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THE COMMON MOLE (*Scalops aquaticus*). Original.

The Common Mole.

BY

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THE COMMON MOLE.

By THEO. H. SCHEFFER.

SUMMARY.

1. There seems to be but a single species of mole in Kansas. It is common in the eastern half of the state and abundant in the eastern third. In western Kansas the mole is entirely absent or found only occasionally along the watercourses.

2. The mole is not a social animal, being condemned to a solitary existence by the conditions under which he lives. Moles come out of the seclusion of their underground burrows only occasionally, as if by accident.

3. The mole's system of runways threads the soil everywhere in well watered regions. There are two parts to the system—the deeper burrows or highways leading to small underground chambers, and the shallow surface ridges ranging over the hunting grounds.

4. The mole thrives best in a loose, moist soil abounding in grubs and earthworms. It therefore frequents fields and woods shaded by vegetation, but is not able to maintain existence in the hard, compact soil of semiarid regions.

5. The mole does not hibernate, but is more or less active at all seasons of the year. During the rainy periods of summer his work is pushed the most vigorously.

6. The young of the mole are produced within a period of three to five weeks, mainly in March and early April. They number from three to five.

7. The labyrinth of tunnels constructed by the mole serves as passageways for several species of mice, which are alone responsible for most of the damage to seeds, roots, and tubers encountered in the soil.

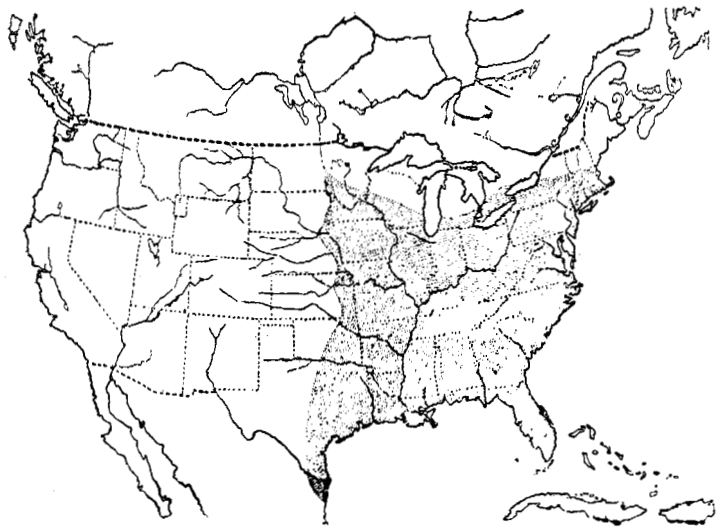
8. The diet of moles consists almost exclusively of the various insects, grubs and worms to be found in the soil. The amount of vegetable substance found in stomach examinations is usually no more than might have been taken in incidental to the ingestion of other food.

9. By reason of its secluded life underground, the mole has but few natural enemies. Coyotes, badgers and skunks dig out a few of them, and occasionally a hawk or owl surprises one aboveground. The flooding of lowlands during spring freshets is probably the greatest danger that menaces the adult mole and his progeny.

10. From the standpoint of food habits, and also in respect to tunneling the soil, the work of the mole is highly beneficial to the interests of agriculture. Moles should not be tolerated, however, in lawns, small garden plats and parks, because of the disfigurement and the injury to plant roots that result from their work.

11. The best method of combating the mole is by means of a trap in the hands of a person who knows how to set it. Crystals of strychnine in raisins or bits of fresh meat make fairly effective poison baits.

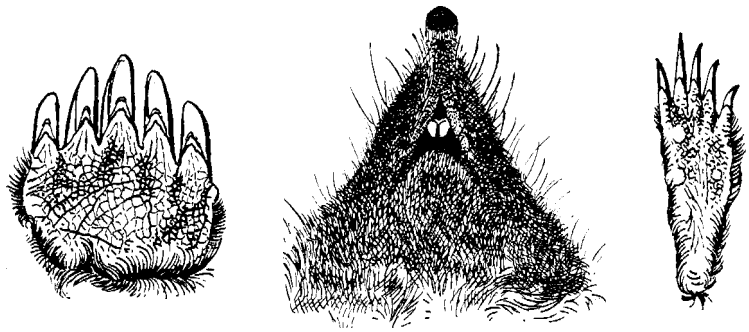
12. The mice which take seed corn in the ground may be destroyed by introducing poisoned grain baits into mole runways throughout the field. The theft of seed corn may sometimes be prevented by treating it with coal tar, tobacco decoction, or stock dip before planting.



Geographical distribution of the common mole (genus *Scalops*), shown by the shaded area. (From True's Revision of American Moles.)

DESCRIPTION AND DISTRIBUTION.

The mole which forms the subject of this discussion is usually referred to as the "common garden mole." It belongs to a genus *(Scalops)* which is distributed very generally over the eastern part of the United States and the Mississippi valley as far west as the plains. There is not enough variation in type over this range to establish more than a single species *(aquaticus),* but four or five subspecies are recognized. The Kansas mole has usually been assigned to the subspecies *machrinus,* but from the large number of specimens examined it seems best to place it in the subspecies *intermedius* of Elliott. Therefore it may be designated as *Scalops aquaticus intermedius.*



Hand, nose and foot of the common mole; under surface in each case. Original.

The true moles may be distinguished from meadow mice, shrews, or pocket gophers—with which they are often confused—by the following peculiarities: They have a naked, pointed snout extending nearly a half inch in front of the mouth opening, which is, therefore, ventral. The eyes are very minute and concealed in the fur. The same is true of the auditory orifice. There are no external ears. The fore feet are very large and broad, the palms being wider than long. The toes of the feet are webbed to the base of the claws, which are broad and depressed. The hind feet are small and narrow, with slender, sharp claws. The variation in size among individuals taken in the same locality is not especially marked, but it is more noticeable when comparing specimens taken in arid and in moist regions respectively.

The following data apply to the first 100 moles taken at Manhattan during the progress of these experiments:

AVERAGE DIMENSIONS AND WEIGHT.

Males (45 specimens):
Average total length, 176 mm. (about 7 inches).
Average length of tail, 30 mm. (about 1 3/16 inches).
Average weight, 4 ounces.
Females (55 specimens):
Average total length, 168 mm. (about 6 5/8 inches).
Average length of tail, 30 mm. (about 1 3/16 inches).
Average weight, 3 ounces.

In contrast to the slight variation in size among moles taken in the same locality is the marked variation in color. The dominant shade is a mingling of lead color and brown, but some specimens are darker than this and, on the other hand, some are a beautiful slivery gray, or perhaps are tinged with purplish. At least two were taken that were suffused all over with rich golden brown. On the average about one-half of the moles taken here have certain regions of the body —particularly the nose, chin and breast —washed with a tinge of orange or have distinct patches of this color on the head or belly. Some of these patches are yellowish or golden brown instead of orange, and occasionally one is nearly white. A common marking is a band on the nose. The patches vary in size from a mere streak to a blotch covering almost the entire area of the belly or head. The following data on color markings are from the same 100 moles discussed under the head of average dimensions and weight:

Males:	
Number having orange or rusty brown markings..	27
Number marked on nose only	5
Number suffused or washed in part..	18
Number having well-defined patches..	6
Females:	
Number having orange or rusty brown markings..	23
Number marked on nose only	12
Number suffused or washed in part.	2
Number having well-defined patches.	9

The distribution of moles seems to depend very largely upon the humidity of the climate and consequent condition of the soil in any particular region. As will be shown later, the mole thrives best in a loose, moist soil, abounding in grubs and earthworms. The hard, compact surface earth of arid and

semiarid regions is not at all inviting to an animal that must make its living by plowing along beneath the feet of the more favored creatures that crop the grass. Though able, perhaps, to burrow wherever an earthworm can burrow, the mole could not thrive and maintain its numbers in regions where these worms were few and small in size.

The accompanynig map (page 2) gives the distribution of the genus *Scalops.* Two other genera—*Condylura* and *Parascalops*—occupy portions of this same territory. Between the shaded area on the map and a narrow strip bordering the Pacific coast there are said to be no moles. This statement must be taken with some reservation, however, for moles are found in decreasing numbers on the lowlands along the watercourses as far west at least as the one hundred and first meridian. On a recent trip through the western part of Kansas, careful search was made for evidences of moles in favorable spots along the Saline, the Smoky Hill and the Arkansas rivers and their tributaries. At Wilson, on the Saline, moles were fairly common in cultivated fields and gardens. They were also reported from the Station grounds at Hays. At Oakley, no traces of the animal could be found, nor did inquiry among the residents show that one had ever been seen there. Along the Smoky Hill it was learned that moles have been taken occasionally as far west as Logan county, but no traces of their work were found. Residents along the river at Wallace assert that there are no moles in the country. At Garden City, on the Arkansas, moles were sufficiently numerous to be troublesome in lawns. A specimen taken at Great Bend did not seem to differ in any respect from those collected at Manhattan.

ACTIVE PERIODS.

