TROL OF Destructive Mice

CONSERVATION BULLETIN NO. 36

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Fish and Wildlife Service

FIVE GROUPS of mice in the United States destroy fruit and timber trees, growing crops, and stored foods. These are the meadow, pine, white-footed, pocket, and house mice. The losses they cause to orchardists, foresters, farmers, nurserymen, and householders amount to millions of dollars annually. Much of this can be avoided. This bulletin contains information on the natural history and habits of these mice and describes methods of control. It supersedes Farmers' Bulletin 1397, Mouse Control in Field and Orchard, and supplements Technical Bulletin 608, Pocket Mice of Washington and Oregon in Relation to Agriculture, both of the United States Department of Agriculture.

CONTROL OF DESTRUCTIVE MICE

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INTRODUCTION

TO the orchardist who has taken good care of his trees until they have reached the age of profitable bearing, nothing can be more discouraging than to see them wither and die under the ravages of the meadow or the pine mice. Nevertheless, throughout the United States thousands of valuable fruit and timber trees, both young and mature, are thus killed every year. These mice damage not only orchards and timber plantations, but also pasturage, alfalfa, tubers, small fruits, flowering plants, and shrubbery. These and other groups of mice cause losses amounting to millions of dollars annually. Included among these destructive mice are the white-footed mouse, which feeds on conifer seeds in logged-over areas and hinders natural reproduction; the pocket mouse, which destroys growing and mature grains and range forage; and the common house mouse, which also feeds on grains and on stored foodstuffs in dwellings and storage places.

For the past several years it has been the general practice to apply the term "field mouse" to the widely known meadow mouse (*Microtus*) and to the pine mouse (*Pitymys*). This is somewhat misleading, for the pocket mouse (*Perognathus*), the white-footed mouse (*Peromyscus*), the house mouse (*Mus*), and occasionally other less common species also injure field crops. The damage to field crops and seeds inflicted by the last-mentioned three forms, which belong to the long-tailed group of mice, is confined to limited areas, whereas the depredations of meadow mice, particularly, and of pine mice, belonging to the short-tailed group, are widely distributed throughout the United States.

In many localities farmers, foresters, and fruit growers must carry on continuous control operations against these species in order to prevent ruinous losses of crops and trees. Information on methods of control is, therefore, vitally important.

MEADOW MOUSE AND PINE MOUSE

Description and Habits

Although the meadow mouse (*Microtus*) and the pine mouse (*Pitymys*) are closely related, their habits differ considerably, and as these have a distinct bearing on control practices, it is important to be able to distinguish the groups. The range of the common meadow mouse and its allies includes almost the whole of North America, but that of the pine mouse is restricted to the eastern half of the United States, from the Atlantic coast to eastern Kansas and Nebraska, and from the Gulf of Mexico to the Great Lakes. The two types may be readily distinguished by their appearance (fig. 1), by the nature of their burrows, and by the kind of injury done.

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Figure 1.—*Above*, pine mouse; *below*, meadow mouse.

The mice of both of these groups are blocky little animals with relatively coarse fur, usually dark brown in color, and with small, beady black eyes and almost concealed ears. The pine mouse, however, is somewhat the smaller, its fur is less shaggy and more reddish brown, and its tail is short, being approximately the same length as the hind foot. The tail of the meadow mouse, on the other hand, is usually nearly twice as long. The average weight of meadow mice is 35 grams (1¼ ounces) and that of pine mice 25 grams (approximately 1 ounce), the females of each species weighing slightly less than the males.

Meadow mice are very prolific and under favorable conditions produce several litters of young a year. Hamilton (1941)[1] says "it is probable in 'mouse years' that there are 8 to 10 litters per year while in years of scarcity only 5 to 6 litters." The number of young in a litter varies from 1 to 11, the average being 5. The size of the litter fluctuates with the population level of the mice, large litters predominating when mice are becoming abundant. Pine mice are less prolific; although they also may produce several litters a year, these number only 1 to 4 young each.

When born, meadow mice are pink and hairless, and their eyes and ears are closed. After a day or two, they commence to grow rapidly. The eyes and the pinna of the ears open on the eighth day. The young mice begin to feed on vegetation about the ninth day and are weaned before they are 2 weeks old. They remain, however, with the mother several days longer and are likely to stay around the parental home until abandoned by their mother when they are about 3 weeks old. They attain adult size at about 2 months of age, but usually reach sexual maturity within 5 to 6 weeks.

According to Hamilton (1938), pine mice at birth are almost exactly like young meadow mice, except that they are somewhat duller in color on the back, which indicates the appearance of the first hair. By the seventh day the head and back are covered with lead-colored fur, and two days later the belly is well furred, but a little lighter in color. The young are crawling about actively by the ninth day, but they are very quiet in contrast to the noisy young meadow mice. The eyes of some open on the ninth day and by the fourteenth the eyes of all the young of the litter are open. On the sixteenth day the young mice begin to eat solid food and are generally weaned by the seventeenth. About the twenty-sixth day the chestnut color of the adult is first noticeable. The pine mice attain adult size and color at about 2½ months of age. They are about 2 weeks longer than the meadow mice in reaching maturity.

Both meadow mice and pine mice are active throughout the year, although the former are more restricted in movements during the winter and the latter are probably less in evidence during dry hot weather. The outstanding difference in the habits of these two mice is that the pine mouse is a burrowing animal, living and feeding very largely under ground, whereas the meadow mouse, although constructing shallow tunnels and nesting chambers under ground, feeds mostly on the surface. Usually the burrows of the pine mouse may be detected only through the occasional small openings reaching the surface of the ground, but the well known surface runways of the meadow mouse are clearly visible.

Because of these different habits, the greater part of the injury to trees and other vegetation by the meadow mouse is inflicted above the

[1] Publications referred to parenthetically by date are listed in the Bibliography, p. 37.

ground, and that by the pine mouse below the surface, where, in the case of crops, it often remains unsuspected until harvest, or in orchards, until the foliage of the undernourished, girdled trees begins to wilt. Meadow mice occasionally girdle the trunk of a tree below the surface of the ground, but they seldom continue to remove the bark from the roots as pine mice do. Deep snow and lack of clean cultivation enable meadow mice to work above the ground level without fear of detection.

The reason that it is important to orchardists to distinguish between the two mice is that mechanical protectors and clean cultivation around trees, which are successful aids in controlling damage by meadow mice, have little effect on pine mice, which do not rely on surface vegetation for food or protection. A knowledge of the habits of pine mice is also useful to truck gardeners, florists, and others engaged in cultivating plants, who frequently ascribe the damage done by these mice to moles and attempt, without success, to stop the depredations by use of mole traps.

Damage to Trees and Crops

The injuries inflicted by meadow and pine mice vary greatly from year to year, depending on the abundance of the rodents, the nature and extent of their food supply, and weather conditions. The fluctuation in the numbers of the mice is continual, irregular, and abrupt, owing to the varying birth rate, disease, abundance or scarcity of food, and the extent to which the rodents are preyed upon by their enemies among wild birds, mammals, and snakes. Thus, the mere presence of these mice is a menace requiring continuous close observation. Even relatively little gnawing may greatly damage fruit trees if it occurs at vital points.

As a rule, the greatest injury to trees is inflicted during winter under cover of snow. Damage is usually more severe, therefore, during a hard winter with deep snow than during a mild one. The rule is not invariable, however, as severe injury has been recorded at all seasons and under a great variety of conditions. In a large Kansas orchard 5,000 trees were girdled before the middle of December during a mild, open winter when there was an abundance of grain and grass in the fields. During the dry fall of 1920 orchardists in California suffered heavy losses through meadow mice; in one orange grove alone 1,300 trees were destroyed.

The kinds of crops injured by field mice are practically without limit, but orchard trees, nursery stock, small fruits, and shrubbery probably suffer the most damage. The mice show little discrimination in attacking fruit trees, although they appear to have a mild preference for the bark of apple trees and an aversion to that of cherry trees. Meadow and pine mice destroyed nearly 60 percent of an orchard of 9-year-old apple trees in Connecticut, and 20 percent of a plantation of young peach trees in Delaware. In another orchard in Connecticut these rodents killed 2,000 of the 3,000 pear trees. An investigation of the damage done by these mice in a New York State park revealed serious injury to young hardwood trees and the complete girdling of more than a thousand 6-year-old Scotch pines in a 5-acre block. In forest nurseries meadow mice may eat the planted seeds or cut off the young seedlings after they appear above the surface of the ground.

The bark of the younger trees is preferred by the mice, but no tree is immune from their depredations when food is scarce. In a large orchard near Charleston, W. Va., more than 1,000 trees, all of which were 18 years old, were killed by pine mice. A loss of $10,000 worth

of trees through mouse injury was sustained in an orchard near New York City. Among these trees were a number of 50-year-old ones that were completely girdled, showing that even trees of that age are not immune to injury by mice.

Damage to farm crops other than fruits is very common, but is less spectacular, except when the mice are present in plague numbers. Although no general survey of this type of injury has been made recently, many cases of severe damage are on record. Root crops, tubers, and bulbs are very attractive to mice, particularly to pine mice, and losses often approach in severity those caused by injury to fruit trees. Mice are fond of clover and alfalfa also, and the aggregate annual loss from inroads on these crops is considerable. Cereals are damaged most heavily in the shock, but are subject to attack at all times. To make a close estimate of the average annual loss from these mice in the United States is impossible, but undoubtedly it runs into millions of dollars.

Determining Abundance of Mice

The meadow mice fluctuate in numbers markedly from year to year. They may increase gradually over a period of 3 to 5 years from a few breeding pairs to 100 to 200 mice to the acre, and then abruptly become scarce because of disease, insufficient food, or adverse weather conditions. A yearly survey of mouse abundance should be made so that increased precautions can be taken during the period of their greatest abundance to protect in the heavily infested areas the trees and plants that might not otherwise escape the keen appetites of these small rodents. Even in years of a generally low population some local condition may cause the meadow mice to feed on the bark of fruit trees. The mice may be scarce in the orchard as a whole, and yet be concentrated in some low, moist spot within it in sufficient numbers to constitute a menace to the fruit trees in and bordering the heavily infested area.

Although damage to fruit trees by mice is more likely to occur during the winter, many instances are on record of serious tree losses incurred in midsummer and early fall. Orchards and adjoining lands should be inspected carefully late in summer to determine the degree of mouse infestation and what methods of control, if any, should be adopted. These simple practices should be followed: (1) When mowing late in the summer, watch for evidences of short-tailed mice; (2) while gathering windfall apples, mark those trees under which mouse-nibbled apples are found; (3) if hawks are seen circling over the orchard, if skunk and fox diggings are noted, or if the dog or the cat is observed catching mice, look for evidence of the presence of these rodents; (4) since the tree-girdling mice are the only real trail builders, search for their runways hidden under hay mulch and rank vegetation; (5) if the soil is a sandy loam, note whether the ground is spongy underfoot, an indication of mole and pine mouse activity; and (6) if the trees appear to be suffering from disease, insect infestation, or some unfavorable condition of soil during the growing season, look for root injury from mouse girdling.

When the presence of mice has been determined, immediate measures should be taken for their control. Wire trunk guards, repellent paints, and graveled tree bases aid in protecting fruit and other trees from damage by meadow mice, but these have little effect in preventing injury by pine mice. The only effective methods of controlling pine mice are trapping and poisoning. The proper time for poisoning oper-

ations against meadow mice is late in the fall after the fruit crop has been harvested and windfalls have been removed from the ground beneath the trees. Extensive poisoning activities late in spring and in the summer are not recommended because of the wide shifting of the meadow mouse population at that time. Extensive control operations are not recommended for pine mice in summer.

