa Hay in Nevada. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp. 116-119.

Marsh, Rex E., A.E. Koehler, T.P. Salmon, 1990. Exclusionary Methods and Materials to Protect Plants from Pest Mammals—A Review. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp.174-180.

Moore, Thomas, D. Van Vuren, 1998. Are Barn Owls A Biological Control For Gophers? Evaluating Effectiveness in Vineyards and Orchards. Proc. 18th Vertebrate Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 394-396.

Salmon, Terrell, P., R.H. Schmidt, R.E. Marsh, 1990. AN Evaluation of Fencing to Exclude Pocket Gophers From Experimental Plots. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp. 95-96.

Salmon, Terrell P., S.J. Lawrence, 2006a. Anticoagulant Resistance in Meadow Voles (Microtus californicus) Proc. 22nd Vertebrate Pest Conf. (R.M. Timm and J.M. O'Brien, Eds.) Published at Univ. of Calif., Davis. Pp. 156-160.

Salmon, Terrell P., S.J. Lawrence, 2006b. Zinc Phosphide-Treated Bracts as an Alternative Rodenticide in Artichoke Field for Meadow Vole (Microtus californicus) Control. Proc. 22nd Vertebrate Pest Conf. (R.M. Timm and J.M. O'Brien, Eds.) Published at Univ. of Calif., Davis. Pp. 161-165.

Silberhorn, Eric M., J.F. Hobson, G.H. Miller, N.J. Condos, 2000. U.S. EPA Reregistration Eligibility Decision (Red) for the Rodenticide Cluster: Overview of the Regulatory Process, Response of Registrants and Stakeholders, and Implications for Agricultural and Urban Rodent Control. Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp. 268-276.

Sterner, Ray T., 1994. Zinc Phosphide: Implications of Optimal Foraging Theory and Particle-Dose Analysis to Efficacy, Acceptance, Bait Shyness, and Non-Target Hazards. Proc. 16th Vertebrate Pest Conf. (W.S. Halverson & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 152-159.

Sterner, Ray T., 1996. Zinc Phosphide Residues in Voles: Scenarios Showing Low Risks to Domestic Cats And Dogs. Proc. 17th Vertebrate Pest Conf. (R.M. Timm & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 139-142.

Sterner, Ray T., 1998. The Bait Surcharge Program: Research Improves Zinc Phosphide Use For Vole Control in Alfalfa. Proc. 18th Vertebrate Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 176-180.

Sullivan, Thomas P., D.S. Sullivan, E.J. Hogue, 2000. Impact of Orchard Vegetation Management on Small Mammal Population Dynamics and Species Diversity. Proc. 19th Vertebrate Pest Conf. (T.P. Salmon & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 398-403.

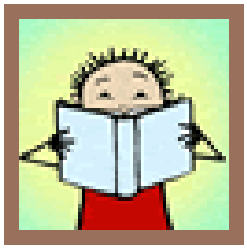
Van Vuren, Dirk, 1998. Manipulation Habitat Quality to Manage Vertebrate Pests. Proc. 18th Vertebrate Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 383-390.

BIOLOGY, LEGAL STATUS, CONTROL MATERIALS, AND DIRECTIONS FOR USE

Moles

Scapanus spp. **and** ***Neurothichus gibbsii,*** **"Shrew-mole"**

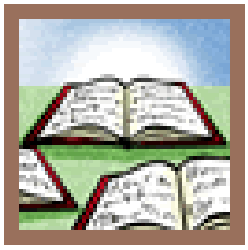
Family: Talpidae



Introduction: The mole is common throughout the US. In California, the broad footed mole (*S. latimanus*) is the main pest species. They inhabit the Sierra Nevada and Coast Range mountains, and coastal zone.

The mole is a small insect eating subterranean animal which develops complex tunnel networks. Shallow tunnels close to the surface, which the mole utilizes for food gathering, are responsible for major damage, particularly to turf, dislodged plants, and other cultivated settings. In general mole control is most efficient when an understanding of the animal's behavior is achieved. Indicative of the issue is the fact that mole trap development can be traced historically 150 years (Marsh 1996).

Identification: Moles can be distinguished from rodents such as meadow vole, shrews, and pocket gophers. Moles are 5 to 6 inches long with cylindrical bodies and a slender hairless pointed snout and short, bare, sparsely haired tails. Their limbs are short and spade like. They have poorly developed eyes, and their ears are not visible. Fur is short, dense, and velvety.



Legal Status: Moles are classified as nongame mammals by the California Fish and Game Code. Nongame mammals which are found to be injuring growing crops or other property may be taken at any time or in any manner by the owner or tenant of the premises. They may also be taken by officers or employees of the Department of Food and Agriculture or by federal or county officers or employees when acting in their official capacities pursuant to the provisions of the Food and Agricultural Code pertaining to pests.

Damage: Mole hills and tunnels disfigure lawns, gardens, parks and may interfere with hay harvesting machinery or other farm machinery. Townsend moles may eat tubers and roots of garden plants and disrupt small garden areas.

Mole damage is caused by their 'hunting' for food worms, insects, grubs in the soil. Shallow tunnels disturb and dislodge plants and their root systems.

It is important to properly identify the kind of animal causing the damage as control methods do differ for each species. Moles are often mistaken as members of the rodent family and pocket gopher damage is often misidentified as mole damage (Courtney & Barnes 2002).)

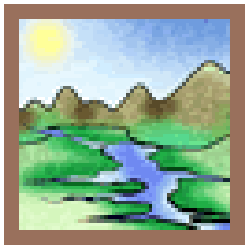
The easiest way to distinguish which animal is responsible is by looking at the burrow mounds. Moles create volcano shaped hills, made from clods of soil. The mole hills are pushed up from deep tunnels and may be 2 to 24 inches tall. In contrast, pocket gopher mounds are crescent shaped made from sifted and cloddy soil.

Range: Seven species of mole occur in North America. Four are found in the West. *Scapanus townsendi* (Townsend) and *S. orarius* (coast mole) are limited to northwestern coastal California. *Neurotrichus gibbsii* is found in northwestern California and along the coast to Monterey and in the Shasta-Trinity area. The shrew mole is also found along the West Coast from Santa Cruz to southern British Columbia (Yates and Peterson 1982). In California the broad footed mole (*S. latimanus*) is the main pest species.

Coast Mole

Shrew-Mole

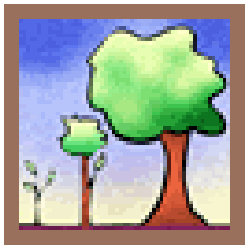
Townsend's Mole



Habitat: *S. latimanus*: soft soils in valleys and mountain meadows; *S. townsendi*: moist meadows, fields, lawns and coniferous forests; *S. orarius*: meadows and deciduous forests; *N. gibbsii*: moist areas in shady ravines and along streams where ground is free of turf, from sea level to 8,000 feet.

In general moles live an isolated existence in underground burrows. Their tunnel systems are complex deep and shallow because the mole forages for food such as worms, insects grubs etc by tunneling. Food requirements of each mole mean 3 to 5 moles per acre is considered a high population. Thus when a mole problem is encountered it is often only one mole ranging throughout the area in search of food.

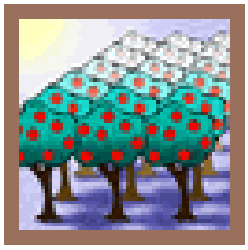
Moles make their home burrow in high dry spots but 'hunt' in cool, moist soil where their food preferences are more plentiful. The home burrows are often found under large trees, buildings or sidewalks. Other animals such as voles and mice commonly use mole burrows as runways



Biology: Moles are active the year round, and except for the Townsend mole, chiefly diurnal. The shrew mole spends considerable time on the surface of the ground but the other three moles rarely venture out of their tunnels. Tunnels are of two types: temporary surface tunnels where the sod is raised in ridges as the mole searches out worms and other food, and deeper tunnels from which the mole must excavate dirt, forming molehills. The deeper tunnels are resorted to when surface soil becomes dry, and, by some moles, as nest sites. Moles are solitary for the most part, though common pathways are occasionally used by Townsend moles to get to different areas. Moles are adept at running backwards and at turning around in their burrows.