WET AND DRY PERIODS. The mole does not hibernate. Like the pocket gopher, he is more or less active at all seasons of the year. It is during the rainy periods, however, when the soil is moist quite to the surface, that his work is pushed the most vigorously. Shallow runways are then rapidly extended in all directions, and old runways repaired. When, later, the ground becomes dry and hard, extensions to the system of tunnels are made only in shaded spots, in cultivated fields, or in other favored areas where for some reason or other the soil has become less compact. When a mole chooses to go in a certain

direction, however, nothing but concrete or stone will stop him. The strength of the little animals is marvelous. They will heave up the surface of a path trodden so hard that repeated blows of a pick would be required to break the crust. In like manner the bricks of a sidewalk are pushed up out of place, and on one occasion a run was noticed heaved up across the hard, baked roadway over which a heavy traction engine frequently passed.

THE FALL SEASON. In the late fall one will observe an increasing number of the little mounds of earth often associated with a system of mole runways. The presence of these indicates active operations in some of the deeper parts of the system. Ordinarily a mole makes his way through the soil much as a root does, or a stake when driven by the blows of a sledge. The earth is not excavated, but simply crowded aside. This is true of the work even at considerable Depths when the soil is moist. But when the ground becomes harder, as it usually does in the autumn, the mole is obliged to excavate the passageways with his stout front feet and dispose of the loose earth by pushing it out through openings in the roof of his surface tunnels.

IN WINTER. At any time in winter when the ground is not frozen too hard, the mole keeps up his work. During the freezing days of January observations have shown fresh burrows ridging up a hard crust of snow covering a thin layer of frozen soil, There seems to be no good reason for assuming, as Some do, that during hard freezing weather the mole keeps burrowing away beneath the frost line. He could not make his way at this depth by compacting the soil, and observations have not shown loose earth brought to the surface at such times. Again there would be no need to carry on burrowing operations under such unfavorable conditions. The system of passages already constructed could be retraversed in search of food until opportunity offered for extending it. Worms and hibernating insects are just as likely to be found in a passageway the second or third time it is traversed as they were when it was being constructed, for many of these little creatures of the soil are on the move also.

FOOD STORAGE. Owing to the peculiar character of a mole's diet, storage of food for an unfavorable period or season would Seem out of the question. There seems to be no indications that supplies are thus laid up for a "rainy day." A

French writer avers that the common European mole stores earthworms, first biting off their heads so they cannot escape. Such a trifling thing as the loss of a head would not hinder our American earthworms from making their escape tail first.

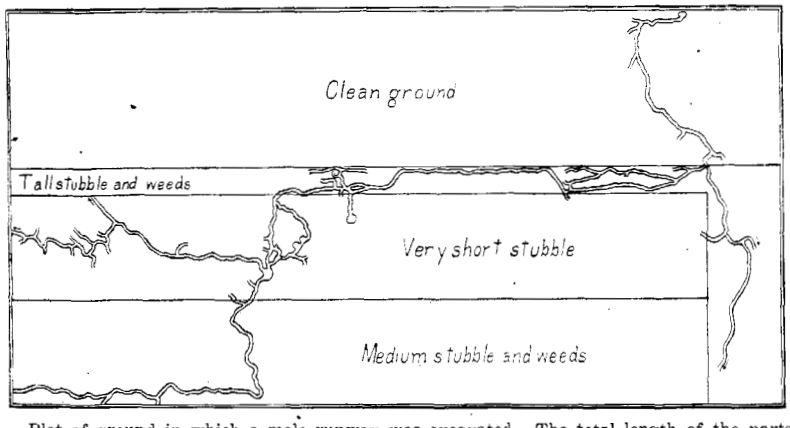
WORKING HOURS OF THE DAY. It seems to be a matter of common observation that the mole can be found at work more frequently in the morning and evening than at any other time of day. Some observers also state that there is a third period of activity, between eleven and twelve o'clock, noon. This statement has not been verified by these observations.

HABITS.

GENERAL. Like the various species of pocket gophers that inhabit the prairies and plains, the mole lives in the seclusion of underground burrows, coming to the surface only by accident. He does not even permit himself the diversion of an airing at the mouth of an open burrow, as does the gopher when he comes out at dawn or twilight with load after load of fresh earth from his excavations. When the mole has occasion to dispose of any surplus dirt he simply pushes it up from beneath until it forms a loose pile with radiating cracks, unlike the dump formed coal-pit fashion by the pocket gopher. Living thus in darkness, removed from the sights and sounds that attend the lives of insects, birds and mammals above him, the round of his experiences consists mainly of the smells of fresh moist earth, of plant roots, and of the various worms and grubs he seeks out for food. He feels also the jar of passing feet, the trickle of percolating waters after a shower. and the changes in temperature as the seasons come and go. Observations have led us to believe that the mole is not a social animal —that the very character of his environment compels him to lead the life of a hermit. This must necessarily be the case with any animal that spends all of its time underground. It is true that on several occasions two or even three moles have been trapped at the same spot, but that need not lead to the inference that they had lived together in a social way in that particular burrow. In soil ridged up by a labyrinth of runways frequent intersections of separate burrows must necessarily result.

THE RUNWAY. After following along the devious course of a mole's path, just beneath the surface of the ground, one will find sooner or later that it begins to run slightly deeper in a

certain direction. Approaching from another quarter of the infested plat the surface runway will again be found to turn downward somewhere in the same direction as before. These deeper runs are the highways leading from the mole's home to his hunting grounds. In fact, they may be said to constitute a part of his permanent residence, although the home proper is an irregular chamber here and there connected with these runs. The latter follow a course from five to seven or eight inches beneath the surface of the ground—deeper than the soil is usually stirred by agricultural operations. The chambers from which these runs radiate are not large, their average capacity being about a quart. These investigations have never revealed any nesting material in them. The American genera of moles do not construct "mole hills," as the European genus *Talpa* is said to do.



Plot of ground in which a mole runway was excavated. The total length of the parts of the runway shown was 475 feet. The deeper parts of the runway are just to the left of the center of the illustration. Several small chambers were found in this part of the system.

By far the greater extent of a mole's system of runways is made up of the shallow burrows ranging over his hunting grounds. These are merely subsurface paths pushed hither and thither by the vigorous little animal in his search for food. They may not be used again or they may be retraversed at irregular intervals. After a time they become filled up by the settling of the soil above, especially after heavy showers. In some cases, also, the mole evidently pushes into them the dirt which he has excavated in his deeper runways. These subterannean hunting paths are about an inch and a quarter to an

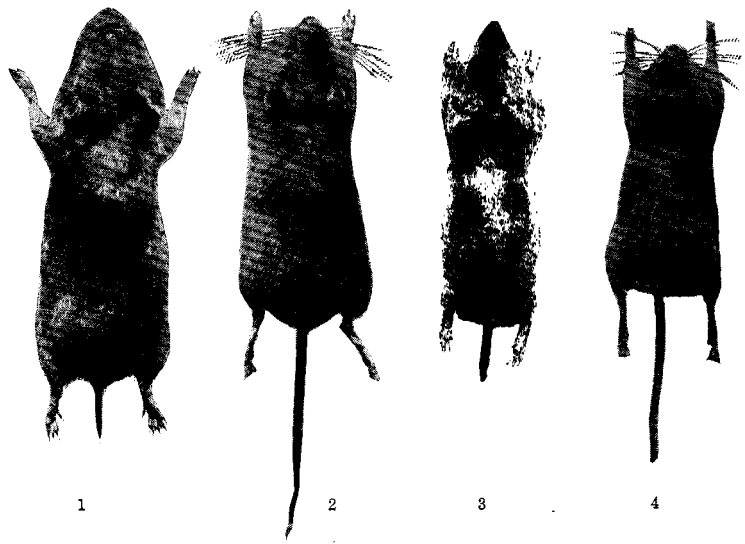
inch and a half in diameter. They usually ridge up the surface of the soil so that their course can be readily followed. In wet weather they are very shallow; during a dry period they range somewhat deeper, following the course of the earthworm.

HABITAT. While the mole seeks out the higher and dryer spots for his home and his highways, he hunts preferably in soil 'that is shaded, cool and moist. Here worms and grubs abound, and these favored areas soon become traversed by a perfect labyrinth of subsurface paths. This accounts for the persistency with which moles stick to our lawns and parks. In neglected orchards and natural wood-lands, where the mole works undisturbed, the ground yields everywhere to the tread, giving evidence of the presence of runways under the leaves or matted grass. In the vicinity of buildings or sidewalks the mole very commonly makes his headquarters under portions of these structures.

Persistent as the spider in repairing its web when torn by accident or design, the mole patiently labors to reconstruct his principal runways when gullied by heavy rains or otherwise damaged. His invariable practice is to burrow under and heave up the floor of the old run wherever the roof has fallen in, thus forming a new passageway beneath. He will repeat this process time after time when one opens up his burrows by hand, until the most recent effort at tunneling and repairing will have taken him down beneath the floor of a narrow trench as much as a foot in depth.