Methods of Control

The Bureau of Biological Survey, now part of the Fish and Wildlife Service, made a detailed study of the meadow and the pine mice in Virginia in 1934–35 and in the New England States in 1936–38. During these investigations the control methods herein recommended were developed, thoroughly tested, and introduced to orchardists in the apple-growing sections.

CULTURAL PRACTICES

Tree-girdling mice may be eliminated from an area by continuous clean cultivation. This is often a poor cultural practice, however, because it destroys soil humus, hastens erosion, and exposes the fruit crop to damage by drought. The numbers of meadow mice can be reduced to the minimum in a grassy orchard by keeping the cover

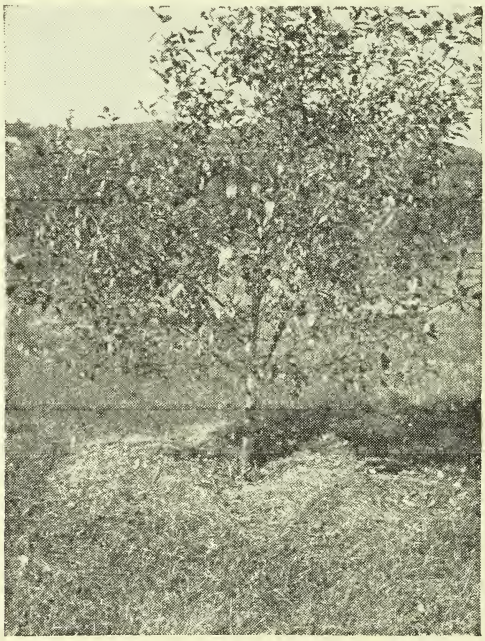

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Figure 2.—Mulch of hay about tree base under which the mice may make trails.

low through repeated mowing. Even where it is advisable to put a mulch of hay about the bases of the trees (fig. 2), the mouse population can be kept in check by breaking the continuity of cover by close-mowing during the growing season and by disking late in the fall. Rough orchard terrain favors mouse concentrations by making close mowing difficult (fig. 3). So far as possible the orchard should be free of terraces, mounded tree bases, ruts and furrows left by heavy spray

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Figure 3.—Orchard showing improper cultivation and mowing in tree rows, which allow cover for mice in the tall grass and furrows for runways along the edges of the mounded tree rows.

equipment, rock outcrops, and holes left by removal of trees. Seepage or marsh areas within or adjacent to an orchard serve as reservoirs for mouse concentrations (fig. 4). These should be drained or filled. Bordering fence rows should be kept free of tall vegetation and rubbish to eliminate harborage.

Meadow mice are most active during daylight hours. They are un-

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Figure 4.—A luxuriant grassy meadow within an orchard, which makes an excellent habitat for meadow mice and serves as a reservoir for mice that may attack the fruit trees.

observed because they conceal their runways beneath rank grass and vegetation and avoid the open. Hence the removal in summer of all vegetation within a radius of 1 or 2 feet from the trunk of a fruit tree gives good protection, since the feeding mice shun exposed places. To avoid repeated grubbing about the base of each fruit tree every season, many orchardists prefer to remove a certain amount of soil and replace it with coarse gravel or cinders. This prevents the growth of vegetation and interferes somewhat with shallow burrowing. If this practice is adopted, care should be taken to see that water pockets are not formed at the base of trees as these might be injurious to tree growth and production. A blanket of snow during the winter affords cover under which a meadow mouse can reach the tree and inflict damage.

WIRE TREE GUARDS

Instead of maintaining clear spots about the bases of trees, many orchardists prefer to encircle the trunks with wire netting (fig. 5). The

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Figure 5.—Tree guard of ¼-inch mesh galvanized hardware cloth for protecting tree from mice and rabbits. Note that area surrounding trunk is cleared of shelter.

best material for this purpose is ¼-inch mesh galvanized hardware cloth. The wire guard should be well seated 3 or 4 inches in the ground and should extend about 18 inches above the surface. The distance above the ground should be governed by local conditions, including the height of vegetation and the depth of snow. The guard should be loose enough to allow for tree growth, adjustments being made from year to year. Such tree guards, however, are ineffective against the underground work of pine mice. During an open winter even meadow mice may inflict serious injury by burrowing beneath the wire guards (fig. 6). Mice frequently burrow into the ground as much as 10 feet from the trunk of a tree and, finding a root, follow it to the crown of the tree. There are many records of mice tunneling through drifted snow to positions above the wire guard to girdle the tree.

Preventing damage to trees is preferable to applying remedies, but prevention is not always possible. When mouse damage occurs in orchards, great losses may often be averted by prompt treatment of

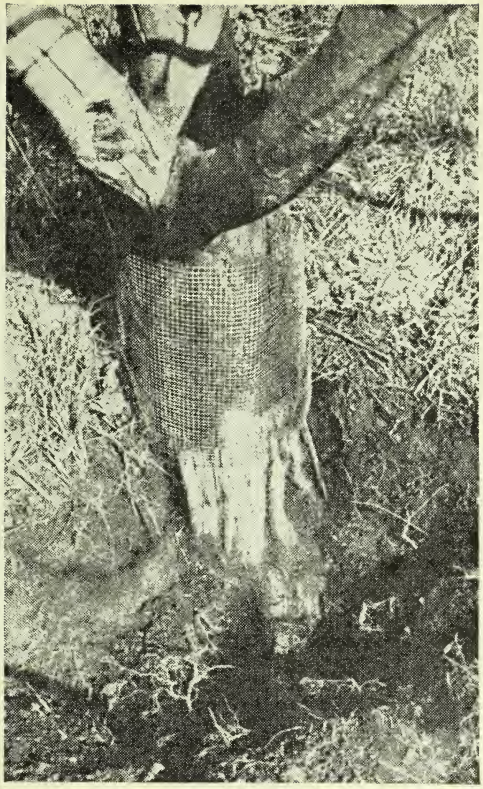

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Figure 6.—Damage to tree by meadow mice that burrowed beneath the wire tree guard.

the injured trees. Trees slightly damaged by field mice will usually recover if the injured parts are completely covered by mounding up soil around the bases of the trees or if paint or other material is applied to the wounded parts to retard drying. If the injury is severe or the trees are completely girdled, bridge grafting[2] will be necessary. After the severe mouse outbreak of 1919-20 in Massachusetts, a number of fruit specialists of the State Agricultural College directed the successful bridge grafting of 13,000 trees valued at $90,000.

NATURAL ENEMIES

The removal of tree-girdling mice from the orchard during the fall and winter is the only means of affording complete protection. Through the work of predators and by the use of traps and economical rodenticides, mouse control by reduction of numbers is practicable and necessary in orchards where cover crops are maintained.

A number of mammals and birds prey upon meadow and pine mice. Chief among these are skunks, foxes, hawks, owls, dogs, and cats (fig. 7). They cannot be depended on to keep an orchard free of mice, but they help to reduce the mouse population and consequently orchardists should extend them protection and encouragement if they do not otherwise constitute a pest problem in the locality.

[2] Information on this subject is contained in the following publication: Yerkes, Guy E. Bridge Grafting. U. S. Dept. Agr. Farmers' Bulletin 1369, 20 pp., illus. 1923.

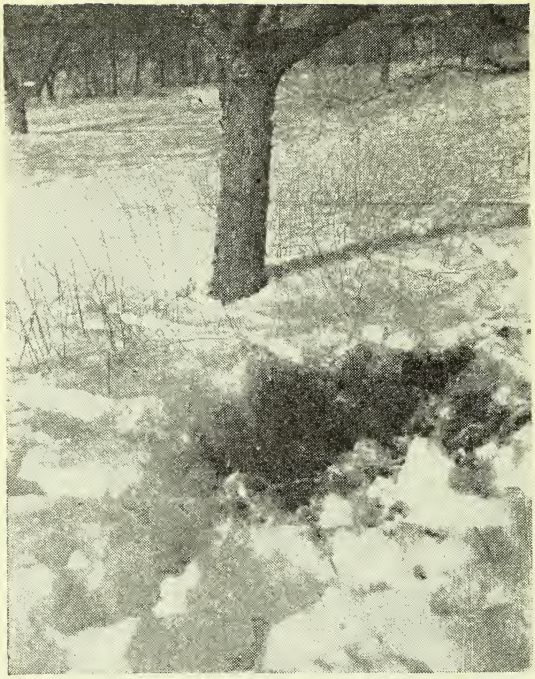

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Figure 7.—Work of a fox or skunk that through the snow detected a meadow mouse nest and dug it out.

TRAPPING

Meadow and pine mice are easily trapped in small wooden-based snap traps. These should be set in the runways and at right angles to them so that a mouse in following its usual route will pass directly over the trigger. Near the entrances to burrows is a good location for traps. For best results the trap should be baited with oatmeal, apples, or vegetables, but mice can be caught in an unbaited trap if it is properly set in a runway. For convenience in finding a trap, it is well to mark the site with a bit of cotton twisted on a nearby weed or twig or on a stick stuck into the ground. The traps should be examined and reset twice daily.

POISONING

The most effective and least expensive way of controlling meadow and pine mice is the use of poisoned baits. Formulas for preparing the baits and methods of distributing them have been developed that will give good results if carefully followed. Although the effectiveness of baits varies in different localities, it has been shown that even under some unfavorable local conditions the proper application of well prepared poisoned baits will destroy a sufficient number of the mice to insure satisfactory protection to trees and crops. In many cases nearly all the mice may be killed.

Cooperators of the Fish and Wildlife Service have established bait-mixing plants to facilitate the preparation and distribution of poisoned bait for use against these mice. Information on how to procure mixed bait can be obtained from the Fish and Wildlife Service, Chicago, Ill., or from its several field offices.

There are three practical toxic chemicals, differing in degree of acceptance and effectiveness, that may be used for controlling mice. Zinc phosphide, recently developed as a rodent poison, has proved to give best results. It is highly toxic to the mice and is readily taken. Most phosphide compounds deteriorate rapidly on exposure to the air, but this one retains its toxicity for 3 weeks or more after exposure on dry bait material. On moist bait it loses its toxicity more rapidly, but even so its toxic period is sufficiently long to make the bait effective. Zinc phosphide is insoluble in water but slightly soluble in fats and oils. Hence oils may be used in the formulas.

To reduce the concentration of zinc phosphide and increase the volume of the toxic material (rodenticide) so as to obtain a more uniform distribution of the poison on bait materials, one part by weight of finely powdered magnesium carbonate is thoroughly blended with two parts of zinc phosphide. One-half ounce (15 grams) of the blended material, hereafter referred to as zinc phosphide rodenticide, is sufficient for 10 quarts of apple cubes or 3 quarts of steamed rolled oats.

When finely pulverized (micro-sized) arsenic trioxide is available, it may be used in the same manner as zinc phosphide. It does not deteriorate as does the zinc phosphide, nor does it give as effective results, but it may be used as a substitute.

Strychnine alkaloid is an efficacious poison, but its bitterness and its initial physiological action in cramping the muscles may cause the mice to fail to eat enough at one time to be fatal. In western States where the mice are accustomed to feeding on grains, strychnine placed on oat baits often produces satisfactory results.

