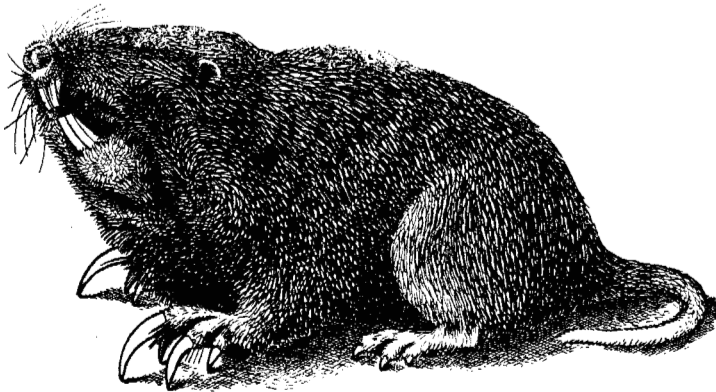


FEBRUARY, 1908.

BULLETIN 152.

Kansas State Agricultural College
Agricultural Experiment Station.

THE POCKET GOPHER.



The Prairie Pocket Gopher, *Geomys bursarius*. (Reduced.)

BY
THEO. H. SCHEFFER.

MANHATTAN, KANSAS.
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LETTER OF TRANSMITTAL.

*C. W. Burkett, Director, Agricultural Experiment Station,
Manhattan, Kan.:*

SIR—I herewith transmit the manuscript of a report on the habits, life-history and methods of combating the pocket gopher. Mr. Scheffer has spent his available time during the past several years in this study, but has not heretofore published anything on the subject. It has been my pleasure to encourage the author and to urge this work to its completion. The recent remarkable increase of gopher work in alfalfa has led to such a widespread interest in the subject that I recommend the publication of this report as one of the regular Station bulletins.

Respectfully,

T. J. HEADLEE, *Entomologist.*

SUMMARY.

1. The prairie pocket gopher is most abundant in the central and northeastern parts of the state, particularly in the region drained by the Kansas river and the lower courses of its main tributaries. The plains pocket gopher is found in more scattering numbers in the western third of the state and down the Arkansas valley to some distance east of the great bend. Southeastern Kansas is comparatively free from gophers.

2. The gopher digs extensive runways in the subsoil of wild lands and cultivated fields, piling the excavated earth in mounds on the surface. These runways have no exit above ground. A single animal will throw up several mounds a day for weeks at a time. A gopher spends his entire time in his underground burrow.

3. Gophers breed in the late winter and early spring. Pregnant females may be found from January to May, but the young are nearly all born in March and April. There is but one brood a year. The number of young varies from three to six, and averages a little more than four.

4. The natural food of the pocket gopher consists of the fleshy roots it encounters in extending its runways, with the addition of some succulent vegetation drawn down into the burrow from above ground. Some food is stored in underground chambers for winter use.

5. Gophers are active at all seasons, but particularly so in the fall and spring. They do not hibernate. They throw up mounds any day in the year when the ground is not frozen too hard for mining operations.

6. The pocket gopher, by reason of his secluded life, has but few natural enemies. Bull-snakes, weasles, owls, cats and striped skunks destroy some of them, but cannot be depended upon to keep them in check.

7. Cultivated crops are damaged by the attacks of gophers on their root systems and by being covered with excavated earth. Much loss to the farmer also occurs through the obstruction to harvesting operations occasioned by the presence of the mounds. The alfalfa grower has the most ground for complaint, but nurserymen, orchardists, truckers and potato farmers also suffer heavy losses.

8. We have in Kansas two laws affecting the gopher; one a compulsory extermination law, the other a bounty law. The compulsory extermination law has two weak points, which render it practically inoperative. The bounty law has been tried and found wanting. Better results can be obtained, and at much less cost, by the plan of furnishing poison at the expense of the county or township.

9. Poisoning is the best method of combating the pocket gopher we have so far discovered. Trapping is effective, but slower than poisoning. Fumigation does not give good results, and we do not therefore recommend it. The poisoned bait that has given us the best results is soaked corn treated with a syrup prepared by the Experiment Station. Raisins, prunes and pieces of apple, potato and sweet-potato into which crystals of strychnine have been inserted also make excellent baits, but require much more time in preparation than the corn bait.

10. Extermination of the pocket gopher in Kansas is not to be looked for, but communities may be entirely freed from the pest by persistent and concerted action on the part of landowners.

THE POCKET GOPHER.

By THEO. H. SCHEFFER.

INTRODUCTORY REMARKS.