THE MOLE'S GUESTS. Whether willing or not, the mole finds himself compelled to act as host to a large number of guests that throng his hallways. The maze of passages that thread the soil everywhere furnishes concealment and lines of traffic to several species of small mammals not favored by nature with the means for digging runways of their own. What the mole's attitude towards each species of these intruders may be these investigations have not revealed. In the case of the shrew it would seem to be one of hostility, for the shrew and the mole are on the lookout for the same kinds of food. The shrew is generally supposed to do some burrowing on his own account, but any number of the little animals have been trapped in runways that from their size and general appearance were undoubtedly constructed by

moles. In fact, observations more than once showed a trap holding a dead shrew pushed up by fresh mole work almost out of the small excavation that had been made. Whether tolerated or not, the shrew by no act contributes to blackening the reputation of his host as do the other guests — mainly voles (meadow mice), white-footed field mice and the common house mouse. These latter are directly responsible for most of the thefts of grains, seeds and tubers commonly laid to the charge of the mole. Conclusive evidence of the truth of this statement will be found in another part of this bulletin. It is sufficient to state here that the presence of these little rodent pests in considerable numbers in the mole's runways can easily be demonstrated by the use of small traps.



The Mole's Guests. (Original.) 1—Meadow mouse (*Microtus*). 2—White-footed mouse (*Peromyscus*). 3—Shrew (*Blarina*). 4—Common house mouse (*Mus musculus*).

BREEDING. Though one of the most abundant of our small mammals, the mole is a slow breeder. This would be expected of an animal withdrawn from the strife and competition that reddens tooth and claw in the world above his secluded burrows. As will be seen from the accompanying table, the number of young at a birth is normally four and but one litter is produced annually. These facta were ascertained from the examination of a large number of females (101) taken in all months of the year. Thirty-three of these were either pregnant

or gave indisputable evidence of having recently born their young. The first specimen of this latter number was trapped February 27, the last April 20.

It would appear, then, that in this vicinity (Manhattan) the young are produced within a period of three to five weeks, mainly in March and early April. The period of gestation must be comparatively short, for signs of pregnancy did not appear until about five weeks before the first females gave evidence of having borne their young. My data on this point are not full enough to warrant a positive conclusion; for, of the twenty-five moles trapped during the months of December and January, and up to February 27, only five were females. This fact itself may be significant of a period of seclusion or less activity among the females during the period of pregnancy.

While, as stated above, the normal number of young is four, there were two cases in which there was but a single fœtus in one horn of the uterus; the other horn contained two, as usual. In one instance also there were five fœti.

That development after birth is very rapid is shown by the litter of young moles referred to in the last item in the accompanying table. These were discovered in a nest of dry grass under some sod, April 22. The sod had been turned over by the plow only about ten days previously. Although still perfectly hairless, these young moles weighed one ounce each—from one-fourth to one-third the weight of the adult.

Results of the Examination of 38 Female Moles for Breeding Conditions.

Date.	Conditions for breeding, number of embryos, etc.
Dec. 11,	No signs of pregnancy.
Dee. 17,	No signs of pregnancy.
Feb. 6,	No signs of pregnancy.
Feb. 20,	No signs of pregnancy.
Feb. 22,	No signs of pregnancy.
Feb. 27,	Uterus congested; very evidently pregnant.
Feb. 27,	Uterus very much congested, but fœti not distinguishable.
Feb. 27,	Uterus very much congested, but fœti not distinguishable.
Mar. 6,	Uterus very much congested, but fœi not distinguishable.
Mar. 7,	Three fœti in one horn of uterus, two in the other; scarcely distinguishable.
Mar. 8,	Pregnant. Number of fœti apparently four; scarcely distinguishable.
Mar. 8,	Two fœti in each horn of the uterus; very small.
Mar. 8,	Pregnant, but number of fœti not distinguishable.
Mar. 18,	Pregnant, but number of fœti not distinguishable.

Date.	Conditions for breeding, number of embryos, etc.
Mar. 22,	Pregnant, but number of fœti not distinguishable.
Mar. 26,	Pregnant, but number of fœti not distinguishable.
Mar. 29,	Pregnant, but number of fœti not distinguishable.
Mar. 30,	Two fœti in each horn of uterus; about as large as navy bean.
Mar. 30,	Two fœti in each horn of uterus; about as large as navy bean.
Apr. 1,	Two fœti in each horn of uterus; a little smaller than the above.
Apr. 2,	One fœtus in right horn of uterus, two in left; size of hulled peanut.
Apr. 8,	Indications that the young had been recently born.
Apr. 9,	Two fœti in each horn of uterus; size of navy bean.
Apr. 10,	Indications that young had been recently born; milk in glands.
Apr. 11,	Three fœti; size of small navy bean.
Apr. 13,	Four fœti, very small but easily distinguishable.
Apr. 13,	Young evidently recently born; uterus flabby and veins congested.
Apr. 14,	Young evidently recently born; number of fœti had been four.
Apr. 14,	Young evidently recently born; number of fœti had been four.
Apr. 14,	Young evidently recently born; number of fœti had been four.
Apr. 15,	Young born; evidences of being suckled.
Apr. 16,	Young evidently born.
Apr. 17,	Young born. Number of fœti had been four.
Apr. 17,	Young evidently born.
Apr. 19,	Young evidently born.
Apr. 20,	Young evidently born.
Apr. 20,	Young evidently born.
Apr. 22,	Four young moles taken in nest; weighed one ounce each.

SUMMARY.

Number of females pregnant or having recently borne young.	33
Normal number of young, apparently..	4
Largest number of young in any case..	5
Smallest number of young in any case..	3
Number of cases in which fœti were distinguishable.	10
Cases in which condition of uterus indicated number of young recently born	4
Nests of young moles.	1
Cases of 4 fœti	12
Cases of 3 fœti	2
Cases of 5 fœti	1

FOOD. The moles and the shrews constitute the sole representatives in North America of the mammalian order Insectivora (insect-eaters). A study of their dentition, the character of their food, and their general behavior in several respects, shows that they are much more closely related to the carnivorous or flesh-eating mammals than to the rodents, a group which includes the rats, mice, rabbits, squirrels and the like. This is especially true of the shrews, which are quite weasel-

like in character. They fight savagely, kill and eat other small mammals larger than themselves, and when angry or excited emit a musky odor like the weasel and the mink.

Comparative dentition of a carnivore, a rodent, and a mole. (Adapted from D. G. Elliot.) 1—Skull of a weasel (*Putorius*). 2—Skull of a wood-rat (*Neotoma*). 3—Skull of a mole (*Scalops*).

It has long been known to scientists, through careful study and investigation, that the diet of moles consists mainly of the insects, grubs and worms to be found in the soil. This fact, however, has been slower in gaining popular credence than most scientific pronunciamentos. In another part of this bulletin the mole's guests have been called to account for the general prejudice which has arisen against him, and, again, in this connection, let it be understood that the mole is directly responsible for only a very small portion of any damage to seeds, grains and tubers in the ground. Field mice, voles and

the common house mice are the guilty parties. If anyone is skeptical on this point he has only to set a few small mouse traps, properly baited, in the mole's runways and await results. In setting the trap a small excavation should be made with a knife or trowel. Place the trap on a level with the bottom of the runway. See that the latter is open both ways, and cover the excavation with a board or piece of sod to exclude the light and prevent the entrance of any small animal except by way of the burrow. Try various baits, such as soaked corn or peas, bits of meat, insects, and pieces of potato.

With respect to damage to roots and tubers by eating into them, it will usually be found on careful examination that the tooth marks are those of rodents.

Potatoes gnawed by rodents following in mole runways. Original.

EXAMINATION OF STOMACH CONTENT. Direct evidence of what an animal eats may usually be obtained in one or all of three ways: By examination of stomach contents, by observations in the field, and by experiments with captives. In the case of the mole field observations are of course impracticable. By the other two methods, therefore, we have endeavored to satisfy ourselves, and, we hope, others, as to the character of a mole's diet. The accompanying table gives the results of the careful examination of the stomach contents of 100 moles.

Results of Examination of 100 Moles' Stomachs.