There are four preferable bait materials that are acceptable to meadow and pine mice—fruits, vegetables, grains, and seeds. Of the fruits the apple is best; of the vegetables, sweetpotato or carrot; and of the grains and seeds, oats. Apples cut into half-inch cubes without peeling or coring constitute the most economical and efficient bait material for use in an apple orchard. Cull fruit of the firmer or winter varieties should be used because they do not bruise and discolor in preparation and handling as readily as do the softer apples. Each quart of apple cubes so cut will number approximately 125 pieces. These apple baits should be prepared fresh each day, and only one cube should be placed at a bait spot. Vegetable baits are made in the same way as those of apples.

If the windfalls have not been gathered from the ground before the poisoned baits are exposed, satisfactory results may not be obtained with the fresh fruit bait alone. Under such conditions it is advisable to place a grain bait along with it, as the effectiveness of each is impaired by the presence of windfall fruit. Together they produce fairly successful results though not as good as they would if there were no windfalls on the ground. Oats of a good grade should be used, and these should be steam rolled in order to spread the hull and expose the edible kernel so that the poison will adhere to it. Clean poultry-rolled oats or breakfast-rolled oats may also be used, but they should be mixed carefully or the kernels will be crumbled and much of the poison lost.

For preparing a small quantity of poisoned bait for immediate use, the following fresh apple bait formula will prove satisfactory:

Fresh Apple and Zinc Phosphide Bait

(Formula 1)

Fresh apple cubes.....1 quart.
Zinc phosphide rodenticide.....1 level teaspoonful (1.5 grams).

Put the apple cubes in an enamel pan and sift the poison over them, stirring constantly with a paddle to insure even distribution.

For poisoned bait material that can be made in quantity and stored for future use, the following grain bait formulas are recommended:

Steamed-rolled Oats and Zinc Phosphide Bait

(Formula 2)

Steamed-rolled oats	98 pounds.
Amber petroleum jelly	10 ounces.
Mineral oil	10 ounces.
Zinc phosphide	1 pound.

Warm the mineral oil and the petroleum jelly together until they are fluid but not hot. Add the zinc phosphide to this mixture and stir briskly to suspend the poison. Pour the suspension over the oats in an open box or mechanical mixer and mix thoroughly until the grains are evenly coated. The poisoned grain may then be sacked immediately.

Steamed-rolled Oats and Strychnine Alkaloid Bait

(Formula 3)

Steamed-rolled oats	12 pounds.
Powdered strychnine alkaloid	1 ounce.
Baking soda	1 ounce.
Gloss starch	¾ ounce.
Water	1 pint.
Heavy corn sirup	¼ pint.
Glycerine or petrolatum	1 tablespoonful.

Mix the starch with ¼ teacupful of cold water, stir it into ¾ pint of boiling water, and cook until it forms a thin clear paste. Mix the strychnine with the baking soda, add to the starch paste, and stir until it is free of lumps. Add the heavy corn sirup and the glycerine or petrolatum. Pour mixture over the oats and stir thoroughly until each kernel is uniformly coated. Allow bait to dry before sacking it.

The strychnine formula is recommended for use only in localities where the mice will readily take grain bait, usually in areas where grains are grown extensively.

Meadow mice are trail makers. Their trails in orchards may be found in tall grass (fig. 8), under mulch, in ruts, and along furrows.

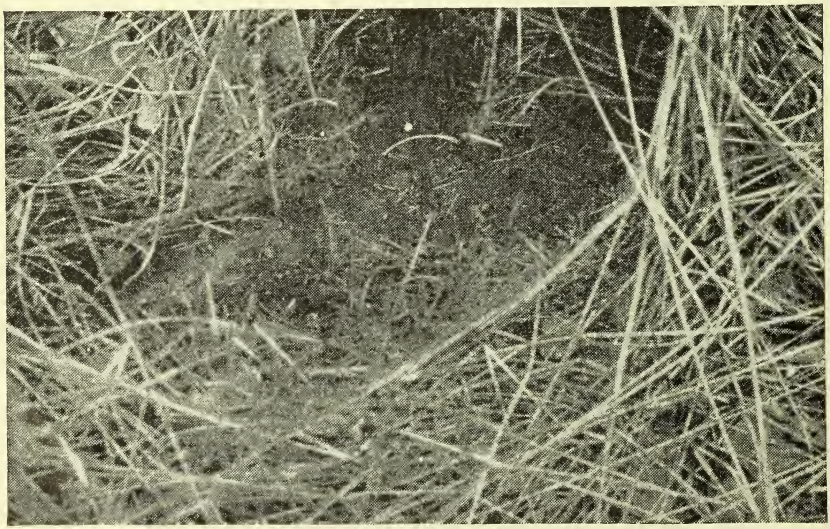

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Figure 8.—A characteristic meadow mouse trail beneath heavy grass.

Whether a runway is in use can generally be determined by its appearance and by the presence of freshly cut short pieces of grass stems or of fresh droppings on the trail floor. Poisoned baits should be placed directly on the floor of used trails and covered with a handful of grass or other litter. Baits not placed in trails are usually wasted. If no used runways are discovered late in the fall under rank grass, mulch, or the baiting-station covering described later in this bulletin, it can safely be assumed that no tree-girdling mice are present and no poisoned bait need be exposed.

In areas in which only pine mice or pine mice and moles, but no meadow mice, occur, there may be few or no trails on the surface of the ground. This is often the case in sandy loam soil. The presence of mice is indicated by small open holes about 1 inch in diameter. Poisoned baits may be dropped into these holes. The orchard should be thoroughly baited, care being taken to see that both the surface trails and the deeper pine mouse burrows are treated. Control depends as much on complete coverage of all mouse-infested sites within the orchard as on the effectiveness of the poisoned bait. Baits should be placed at all rock outcrops, along stone walls and drainage ditch banks, and in meadow areas within the orchard, as well as at the base of each tree where mouse trails or holes are found.

If there is windfall fruit on the ground at the time of baiting, expose in the same trails both a grain bait and an apple bait that have been treated with the same kind of poison. Better results will be obtained by using both kinds of baits than by exposing either alone when windfalls are present.

CAUTION: Whenever exposing a poisonous bait, be sure to place over it some kind of cover. This is very important.

The distribution of poisonous baits in an orchard may be greatly simplified by establishing baiting stations, as they tend to attract the mice. Stations, which may be used for both meadow and pine mice, may consist of forkfuls of hay or mulch, small bundles of cornstalks, empty fertilizer bags, or box tops placed in carefully selected spots in the grass-covered areas late in the summer (fig. 9). Because these offer better cover than the surrounding area, mice will soon extend their trails under them, often building nests and winter quarters there. Depending on the degree of infestation, 3 to 5 such stations should be placed under each infested tree or, at least, one to each 10-foot-square area. They should be located at intervals of 20 feet along drainage ditch banks and in meadow, or open and rough, areas covered with vegetation within the orchard, and along the side of rock outcrops, stone walls, and brush areas within or adjacent to the orchard. The establishing of stations in the orchard and in other areas to be treated is the first step in this method of exposing bait and should be done 2 weeks or more before the control operations proper are to start.

Most orchardists may prefer to use hay to cover baiting stations, as it will rot before it is necessary to mow or disk the orchard the following spring. Such hay stations need not be regularly spaced or formed. At the time a grassy orchard is mowed for the last time in summer, the board back of the sickle bar of the mowing machine can be so set that the grass will fall in irregular clumps behind the machine. In this way baiting stations are formed without an extra operation. It is also practicable to make small haycocks while hand-mowing around young trees.

Stations serve a threefold purpose: They simplify the work of search-

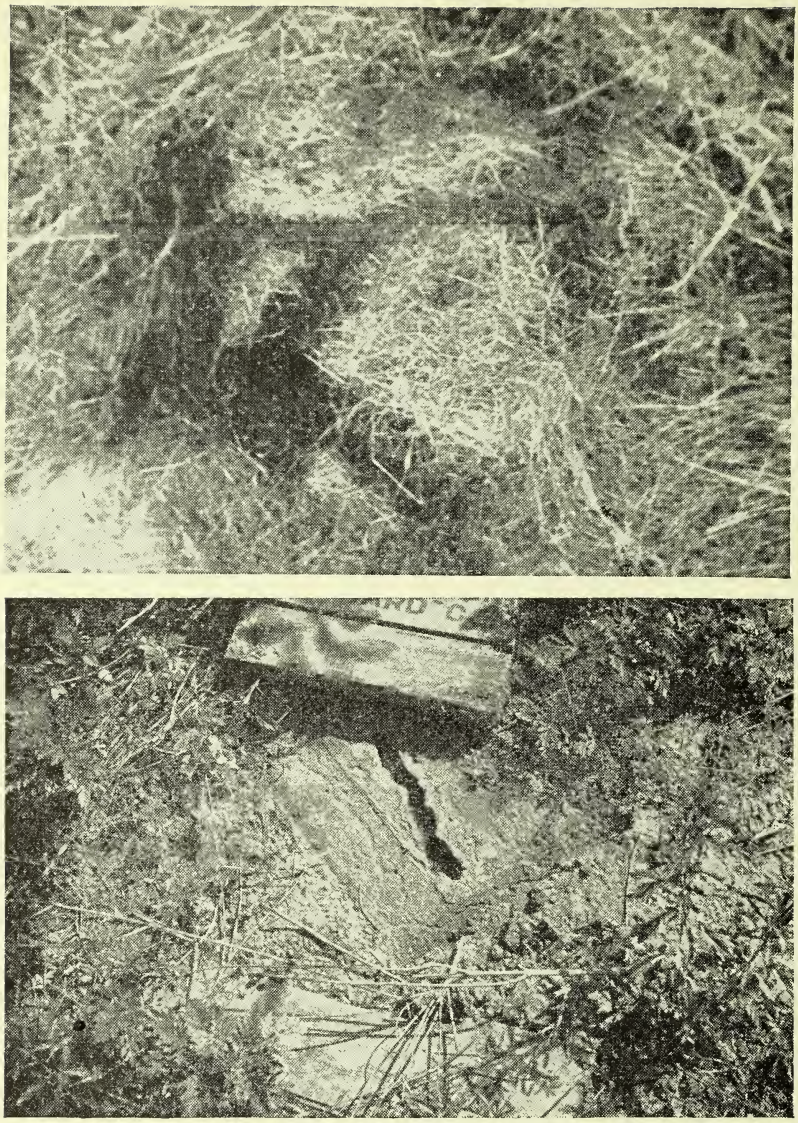

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Figure 9.—Mouse runways under baiting stations. *Above*, the hay cover has been parted to show meadow mouse trails that were made under the small pile of hay after it had been placed; *below*, trail of a pine mouse that was made under a box-top cover. The bait is placed in the trails and the cover put back in position.

ing for used runways of mice and of exposing toxic baits; they provide a covered feeding spot, for mice will not feed in the open; and they prevent poultry and beneficial forms of wildlife, such as song and game birds, from having access to the poisoned baits thus covered. The orchardist should not, however, rely entirely on baiting stations for indications of the occurrence of mice. He should occasionally examine all grassy areas to detect fresh runways.

As a general rule, one application of poisoned baits late in the fall after the fruit crop has been picked and the windfalls have been gath-

ered is sufficient to assure a mouse-free orchard for the entire winter. Winter not being the breeding season, meadow mice do not drift to any extent at that time, so there will be little reinfestation until the following spring. At intervals throughout the winter, however, it is well to inspect the orchard carefully for signs of mouse activity. If any are found, poisoning may be repeated.