All moles eat worms and insect larvae chiefly, and many eat some vegetable matter as well. Their sight is very poor. They are sensitive to odors and ground vibrations which aid in locating food. Moles will leave surface tunnels and go deeper when ground vibrations are felt, although this is only temporarily. Relatively little is known about their breeding habits due to their secretive existence. The shrew mole has more than one litter a year of 1 to 4 young; the shrew mole breeds throughout the year except possibly in December and January. The shrew mole nests in rotting stumps or logs. The *Scapanus* species have one litter a year of 2 to 6 young. The young are born in March or April after a probable gestation of about 4 weeks. The young are born relatively large and in Oregon they reach adult size in two months.

There is little information on natural enemies or longevity in the literature. The hairy tail mole of the eastern United States has longevity of 4 to 5 years and their young attain sexual maturity at 10 months.



Damage Prevention and Control Methods: Moles remove insects and grubs from lawns and gardens which might be of some benefit. On the other hand moles can cause significant problems in landscape or garden areas i.e. turf and plant disruption. No one method of control has proven entirely successful, a combination of techniques may be necessary.

Exclusion: This is practical for smaller areas, seed beds, raised flower or vegetable gardens.

Use ¼ inch wire mesh or hardware cloth to line the bottom of flower beds etc. This will exclude moles and pocket gophers.

Alternatively, in larger areas use underground wire mesh barriers. Dig a trench 24 inches deep six inches wide and place wire mesh or hardware cloth perpendicular in trench bending bottom 6 inches at 90 angle and allowing barrier to protrude from surface (Marsh 1996). While this may provide a temporary effect, it should be noted cost and the fact moles can dig deeper than 24 inches should be taken into consideration. Barriers ultimately only slow mole movement.

Habitat Modification: Restriction of available food by using available pesticides to reduce mole food resources is not recommended (Marsh 1996). This theory requires invertebrate control to restrict the mole population. The data are sketchy at best as to success.

Packing soil with a roller is one method that may work temporarily. This may even have the effect of killing moles if done in the early morning or late evening.

Frightening: Caveat emptor – buyer beware. There is a 50 year history of vibration, magnetic, and electronic devices being promoted as effective in frightening or repelling moles (Marsh 1996). While it is true moles are sensitive to vibrations, it is equally true that they have learned to live alongside busy railroads where, each time a train passes, the ground vibrates for several hundred feet around the tracks. Consequently while such devices may have some temporary effect they are not considered effective for permanent control.

Fumigants: A variety of fumigants have been explored and registered for use on moles, including gas cartridges. Most have proven ineffective or too expensive due to the moles ability to rapidly plug tunnels, avoid toxic gasses, and the depth and complexity of mole burrow systems, which prevents gasses from penetrating.

Gas cartridges may the best alternative and will work on recent mole arrivals where burrow systems are shallow. Marsh 1996 reports that golf course owners report successful use of aluminum phosphide to repel moles from surface tunnels.

Repellents:
In general repellents do not work for mole control. Several plants and chemical substances have been registered or sold as repellents but there is no evidence of their effectiveness (Marsh 1996).

Literature and websites often refer to home remedies as repelling moles e.g. lye, kerosene, castor oil and derivatives, and plants *Euphorbia lathyris*. The evidence is inconclusive at best. More likely is that the moles feeding and activity patterns provide the rationale for claiming success. Moles are singular animals that 'swim' in large tunnels often several hundred feet. Thus, those who claim to have removed a mole may be the inadvertent victim of timing when placing the repellent at which time the mole has gone to a new area of its tunnel. When it returns it appears to be a new mole. Other repellent methods, such as placing ground glass, razor blades, barbed wire, rose bush thorn canes have no scientific basis and may in fact be harmful to the person placing them. Moles are able to successfully tunnel around such measures.

Toxic Bait: The moles main diet is earthworms and insects. Poisoning with traditional grain based baits has been relatively ineffective.

However, several forms of toxic control are commercially available that have been reported effective in some situations. These are either in the form of a 'gel' (warfarin based Kaput® Mole Gel bait) or an artificial worm Talpioid™, intended to mimic the moles food source (Poche 2002 and Courtney and Barnes 2002).

The gel is a relatively new product. The initial scientific testing has been positive as a control method for ease, of use, safety and efficacy. Application of the gel is by injection directly into a tunnel. Care should be taken to not cover the gel bait when resealing the tunnel. Alternatively utilizing a plastic pipe bait station similar to that for ground squirrels is recommended as this makes for ease of gel application on a continuous basis. Only apply the gel in tunnels, not above ground, as the bait may prove harmful to children or wildlife.

An alternative is pellet form bait. A number of commercially available products are sold this way and use castor oil as the active ingredient. Recent scientific studies suggest some efficacy in treatment with clay pellets on lawn areas where Eastern moles were present (Courtney and Barnes 2002).

A new product on the market is Talprid®. It is a bromethalin based gum/gel formed in the shape of a worm. These baits are placed underground in mole's burrow. Follow label instructions carefully.

Trapping: Trapping is the most universally recommended method of mole control.

A number of different mole traps are available at hardware stores, nurseries, or direct from the factory. Keep in mind that the best mole traps differ from those for pocket gophers; very few traps are effective for both animals. Understanding mole behavior helps improve trapping. Most mole traps utilize the theory that a mole will push his way into a soil block in its tunnel. For this reason, 'set' traps generally straddle the runway, encircle it or are suspended above it, and are usually sprung by the pressure of the mole's body or the movement of soil against a triggering plate.

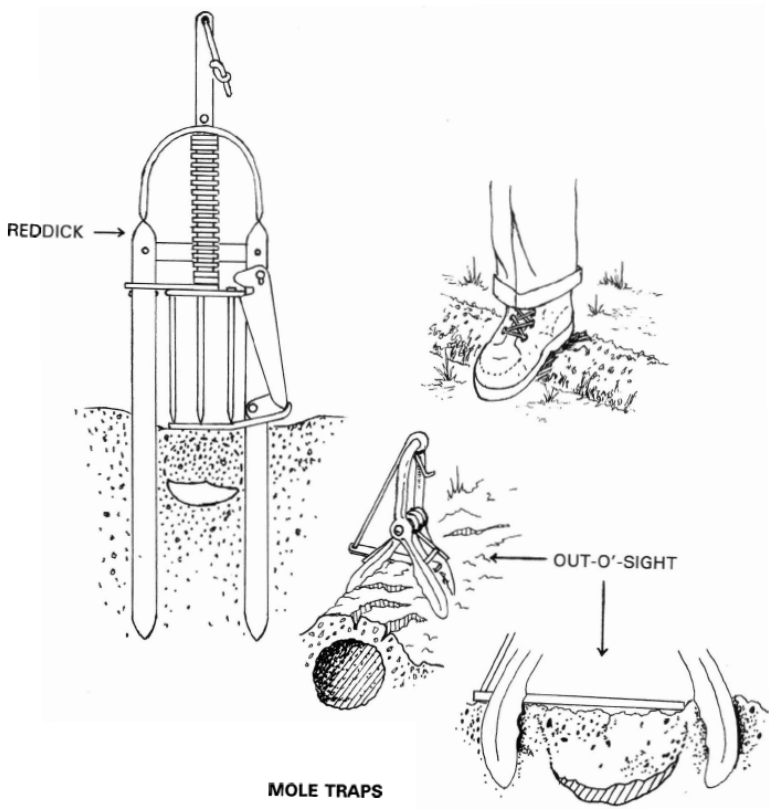
Before setting any traps, it is necessary to determine which runways are in current use. To determine activity, stamp down short sections of runways and mole hills and observe daily; restamp any raised sections or mounds. Moles dig a system of deep tunnels as well as a network of surface runs. Some of the surface tunnels are only temporary runs dug in search of food and may not be reused, while the deep

runways are more or less in permanent usage. The deeper runways may be located by probing downward with a pointed stick, slender metal rod or a standard gopher probe see illustration; between, or next to, a fresh mole hill. Success in locating the deeper runs is determined when a sudden give is felt as the probe breaks into the burrow. The selection of a main or frequently used runway in which to set a trap is of prime importance in obtaining results.