Serial number.	Stomach Contents.
1	7 white grubs, 20 ants, 2 centipedes, 1 wasp.
2	2 white grubs, 1 earthworm, 1 beetle.
3	3 white grubs, 2 earthworms, 5 Diptera, beetle fragments.
4	8 white grubs, 3 larvæ (cutworms?), 1 beetle, plant rootlets.
5	2 white grubs, beetle fragments, 1 insect larva, plant fibers.
6	2 earthworms, 1 May beetle, 1 plant rootlet.
7	2 white grubs, 1 beetle larva, plant fibers.
8	5 white grubs, 5 beetle larvæ, 1 earthworm, 3 other larvæ, 1 cricket, fragments of vegetable tissue.
9	2 earthworms, 2 white grubs, 2 larvæ, 1 beetle, plant fibers.
10	15 white grubs (small), insect fragments.
11	5 earthworms, 1 white grub, 1 centipede, 1 fly, 1 cricket, 1 puparium, insect fragments.
12	2 earthworms, 18 ants, 1 beetle larva.
13	3 earthworms, 17 ants, 2 puparia, insect fragments, plant fibers.
14	2 white grubs, 2 beetles.
15	2 white grubs, 1 beetle larva, 2 beetles, 1 cricket, 1 ant, 3 centipedes.
16	2 earthworms, 3 insect cocoons, insect fragments.
17	8 earthworms, 19 white grubs, plant fibers.
18	1 earthworm, 1 puparium, 1 spider, 1 larva, plant fibers.
19	1 white grub, 1 earthworm, 1 centipede, 328 ants, 3 beetles, 1 tree cricket, plant fibers.
20	4 earthworms, 1 May beetle, 1 tiger beetle, 10 puparia, 2 beetle larvæ, 2 other larvæ.
21	1 beetle, 20 ants, 1 earthworm, insect fragments.
22	1 white grub, 3 cocoons, 6 larvæ, 1 beetle (Carabid), 1 beetle (Scarabid), plant fibers.
23	3 earthworms, 2 white grubs, 2 centipedes, 5 ants, 1 May beetle, 1 other beetle, 1 beetle larva.
24	1 earthworm, 1 centipede, 30 ants, 2 beetles, 1 beetle larva.
25	19 puparia, 1 earthworm, 16 ants, 1 beetle.
26	5 earthworms, 6 puparia, 2 beetles.
27	4 centipedes, 2 white grubs, 4 beetles, 5 beetle larvæ.
28	1 centipede, 2 beetle larvæ, insect fragments.
29	1 white grub, 2 ants, 1 beetle, insect fragments.
30	2 white grubs, 1 spider, 1 beetle, 1 May beetle, plant fibers.
31	1 beetle (Chrysomelid), 1 cocoon, 1 puparium, fragments of plant tissue.
32	1 white grub, 1 spider, 1 centipede, insect fragments, fragments of plant tissue.
33	1 May beetle, 1 ant, 1 beetle.
34	1 white grub, 82 ant puparia, 3 ants, 1 beetle, 1 beetle larva.
35	2 white grubs, 1 spider, 1 beetle larva, insect fragments.
36	1 white grub, 7 puparia, 1 centipede, 1 ant, 1 bug, 1 grasshopper, 1 May beetle, 1 tiger beetle.

Serial number.	Stomach Contents.
37	1 earthworm, 1 white grub.
38	1 beetle (Carabid), 2 white grubs, 2 larvæ, 1 beetle larva.
39	4 earthworms, 1 white grub, 10 cocoons, 1 centipede, 1 beetle (Carabid), 21 larvæ.
40	6 white grubs, 1 beetle, fragments of plant rootlets.
41	1 white grub, 1 cocoon.
42	2 beetle larvæ, 2 earthworms, several plant fibers and rootlets.
43	6 beetles, 3 beetle larvæ, 1 white grub, 1 spider.
44	1 beetle larva, 1 pupa, 1 white grub, 1 beetle, 1 earthworm.
45	4 earthworms.
46	3 earthworms, 15 small beetle larvæ, 1 white grub, 1 beetle, fragments of plant tissue.
47	1 white grub, insect fragments, 1 seed husk.
48	12 earthworms, 1 beetle larva, 2 white grubs.
49	4 white grubs, 2 earthworms, 1 ant, 1 bug, 1 cocoon, a few plant fibers.
50	3 white grubs, beetle fragments, a few bits of plant fiber.
51	4 earthworms, 1 white grub, 6 beetle larvæ, 1 wasp, fragments of plant tissue.
52	2 white grubs, 1 spider, 1 larva, insect fragments.
53	4 earthworms, 3 white grubs, 2 beetle larvæ, 1 cricket, 1 centipede, a few plant fibers.
54	5 white grubs, 1 earthworm, 15 beetle larvæ, 1 beetle, 1 cocoon of eggs, plant fibers.
55	6 earthworms, 7 white grubs, 2 beetle larvæ, 1 beetle.
56	6 white grubs, 1 earthworm, 1 beetle larva, insect fragments, fragments of plant tissue.
57	14 white grubs, 2 beetle larvæ, 2 beetles, 20 small larvæ.
58	2 white grubs, 2 wasps, 1 beetle, 1 beetle larva, insect fragments, 1 seed pod.
59	5 white grubs, 2 wireworms, 1 cricket, 1 wasp, 1 beetle, 3 beetle larvæ, 7 puparia.
60	4 white grubs, 2 earthworms, 1 beetle, 1 centipede, 1 spider.
61	12 white grubs, 2 earthworms, 2 beetle larvæ, 1 beetle, a few bits of plant tissue.
62	26 white grubs, 4 wireworms, 2 beetles, 1 centipede, 1 beetle larva.
63	2 puparia, 2 white grubs, 2 beetles, 3 centipedes, 2 beetle larvæ.
64	4 white grubs, 1 beetle, 1 beetle larva.
65	2 earthworms, 2 beetle larvæ, 1 beetle.
66	3 earthworms, 3 centipedes, 1 beetle, 1 puparium, 2 seed husks.
67	3 centipedes, 4 beetle larvæ, 2 beetles, 1 spider, 1 bit of plant tissue.
68	7 white grubs, 1 earthworm, 1 spider, 1 wasp, 1 beetle larva, 1 beetle, bits of plant tissue.
69	3 spiders, 1 beetle, 1 beetle larva, 1 plant rootlet.
70	171 small white grubs, 3 large white grubs, 1 May beetle, 1 beetle larva, 2 plant rootlets.
71	55 small white grubs, 1 grasshopper.

Serial number.	Stomach Contents.
72	Several spiders, 8 beetle larvæ, 1 earthworm, 1 wasp, fragments of several beetles.
73	3 beetles, 1 earthworm, 1 cocoon, 1 wasp, 3 beetle larvæ, skin of seed or root.
74	1 cocoon, 1 spider, 1 cricket, 1 earthworm, 1 beetle larva, 1 beetle, a few plant fibers.
75	4 earthworms, 8 puparia, 1 beetle, 1 cricket, 1 beetle larva, skin of seed or root.
76	1 earthworm, 1 spider, 1 May beetle, a few plant fibers.
77	1 earthworm, 7 beetle larvæ, 1 beetle, miscellaneous insect fragments.
78	3 beetles, 1 bug, 1 beetle larva, 1 white grub, insect fragments.
79	4 white grubs, 1 spider, 1 beetle, 2 beetle larvæ, a few plant fibers.
80	12 white grubs, 1 seed husk, a few plant rootlets.
81	44 insect larvæ, 1 beetle.
82	73 white grubs, 4 cutworms, 1 beetle, 1 larva, 1 seed husk, a few plant fibers.
83	1 earthworm, 2 spiders, 3 beetles, 1 cricket.
84	250 ant puparia, 2 beetle larvæ, 2 spiders, 2 beetles, a few plant rootlets.
85	3 earthworms, 1 spider, 8 puparia, 2 beetle larvæ, 1 beetle.
86	205 ants, 4 white grubs, 38 cutworms, 2 beetles, 1 spider, plant fibers.
87	2 earthworms, 1 puparium, 5 white grubs, 1 spider.
88	12 insect larvæ, 58 ants, 4 spiders, 1 hairworm (*Gordius*), 3 beetles.
89	3 cutworms, 60 ants, 1 beetle, 2 earthworms, skin of seed or root.
90	1 earthworm, 1 centipede, 18 puparia, 1 beetle.
91	10 cutworms, 1 spider, 1 beetle, insect fragments.
92	5 white grubs, 3 centipedes, 1 puparium, 1 cricket, 4 cutworms, a few plant fibers.
93	1 earthworm, 1 white grub, 3 larvæ, skin of seed or root, a few plant fibers.
94	2 centipedes, 5 cutworms, 1 spider, 2 larvæ, skin of seed or root.
95	2 centipedes, 1 puparium, comminuted mass of insect and centipede fragments.
96	3 white grubs, 1 larva, 1 centipede, 1 beetle, skin of grain or root.
97	4 white grubs, 1 cutworm, 1 ant, insect fragments, a few plant rootlets.
98	3 earthworms, 2 centipedes, 3 larvæ, 1 spider, 1 beetle, 1 puparium.
99	2 earthworms, 1 white grub, 2 centipedes, insect fragments.
100	1 white grub, 2 centipedes, 8 ants, mass of beetle fragments.

SUMMARY OF TABLE.

White grubs	64	stomachs
Earthworms	49	"
Beetles	67	"
Beetle larvæ	44	"
Other larvæ	25	"
Centipedes	25	"

Ants	19	stomachs
Wasps	7	"
Flies	2	"
Plant fibers and rootlets	43	"
Seed pods or husks	8	"
Crickets	10	"
Insect fragments	31	"
Puparia	21	"
Cocoons	10	"
Spiders	23	"
Grasshoppers	2	"
Bugs	3	"
Skin of grain or roots	6	"
Hair-worm	1	"
Number of stomachs infested by parasitic threadworms		28

In the course of the two years' investigations concerning the ways of the mole about 200 specimens have been checked up on our field notes. From this number the hundred individuals given above were selected so as to include some from each month of the year and to exclude any whose stomachs were empty or nearly so. The selections had no reference to stomach content, however, for they were made before examination of the latter.