Meadow mice are active throughout the winter except during short periods of severe weather. They are particularly sensitive to wind and at windy periods are inclined to remain in their nests. They are most active during daylight, especially late in the afternoon. Poisoned baits should therefore be exposed on quiet, warm days, preferably during the forenoon. In this way the baits will be distributed before the favorite afternoon feeding period begins.

Cooperation in Mouse Control

When field mice become so abundant that they menace the fruit trees and crops of a whole community, concerted action by all residents is required to control them and possibly to avert a disastrous plague. In 1922 a serious outbreak of mice in the famous fruit-growing sections of the State of Washington was promptly checked through a cooperative-control project. Twenty-two thousand pounds of poisoned baits were prepared and distributed with telling effect by 750 orchardists in one county.

During recent years in several of the Eastern States where mice have been causing serious losses in orchards, organized mouse control has been conducted on a cooperative basis with excellent results.

WHITE-FOOTED MOUSE

Description and Habits

The white-footed mouse (*Peromyscus*) is widely distributed throughout the United States. It is found from sea level to the vegetation line of the highest mountain peaks, and from the heavily timbered areas

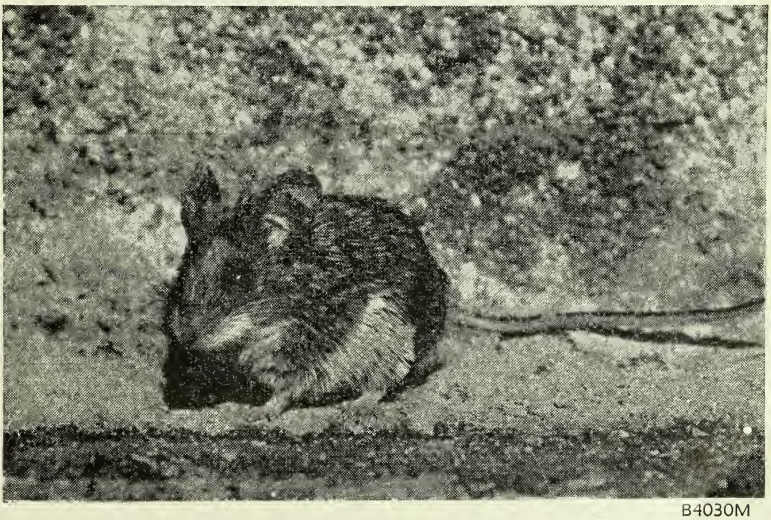

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Figure 10.—White-footed mouse (*Peromyscus* sp.). The large ears, prominent eyes, long tail, conspicuous white underparts of body and tail, and the white feet can be seen.

to the desert. There are many species and subspecies, but all have the characteristic white underparts and white feet. The color of the sides and upperparts varies from dark gray, nearly black, in forms inhabiting regions of heavy rainfall to ochraceous buff in those living in desert regions. The species also vary in size, the largest being about twice the size of the smallest. The average weight of adults of medium-sized species is 25 grams (1 ounce). All have large ears, prominent eyes, and long tails (fig. 10).

White-footed mice are almost completely nocturnal and do not make runways of their own like the meadow mice, although they use such trails. They may be caught in the runways of meadow mice and in the tunnels of moles and pocket gophers. They are found in practically all types of habitat—in woodlands and swamps, along watercourses, in the wide open spaces of the upland prairies, about rocks and cliffs, and in deserts. Those inhabiting the prairies, open cultivated areas, and fence rows usually make their nests in short, simple burrows (fig. 11);

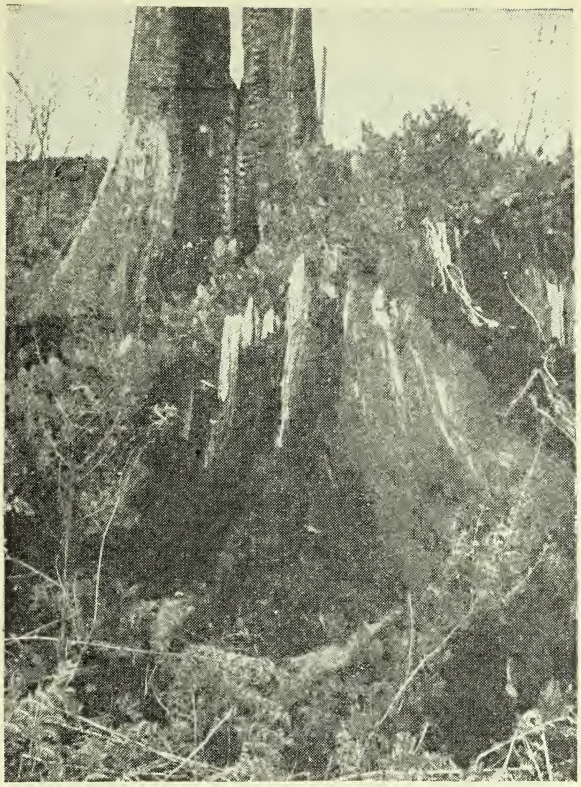
B26243

Figure 11.—Burrow and nest of a white-footed mouse in an agricultural area. Note the nest near the surface and not distant from the entrance to the burrow.

and those in woodlands live largely on the surface of the ground, building their nests and living quarters among the roots of shrubs and trees, in decayed stumps and hollow trees (fig. 12), and under logs. They may even make use of deserted nesting cavities of birds or abandoned birds' nests in bushes. A few live and travel about in trees. They may also establish temporary quarters in cultivated fields and make permanent homes in barns and houses where the house mouse is not abundant.

These mice do not hibernate; their little tracks may be seen in the snow the day following the coldest night, showing that they had been out seeking food.

White-footed mice are very prolific. They breed each month of the year in the temperate regions, and produce 4 to 6 young at a litter.



B56566

Figure 12.—Habitat of the white-footed mouse in logged-over area.

Although they occur throughout the United States in great numbers, they concentrate in excessive abundance only in certain restricted areas, in which they may become of economic importance. They are extremely numerous in the Western States.

As might be expected from their wide distribution, white-footed mice consume a great variety of foods, but they apparently prefer seeds, nuts, and grains. The seeds include those of grasses, weeds, shrubs, and trees. A. W. Moore (1940) reports that in preference tests made on fir-forested areas these mice chose conifer seeds in the order of Douglas fir, hemlock, and western red cedar. Osgood (1909) says that they also eat the seeds and nuts of such deciduous trees as basswood, wild cherry, beech, and oak, and that they often store them in burrows and in the cavities of old stumps. They will devour the bodies of mice that have been caught in traps and will kill and eat pocket mice (*Perognathus*). Insects, their eggs, and larvae are also consumed.

Damage to Timber and Foodstuffs

When very numerous, white-footed mice may become pests in logged-over forest areas, where they destroy the seeds that remain in the ground or that fall from the seed trees left for the purpose of reforestation; in new areas to be seeded to forest trees; in grainfields, particularly those containing shocks of corn and wheat; and in feed and food storage places in farm buildings and houses. They also eat the

buds and bark of young trees, but in this respect they are not nearly so destructive as meadow mice.

Methods of Control

TRAPPING

For trapping white-footed mice about houses and farm buildings, the small wooden-based snap trap is very satisfactory when set as described for catching house mice (p. 33). The traps should be baited with breakfast rolled oats or nut meats. Mice can be controlled around seed beds in forestry nurseries by trapping if enough traps to cover the area well are used at a time.

POISONING

For large-scale operations poisoned baits may be employed to reduce the numbers of white-footed mice. Strychnine alkaloid proves only fairly efficient under most conditions. In those localities in which the acceptance of strychnine-poisoned bait is very low, as a follow-up to its use, thallium sulphate or zinc phosphide baits may be employed, but these poisons are extremely hazardous to other forms of wildlife and must therefore be used with great care.

Studies of white-footed mice on reforestation lands on the West Coast showed that the best baits were, in order of preference, Jeffrey pine seeds, ponderosa pine seeds, steamed-rolled oats, and wheat. The first two are not readily available for bait material, and from the standpoint of acceptance by the rodents there is little difference between them and the wheat or oats. Since steamed-rolled oats are easily obtained, they may well be used in large-scale, control operations. Breakfast rolled oats and corn meal are accepted fairly well and may be employed in a limited way. Such special baits as steamed-rolled oat groats and hulled sunflower seeds[3] are well accepted by these mice and may be used extensively if the materials are readily available and not prohibitive in cost.

Breakfast Rolled Oats (or Corn Meal) and Strychnine Alkaloid Bait (Formula 6)

A bait for use in controlling white-footed mice in dwellings and farm buildings may be prepared with breakfast rolled oats or corn meal, baking soda, and strychnine alkaloid in the same way as that described on page 35 for use against house mice.

Grain and Strychnine Alkaloid Bait (Formula 3)

For more extensive control operations against white-footed mice, a bait of steamed-rolled oats and strychnine alkaloid prepared as described on page 12 for meadow and pine mice may be used.

Steamed-Rolled Oat Groats and Thallium Sulphate Bait (Formula 4)

Steamed-rolled oat groats	125 pounds.
Thallium sulphate	1¼ pounds.
Water	1 gallon.
Dry gloss starch	½ pound.
Glycerine or petrolatum	⅜ pint.

Dissolve the thallium sulphate in 3½ quarts of boiling water. Mix the starch with 1 pint of cold water, stir this into the thallium solution,

[3] Steam-rolled oat groats are hulled oat kernels, steamed and lightly rolled specially for use in the control of rodents. They can be obtained from milling companies in California and Minnesota. Hulled sunflower seeds are the kernels with the hard outer hulls cracked and removed. This process was devised by a manufacturing firm in Berkeley, Calif., but there are doubtless other firms that now so prepare the product.

and cook until a clear paste is obtained. Add the glycerine (or the petrolatum), but this may be omitted if the poisoned grain is to be used immediately. Pour the mixture over the oat groats and mix thoroughly. In preparing thallium mixtures use only enameled or wooden utensils. Use a spoon or a special dipper to distribute baits. Do not touch thallium or thallium baits with the bare hands. Thallium is extremely toxic and must be handled with the greatest care.

Sunflower-Seed and Thallium Sulphate Bait
(Formula 5)

Hulled sunflower seeds	80 pounds.
Thallium sulphate	1 pound.
Water	3½ quarts.
Dry starch	8 ounces.
Glycerine or petrolatum	10 ounces.

Dissolve the thallium sulphate in 3 quarts of boiling water. Mix the starch with 1 pint of cold water, stir this into the thallium solution, and cook until a clear paste is obtained. Add the glycerine (or the petrolatum). Pour the mixture over the seeds and mix thoroughly.

The simply prepared breakfast rolled oats (or corn meal) and strychnine alkaloid bait (formula 6, p. 35) may be exposed in buildings, particularly in summer homes that are to be closed for the winter. A teaspoonful should be put in a small container, such as a baking-powder can lid or small cardboard dish, and a number of these containers placed on the floor along the walls, under furniture and equipment, or in any other places that the mice frequent. The baits may also be exposed about farm buildings.