In California, the Out-O-Sight and the Victor (spear or harpoon type) are the two traps most often seen used, however, other kinds and types of mole traps are employed. Moles have occasionally been caught with Macabee gopher traps that were set in mole runways, but this is not a recommended trap for moles. Trap manufacturers often provide detailed instructions for the use of their particular mole traps. For best results, these directions should be followed explicitly. Mole traps can be relatively expensive so most people buy only one. As moles are active throughout the year, they may be trapped at any time. However, the opportune time is when fresh signs of mole activity are evident. Moles are much more difficult to trap then are pocket gophers.

Scissor-jaw traps should be set in a main underground tunnel, usually 8 to 12 inches deep. Using a garden trowel or small shovel, remove a section of soil slightly larger than the trap width about 6 inches. Build a plug of soil in the center of the opened runway for the trigger pan to rest on. Use moist soil from the opened tunnel or from a nearby fresh mound to build the plug. Wedge the set trap, with safety catch in place, firmly into the opened burrow with the trigger placed snugly against the top of the soil plug. Scatter loose soil onto the set trap to about the level of the top of the tunnel. This will exclude light from the opened burrow and likely make the mole less suspicious of the plugged tunnel. Finally release safety catch.

Harpoon traps work in deeper tunnels and also on the surface over an active runway ridge that has been pressed down under the trigger pan. To install a harpoon trap, depress a small portion of the ridge about halfway down to the bottom of the tunnel and set the trap so that the trigger rests lightly on the depressed area. The trap will be set off when the mole attempts to pass through the depressed section of the tunnel.



MOLE TRAPS

Other Methods: There are numerous 'home remedies' as already discussed. These are not recommended.

Flooding burrow system to drown or force moles out or above ground where it can be dispatched is not recommended. Moles have deep burrow systems and flooding is likely to be ineffective and wasteful of a valuable resource (Marsh 1996).

REFERENCES AND ADDITIONAL READING

Borrecco, John E., H.C. Black, 1990. Animal Damage Problems and Control Activities on National Forest System Lands. Proc.!4th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis. Pp. 192-198.

Courtney, Amy, T.G. Barnes, 2002. The Efficacy of Molexit for Reducing Damage from Eastern Moles (Scalopus aquaticus) Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp.299-302.

Poche, Richard M., 2002. Field Tests of a Warafin Gel Bait for Moles. Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp. 295-298.

Jackson, Jeffery J., 1990. Controlling Vertebrate Animal damage in Southern Pines. Proc. 14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis. Pp. 199-202.

Koehler, Ann E., R.E. Marsh, T.P. Salmon, 1990. Frightening Methods And Devices/Stimuli to Prevent Mammal Damage- A Review. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp. 168-173.

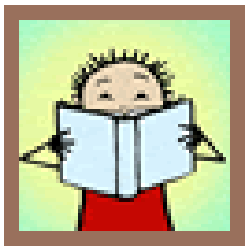
Marsh, Rex E., 1996. Mole Control-A Historical Perspective. Proc. 17th Vertebrate Pest Conf. (R.M. Timm & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 34-39.

BIOLOGY, LEGAL STATUS, CONTROL MATERIALS, AND DIRECTIONS FOR USE

Muskrat

Ondatra zibethica

Family: Cricetidae

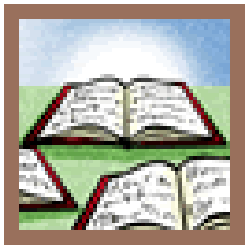


Introduction: The muskrat is the largest microtine (relating to voles or lemmings) rodent in the United States. It spends most of its lifespan in aquatic habitats and swims well. The term muskrat derives from paired perneal musk glands found beneath the tail area of both sexes. These musk glands are used throughout the breeding season to mark an area.

Identification: The muskrat is a large, stout, semi-aquatic rodent. Its head is broad and blunt with small eyes and rounded short ears. The muskrat's coat is practically waterproof and is soft, dense, and grayish brown in color. Its large hind feet are partially webbed, stiff hairs align the toes, and its laterally flattened tail is about the length of its body. Its front feet are much smaller than the hind feet and are adapted for digging and feeding. The muskrat is further adapted for its semi-aquatic life with lips that act as valves, closing behind the front incisors so it can actually gnaw underwater.

Adult muskrats are 18 to 24 inches) in length. Males can be larger, up to 30 inches. Average weight is 1 ½ pounds to 4 pounds.

Muskrats can swim slightly faster than 3 miles per hour and when feeding often swim backwards. They can stay underwater for up to 20 minutes. Muskrat activity is mainly nocturnal, seen chiefly in the twilight they occasionally can be seen during the day.



Legal Status: Muskrats are classified as fur-bearing mammals by the California Fish and Game Code. Muskrats which are injuring growing crops or other property may be taken at any time and in any manner.

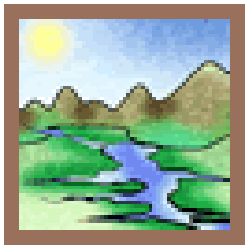
When trapping fur bearing mammals in California the manner of taking is strictly controlled. California law is very specific regarding trapping conditions and restrictions: steel jawed, spiked and large body gripping traps are prohibited, restricted use in some cases. Trap and snares are restricted both as to type and placement, and each trap is required to have individual trap identification issued by the California Fish and Game Department; and daily trap visitation and maintenance is required.

Note this 'trapping statute' still applies to Structural Pest Control Licensed Operators and DPR Licensed and Certified Persons or Businesses when trapping mammals other than rats, mice, gophers, moles, and voles.

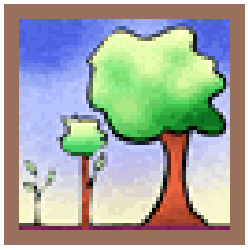
Damage: Muskrats damage rice, milo, sugar beets, and tomatoes. Much crop damage attributed to muskrats in the Delta area is actually caused by resident Norway rat populations. The major damage done by muskrats is the weakening or washing out of levees, culverts and head gates due to their burrowing in earthen banks. This problem is more serious where levee soils are peaty or sandy, and where levee or ditch bank walls are thin. Other burrowing damage may include pond dams, floating styrofoam marinas, docks, boathouses, and lake shorelines.

Range: Central Valley of California, Imperial Valley and Colorado River area, northeastern California and scattered along coastal California, mostly in aquatic habitats; streams, ponds, wetlands, swamps, drainage ditches and lakes. In the 1920's they were introduced to the central valley for the fur trade (Messa 1980).

Common Muskrat



Habitat: Muskrats live year round wherever water and food are present; marshes, edges of ponds, lakes, and streams; cattails, tules, water lilies, and open water (Errington 1961).



Biology: Muskrats are almost always found near water. They may wander overland in search of new feeding grounds or to escape floods.

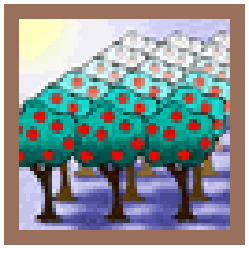
Muskrats may live in burrows in banks, or they may build conical houses 3 or 4 feet in height out of reeds in ponds or marshes. There may be one or more entrances, which are usually underwater. Burrows made by crayfish may be confused with those made by muskrats. Where water levels fluctuate, the nest chambers are above high water.

Muskrats are primarily vegetarians, eating cattails, tules, and other aquatic plants, bulbs, grasses and some animal food such as tadpoles, mussels, and snails. Some wildlife refuges are stocked with muskrats in hopes of keeping tules and other water plants under control; other refuges encourage trapping to alleviate damage to dikes and levees.

Muskrats are more active by night than by day and do not hibernate. Young may be born at any time of year, but there are fewer births in winter. The gestation period is 22 to 30 days, and 2 or 3 litters a year are raised. There are usually 5 or 6 young (range of 1 to 11) per litter and they are weaned when about one month old.