The proportions of the various articles of food do not vary with the season as they do in the case of birds, for in some form the insects, worms and grubs listed in the above table are about as abundant in the soil at one time of the year as at another. It is scarcely necessary to add, however, that these supplies are not always equally accessible. In the summer when the soil is wet with recent rains the mole plows along very near the surface, extending his runways rapidly and gathering in a harvest of insects and worms, some of which have also come nearer the surface under these conditions. In dry periods or during portions of the winter season the mole must range deeper, for his prey has likewise found retreat farther down in the soil.

No attempt has been made to compute the actual percentages of each article of food in the list of twenty or more kinds given in the table. Such figures would be mere approximations at best. The end in view in the examination of each stomach was to discover what kind of creatures or substances it contained and, by noting repetition of similar parts of these organisms, how many of each kind.

While plant fibers or rootlets show up in forty-three cases, *in no case was the amount of identifiable plant tissue more than might have been taken in incidental to the ingestion of other food.* In many of the stomachs there was a considerable residue after repeated washings, filterings and eliminations of identifiable substances. This residue undoubtedly consisted largely of soil from the intestines of earthworms and finely comminuted animal and, perhaps, plant tissues. Even though starch, sugar or cellulose might be detected by chemical analysis, there would be no means of telling how much of this might have come from the digestive tracts of the insects taken as food.

Six stomachs contained fragments of plant tissue which may have been parts of the seed coat of corn, but resembled very closely thin bark from plant roots.

EXPERIMENTS WITH CAPTIVE MOLES. It is a difficult matter to keep a mole any considerable length of time in captivity. Altogether we have had more than a score under observation for a short time, but seldom have any of them been kept alive for more than a day or two. Either fright and worry, or lack of proper food in sufficient quantity, soon terminated the life of each captive. They have always been kept in tubs or boxes with a layer of earth several inches deep on the bottom. They were supplied with water and with food of several kinds, some of which they would eat readily. One individual survived for nearly two weeks and seemed to grow fat and sleek under the care we gave him. He finally died of too much kindness.

These imprisoned moles had insatiable appetites, eating ravenously bits of beefsteak and large numbers of earthworms. When freshly killed English sparrows were put in the cages in the evening, very little but bones and feathers would be left by morning. All refused to touch corn, potatoes or sweet potatoes, except the individual kept so long. He would eat these articles with some apparent relish, although he went about it very awkwardly. Instead of nibbling at a grain of corn as a rodent does, he would crowd it against the ground with his cheek and, gaining possession of it, chew it in the side of his mouth much as a steer chews a nubbin. The act or drinking water from a shallow dish was accomplished hog fashion, owing to the considerable projection of his snout beyond the aperture of the mouth.

When he was feeding on earthworms, there was no evidence of any attempt to first strip out the contents of the worm's alimentary canal, as has been reported by one investigator.

NATURAL ENEMIES AND CHECKS.

BIRDS. Probably no mammal on the North American continent has so few natural enemies as the common mole. Since it probably never leaves the darkness of its underground burrows except by accident, it is much less subject to attack by predatory animals than even the pocket gopher and the shrew, whose habits are somewhat similar to those of the mole. The following data gleaned from "Hawks and Owls of the United States," published by the United States Department of Agriculture, substantiates the above statement and shows how little the mole has to fear from the so-called birds of prey.

BIRDS.	No. of stomachs examined.	Remains of common moles.	Remains of shrews.	Remains of pocket gophers.
Red-tailed hawk (*Buteo borealis*)	562	6	46	8
Red-shouldered hawk (*Buteo lineatus*) ..	220	3	40	0
Broad-winged hawk (*Buteo latissimus*),	65	1	16	0
Barred owl (*Syrnium nebulosum*).....	109	3	3	0
Barn owl (*Strix pratincola*).....	39	0	5	8
Ten other hawks and owls (all that had eaten common moles, shrews, or pocket gophers)	1,131	0	35	14
Totals	....	13	145	30

In the above comparison it should be borne in mind that owls disgorge the pellets of bones and hair shortly after a meal. If to the figures on the pocket gopher in this table should be added the large numbers of those animals whose remains are found about the nests and roosting places of the barn owl and great horned owl, particularly, the total would be swelled enormously. Data on the number of moles and shrews found in similar situations are not at hand, but if their remains were at all conspicuous in the piles of disgorged pellets the matter would have received mention.

MAMMALS. The investigator has known personally of a few cases of keen-scented dogs acquiring the habit of searching out moles in fresh runways. The dog's sense of smell served to locate the mole, which was then pounced upon and speedily brought to the surface. In the files of the *Rural New Yorker* is found a short article by a subscriber in Missouri, who claimed to have several dogs that were adepts at this work.

These dogs, he states, were a cross between a Scotch collie and a prairie wolf, or coyote. This and other evidence at hand goes to show that the coyote, with his stealthy, skulking ways and his inquisitive nose, probably unearths many a luckless mole from the fancied security of his underground burrow. Judging from their general habits, it is probable also that foxes and badgers, and perhaps skunks, occasionally add moles to their bill of fare.

FLOODS. By far the greatest danger that manaces the adult mole and his progeny is the inundation of lowlands by heavy local rains or the waters of streams passing out of their banks. Such flooding of the soil is of comparatively frequent occurrence in the very situations where moles most abound, and probably serves more than all other things combined to check inordinate multiplication of the species. During the progress of the great June floods in 1903 and 1908, in the valleys of the Kansas and the Blue rivers, moles in large numbers could be found along the railroad embankments and in the driftwood that had lodged against the piers of bridges. What percentage of the adults perish under such conditions it is not possible to conjecture, but undoubtedly earlier spring freshets destroy most of the young on the flooded grounds. Certainly many of the adults survive these conditions, for they are good swimmers. On one occasion I captured more than a score in a single drift lodged against some piers. They seemed to be as vigorous and well fed as when taken under ordinary circumstances from surface burrows. This may be partly accounted for by the fact that the drift was full of beetles and other insects also seeking refuge from the water. Farmers and truck growers on the bottom lands have reported that after a flood subsides the moles and pocket gophers are not long in regaining their lost ground.

DAMAGE.

Considered from the standpoint of food habits alone, it has never been shown that the mole affects detrimentally the interests of the farmer and gardener. Indeed, it can be proven that quite the reverse is true. This statement will receive further consideration under the next heading. When, however, the mole is charged with disfiguring lawns and parks, destroying flower beds, tearing up the roots of grasses and

making himself a general nuisance in small garden plots, he will have to plead guilty. The evidence against him is abundant and direct.

ECONOMIC STATUS.

In dealing with a mole it is all a question of whether or not that particular individual is out of place. The mole has his place among the forces of nature, and no unimportant role does he play. One of the most abundant of small mammals, his kind has for ages been working over the soil and subsoil in the interests of plant life. Within the limits of his normal range it is almost safe to say that every square yard of arable land is traversed one or more times each season by portions of his extensive runways. A part of this work is visible at the surface, but much of it is not. The hoe, the plow, the cultivator strike into unsuspected burrows everywhere. After a flood has subsided on lowlands the unequal settling at the surface of the ground discloses the fact that the soil is simply honeycombed with the runways of the mole and one or two other burrowing mammals. This tunneling and the shifting of earth particles permits better aeration of the soil and favors the entrance of water from the surface. It also mixes the soil and subsoil, carrying humus farther down and bringing the subsoil nearer the surface, where its elements of plant food may be made available by the agencies at work there. As an offset to this good work of the mole it may be urged that the earthworms, which form a large part of his diet, play a similar part in the economy of nature. This is true; but who knows but that the earthworm, which lives partly upon green vegetation, might become a terrible scourge if the mole were not placed as a check upon its increase. Nature preserves the balance of power very nicely in the animal world.

A large item in the stomach content of moles is made up of white grubs, those scourges of grass and other valuable plant roots. The table of stomach analyses (on pages 17-18) shows that nearly two-thirds of the moles had eaten white grubs. One had performed the astonishing feat of eating 175, another 73, and another 55. For his good work in destroying grubs alone, therefore, the mole deserves much credit. Among the beetles also, and the insect larvæ in general, which form a considerable part of the mole's food, are many

forms that are injurious to agriculture. On the other hand, perhaps the bulk of the beetles were of those ground types that are predacious in habit and therefore may be considered either neutral or beneficial. It would be a tedious if not impossible undertaking to attempt to so classify these beetles as to determine the economic status of each individual or lot. In the vast majority of cases the fragmental character of the remains no more than served to distinguish the order. The spiders, centipedes and ants listed in the table may, as far as present knowledge goes, be reckoned as neutral or beneficial in their relation to agricultural interests.

The proportionately large amount of food consumed by a mole in a given time serves also to raise him in the rank of importance as a destroyer of noxious insects and their larvæ. A mole's appetite seems to be insatiable. Experiments with captives show that they will usually eat voraciously as long as they are supplied with food to their liking, often consuming more than their own weight in a day. This is not gluttony, as it is sometimes characterized. The tremendous amount of energy expended in plowing through the resistant soil requires a correspondingly large amout of food to supply that energy. That they must have this food at frequent intervals also is shown by the fact that a mole in captivity usually starves in a few hours unless supplied with nourishment.