The steamed-rolled oats and strychnine alkaloid bait (formula 3, p. 12) may be used for the initial baiting in large-scale operations. On reforestation areas on which rodent-control measures are taken before planting seed, the poisoned bait is exposed by scattering it, a teaspoonful at a place, about the base of shrubs or trees, around old stumps, along decaying logs, or at the base of rocks or cliffs, and at intervals of 20 feet over open areas with little vegetation and along strips that have been made through brush for planting seeds. The first treatment should be followed within 10 to 20 days by a second in which the steamed-rolled oats groats and thallium sulphate bait (formula 4, p. 18) should be used. **This latter bait must be exposed with great care.** A teaspoonful should be placed under pieces of bark, chips, or other cover under which mice run. There should be at least one bait to every 400 square feet.

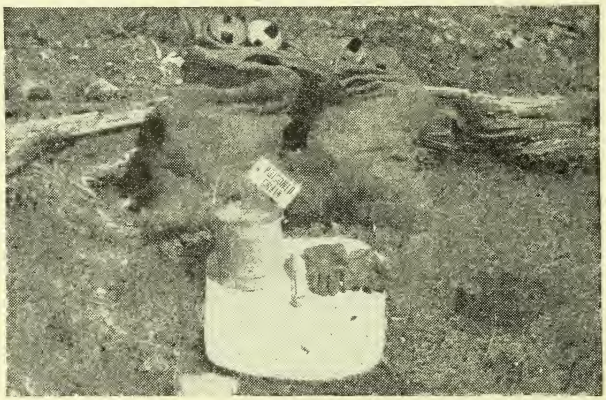
If poisoning and planting are done in the fall, it is well to treat the area again with formula-4 bait as soon as the snow is gone in the spring in order to destroy any mice that may have been inactive or did not eat any of the poisoned bait the previous fall or that may have drifted into the area since that time.

This rotation method of poisoning may be employed on an area where larger seed-eating rodents occur, for the strychnine-treated grain may also destroy most of the ground squirrels and chipmunks, but it is not so effective on mice. Formula-4 bait is more effective on mice and since placed under cover, it is more likely to be eaten. The cost of this rotation system on the kind of lands on which reforestation areas are generally located is 25c to 35c an acre per treatment.

Satisfactory results can be obtained with the sunflower-seed and thallium sulphate bait (formula 5, p. 19) alone if it is properly exposed. One treatment may be sufficient to destroy practically all the white-footed mice and meadow mice on an area and protect seeds and seed-

lings for one season, which is generally long enough for adequate protection from mice. The ingredients of this formula are, however, expensive and not readily available.

A systematic method of exposure is recommended because best results depend much on thorough coverage. A crew of 5 men is the most convenient size. Each man should be equipped with a pair of gloves, a poison dipper, and a bag or bucket for carrying the bait (fig. 13).



B62122

Figure 13.—Equipment used in exposing thallium-poisoned sunflower-seed bait. Bucket for carrying poisoned grain on the left, gloves on the right, and poison dipper in the center. The two bags in the background hold tin cans for use in establishing permanent bait stations by the two extra men.

The members of the crew, placed about 20 feet apart, should walk abreast through the forested area, taking care not to lose their relative positions in the line. They should place one dipperful of poisoned bait at about 20-foot intervals, or at every ten 2-foot steps. The crew members will have to exercise judgment in placing the baits, for where the forest floor is covered with dead trees and other rodent harbors more bait spots will be needed than where the area is clear. About 100 bait spots, or approximately 1 pound of poisoned bait to the acre, is satisfactory. **Particular care must be taken to put the poisoned bait under logs, pieces of bark, or other suitable cover.** This not only protects it from rain but also prevents various beneficial forms of wildlife from getting it. In order to insure thorough coverage, the man at one end should drop white cloth markers on the limbs of trees, or shrubs as he is advancing across the forest. These could then be gathered up by him on the return trip.

In addition to this exposure of baits, permanent bait stations made of discarded quart oil cans[4] may be set at 40-foot intervals over the area, or about 30 stations to an acre. If two or more men are added to the crew, these stations can be established at the same time that the other baits are being distributed. The two additional men, each carrying two to four burlap bags full of oil cans, can supply the second and fourth members of the crew with cans. Two dipperfuls of bait should be put in each can, which should be so set that no water can reach the bait. The can should be fixed firmly in a place that is attractive to mice, as under a piece of bark (fig. 14).

[4] These cans may usually be obtained in quantity from gasoline filling stations. The holes through which the mice can enter are already made and the cans need only to be cleaned of the oil, which can be done rapidly by burning.

B62121

Figure 14.—A permanent bait-exposure station in a good location to obtain satisfactory results.

Where white-footed mice have become destructive in fields under cultivation, formula-3 bait may be placed at 20-foot intervals on the ground near the base of crop plants, under cover of weeds or grass growing in fence rows, and under shocks of grain. To keep fence rows and rock outcrops free of mice after poisoning operations, the weeds and tall grasses should be burned or kept short so that mice will not become established again (fig. 15).

B44829

Figure 15.—A mouse-control crew cleaning a fence row bordering a cultivated grainfield.

COVERING SEED SPOTS WITH WIRE SCREENS

When the seed-spot method of planting is used in reforestation, the planted seed spots may be protected from the depredations of white-footed mice and other small rodents by covering them with wire-mesh domes. The objection to this practice, however, is the excessive cost of the domes and their placement.

The domes are made of ⅓-inch mesh, 21-gage, galvanized iron wire

hardware cloth cut into disks. Standard 48-inch widths of the hardware cloth can be cut with cutting dies and a hydraulic press into disks 9.6 inches in diameter with only a small loss of material. The bowl of the die is 3.75 inches deep and 6.5 inches in diameter at the rim, inside measure, and may be made of wood or steel. If made of wood, it should have a band of strap-iron about it to prevent it from splitting. The punch of the die is made of steel and is of a size and shape to fit into the bowl. It should be provided with a suitable handle (fig. 16).

The dome should be placed over the seed spot by the person planting the seeds. It should be grasped around the top with one hand and worked into the soil with a twisting motion until it is solidly anchored and the rim is about 1 inch below the surface of the ground. The soil

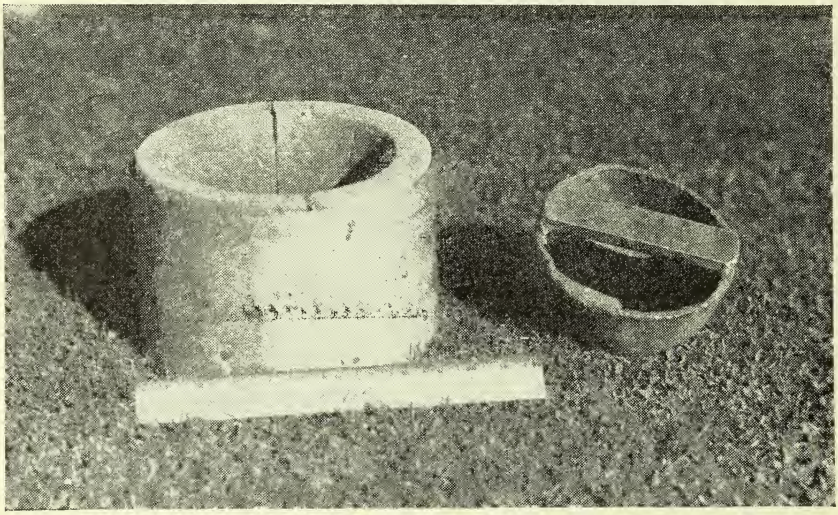


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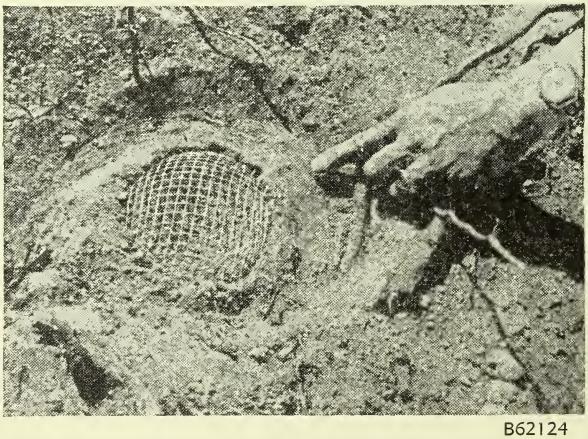
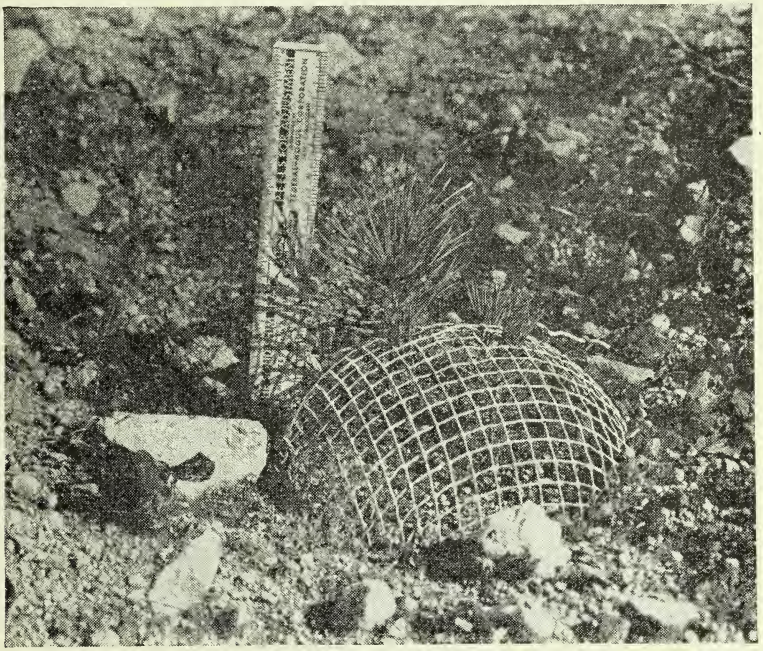
Figure 16.—A roughly made bowl and punch die for making the wire domes either by hydraulic press or by hand from the disks of hardware cloth.



B62124

Figure 17.—A dome in position. This has been placed for some time and has been investigated thoroughly by the rodents, which made the trail shown. The seeds under the dome were fully protected from attack.

should then be firmly packed about the edges. This will leave the top of the dome about 3 inches above the surface of the soil covering the seeds (fig. 17). Domes should be left over the seed spots during the first year. They will not seriously affect the growth of the seedlings (fig. 18).



B62125

Figure 18.—A dome that has been in place during two growing seasons. The pine needles have grown through the mesh, but the dome can be lifted off without injury to the seedlings. This photograph was taken at the end of the second season.

Covers of this kind may be picked up at the end of each year and used again. They should last about 10 years, and their repeated use considerably reduces the cost of rodent control. Under normal conditions one of these wire domes costs about 3.75 cents to manufacture, and since it may be used 10 times, the cost of protecting each seed spot would be about 0.375 cent. Distributing domes in the field, planting seed and pressing domes into place, and picking them up at the end of a year cost about 0.27 cent a seed spot. On the basis of 600 seed spots to an acre, to protect the seeds against small seed-eating rodents and birds would cost about $3.87 an acre, including labor costs of placing and gathering up the domes. This control method is not effective, however, in localities in which such larger rodents as ground squirrels and tree squirrels occur and take the seeds despite the presence of the domes, which they can move from position over the seed spots.

The cost of treating areas with poisoned baits as described in this bulletin varies from 65c to $1 an acre for 1 to 3 treatments. This is the least expensive method of controlling small seed-eating rodents on reforestation areas, but the chances of obtaining a high degree of protection are less than when domes are used over seed spots. The dome method is fully described by Keyes and Smith (1943).