Young muskrats are especially susceptible to predation by owls, hawks, raccoons, mink, foxes, coyotes, even adult muskrats. Man is also an enemy, the muskrat being the most important fur-bearer in the United States. The flesh is palatable and is sold in some areas as "marsh hare."

Muskrats are hosts to parasites and carry a number of diseases; tularemia, hemorrhagic diseases, leptospirosis, ringworm, pseudotuberculosis. Common extoparasites include mites and ticks.



Damage Prevention and Control Methods

Exclusion

Damage caused by muskrats is mainly burrowing damage. Often this damage may not be readily apparent. One way to identify early burrowing is to walk along the edge of the dam or shorelines when the water is clear and look for 'runs' or trails just below the water surface to a depth of 3 feet. Also look for droppings along the bank or on logs or structures. Any burrows found should be filled, tamped in and covered with rock.

In some situations the digging can be prevented in farm ponds by using stone riprap at the edge of the pond or dam. Serious damage can be prevented by this type of construction. Specifications include: the inside face of the dam should be built at a 3 to 1 slope; the outer face of the dam at a 2 to 1 slope with a top width of not less than 8 feet, preferably 10 to 12 feet. The normal water level in the pond should be at least 3 feet below the top of the dam and the spillway should be wide enough to support heavy rainfall.

Fencing is another exclusion method to prevent muskrats from leaving areas such as ponds where plants and crops are at risk.

CONTROL IN RICE FIELDS

Preventive measures: The enlargement of check-banks and the construction of substantial check boxes reduce damage from muskrat burrowing. A check-bank with a base of six feet offers more resistance to the erosion of muskrat burrows than does a narrower bank. Wide banks require wider check boxes, which are less vulnerable to burrowing by muskrats. A recommended box size is two feet wide, eighteen inches high, and four feet long; made of two inch lumber. Additional protection is obtained by the use of lateral wings, two feet in length, to discourage muskrats from burrowing along the side of the box. Headgate foundation should be constructed to prevent muskrat burrowing. This may be done by extending a concrete apron 15 feet in both directions from the headgate, along the sides and bottom of the canal.

CONTROL IN IRRIGATION CANALS

Frequently muskrats make burrows at junctions of canals, especially when there is a wooden or cement structure damming the water. Such burrows may lead from one canal to another, often beneath the protection of the structure. Differences in water level cause burrows to erode rapidly and those covered by the cement structure of the headgate are difficult to destroy or fill.

Preventive measures: Headgate foundation should be constructed to prevent muskrat burrowing. This may be done by extending a concrete apron 15 feet in both directions from the headgate, along the sides and bottom of the canal.

Using the wire netting on canal banks about headgates and other especially vulnerable trouble spots will prevent digging. Two inch diamond mesh (no. 14 gauge, galvanized after weaving) placed two feet above and two feet below the water should be used.

Habitat Modification

Eliminating food and other aquatic matter eaten by muskrats can make the habitat less desirable to muskrats. Where farm ponds and levees are being damaged, use winter 'draw down' to expose muskrat dens, burrows, and runs. Fill these and then riprap the edges with stone. Also while the water is drawn down, trap muskrats.

Frightening

Not a recommended method, ineffective as a permanent solution.

Fumigants

Not a recommended method.

Repellents

Not a recommended method.

Toxic Bait

CDFA labels 0.005% Chlorophacinone grain bait
0.005% Diphacinone grain bait
0,005% Diphacinone Rodent Bait Block

Anticoagulant baits, 0.005% (diphacinone, chlorophacinone) are also effective. Spot Baiting - (Bait boxes and paraffin blocks see below) are effective. Broadcast baiting is NOT EFFECTIVE.

Directions for Use:

Anticoagulant baits: Bait must be eaten over a period of several days to give adequate control.

Anticoagulant paraffin bait blocks: The anticoagulant block (diphacinone) is a muskrat control alternative which is effective along ditches and waterways. The bait is used by placing near muskrat burrows, runways, and locations where fresh activity is apparent. The method has proven effective in agricultural areas. No adverse effects are known to occur to waterfowl or other birds. Care must be taken if dogs are in the area since they might chew on and ingest some of the bait.

Floating bait stations: Exposure to anticoagulant baits in floating bait stations is a satisfactory method of muskrat control. Place one to five pounds of bait in floating bait box. Inspect stations daily and add bait as needed; increase the amount when bait in bait box is entirely consumed overnight. Replace moldy or old bait with fresh bait. An uninterrupted supply of bait should be maintained as long as any bait is taken. Stations can be constructed of 1/4" plywood. Styrofoam glued to the base provides an adequate float when waterproofed. Floating bait stations will drop as the water level lowers and may be difficult to service. A handy device to service these boxes may be made by fastening a small can on one end of a six foot pole and a hook (used to raise and lower the lid) on the other end.

Trapping:

In California muskrat leg hold type traps are illegal. When trapping fur bearing mammals in California the manner of taking is strictly controlled. California law is very specific regarding trapping conditions and restrictions: steel jawed, spiked and large body gripping traps are prohibited, restricted use in some cases. Trap and snares are restricted both as to type and placement, and each trap is required to have individual trap identification issued by the California Fish and Game Department; and daily trap visitation and maintenance is required.

Note this 'trapping statute' still applies to Structural Pest Control Licensed Operators and DPR Licensed and Certified Persons or Businesses when trapping mammals other than rats, mice, gophers, moles, and voles.

An effective muskrat trap is the Conibear trap, size 110, which kills the animal almost immediately. These should be set in the run, house, or den entrance.

Other:

Shooting where legal is only useful in eliminating one or two individual muskrats i.e. from a small farm pond. Dusk or during dawn are the best time.

REFERENCES AND ADDITIONAL READING

Errington, Paul L. 1961. Muskrats and Marsh Management. Wildlife Management Institute. 168pp.

Fiedler, Lynwood A., 1990. Rodents as A Food Source. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp.149-155.

Ingles, L. G. 1965. Mammals of the Pacific States. Stanford University Press. 506pp.

Messa, D. J. 1980. Population Dynamics of Sacramento Valley Muskrats. Federal Aid in Wildlife Restoration Project W-54-R-11, Job II-1.6. California Department of Fish and Game. 17pp.

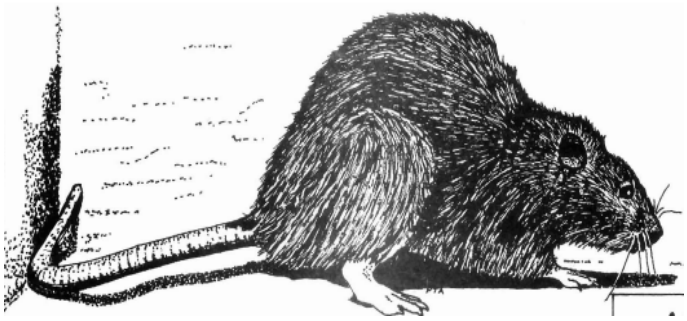
Shuler, J., A History of Muskrat problems in NorthEastern California, Proc. 19th Vertebr. Pest Conf. (Salmon, T.P & Crabb, A.C, Eds.) Published at Univ. of Calif., Davis. 2000

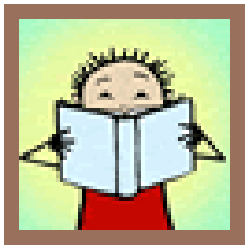
BIOLOGY, LEGAL STATUS, CONTROL MATERIALS, AND DIRECTIONS FOR USE

Norway Rat

Norway Rat, *Rattus norvegicus*

Family: Muridae



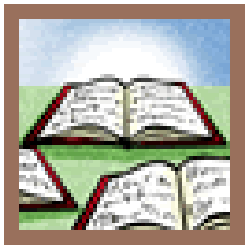


Introduction: Worldwide, rats are some of the most troublesome and damaging rodents. They consume and contaminate food, damage structures and property, and transmit parasites and diseases to other animals and humans. Rats live and thrive under a wide variety of climates and conditions; they are often found in and around homes and other buildings, farms, gardens, and open fields. Additionally, damage to livestock feed and agricultural crops can be extensive.