The mole is one of nature's forces to be reckoned with by the agriculturist as he would reckon with nitrogen-forming bacteria, the birds that visit his fields and the bees that pollinate his fruit blossoms. If the individual mole is not out of place, mark him down as an asset and proceed accordingly. If he is where we do not want him, we are privileged to set swift death on his track in the form of traps, poison or club. For this reason—that a mole's presence in lawns, small garden plots, parks and cemeteries becomes intolerable—a line of experiments was undertaken to determine the better methods of getting rid of him in such situations. The results of these experiments follow.

COMBATING THE MOLE.

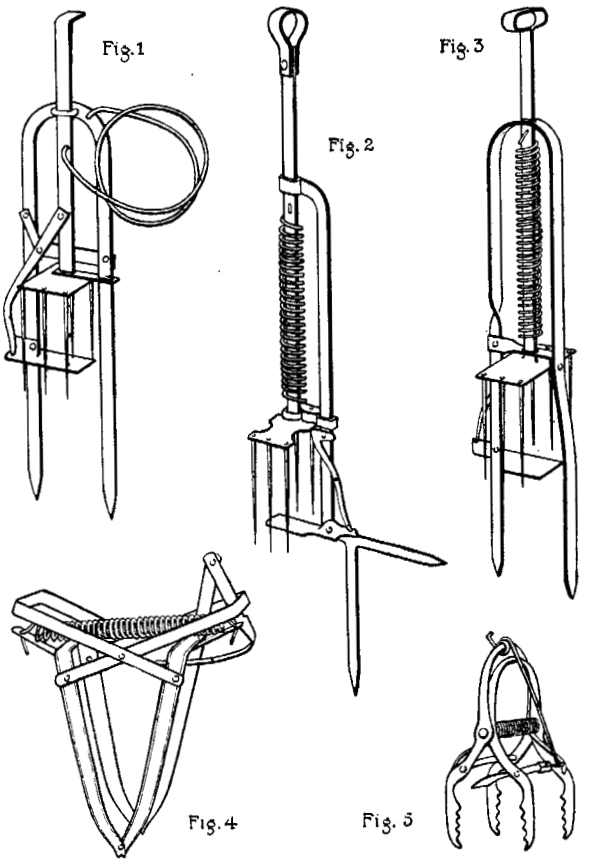
The mole seems to possess a natural shrewdness and ability to sense danger out of accord with the life of seclusion which it leads. The common rat, from long association with man and hereditary knowledge of poisons and traps, has become pro-

verbial for his sagacity and cunning, but the mole is almost his peer in these respects. This conclusion has been reached after dealing intimately with the mole for a period of two years. Like experience with the pocket gopher, an animal of somewhat similar habits, has demonstrated the fact that in this comparison he is stupidity itself, blundering into any sort of trap laid for him by the wiles of man.

TRAPPING. Trapping is the surest and, so far as my experience goes, the most practical method of getting rid of moles. I make this statement, however, without intention to disparage the utility of other methods. In some of the European countries villages and rural communities have their professional mole catchers, who follow the business for a livelihood. Correspondence with agricultural societies in two or three of these countries elicited the information that these professional catchers commonly use some sort of a trap which they construct themselves. These traps all have as part of their mechanism horse hair or fine wire loops which are drawn tightly about the body of the mole by the release of a pliant stick bent downward when the trigger is set.

There are a number of excellent mole traps on the market in this country, any one of which, when properly handled, will give good results. All the different makes that have come under my notice depend upon the same sort of mechanism for releasing the spring; namely, a broad trigger-pan intended to be placed directly over a depressed spot in the mole's runway when setting the trap. The raising of this trigger-pan as the mole again upheaves the depressed portion of his surface burrow releases the contrivances designed to kill. The latter are of two types — sharp spikes which impale the mole when driven into the ground by the spring, or two pairs of scissor-like jaws which close firmly across the runway, one pair on either side of the trigger-pan. The arrangement of the spring, the safety catch and other details of individual trap construction are matters of secondary importance.

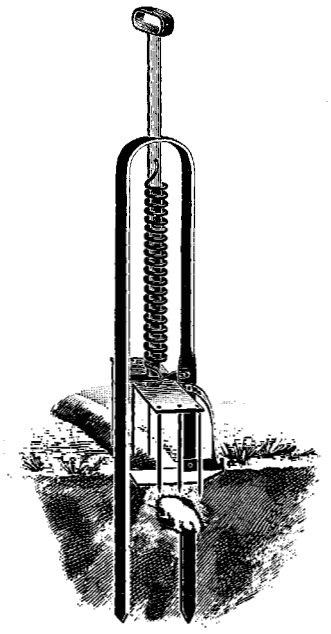
Plainly the efficiency of any animal trap depends upon its being so constructed as to adapt itself to the habits of the animal it is designed to capture. These mole traps conform to such requirements in at least two particulars — they can be set without exciting the animal's suspicions by entering or introducing anything into its burrow and are sprung by the mole in



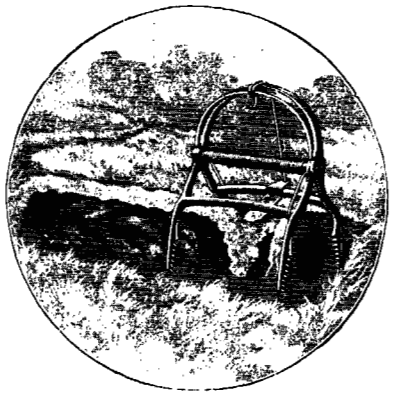
Types of mole traps. 1—The Side-spring trap. 2—The Wherry trap. 3—The Reddick trap. 4—The Chandler (Heartley) trap. 5—The Out o' Sight trap.

following its natural instinct to reopen its passageways when trodden down by passing feet or otherwise obstructed. Success or failure in the use of these devices depends largely upon the operator's knowledge of the mole's habits and of the machanism of his trap. To set a trap properly one should select a place in the surface runway where there is evidence of fresh work and with the toe of the boot firmly compress the ridge at one spot. If the trap is one of the harpoon or impaling types, raise the spring, set the safety catch and push the supporting spikes into the ground, one on either side of the runway, until the trigger-pan just touches the earth where it was trodden down. Now release the safety catch and allow

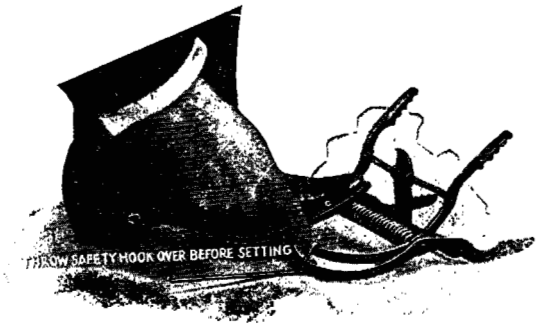
the impaling spike to be forced down into the ground by the spring. This will facilitate their penetrating into the burrow when the trap is sprung later. Set the trap and leave it, taking care not to tread upon or otherwise disturb any other portion of the mole's runway. In setting the scissor-jawed trap known as the "Chandler" (see illustration, page 25), the points of the jaws are forced directly into the mole's runway until the trigger-pan rests upon the depressed portion as before, and the levers at the top are then pushed apart until the trap is locked. Care should be taken to see that the trap is in line with the mole's runway so that the little animal will have to pass through directly between the jaws. These



The Reddick set on a runway.



The Out o' Sight set on a runway.



Setting the Out o' Sight.

have already cut a path for themselves in the process of being spread apart. Another trap of this type, the "Out O' Sight" (see illustration, page 26), has a very strong spring and must be set by the aid of the foot while resting on a firm surface. It is then secured by a safety hook and its jaws forced into the ground, straddling the runway, until the trigger-pan touches as in the other traps. As the jaws of this trap are rather short it may be necessary sometimes to scrape off some of the grass and dirt on the top of the mole ridge in order to bring the trap down nearer to the actual burrow. Release the safety hook before leaving the trap.

It is useless to attempt the capture of moles by means of small steel traps or the ordinary snap mouse traps set in their runways. This fact became evident in trapping for mice and other guests of the mole. Scores of times the traps were carefully introduced into the burrows and the small excavation covered with sod so as to exclude all light. The results were always the same: scorning the bait or avoiding the unbaited trigger, the mole would plow his way beneath or to one side of the trap and pass on.

POISONING. There are a number of difficulties in the way of getting measurable results in experiments having to do with the poisoning of moles. The method used in conducting these experiments was as follows: A certain number of fresh runways—usually twenty-five—were selected and located by numbered stakes. Into each of these runways the poisoned bait was introduced at three to five different points through small openings made with a lead pencil or sharpened stick of about that size. These openings were then closed with a clod and the exact spot marked by a small pot label. After three or four days a careful inspection of all these locations was made to determine whether or not the bait had been taken or in any way disturbed. The runway was then opened up for a foot or two in each direction from the former location of the bait and left in this condition. In a few days another inspection of the runways was made to ascertain whether the moles were still at work, as would be evidenced by fresh ridging of the earth or by the filling up of that portion of the runway left open as stated above.