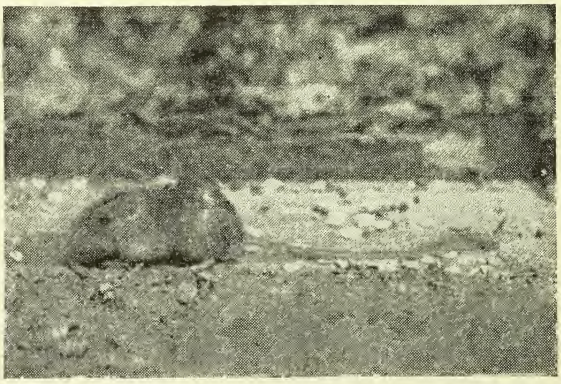
POCKET MOUSE

The economic status of some species of the pocket mouse (*Perognathus*) has been modified in several localities by changes in the food supply brought about by extension of grain farming and the introduction of certain weeds that give the mice better cover and more easily accessible food. This is particularly the case in the grain-growing sections of eastern Washington and Oregon, and also in eastern South Dakota. In these regions the breaking up of extensive tracts of the original growth of sage, rabbitbrush, bunchgrass, and buffalo grass for raising crops of grain under dry-farming conditions, and the fortuitous introduction of such noxious weeds as Russian-thistle, wild mustard, and pigweed have greatly increased the food supply for mice. Because of these more favorable conditions, the numbers of pocket mice have increased to a point where it has been necessary in some places to control them in order to save the grain crops. Pocket mice in some parts of the southwestern United States contribute importantly to the threat of rodent damage on the range lands. It is generally not necessary to exert control especially against pocket mice in the Southwest, however, as they are usually reduced sufficiently in numbers during regular control operations against prairie dogs, kangaroo rats, and ground squirrels.

There are other species of mice associated with the pocket mice but they are seldom found in numbers sufficient to cause economic concern. These include some forms of white-footed mice (*Peromyscus*), the grasshopper mouse (*Onychomys leucogaster*), harvest mouse (*Reithrodontomys megalotes*), and house mouse (*Mus musculus*). The harvest mouse feeds on seeds, fruits, green vegetation, and wild grains but rarely on cultivated varieties. The other three eat not only plant food but also insects and other animal food.

Description and Habits[5]

Many species and subspecies of the pocket mouse (fig. 19) occur in the United States, distributed generally over the desert or semiarid regions of the Western and Plains States. These mice are not found in dense forests although they may occur in dry, open forests in the South-



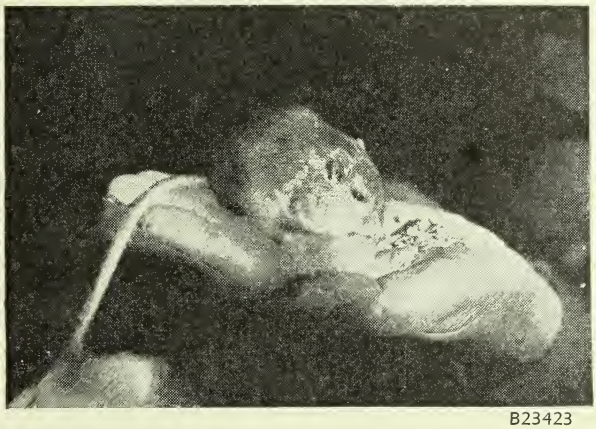
B23428

Figure 19.—Pocket mouse (*Perognathus sp.*). Note the small ears; the long, slightly bushy, tail; and the white feet. The underparts are less white than those of the white-footed mouse.

[5] Most of the information on habits is taken from Scheffer (1938).

west. The three species of known economic importance are the northwest pocket mouse (*Perognathus lordi*), the Oregon pocket mouse (*Perognathus parvus*) of eastern Washington and Oregon, and the plains pocket mouse (*Perognathus flavescens*) of central and eastern South Dakota.

The pocket mouse, which receives its name from its fur-lined cheek pouches, or pockets, used for carrying food for storing underground, is buff in varying shades, with black hairs interspersed, on the upperparts and usually white on the underparts. The feet and legs are generally white. These mice are about the size of the common house mouse but have smaller ears. Their hind legs are considerably longer and stouter than the front ones, although the latter are sturdy and are used for digging and for filling and emptying the cheek pouches (fig. 20). The



B23423

Figure 20.—Pocket mouse stuffing its fur-lined cheek pouches with rolled oats.

average weight of the males is 20 grams (4/5 ounce) and that of the females 15 grams (3/5 ounce).

Not being carnivorous or cannibalistic, the pocket mouse does not quarrel with members of its own species or with other kinds of mice, but, unless it is able to escape, it may itself be killed and eaten by some of its associates. The pocket mouse utters a characteristic squeak, which may be heard at times coming from under thickets of Russian-thistles along fence rows. It does not live in family groups but singly in individual burrows; neither does it colonize.

These mice are active in the evening, during the night, and early in the morning, but are seldom seen in the daytime; during stormy weather they are quiet. In the northern part of their range their season of activity covers 8 or 9 months, March to December. During the remainder of the year, December to March, the openings to their burrows remain closed and the mice stay underground, either dormant or moving about in their burrows feeding on stored food. Only occasionally during that period is one seen on the surface. In spring the males appear in numbers earlier than the females.

The burrows are about 1 inch in diameter, being smaller than those of the white-footed mouse. The openings are circular, and during the day may be plugged like those to the burrows of the pocket gopher. The burrows may be found in wild lands under sagebrush, bunchgrass, rabbitbrush, or other vegetation, and in cultivated lands at the base

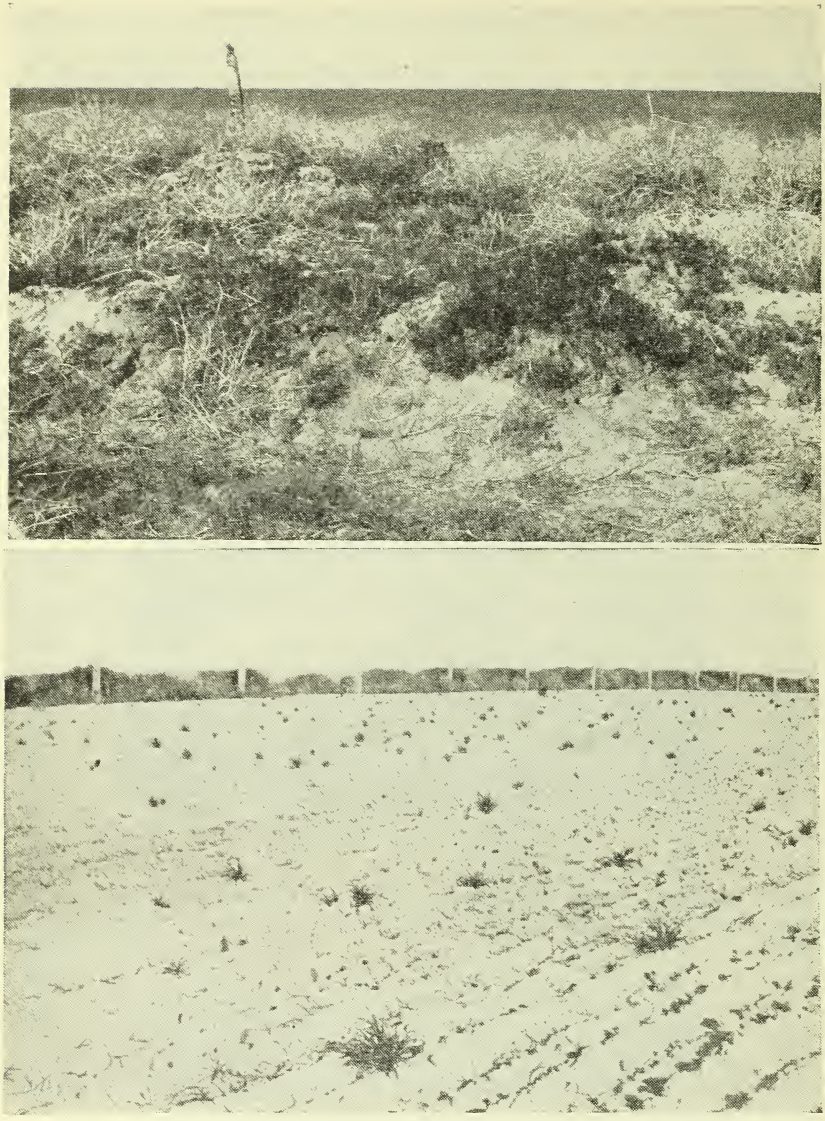


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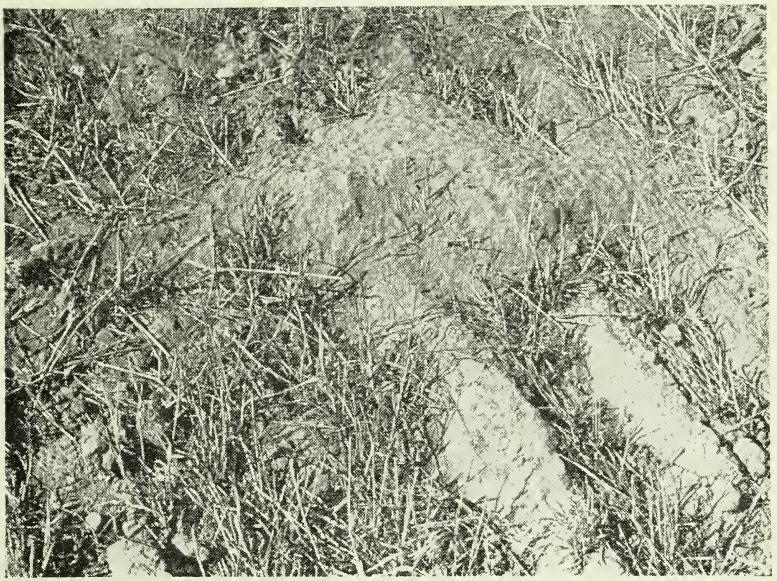
Figure 21.—Typical fence-line conditions in the dry-farming region. *Above*, soil drifts and tumbleweed cover are infested with pocket mice and other species; *below*, tufts of volunteer wheat springing up from shallow caches of grain made by pocket mice. The small round entrances to the mouse burrows can be seen in both illustrations.

of grain stubble or other plants and along fence rows under tumbleweeds or other growth (fig. 21).

The burrow system generally has one main tunnel extending spirally down into the ground to a depth of 3 to 5 feet or more, depending on the slope of the land, character of the soil, vegetative cover, and the surface cultivation, all of which determine the depth to which moisture penetrates. The tunnel ends at a dry, hard stratum of soil, under which the mouse usually has its nest. Occasionally the nest is near the surface, where the food caches are located, this being particularly the case when

burrows are under dead weeds that have drifted along fence rows. Near the top of the burrow there may be three or four branches leading from the main tunnel to the surface.

In midsummer and fall the presence of pocket mice may be recognized by the characteristic dust mounds that these mice throw up on the surface of the ground. These are formed from soil excavated from the deep burrows and from runway extensions and storage chambers nearer the surface. They resemble the mounds made by pocket gophers, even to the extent of having the openings plugged. They can be distinguished from the latter, however, by the smaller core-plugs and by the mouse tracks and tail marks in the dust (fig. 22).