Often people do not see rats, but signs of their presence are easy to detect. In California the most troublesome rats are two introduced species: the roof rat and the Norway rat. It is important to know which species of rat is present in order to place traps or baits in the most effective locations.

Identification: Norway rats (*Rattus norvegicus*), sometimes called brown or sewer rats, are stocky burrowing rodents that are larger than roof rats. Their burrows are found along building foundations, beneath rubbish or woodpiles, and in moist areas in and around gardens and fields. Nests may be lined with shredded paper, cloth, or other fibrous material. When Norway rats invade buildings, they usually remain in the basement or ground floor. The Norway rat occurs throughout the 48 contiguous United States. Generally they are found at lower elevations but may occur wherever people live.

Table 1. Identifying Characteristics of Adult Rats.		
Characteristic	**Roof rat**	**Norway rat**
General appearance	sleek, agile	large, robust
color of belly	gray to white	mostly grayish
body weight	5 to 10 ounces	7 to 18 ounces
tail	extends at least to snout; black, fine scales	shorter than body; dark above; pale below; scales
head	muzzle pointed	muzzle blunt
ears	long enough to reach eyes if folded over	do not reach eyes



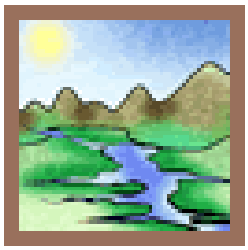
Legal Status: Norway rats are classified as nongame mammals by the California Fish and Game Code. Nongame mammals which are found to be injuring growing crops or other property may be taken at any time or in any manner by the owner or tenant of the premises. They may also be taken by officers or employees of the department of Food and Agriculture or by federal or county officers or employees when acting in their official capacities pursuant to the provisions of the Food and Agricultural Code pertaining to pests.

Damage: Rice, corn, melons, squash, asparagus, citrus, avocados, olives and nuts are among the crops damaged by Norway rats. Stored agricultural commodities may be consumed or contaminated by rat urine, hairs and feces, thus endangering human health and requiring stringent inspection procedures and preventive measures to exclude rats from warehouses and other food handling facilities. Rats may eat eggs and kill young birds on poultry farms as well as eating feed. Rats are hosts to the Trichinella worm. Humans may become infected with Trichinella if they eat poorly cooked pork after the hog has been eaten by an infected rat. Rat urine may transmit leptospirosis, and the feces may contain Salmonella bacteria. Bubonic plague and murine typhus fever may be transmitted by infected rat fleas. Rat bites may cause bacterial rat-bite fever or infection, as well as ugly scars.

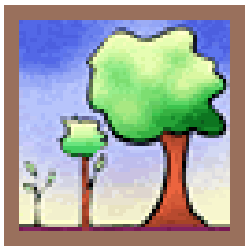
Rat gnawing causes spillage of feedstuffs and damage to woodwork and electrical wiring, resulting in shorted circuits and possibly in fires. Rats cut and shred clothing and other fabrics when making nests. And, rats may annoy or frighten some persons.

Range: Norway rats can be found throughout lowland California in urban and agricultural zones, except for arid desert areas.

Norway Rat



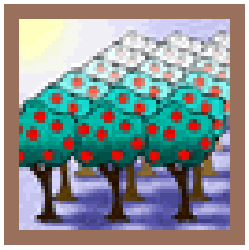
Habitat: Norway rats live in close association with people. In urban or suburban areas they live in or around warehouses, farm buildings, houses, irrigation dikes, sewers, rubbish dumps, wood piles, building foundations, ships. Norway rats are good climbers, but they are usually found within one story of ground level on multiple level buildings.



Biology: The Norway rat is a good digger and burrows along foundations of buildings, beneath rubbish piles and in fields. Rats are superb gnawers and can enter and live in most buildings. Norway rats are aggressive and will drive out roof rats from the lower floors of buildings. They will not hesitate at times to attack children, especially if provoked. Norway rats will fight viciously if cornered. Despite these traits, the Norway rat is colonial and gets along fairly well with other Norway rats though there is a definite "pecking order."

The tail of a Norway rat is shorter than its head and body combined. Norway rats have relatively poor vision but keen senses of smell, touch, taste, and hearing. The sense of touch is served by the long whiskers (vibrissae) on the snout. Domestic rats and mice run close beside a wall where these sensory hairs touch to give the animal information about its surroundings. The home range is frequently 100 to 150 feet. Norway rats and other domestic rodents are mainly nocturnal but they may come out in undisturbed places during the day. They feed on virtually anything edible and are vulnerable to predation by owls, hawks, weasels, and foxes.

Norway rats are prolific breeders, a fact which has made them useful, in their albino form, as the standard laboratory rat in biological experiments. The average length of life is about one year, and sexual maturity is attained in three to five months. The young average eight to ten per litter (extremes 2 to 22), and although 12 litters a year are possible, the average is four to seven per year. The gestation period is 21 to 22 days and the young may run about at three weeks of age. The average number of young weaned per year by a female in the wild is 20.



Damage Prevention and Control Methods

Rat Damage Indicators: Droppings can be found along 'runways' in feeding areas, and near shelter. They may be as large as ¾ inch long, and ¼ inch wide. Fresh droppings are soft in texture.

Tracks can include footprints or tail marks, and can often be seen on dusty surfaces or mud. Rats can be tracked by placing a small amount of flour in a patch across a suspected runway area overnight. The presence of tracks indicates rodents.

Urine both wet and dry will fluoresce under unltraviolet light. Urine stains may occur along travelways or in feeding areas.

Runs or burrows can be found next to walls, along fences, next to buildings, under bushes or debris. Rats memorize pathways and use the same routes habitually.

Smudge marks (rub marks) can occur on beams, rafters, pipes, and walls due to oil and dirt rubbing off a rats fur as it frequently travels routes.

Gnawing is a basic rat activity. One way rats keep their paired incisor teeth worn down is by gnawing on hard surfaces. Size of entry holes differ from mice, rat entry holes are often 2 inches whereas mice are slightly smaller. Rats can easily enlarge holes and cracks in wood and even concrete.

Rats can often be heard climbing in walls, gnawing, clawing, squeaking, and making fighting noises.

Exclusion: Physical barriers are an excellent way to prevent rats from gaining entry to structures where food and shelter are available.

Rats can be excluded by sealing all holes and openings larger than 1/2 inch. Use strong materials that will resist rodent gnawing; concrete mortar, galvanized sheet metal, steel wool, and heavy-gauge hardware cloth.

To prevent rodents from climbing or traveling along a particular route, install guards made of sheet metal or similar materials. Guards must be wide enough and positioned to keep rodents from reaching their outer margins by climbing or jumping. Exclusion with this method is quite difficult because of the rats climbing abilities.

Sheet metal band attached to a wall can sometimes prevent climbing by rodents. Rodent guards should be 12 inches to 18 inches wide. Inside buildings, such guards can prevent rats from climbing at corners. Guards also can be installed to prevent rodents from climbing the outside of buildings having rough exterior walls. When used in combination with hardware cloth or other suitable material, they can make a building essentially rodent-proof. This technique has been used to make corn cribs, barns, and other older buildings rat-proof. However, rats are quite ingenious and can sometimes find a foot hold and circumvent those types of barriers.

Habitat Modification: Good sanitation is an excellent way to minimize rat pest problems. The elimination of food and water through good building sanitation can do much towards reducing any type of rodent infestation. Proper garbage and refuse disposal containers along with an exterior sanitation program are also very helpful. Emphasis should be placed on the removal of as much harborage as is practical.

Poor sanitation is one of the basic reasons for the continued existence of moderate to high rat populations in urban and suburban areas. In agricultural environments, proper sanitation cannot always eliminate rat populations, but it can often prevent rats from flourishing in large numbers and can help detect their presence.

Sanitation involves good housekeeping, including proper storage and handling of food materials, feed and edible garbage. Warehouses, granaries and grain mills, silos, port facilities, and similar structures may provide excellent habitat for rats. Store bulk foods in rodent-proof containers or rooms. Stack sacked or boxed foods in orderly rows on pallets in a way that allows thorough inspection for evidence of rats. In such storage areas, keep stored materials away from walls. A 12-inch white band painted on the floor adjacent to the wall will aid in detecting rodent droppings and other rat sign. Sweep floors frequently to permit ready detection of fresh rat presence.