Now as to the interpretation of results: If the baits were taken wholly or in part there would be no means of telling

whether they were eaten by the mole or by his guests, or even whether the mole had a chance to accept or refuse the bait before it was taken by other occupants of the burrow. The fact that a system of runways showed fresh work after poison had been introduced and the baits taken was, therefore, no evidence that the particular kind of bait was not suitable for the purpose. A mole's system of runways is so extensive that failure to retraverse or work that part of it under observation during the period of the experiment would not be positive evidence that the mole had been destroyed by the poison. Since there is so much intersection of burrows that it is difficult to determine the limits of each individual mole's system of runways, continued activity in the vicinity of a spot where poison had been put out would prove nothing more than that there was at least one mole alive there yet. The summary of more than a thousand records of poisoning operations show that but one dead mole was found.

In all poison experiments strychnia sulphate was used. Various baits were tried, with the following results and conclusions:

Peas. Peas were soaked for forty-eight hours in a solution of one-eighth ounce of strychnia in one quart of soft hot water. Seventy-eight per cent of the baits were taken, probably largely by mice, as sixty per cent of the runways continued to be worked by moles. This is undoubtedly an efficient bait for destroying the mice that follow the mole's runways in newly planted cornfields.

Fresh meat. Small bits of beefsteak were poisoned by inserting a crystal or two of strychnia into small slits made in the bait with the point of a penknife. About the same per-cent of baits was taken as in the case of the peas, but a few of them were dug up from the surface. There is, therefore, danger of poisoning such keen-scented animals as dogs and cats by the use of these meat baits. Forty-two per cent of the runways treated showed fresh work after the close of the experiment.

Grasshoppers. The bodies of grasshoppers were poisoned in the same manner as the fresh-meat baits, the heads of the insects having first been pulled off. Sixty-one per cent of the baits were taken, but forty-four per cent of the runways continued to be worked.

Raisins. Raisins were poisoned by removing the seeds and inserting crystals of strychnia. About sixty per cent of these raisins were taken, but they proved to be the most efficient bait tried. Thirty-six per cent of the runways still showed fresh work, however. This bait is recommended by the department of botany of the Michigan State Agricultural College.

Green corn. Corn in the roasting-ear stage was cut from the cob and treated with a poisoned mixture prepared by dissolving an ounce of strychnia sulphate in a pint of hot water and mixing this with a pint of thick sugar syrup. This bait proved to be of little value, for in seventy-six per cent of the trials it was left untouched. In the remaining cases one-third of the runways continued to be worked.

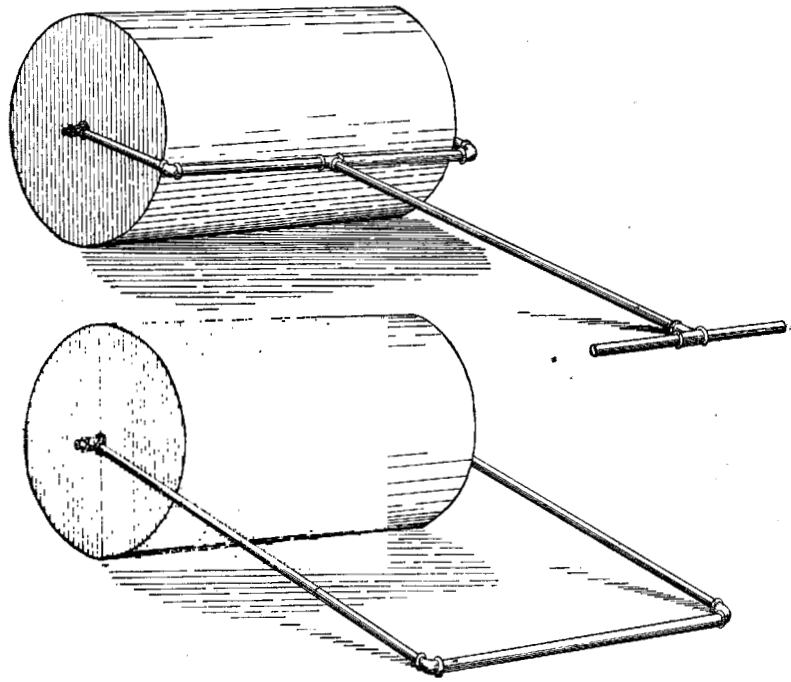
Corn. Corn soaked over night and then treated with the poisoned syrup prepared at this Station for prairie dogs gave largely negative results. Seventy-five per cent of the runs treated continued to be worked by moles. Syrup prepared for pocket gophers was used on soaked corn as bait with somewhat better results, about fifty-six per cent of the runways treated showing no further evidence of mole operations.

CATCHING ALIVE. If one cares to take the time in morning or evening he can often catch a mole at work by watching in a spot where fresh burrowing operations have been noted. Approach very quietly the place where the earth is being heaved up and suddenly strike a spade into the ridge behind the animal and throw it out on the surface. If no spade or other suitable implement is at hand stamp the burrow down behind the mole with the foot and then subject the spot directly over the mole to like treatment or dig the animal out by hand.

When watering a lawn or irrigating a garden one can occasionally drive a mole to the surface by permitting a stream of water from hose or ditch to run into an open burrow for some time. This plan is not usually practicable, however, for it entails a waste of water, softens up spots in the lawn until they become boggy, and may result in flooding a cellar through an unsuspected runway following along the wall.

ROLLING THE LAWN. Repeated leveling of the mole ridges on a lawn by means of a suitable roller not only tends to discourage the animals from making any further inroads on the

premises, but prevents that injury to the grass roots which would otherwise have resulted, and makes the lawn always appear sightly. A practical and substantial roller for this purpose may be made of cement, with gas-pipe axle and handles. It should weigh about 200 pounds.



Types of lawn rollers made of cement, with gas-pipe axle and frame. The form for setting the cement may be of wood, very narrow slats, or of galvanized iron. In the latter case the form may be left on the roller. The dimensions of the roller should be about 20 inches long by 14 inches in diameter.

TREATING SEED CORN TO PROTECT IT FROM BURROWING ANIMALS.

For several seasons the Station has been working on a line of experiments to determine means for preventing the theft of seed corn in the ground. A preliminary circular or bulletin on the subject was published a year ago, but at that time sufficient progress had not been made to warrant any final recommendations. Since the mole is very generally charged with these thefts, and since he is in reality accessory to the crime—by constructing highways which the real thieves follow—the results of this seed corn treating can be very properly given here.

These experiments have all followed one of three lines—baiting the pests some days in advance of planting, regular planting of poisoned seed, and surface coating of seed with ill-flavored substances.

POISONED BAIT. By baiting is meant the introduction of poisoned grain baits into the mole runways through small openings made with a stick. This puts the bait where it is sure to be found and minimizes the danger of its being taken by birds or any other animals than those for which it was intended. This plan also tends toward conserving the mole and destroying the mice, for the former is exceedingly suspicious of poisoned baits, while the latter will accept them readily. The sharp stick used for making the openings through the roof into the burrow should be no larger than one's finger. Close this opening with a clod after dropping in the kernels of poisoned grain. Corn, wheat or Kafir treated with the poisoned syrup prepared at the Station for destroying pocket gophers will make efficient baits. An excellent syrup for poisoning these grains may also be made as follows: Dissolve one ounce of strychnia sulphate in a pint of hot soft water. Add to this a pint of thick sugar syrup and mix the two by stirring. Pour enough of this syrup over the grain to thoroughly coat it. The one-quart mixture prepared as above should be sufficient for a half bushel of grain.

POISONED SEED. An exhaustive series of tests has proven that seed corn intended for the regular planting may be poisoned without any resulting injury to its germinating qualities. For this poisoning, strychnia sulphate should be used.

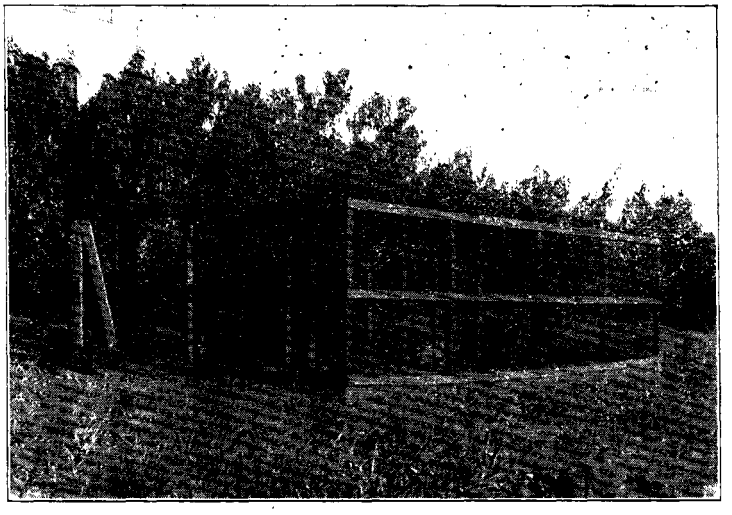
As will be seen by reference to the table on page 35, both arsenic and corrosive sublimate seriously affect the viability of the seed. If the corn can be planted by hand it may be treated with either of the poisoned syrups referred to above. In garden plantings or along creek bends where the mole-mice pest is the most serious this method of planting can be followed to advantage. The seed corn may be allowed to dry after treating with the syrup, but if planted at once it should be handled with a spoon.