B27377

Figure 22.—Dust mound at the open burrow of a pocket mouse.

The breeding season of the pocket mouse extends from May to August, the peak being in July. The number of young varies from 2 to 8, with an average of 5. Theo. H. Scheffer (1938) concluded, from indirect evidence, that the period of gestation is 21 to 28 days, and that a female may have two litters a year.

The food of pocket mice consists chiefly of seeds and wild grains that the rodents harvest from native plants, supplemented by the green parts of plants available in the semiarid country at certain seasons. When cultivated grains were introduced into their habitat, these mice soon learned to eat them and to adapt themselves to the soil and surface conditions changed by cultivation.

In typical pocket mouse habitat green food is available only in spring for periods of varying length and in fall after the fall-sown grain or some of the weeds have come up after the fall rains.

These mice do not feed upon insects or the flesh of other animals. Hence traps baited with flesh are not visited, but when grain or cereals are used as bait the mice are readily drawn to them.

Pocket mice use their cheek pouches to carry food to store for later use. Grains, seeds, sections of tender green stems of grain and herba-

ceous plants, bud clusters, and similar materials are cached in chambers, usually near the surface of the ground and connected with the main tunnel or its branches. Sometimes, however, the storage rooms are located at depths of 2 feet or more and near the deep living quarters. When grain is stored near the surface and moisture reaches it, it may sprout and green tufts may be seen scattered over the field (fig. 21). This is troublesome to the seed-wheat grower trying to keep his varieties pure. To do so, he has to go to the expense of hoeing out all such volunteer tufts of wheat.

Damage to Growing Crops

The pocket mice begin their depredations on wheat shortly after it is sown. Following along the rows, they dig up the sprouted kernels and so reduce the stand (fig. 23). Damage is less, however, at the spring

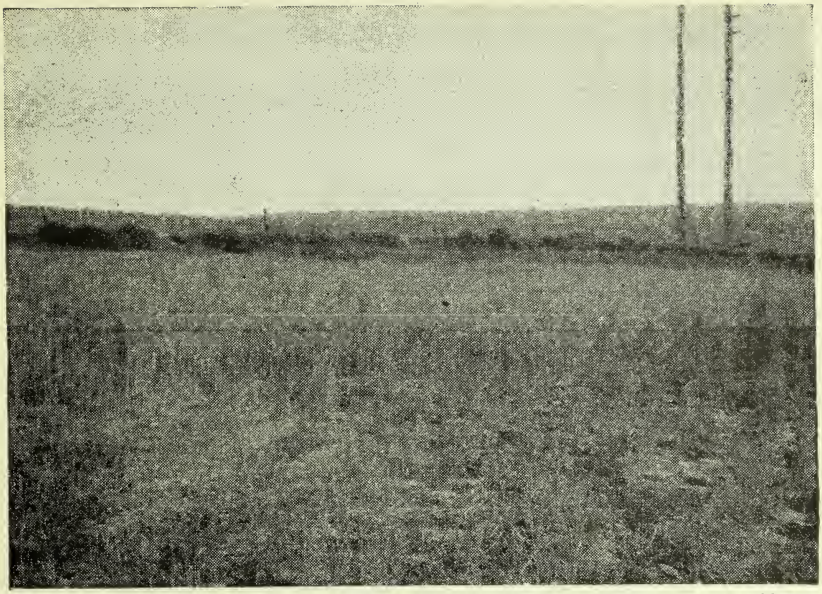
B26235

Figure 23.—Damage by pocket mice to spring wheat at Lind, Wash. The burrows and open runways in the wheat rows are clearly distinguishable.

and the fall sowings than during the time that the grain is ripening. Fortunately at the latter period there is usually much waste grain on the ground which tends to attract the mice away from the standing grain.

When the grain begins to mature, the mice cut the heads from the stalks and feed on the tender kernels. They may cut off the stalks just beneath the heads, or partially off at some point lower to enable them to bend the stalks over to the ground so that they can reach the heads. Later when the wheat ripens, they remove the kernels and carry them to their storehouses underground.

Scheffer, who made careful estimates of the damage by pocket mice in wheat fields in Washington State, says that on areas of considerable size within some fields the mice had destroyed 40 to 50 percent of



B22754

Figure 24.—A greatly reduced stand of ripening wheat resulting from damage by pocket mice. The burrows of the mice are plainly seen.

the standing grain, and that over entire fields they had taken 5 to 20 percent of the crop (fig. 24). He also makes the interesting observation that pocket mice are not responsible for cutting holes in sacks of grain dropped by the combine and left lying in the field for a few weeks. The pocket mice may push dirt up about the sacks, but if the sacks are cut, it is the work of some of their associates in the field, generally of the white-footed mice or of the house mice. White-footed mice and house mice may damage grain in sacks that are left long in the field, but otherwise they feed only on the waste grain scattered on the ground.

Methods of Control

NATURAL ENEMIES

As pocket mice are mostly crepuscular and nocturnal in their activities and seldom appear above the surface of the ground in the daytime, the number of species of birds that can feed on them is limited. The burrowing, short-eared, and other owls found in the areas where these mice are abundant, however, feed extensively on them, and the ferruginous roughleg, Swainson's, and red-tailed hawks in their early and late feedings pick up many of these rodents. The marsh hawk and the shrike also may catch some of them. The nocturnal carnivorous mammals are their greatest natural enemies. Skunks, badgers, weasels, foxes, coyotes, and the white-footed and grasshopper mice help to keep the population down. The badger, when the soil is moist in spring, digs out many of the nests. The other animals, however, seize the mice when they are on the surface.

Where the natural habitat of pocket mice has remained undisturbed, they generally do not present an economic problem, but where food and harbor conditions have become favorable, particularly in grainfields, their numbers may so increase as to require repressive measures to protect cultivated crops.

REMOVAL OF FOOD AND COVER

Russian-thistle (*Salsola pestifer*), tumblemustard (*Norta altissima*), and other noxious weeds have an abundance of seeds, which are scattered generously on the ground. Such weeds should be kept under control and not allowed to cover fields or fill up fence rows and thus provide both shelter and food for the mice.

POISONING

Pocket mice are not difficult to poison for they take strychnine-poisoned grain readily. The steamed-rolled oats and strychnine alkaloid bait (formula 3) recommended for controlling meadow mice may be used.

In grainfields the poisoned grain should be scattered about burrow entrances along grain rows or about clumps of other plants growing within the fields. If there are growing vegetation and wind-blown tumbleweeds along the bordering fence rows, the grain bait should be scattered near the burrows under such cover. If the grainfield is surrounded by wild or idle lands covered with weeds and shrubs that may favor the activities of the mice, a quarter-mile buffer strip around the field should also be treated.

Detailed instructions and assistance in controlling pocket mice may be obtained from the local representative of the Fish and Wildlife Service or from the county agent of the Agricultural Extension Service.

HOUSE MOUSE

The house mouse with its habit of stealing food has long been known to mankind. The word "mouse" together with the Latin *mus,* the Greek *mys,* and the Persian *moosh,* traces to the Sanskrit word *musha,* which is derived from a verb meaning "to steal." This designation probably applied to both wild and domestic mice and also to rats.

With the early migrations of peoples the house mouse traveled from its original home in central Asia south to India and west to interior Asia, northern Africa, and the Mediterranean Sea coast, where it probably arrived during the Neolithic Age. Later it spread to Europe and then, aided by shipping, over the rest of the world.

Species and Distribution

There are four recognized wild forms of the house mouse (*Mus musculus*) at the present time. These are found from the Pacific coast in Asia to the Atlantic in western Europe. From recent studies it appears that the two commensal subspecies (*Mus musculus brevirostris* and *Mus musculus domesticus*) that have been introduced into the United States developed from *Mus musculus wagneri,* one of the wild forms of central Asia. From *M.m. wagneri* evolved the man-dependent group of house mice that spread westward to the Mediterranean Sea, northern Africa, western Europe, and the Americas, including Hawaii. One of these commensals, *M.m. brevirostris,* became established about the Mediterranean Sea in southern Europe, and then during the exploration and colonization periods in the Western Hemisphere it came with the people of southern Europe to South and Central America and the southern United States. The other commensal subspecies, *M.m. domesticus,* established itself in western Europe north of the range of *brevirostris* and migrated with the peoples of that part of Europe to North America, eventually spreading over the northern half of the United States, and over Canada, Alaska, and Hawaii. It has been

customary to consider the house mouse in the United States as *Mus musculus musculus,* but *M.m. musculus* is a commensal subspecies developed from the wild form *Mus musculus spicilegus* and inhabits eastern Europe. Individuals of *M.m. musculus* may come into the United States occasionally with shipments from Scandinavia, Poland, or Russia, but it is not established in this country.

The common house mouse of the United States (fig. 25) is tawny

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Figure 25.—House mouse, showing the characteristically short, broad, and dark-colored feet.

to dark gray on the back, the color gradually changing down the sides to ashy gray on the abdomen. The feet are shorter, broader, and much darker than those of the white-footed or the pocket mice. The tail is shorter than that of the white-footed mouse but longer than that of the pocket mouse. The average weight of each sex is 16 grams (3/5 ounce).

Habits

House mice have a long breeding season. The gestation period is 21 to 24 days, and the average number of young, born blind, hairless, pink, and helpless, is 5. They become independent of the mother in about 3 weeks and are sexually mature in 2 to 3 months. The mother breeds 3 to 6 weeks after a litter is born and ordinarily has from 5 to 8 litters a year.

The usual length of life is 15 to 18 months, but individuals may live as long as 6 years. Their breeding potentialities considered, it is easy to understand why, under favorable conditions of weather and food, there have been great plagues of mice. The last great mouse plague in the United States was at Buena Vista Lake, Calif., in the fall and winter of 1926–27.

This little rodent has keen senses, with the exception of that of sight. It is good-natured and curious; climbs, jumps, and swims well, although

it rarely goes into water. The female is a faithful mother, preparing a warm nest for the young, taking good care of them, and guarding them with her life, if necessary. This trait leads her to destroy fabrics for nesting materials and to collect food for her young. House mice readily adapt their ways of living to changing environment. They generally follow regular lines of travel that they have established.

House mice eat about the same kinds of food as do human beings, including meats, grains, cereals, seeds, fruits, and vegetables. They prefer sweet liquids to pure water for drinking.

Menace to Public Health

House mice are suspected of carrying several diseases that are communicable to man. The United States Public Health Service reports that these rodents may harbor the virus causing choriomeningitis in people. They have been found frequently with an infection resembling poliomyelitis. Recently several carrying typhus virus were noted in a southern city. It is very important, therefore, that these little animals should not be permitted to live about homes or in any place where they can contaminate foods.

Damage to Food and Other Materials

In localities where only a few house mice occur, they do little damage and may be considered merely a nuisance. Where there are many places in which they can hide and food is accessible and abundant, however, they increase greatly in numbers and become very destructive to foodstuffs, clothing, furniture, and books in dwellings and to stored materials in warehouses, granaries, and store buildings (fig. 26).