Pet food is a common source of food for rats in and around homes. Keep all such materials stored and subsequently removed for disposal. Proper refuse storage containers are heavy-duty, rust resistant, rat-and damage-resistant, and equipped with a tight-fitting lid. Sturdy vinyl or plastic containers are good but rats can gnaw into them. Racks or stands prevent corrosion or rusting of containers, reduce rat shelter under containers, and minimize the chance of containers being overturned.

Bulk storage containers for refuse, such as those used at apartments, businesses, and housing projects, should be similarly rodent-proof. Large metal refuse containers (dumpsters) sometimes have drain holes to facilitate cleaning. These drain holes should be fitted with a wire mesh screen or a removable plug; otherwise, the container becomes a hugh feeding station for rodents.

Sewers are inhabited by Norway rats in some towns and cities. Rats may enter at outlets and through manholes, catch basins, broken pipes, or drains. Since Norway rats are excellent swimmers, water traps do not impede their movement; in fact, they can travel upstream against a current. The problem of rats in sewers is usually greatest in places where sanitary sewers are interconnected with storm sewers, thus providing multiple entry points for rats. The domestic sewage of an average community provides enough food to sustain a large number of rats..

Regular removal of debris and control of weeds from around structures will reduce the amount of shelter available to rats. In some instances, a strip of heavy gravel placed adjacent to building foundations or other structures will reduce rat burrowing at these locations. Gravel should be at least 1 inch in diameter and laid in a band at least 2 feet wide and 1/2 foot deep. In any event, keeping the periphery of buildings and other structures clean of weeds and debris (including stacked lumber, firewood, and other stored materials) will discourage rat activity and will allow easier detection of rat presence.

Frightening: Rats are wary and frighten easily when they encounter unfamiliar sounds. However, most rodents, including rats, rapidly become accustomed to new sounds when heard repeatedly. Frightening devices may lead to temporary success, and rats may be repelled from an immediate area, but they will ultimately return and resume their normal activities.

Many commercially available devices produce ultrasonic sound to frighten, claiming it controls rodents. Research shows that rodents may be repelled temporarily from an immediate area, but will return and resume normal activities in the same way any new sound will affect the rodents. Ultrasonic devices are often expensive and their effectiveness is questionable. They are not recommended as a solution to rodent problems.

Fumigants: Fumigants (poisonous gases) are used to control rats in their burrows at outdoor locations. Compounds including aluminum phosphide and gas cartridges are registered for this purpose. The gas cartridge burns, producing carbon monoxide and other gases that suffocate rodents in their burrows.

Because most fumigants are highly toxic to humans and other animals, they should be used only by persons familiar with the necessary precautions. Do not use fumigants within 15 feet of an occupied building or in any situation that exposes the occupants of a building to the fumes. Only licensed structural pest control operators should use fumigants in buildings or other structures.

To fumigate rat burrows, close the burrow opening with soil or sod immediately after introduction of the fumigant. Rat burrows often have multiple entrances, and all openings must be sealed in order for fumigants to be effective. Fumigants are less effective in soils which are very porous or dry.

Repellents: None registered and not an effective method of rat control.

Toxic Bait

CDFA labels

2% Zinc Phosphide grain bait

0.005% Chlorophacinone grain bait

0.005% Diphacinone grain bait

0.005% Diphacinone Rodent Bait Block

Toxicants: for controlling rats are classified into two groups: anticoagulants and acutes.

Anticoagulants are a good bait material for controlling rats. They do not cause bait shyness, are easy to apply, and when used properly are relatively safe to use around humans, livestock, and pets.

Rats poisoned with anticoagulants die from internal bleeding; the result of the loss of the blood's clotting ability and damage to the capillaries. Most anticoagulants (except bromadiolone and brodifacoum) require multiple feedings over several days to cause death. Normally, low chronic doses are fatal. Feeding does not always have to be on consecutive days, where it is, death may occur as early as the third or fourth day. For optimal effect, several feedings should occur within a 10 day period no longer than 48 hours apart.

Norway rats are susceptible to all anticoagulants. However, anticoagulant resistance can occur from time to time within any population of Norway rats. Some individuals are always less susceptible to anticoagulants than others. Research indicates both in the USA and internationally that wherever anticoagulants have been used for long periods of time in one location there is an increased potential for some members of the rat

population to be resistant to the lethal effects of bait.

Resistance is often difficult to determine since documentation of resistance is not normally part of operational rat control programs.

If resistance is known to be present or suspected, second generation anticoagulants or non-anticoagulant type baits are the preferred method of control.

Resistance is only one possible reason for failure of anticoagulants. Care should be taken to ensure that one of the following reasons does not apply:

Where highly accepted baits fail:

- The period of bait exposure is to short, or bait has not been replenished.
- There are too few bait stations, or bait stations are to far apart.
- The control area for treatment is too small. This allows rats to move from untreated areas.
- Genetic resistance (see above). This is likely the case if the same amount of bait is taken daily for several weeks.

Where anticoagulant baits are poorly accepted:

- Poor bait choice may be the reason, or bait is improperly formulated. Other food choices may be preferred by the rats.
- Bait may be tainted e.g. moldy, rancid, or insect infested. Replace periodically.
- Improperly placed bait stations.

Non Anticoagulants: There are four non-anticoagulant rodenticides registered by the EPA for control of Norway rats: bromethalin, cholecalciferol (vitamin D_3), red squill, and zinc phosphide. However, only zinc phosphide is registered for agricultural use. All can be used for controlling anticoagulant-resistant populations of rats. Where rat numbers are large costs of baiting with non anticoagulants may reduce overall costs.

Bromethalin (Assault®, Vengeance®) is formulated in ready-to-use bait as a chronic rodenticide, applied so that rats will have the opportunity to feed on the bait one or more times over a period of one to several days. Because it is a slow-acting compared to zinc phosphide or red squill, bait shyness is not usually a problem, nor is prebaiting necessary to get good control in most situations.

Cholecalciferol (vitamin D_3, Quintox®) is similarly formulated in ready-to-use bait, serving as a chronic rodenticide. Death occurs 3 or 4 days after ingestion of a lethal dose. Because the toxicant is slow-acting, bait shyness is not reported to occur. It is claimed that rodents cease feeding once a lethal dose has been ingested.

Red squill is a selective and relatively safe toxicant for use only against Norway rats. It acts as an emetic, which provides some degree of protection to certain nontarget species that might accidentally consume the

bait. Rats, which cannot vomit, are unable to rid themselves of the toxicant once it is consumed. In the past, one problem was the variation in the quality of the material, which is derived from a plant. Red squill must be stored in a sealed container, as moisture will cause it to lose potency. Use for more than a few days at a time may result in bait shyness.

Zinc phosphide is a dark gray powder, insoluble in water that has been used extensively to control rodents. It is available in ready-to-use dry baits and also in concentrates to prepare fresh baits. Its strong garlic-like odor appears to be attractive to rodents that are not bait-shy.

Toxicants (for Norway and Roof Rats):
Anticoagulants -- % on bait for:

Spot baiting -- (Bait stations or stations, bait trays, and paraffin blocks):

0.005% (chlorophacinone, diphacinone).

Zinc phosphide -- % on bait for:

Spot baiting -- 2.00%

Directions for Use (with reference primarily to farms and other agricultural or field use)

Spot Baiting (non-anticoagulants): Follow bait label instructions carefully. Generally, place bait in each active burrow or scatter small amounts of bait in protected places frequented by rats, but inaccessible to livestock, poultry, wildlife and children. Whenever practical and if recommended on the label, prebaiting several days before applying acute or one-shot toxic bait will achieve better control and will give an indication of how much toxic bait to put out. Prebaiting should be conducted where natural food is abundant if possible.

Bait should be picked up and disposed of upon completion of rodent control program. Do not retreat with zinc phosphide baits for at least three months.