To poison seed corn so that it will still work in a planter, dissolve one ounce of strychnia sulphate in eight quarts of hot water, preferably rain water. In this solution, after cooling, soak one peck of seed for forty-eight hours, using as a container a vessel that will close tightly enough to prevent evaporation. When draining the corn at the end of the period of soaking save the poisoned water, as there will ordinarily be enough to soak a half peck more of seed. When corn so treated is thoroughly dried it will return to its former bulk, will have its germinating qualities unimpaired, and will work in a planter as well as untreated seed. Field experiments seem to indicate, however, that if heavy rains follow shortly after planting the poison tends to leach out of the grain. Under similar conditions the surface coating given by the poisoned syrup will also be partially washed off.

COATING SEED WITH OFFENSIVE SUBSTANCES. During the past two seasons an extensive series of tests has been made in treating seed corn with various ill-tasting substances calculated to deter burrowing animals from taking it. The results in most cases have been negative; that is, the seed was usually taken about as readily as though it had not been treated at all. In every case a counted number of kernels of treated corn were put out in not less than twenty different locations and the trial repeated at different seasons. All locations were accurately marked and carefully examined at regular intervals. The notes show that none of the substances used prevented the kernels of corn, or a portion of them, from being eaten or carried off. In most cases the corn was introduced directly into surface runways through an opening made by a lead pencil or small stick. Field plantings of treated corn were also made for two seasons on lands adjacent to small creeks. One of these plantings was entirely taken by fox squirrels as soon as the

young plants began to show aboveground. A second planting was protected from a like fate by the use of traps and shotgun, and a fairly good stand of corn secured.

Experiments with about a dozen live spermophiles (striped ground squirrels) kept for months in the field cage shown in the illustration on this page demonstrated that these little animals will eat some of the corn, no matter how it has been previously treated. That, too, in spite of the fact that they were given untreated corn to eat during the progress of the experiments. When the freshly treated corn was exposed in saucers or trays they would generally eat the more palatable kinds first. When planted in plots and allowed to germinate or to grow to the height of an inch or two they would dig up all kinds indiscriminately.



The field cage for conducting experiments with captive mammals at the Kansas State Experiment Station.

The results of the tests of deterrent substances may be here briefly summarized:

SUBSTANCES WHICH HAVE BEEN FOUND TO INJURE THE GERM OF THE SEED. Kerosene, crude petroleum, copperas, crude carbolic acid, fish oil, spirits of camphor and turpentine, when used in sufficient quantity or strength to impart an odor to the corn, seriously injured the germinating powers of the

grain. To treat the seed with any of these substances in such small quantity or dilute form as not to injure the germ is a waste of time, for the slight taste or odor imparted is soon dissipated by contact with the soil. Corn soaked in kerosene—an oft recommended treatment—for as short a time as five minutes, seriously impaired its germinating qualities.

SUBSTANCES NOT INJURIOUS TO THE SEED, BUT OF NO VALUE OR NOT AVAILABLE. Mixing pulverized gum camphor with the dry grain and storing in a closed vessel for some days has been recommended as an efficient treatment. The results were entirely negative. Little or no odor was imparted to the grain, and when the latter was placed in mole runways it was readily taken. Coating the corn with a thin paste of red lead and water has been recommended for protecting it against crows. When seed thus treated was placed in the spermophile cage, along with six other trays of corn that had been coated with deterrents, that subjected to the red lead treatment was the first to be eaten. Pine tar was used in some of the experiments. It has a strong odor but leaves the grain too sticky to work in a planter.

SUBSTANCES WHICH MAY BE USED WITH SOME DEGREE OF SUCCESS. Coal tar makes an ideal coating of a rich brown color and a persistent gassy smell. It dries nicely, is not in the least sticky when dried, and will therefore work well in a planter. Wet the grain with a little warm water before stirring in the tar. A tablespoonful of the latter will be sufficient for a peck of corn. The mass must be thoroughly mixed and then dried before attempting to plant. Mice show some aversion to corn thus treated, but ground squirrels do not seem to object to the coating. This deterrent is generally regarded as effective against crows, particularly by Eastern farmers. The Station has had no opportunity to test the matter. Soaking corn in strong tobacco decoction for twenty-four to forty-eight hours gives good results in some cases. Of course the grain must afterwards be thoroughly dried if it is to be planted by machine. It will still have a strong odor and will not be sticky. The decoction was prepared by steeping a pound of ordinary smoking tobacco in eight quarts of water. This will serve for soaking a peck of corn.

Treatment of Seed Corn with Deterrents and Poisons. Germination Table.

(Average germination of the ten varieties of check or untreated corn in this test about 95 per cent.)

Substance used.	Treatment.	No. of grains tested.	Germination.
Kerosene	Corn surface-coated just before planting	600	74%
Coal tar	1 tablespoonful to peck. Planted at once	500	92
Coal tar	1 tablespoonful to peck. Dried before planting	1,100	95
Zenoleum	Corn surface-coated just before planting	400	93
Zenoleum	Corn surface-coated and dried before planting	1,000	93
Crow repellent	Corn surface-coated just before planting	200	94
Crow repellent	Corn surface-coated and dried before planting	800	94
Red lead	Corn surface-coated with paste in water	500	96
Tobacco	Decoction—1⅔ oz. to 1 qt. water. Soak 36 hrs.; dry	900	93
Gopher poison	Corn surface-coated just before planting	500	92
Gopher poison	Corn surface-coated and dried before planting	1,000	96
Strychnia sulphate	⅛ oz. to 1 qt. hot water; corn soaked 48 hrs.; dried	1,000	93
Water	Corn soaked 48 hrs.; dried before planting	1,000	93
Arsenic	Corn wet in very dilute mucilage; powdered with arsenic	100	82
Corrosive sublimate	Corn soaked in 1% solution for 1 hr.; dried	50	14
Spirits of camphor	Corn soaked in spirits for 24 hrs.; dried	100	00
Pine tar	Corn surface-coated; dried before planting	100	92
Crude petroleum	Corn surface-coated just before planting	100	18
Fish oil	Corn surface-coated just before planting	100	54
Crude carbolic acid	Corn surface-coated just before planting	100	44
Copperas	1 oz. to one gallon of water; corn soaked 24 hrs.; dried	100	79

MOLES FOLLOWING THE LISTER FURROW. In connection with the report on treating seed corn it may be well to give here the results of some observations on the mole's alleged habit of following in the bottom of the listed furrow. There is no doubt but that the little animal is guilty, as charged, of following a course by preference along the straight trail of freshly loosened earth made by the drill-shoe. That he is seeking out the seed corn is only a matter of inference from

his following the furrow. The truth of the matter is that it is probably the white grub that attracts him, not the corn. The presence of moles in rich lawns, garden plots and along creeks in cornfields is a symptom, not a disease. The white grub is the disease. The record of accurate observations on a twenty-acre cornfield in Illinois shows an average of over thirty-four grubs to the square yard. It is needless to say that this field produced but little corn. The grub eats the young corn shoots before they are up and attacks the root system at any time throughout the season.

The following table gives the results of careful measurements and counts made day by day on twenty rows of corn in rich ground along a little creek. The data given are calculated to show to what extent the mole traverses or crosses the lister furrow:

PLANTING "A."					PLANTING "B."				
Row.	Greatest number of places traversed by runs at one time....	Greatest total length of runs in furrow at any one time.....	Greatest number of times run merely crossed the furrow..	Total length of row...	Row.	Greatest number of places traversed by runs at one time....	Greatest total length of runs in furrow at any one time.....	Greatest number of times run merely crossed the furrow..	Total length of row...
		feet.		*feet.*			*feet.*		*feet.*
1.....	9	159	3	825	1.....	6	170	8	825
2.....	11	59	8	825	2.....	11	93	5	825
3.....	10	75	10	825	3.....	13	459	4	825
4.....	8	41	6	825	4.....	14	246	4	825
5.....	10	34	8	756	5.....	11	107	3	756
6.....	4	19	13	756	6.....	9	157	2	756
7.....	5	62	6	696	7.....	6	56	3	696
8.....	4	20	9	354	8.....	5	69	4	354
9.....	3	29	6	354	9.....	7	178	2	354
10.....	3	38	4	354	10.....	6	70	5	354

The above figures give the greatest totals noted at any one time. After heavy rains counts and measurements would differ from these figures. Probably nearly the entire lengths of the rows were traversed at different times. The injurious effect of the mole's running under the young corn shoots was most noticeable in the dry periods. However, the number of shoots of corn known to have died from having their roots heaved up totaled but 53.