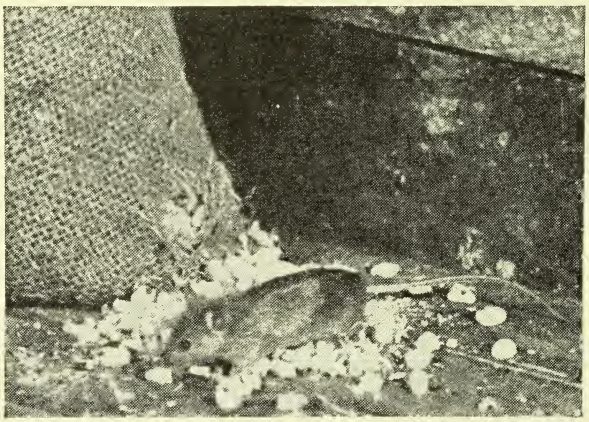

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Figure 26.—Sack of shelled corn that has been cut and the grain scattered on the floor by house mice. The corn has been contaminated and partly eaten.

Favorable climate, food, and living conditions may decrease mortality among mice, shorten the time between pregnancies, and increase the size of litters, with the result that the mouse population may reach plague proportions and be highly destructive to crops and a menace to the health of man as well as of the animals that feed on the defiled grain. During the first World War Australia lost millions of dollars worth of wheat which the mice ate or defiled.

Methods of Control

REMOVAL OF FOOD AND COVER

Food and cover are the two requisites for house mice. Remove these and mice can not tarry long. In houses the furniture and equipment should be so arranged as to leave no partially closed spaces to which mice may run for protection, as for example, under the refrigerator, or behind boxes in clothes closets or in pantries. The refrigerator should set solidly on the floor or be raised high enough above the floor to allow plenty of light to penetrate beneath. Shoe racks or clothes hampers in closets should likewise be elevated. No openings should be left around pantry cupboards through which mice can enter.

Garbage pails within the kitchen should be kept covered and no food left exposed in cupboards. Particular care should be taken that mice do not have access to crumbs or other bits of food. As soon as signs showing the presence of mice are noted, measures should be taken to remove the pests and to find the places where they gained entrance to the building. They are so little that they can crawl under many basement doors and then pass from room to room under inside doors.

NATURAL ENEMIES

House cats are natural enemies of mice, and when not overfed may aid materially in keeping down the numbers of mice around the house. Good mousers may also catch birds, however, and should not be permitted to run at large during the bird-nesting season.

REPELLENTS

Certain chemicals emit odors that are obnoxious to mice and are, therefore, of some value in repelling them from stored products. Among these, flake naphthalene is one of the most effective, and when scattered over and around bags of seeds, overstuffed furniture, books, clothing, and other articles, may protect them from mouse depredations. Since naphthalene loses its strength on exposure to the air, new applications from time to time are recommended. Because of its odor, it is not advisable to use naphthalene near foodstuffs. Powdered sulphur and lime have both been used successfully to protect such stored grain as corn and sheaf oats.

Applying tung oil, coal tar, creosote, pine tar, copper oleate, or kerosene to canvas belting and similar goods will give them some protection. In places where there is no danger of food contamination, dusting with a nicotine sulphate compound, pyrethrum, copper carbonate, or lime sulphur will also aid in preventing mouse damage. Other repellent substances include the oils of citronella, cedarwood, wintergreen, and peppermint.

Such insulating materials as sawdust or ground paper can be protected from house mice by mixing ammonium sulphate with them in a 5-percent concentration.

TRAPPING

House mice in dwellings, on small farms, or in business establishments can often be kept under control by trapping. For this purpose the small wooden-based snap traps and a small all-metal snap trap (fig. 27) now on the market are very satisfactory. Because of their low cost a dozen or more may be set at a time. Use plenty of them the first night. The traps should be so placed that the mice in following their natural runways along walls, behind objects, or in any situation

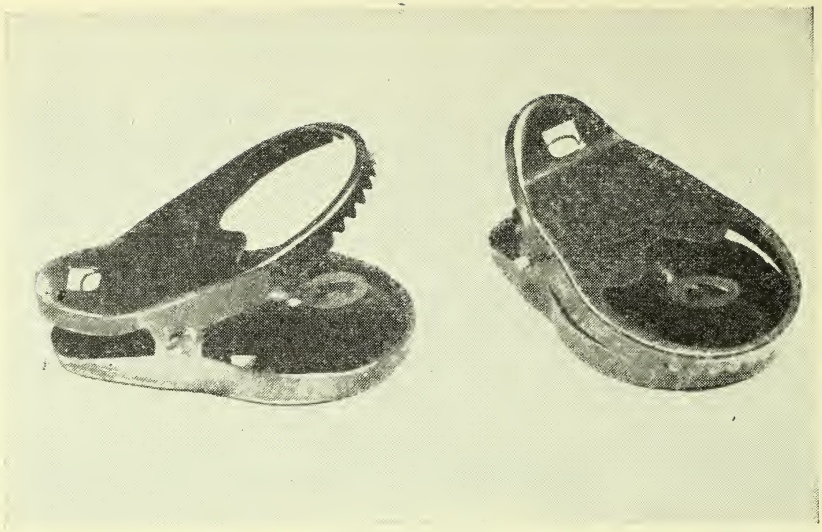

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Figure 27.—An all-metal mouse trap that is easy to set and proves satisfactory when baited with fresh bread, cake, doughnut, nutmeats, or fried bacon. The trap at the left is set, the one at the right is sprung.

where partial concealment is afforded, will pass over the trigger. The best locations for setting traps are near garbage pails, in pantries, kitchens, or cellars, or in any place where a mouse is likely to be attracted by food. The traps should be rebaited and reset each evening.

Fresh bait is essential and preferably should be tied to the trigger of the trap. Fresh bread, cake, and doughnuts are dependable baits, but these should be varied with such others as peanut butter, chocolate candy, cheese, fried bacon, sardines, apple parings, nut meats, or bananas. Rolled oats, flour, or other cereal may be sprinkled lightly over the trap as an additional attraction.

Frequently it is possible to get good results with the small wooden-based trap without any food bait by making a "trail set." To do this, the small trigger should be enlarged by cutting a piece of corrugated cardboard to a size that will fit inside the square wire loop of the trap and then slipping this cardboard onto the trigger. The resulting platform provides a much larger trigger surface. This modified trap is placed in a mouse runway with the trigger at right angles to a wall or other solid object. An inspection every day to remove any dead mice and to keep the trap set is sufficient.

POISONING

For the control of mice on a larger scale poisoning is sometimes necessary. Two kinds of lethal baits may be used, depending on the location and on local conditions. One is a poisoned bait that will remain effective during a long period of time, and the other is a fresh bait that must be used immediately after being prepared.

Poisoned baits are often desirable for use in protecting property in dwellings or camps that are used periodically and kept shut up for the remainder of the year and in some other kinds of buildings. Four lethal baits of good keeping qualities are suggested:

Breakfast Rolled Oats (or Corn Meal) and Strychnine Alkaloid Bait

(Formula 6—for small area)

Powdered strychnine alkaloid	⅛ ounce.
Baking soda	⅛ ounce.
Breakfast rolled oats (or corn meal)	1 quart.

Mix the strychnine and the baking soda together and stir them thoroughly into the rolled oats or corn meal.

Dry Bread Crumbs and Thallium Sulphate Bait

(Formula 7—for small area)

Powdered thallium sulphate	1 ounce.
Dry powdered corn sugar	6 ounces.
Dry bread crumbs (ground)	5 pounds, 5 ounces.
Corn oil	4 ounces.

Blend the thallium sulphate and the corn sugar, add this to the bread crumbs, and mix thoroughly. Then stir in the corn oil until the mixture is moist.

Milo Maize (or Canary Seed) and Strychnine Alkaloid Bait

(Formula 8—for extensive use)

Powdered strychnine alkaloid	1 ounce.
Baking soda	1 ounce.
Heavy corn sirup	½ pint.
Gloss starch	1 tablespoonful.
Water	1 pint.
Glycerine (or petrolatum)	1 tablespoonful.
Milo maize (or canary seed)	10 pounds.

Mix the starch with ¼ teacupful of cold water and stir this into ¾ pint of boiling water and cook until it forms a thin clear paste. Mix the strychnine and the soda and stir into the starch paste. Add the corn sirup and glycerine (or petrolatum) and mix thoroughly. Pour over the grain or seeds and stir until each kernel is coated. Spread on paper to dry.

Milo Maize and Thallium Sulphate Bait

(Formula 9—for extensive use)

Thallium sulphate	1 ounce.
Water	9 ounces.
Gloss starch	1 tablespoonful.
Heavy corn sirup	1 ounce.
Milo maize	6 pounds.

Dissolve the thallium sulphate in 7 ounces of boiling water. Mix the starch with 2 ounces of cold water, add the corn sirup, and stir into the boiling thallium solution. Cook until the mixture begins to thicken. Pour over the milo maize and mix until the grains are evenly coated. Spread out to dry.

Thallium is most dangerous to human beings and domestic animals and should be used only with utmost caution. Thallium-poisoned baits should not be handled with bare hands. Gloves should be worn while mixing the baits, and the baits should be distributed with a teaspoon.

Poisoned baits prepared in accordance with these four formulas will remain in good condition indefinitely if kept in a dry place. They may be placed in small covered boxes that have one or two holes slightly larger than a 25-cent piece cut in each side. These holes allow the mice to enter the box but should be high enough from the floor to prevent the mice from scattering the bait material outside the box. The boxes should be set in places frequented by the rodents, where they will pro-

vide a poison supply that is available at all times without some of the dangers attendant on scattered mouse bait. Such containers should be **plainly marked "POISON"** with red paint, and care should be taken to see that they are inaccessible to children, irresponsible persons, or domestic animals. All utensils used in preparing poisoned baits should be washed thoroughly or destroyed.

If the baits are to be exposed immediately after preparing them, the poison may be mixed with fresh materials.

Apples (or Sweetpotatoes) and Strychnine Alkaloid (or Zinc Phosphide) Bait (Formula 10)

Apples (or sweetpotatoes).....20 ounces.
Powdered strychnine alkaloid.....⅛ ounce.
or
Powdered zinc phosphide.....⅛ ounce.

Dice the apples or the sweetpotatoes into inch cubes. Dust them with the strychnine alkaloid or with the zinc phosphide, stirring gently until each piece is coated with the poison.

Hamburger and Zinc Phosphide (or Arsenic Trioxide or Thallium Sulphate) Bait (Formula 11)

If there are no pet dogs or cats that may be endangered, the following formula may be used:

Hamburger .....6¼ pounds.
Zinc phosphide ..... 1 ounce.
or
Arsenic trioxide .....1¼ ounces.
or
Powdered thallium sulphate.....1⅜ ounces.

Mix thoroughly one of these poisons with the fresh hamburger.

In place of the hamburger, a composite bait made by mixing 2 pounds of ground bacon with 6 pounds of blended bread and cake crumbs may be used.

Hamburger and Thallium Sulphate Bait (Formula 12)

The following is a semipermanent bait:

Hamburger .....2 pounds.
Bread crumbs .....1 pound, 15 ounces.
Thallium sulphate .....1 ounce.

Mix thoroughly the thallium sulphate with the bread crumbs and then stir this mixture into the hamburger.

Fresh baits prepared with zinc phosphide do not remain effective long, the time varying from 2 days to a week, but generally the poison will be efficacious as long as the baits remain acceptable. In dry or oily baits zinc phosphide will retain its toxicity for several months if kept in tight containers in a dry place.

The fresh baits may be exposed in the same way as that described for the stable baits (p. 35). As they are perishable within a short time, care should be taken to place them where the mice will be most likely to find them during the first night of exposure. If they are not put in small covered boxes, all those remaining uneaten should be picked up and destroyed after one or two nights of exposure.

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