Anticoagulant Baits:
NOTE: A single feeding of second generation anticoagulant baits may be lethal to rats although these cannot be used in agricultural areas away from buildings. Baits of first generation anticoagulants must be eaten over a period of several days to give adequate control.

Place 4 to 16 ounces of bait in bait box or shallow container, preferably in protected feeder stations. Place bait stations in dry locations such as in concealed places, in corners, or along walls where rats feed, drink or frequent. Inspect stations daily and add bait as needed; increase the amount when bait in feeder is entirely consumed overnight. Replace moldy or old bait with fresh bait. An uninterrupted supply of bait should be maintained as long as any bait is taken which may be two to four weeks. Put bait at or near ground level and at burrows and harborages.

Where a continuous source of infestation is present, permanent bait stations should be established and the bait replenished as needed. Bait should be picked up and disposed of upon completion of rodent control program.

Paraffin bait blocks: Always follow label instruction and apply only where allowed. Cereal baits (diphacinone) embedded in paraffin are often used in sewers, outdoor placement or other excessively damp locations where unprotected bait would spoil rapidly. The bait blocks are reasonably weatherproof, eliminating the need for bait stations in some situations.

Paraffin bait blocks have been particularly valuable in orchard situations where the blocks can be fastened to a branch near the damage site. Be sure to secure them well so they don't fall and present a hazard to domestic animals. Check the product label to ensure this application method is allowed.

As old blocks are eaten away, replace with new ones. Bait should be picked up and disposed of upon completion of rodent control program.

Tracking Powder: Toxic dusts or powders have been used for many years to control rats and mice. When rats walk over a patch of toxic powder, they pick some of it up on their feet and fur and later ingest it while grooming. Tracking powders are useful in controlling rats where food is plentiful and good bait acceptance is difficult to achieve. Rats are more likely to ingest a lethal amount of a poorly-accepted toxicant applied by this method than if it is mixed into a bait material. There is little likelihood of toxicant shyness developing when using tracking powders.

Because the amount of material a rat may ingest while grooming is small, the concentration of active ingredient in tracking powders is considerably higher than in food baits which utilize the same toxicant. Therefore, these materials can be more hazardous than food baits. For the most part, tracking powders are used by professional pest control operators and others trained in rodent control. Tracking powders containing either single-dose poisons or anticoagulants are commercially available, although some are Restricted Use Pesticides.

Place tracking powders along runways, in walls, behind boards along walls, or on the floor of bait stations. Placement can be aided by using various types of sifters, shakers, or blowers. Dampness may cause the powder to cake and lose its effectiveness. Care must be taken to place tracking powders only where they cannot contaminate food or animal feed, or where not-target animals cannot come into contact with them. Do not place tracking powders where rats can track the material onto food intended for use by man or domestic animals. Because of potential hazards to children and pets, tracking powders are not generally recommended for use in and around homes. Where possible, remove tracking powder after the rodent control program is completed.

Baiting Techniques: All baits should be placed in travel ways or near rat burrows and harborage. Do not expect rats to go out of their way to find bait. Placing bait under cover may assist as rats will feel more secure while feeding. Bait placement for roof rats differs from Norway rats because the two species nest and find shelter in different areas. Roof rat bait should be placed in elevated locations such as in the crotch of a tree, on the top of a fence, or high in a vine. If bait is placed above ground level make sure it is securely fastened so that it will not fall where children or pets may find it.

Bait Stations: Bait stations or boxes limit poison bait exposure and are a safeguard for children, pets, and other animals. The stations should be large enough to accommodate several rats at a time, and should contain a self feeding hopper or bait compartment for holding bait. Each station should have two 2 inch (6.5cm) openings for rats. Commercially available bait stations are available either for rats or mice, and generally come in designs of plastic or metal. Self constructed bait stations are usually made of wood, and are hinged for ease of access, and have a clasp for locking to make them tamper resistant. An alternative to

wood is to use corrugated 4 inch drainage tubing for constructing a bait station.

All bait stations should be clearly labeled with the appropriate warnings. To ensure that bait station used indoors is tamper resistant, it should be secured to the wall, floor, rafter, or some other part of the structure so that it cannot be tipped over, spilling the bait. If used outdoors, away from a building, it should be securely staked to the ground or well anchored in a post or tree. When used outdoors, a bait station provides the additional advantage of keeping bait dry in inclement weather as well as safeguarding non target animals. When using bait stations, follow rodenticide label instructions carefully.

As with traps, bait stations must be placed where rodent sign is evident. Indoors, place them along walls, on rafters, within a cupboard, etc. Indoor baiting is not recommended as rodents may die in an inaccessible place, creating an unpleasant odor.

Non-anticoagulants: Follow bait label instructions carefully. Generally, and if recommended on the label if possible although these cannot be used in agricultural areas away from buildings. Always follow label instruction and apply only where allowed. often in some situations Check the product label to ensure this application method is allowed.

Trapping: Trapping can be an effective method of controlling rats, but it requires more skill and labor than most other methods. Trapping is recommended where poisons are inadvisable. It is the preferred method to try first in homes, garages, and other small structures where there may be only a few rats present.

Trapping has several advantages: 1) it does not rely on hazardous rodenticides; 2) it permits the user to view success; and 3) it allows for disposal of the rat carcasses, thereby eliminating odor problems from decomposing carcasses which may remain when poisoning is done within buildings.

The simple, inexpensive, wood-based snap trap is available in most hardware and farm supply stores. Traps should be baited with a small piece of hot dog, bacon, or nutmeat tied securely to the trigger. Gluing a piece of dry dog food to the trap can be quite effective. Peanut butter or marshmallows also may be used as bait. Baits that become stale lose their attractiveness.

Set traps close to walls, behind objects, in dark corners, and in places where rat activity is seen. Place the traps so that when rats follow their natural course of travel (usually close to a wall) they will pass directly over the trigger. Set traps so that the trigger is sensitive and will spring easily. When traps can be set in rats' runways or in travel routes, effectiveness can be increased by enlarging the trigger. This can be done with a square of cardboard, metal, or screen wire that fits just inside the wire deadfall.

Use enough traps to make the campaign short and decisive. Leaving traps unset until the bait has been taken at least once reduces the chance of rats escaping the trap and becoming trap-shy.

Other kinds of traps are also effective in catching rats. Wire-mesh cage traps such as the Tomahawk® and Havahart® can be used effectively to capture rats alive, although humane disposal is a problem. Wire funnel-entrance traps have also been used for this purpose.

Keep traps reasonably clean and in good working condition. When dirty, clean them in a hot detergent solution with a stiff brush. Human and dead-rat odors on traps do not reduce trapping success.

An alternative to traps are glue boards, which catch and hold rats attempting to cross them much the same way flypaper catches flies. Place glue boards wherever rats travel -- along walls, or in established pathways.

Do not use glue boards where children, pets, or wildlife can contact them. Glue boards lose their effectiveness in dusty areas unless covered, and temperature extremes may affect the tackiness of some glue. They are considered less effective for capturing rats than for mice. You can purchase ready-to-use glue boards, or you can buy glue to make your own boards or traps. Dispose of live trapped rodents in a humane manner; euthanize live, trapped rodents by asphyxiation with carbon dioxide, or use a stick to kill them with a sharp blow to the base of the skull.

Other: Rats may have an initial aversion to some odors and tastes, but no repellents have been found to repel them for more than short time, if at all.

Predators such as owls, foxes, skunks, raccoons, opossums, and snakes do feed on rats. Because. of the rats great reproductive potential, predators are usually unable to keep rat numbers below damaging levels.

Sometimes cats and dogs are good rat catchers, but generally enough rodents escape and thrive in their presence. In fact some studies suggest that owners of cats and dogs are more likely have rodents present, probably because of the availability of food i.e. pet food.

REFERENCES AND ADDITIONAL READING

Bourne, John B., 1998. Norway Rat Exclusion in Alberta, Proc. 18th Vertebrate Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 242-246.

Buckle, A.P., C.V. Prescott, K.J. Ward, 1994. Resistance to the First and Second Generation Anticoagulant Rodenticides—A New Perspective. Proc. 16th Vertebrate Pest Conf. (W.S. Halverson & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp.138-144.

Colvin, Bruce A., R. Degregorio, C Fleetwood, 1996. Norway Rat Infestation of Urban Landscaping and Preventive Design Criteria. Proc. 17th Vertebrate Pest Conf. (R.M. Timm & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 165-171.

Colvin, Bruce A., T.B. Swift, F.E. Fothergill, 1998. Control of Norway Rats In Sewer and Utility Systems Using Pulsed Baiting Methods. Proc. 18th Vertebrate Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 247-253.

Colvin, Bruce A., 2000. A Comprehensive Rodent Control Program for Washington, D.C. Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp. 339-345.

Colvin, Bruce A., 2002. Rodent Control as Part of Engineering and Construction Projects. Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp.46-52.

Corrigan, Robert M., C.A. Towell, R.E. Williams, 1992. Development of Rodent Control Technology for Confined Swine Facilities. Proc. 15th Vertebrate Pest Conf. (J.E. Borrecco & R. E. Marsh, Eds.) Published at Univ. of Calif., Davis. Pp. 280-285.

Corrigan, Robert M., 2004. An Overview of the Significance and Management of Vertebrate Pests around Zoological Parks. Proc. 21st Vertebrate Pest Conf. (R. M. Timm and W. P. Gorenzel, Eds.) Published at Univ. of Calif., Davis. Pp. 327-337.

Corrigan, Robert M., 2006. A Profile of the Norway Rat, *Rattus norvegicus*. In New York City: Its Impact on City Operations and the Need for Collaborative Interagency Rat Management Programs. Proc. 22nd Vertebrate Pest Conf. (R.M. Timm and J.M. O'Brien, Eds.) Published at Univ. of Calif., Davis. Pp. 131-141.

Doane, Becky, D. Blodget, B. Bonnivier, 1996. How to Control A Pest's Pest—Flea and Rodent Efficacy. Proc. 17th Vertebrate Pest Conf. (R.M. Timm & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 197-198.

Eisemann, John D., C.E. Swift, 2006. Ecological and Human Health Hazards from Broadcast Applications of 0.005% Diphacinone Rodenticide Baits in Native Hawaiian Ecosystems. Proc. 22nd Vertebrate Pest Conf. (R.M. Timm and J.M. O'Brien, Eds.) Published at Univ. of Calif., Davis. Pp. 413-433.

Frantz, Stephen C., C. Padula Madigan, 1998. Warfarin Resistance Revisited. Proc. 18th Vertebrate Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 276-280.

Harrison, Jr., Frederick J., 1996. Managing Plague in Endangered Species Habitats. Proc. 17th Vertebrate Pest Conf. (R.M. Timm & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 230-233.

Hueth, Brent, D.Cohen, D. Zilberman, 1998. Non-Predator Vertebrate Pest Damage in California Agriculture: An Assessment of Economic Impacts in Selected Crops. Proc. 18th Vertebrate Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 371-377.

Jacob, Jens, P.R. Brown, K.P. Aplin, G.R. Singleton, 2002. Ecologically-Based Management of Pest Rodents in Rice-Based Agro-Ecosystems in Southeast Asia. Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp. 67-74.

Jacobs, William W., 1990. Required Use of Protective Bait Stations in the U.S. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp. 36-42.

Kaukeinen, Dale E., A.P. Buckle, 1992. Evaluations of Aversive Agents to Increase the Selectivity of Rodenticides, With Emphasis On Denatonium Benzoate (Bitrex) Bittering Agent. Proc. 15th Vertebrate Pest Conf. (J.E. Borrecco & R. E. Marsh, Eds.) Published at Univ. of Calif., Davis. Pp.192-198.

Kaukeinen, D.E., C.W. Spragins, J.F. Hobson, 2000. Risk-Benefit Consideration in Evaluating Commensal Anticoagulant Rodenticides Impacts to Wildlife. Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp. 245-256.

Key, Gillian, K. Hudson, 2000. The Rat Control Program on the Island of St. Helena. Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp. 133-138.

Mach, Jeff J., 2004. Investigations of Commensal Rodenticide Bait against Wild Norway Rats Plus Additional Toxicology Data of Warfarin on Laboratory Norway Rats and House Mice Proc. 21st Vertebrate Pest Conf. (R.M. Timm and W.P. Gorenzel, Eds.) Published at Univ. of Calif., Davis. Pp. 140-144.

MacNicoll, Alan D., G.M. Kerins, N.J. Dennis, J.E. Gill, 1996. The Distribution and Significance of Anticoagulant-Resistant Norway Rats (*Rattus norvegicus*) In England and Wales, 1988-95. Proc. 17th Vertebrate Pest Conf. (R.M. Timm & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp.179-185.
Marshall, Edward F., 1992. The Effectiveness of Difethialone (LM 2219) for Controlling Norway Rats And House Mice Under Field Conditions. Proc. 15th Vertebrate Pest Conf. (J.E. Borrecco & R. E. Marsh, Eds.) Published at Univ. of Calif., Davis. Pp. 171-174.

Miller, Lowell A., K.A. Fagerstone, 2000. Induced Infertility As A Wildlife Management Tool. Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp. 160-168.

Poche, Richard M., 1998. Recent Norway Rats Studies Using Warfarin. Proc. 18th Vertebrate Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 254-261.
Prescott, C.V., M. El-Amin, R.H. Smith, 1992. Calciferols and bait Shyness in the Laboratory Rat. Proc. 15th Vertebrate Pest Conf. (J.E. Borrecco & R. E. Marsh, Eds.) Published at Univ. of Calif., Davis. Pp. 218-223.

Quy, Roger J., D.P. Cowan, C. Morgan, T. Swinney, 1996. Palatability of Rodenticide Baits in Relation to Their Effectiveness Against Farm Populations of the Norway Rat. Proc. 17th Vertebrate Pest Conf. (R.M. Timm & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 133-138.

Quy, Roger J., A.D. MacNicoll, D.P. Cowan. 1998. Control of Rats Resistance to Second-Generation Anticoagulant Rodenticides. Proc. 18th Vertebrate Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 262-267.

Ramey, Craig A., E.W. Schafer, Jr., 1996. The Evolution of Aphis Two Gas Cartridges. Proc. 17th Vertebrate Pest Conf. (R.M. Timm & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 219-224.

Silberhorn, Eric M., J.F. Hobson, G.H. Miller, N.J. Condos, 2000. U.S. EPA Reregistration Eligibility Decision (Red) for the Rodenticide Cluster: Overview of the Regulatory Process, Response of Registrants and Stakeholders, and Implications for Agricultural and Urban Rodent Control. Proc. 20th Vertebrate Pest Conf. (R.M. Timm and R.H. Schmidt, Eds.) Published at Univ. of Calif., Davis. Pp. 268-276.

Tobin, Mark E., R.T. Sugihara, A.K. Ota, 1990. Rodent Damage to Hawaiian Sugarcane. Proc.14th Vertebrate Pest Conf. (L.R. Davis and R.E. Marsh, Eds.) Published at Univ. of Calif., Davis Pp. 120-123.

Tobin, Mark E., R.T. Sugihara, R.M. Engeman, 1994. Effects of Initial Rat Capture on Subsequent Capture Success Of Traps. Proc. 16th Vertebrate Pest Conf. (W.S. Halverson & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 101-105.

Von Wahlde, Matt, B.A. Colvin, 1994. Using Geographical Information Systems for Tracking an Urban Rodent Control Program. Proc. 16th Vertebrate Pest Conf. (W.S. Halverson & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 327-334.

Witmer, Gary W., H. Martins, L. Flor, 2004. Leptospirosis in the Azores: the Rodent Connection. Proc. 21st Vertebrate Pest Conf. (R.M. Timm and W.P. Gorenzel, Eds.) Published at Univ. of Calif., Davis. Pp. 217-220.

Witmer,, Gary W., E.W. Campbell III, F.Boyd, 1998. Rat Management For Endangered Species Protected in the U.S. Virgin Islands. Proc. 18th Vertebrate Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. Pp. 281-286.