DURING the last three years the author of this bulletin has devoted a considerable amount of time to gathering data and establishing facts relative to the Kansas species of pocket gopher. Direct observations and experiment in the field have constituted the larger part of the work considered necessary to the preparation of a paper having any real practical value. An extensive correspondence, carried on independently and also in connection with the sale of gopher poison by this department during the past five years, has added materially to our knowledge, particularly of the distribution and depredations of the animal. In connection with the work a number of extensive trips have been made to various parts of the state, including the banner alfalfa counties, the irrigated lands of the Southwest, the potato-growing districts of the Kansas valley, and nurseries and orchards in several quarters.

The important bearing of pocket-gopher problems on agricultural interests has become very apparent in recent years. No other species of native mammals of the state will rank with the pocket gopher in extent of injury to crops and obstruction to work in harvesting them. From an economic standpoint, therefore, the gopher is our most destructive mammal. There can be no doubt, either, that the numbers of the animal are increasing from year to year, especially in the alfalfa-growing districts of central Kansas. In many localities there are ten gophers now where there was but one a few years ago. With the steady increase in the acreage of alfalfa one may expect to see still more rapid multiplication of the species. This valuable crop (alfalfa) furnishes just the conditions necessary to make life easy for a pocket gopher. The roots of the plant are thick and succulent and extend deep enough to supply the wants of the animal in his natural range, or even when he is burrowing below the limits of frost. This food supply never fails. Then, too, the ground is not broken up by the plow for

The Pocket Gopher.

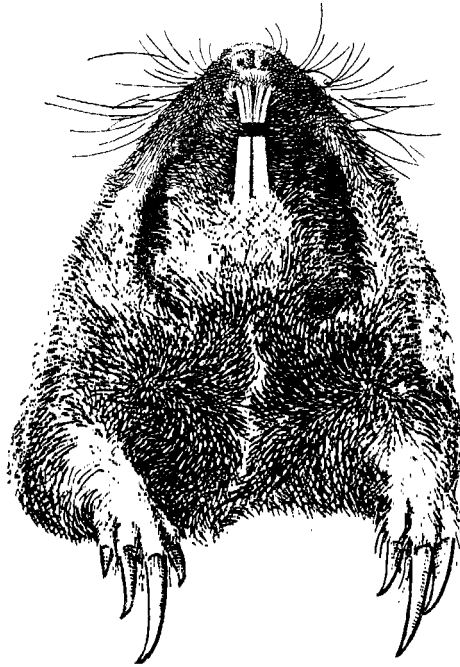
a period of years and the surface scraping given by the harrow or disk does not in the least disturb these burrowing rodents. Consequently vigilance on the part of every landowner and cooperation with his neighbor — nothing short of this — will rid a community of the pocket gopher. We cannot hope to exterminate the animal, for the conditions under which he lives are such as to render extermination practically impossible. Like mice and rats, the gopher is probably with us to stay. But the farmers of any community, as well as any individual landowner, can secure immunity from the ravages of the pest at little cost of time and labor. More than one thrifty farmer has assured me that if one keeps careful watch of his acres, the career of any invading pocket gopher can be nipped short at an expenditure of time totaling not more than a few hours a year. The history of the prairie-dog and his elimination from the agricultural problems of western Kansas well illustrates what can be done in the case of the gopher. It is no longer a matter of seeking a solution for the gopher problem. Solutions are at hand, but we are lacking in persistence and cooperation.

DESCRIPTION AND DISTRIBUTION.

The common gopher, *Geomys bursarius*, belongs to a family of rodents differing in many respects from that including the squirrels. The term "gopher" should therefore not be applied either to the little striped ground squirrel of our prairies or to the larger gray burrowing squirrel, Franklin's spermophile.

General Appearance. —Our true gopher is a short, thick-set fellow, with capacious external cheek pockets. These are wholly outside of the mouth, and are lined with fine soft hair of a lighter shade than that covering the body. The latter is dark brown in color, lighter beneath, and so soft and silky that it is not readily soiled by contact with damp earth. Sometimes there are white patches of various sizes about the nose and throat. Occasionally a pure white specimen is taken. The tail is short and scantily covered with hair. The bead-like eyes are about as large as a No. 5 shot, and external ears are likewise not much in evidence. The incisor teeth are long and prominent, the upper pair being grooved longitudinally.

Size. —The adult animal varies somewhat in size in different



Head of prairie pocket gopher, showing entrances to cheek pockets and grooved upper incisors.

parts of its range. Specimens taken about Manhattan average ten to eleven inches in length from tip of nose to tip of tail. The latter is about three and one-fourth inches long. The hind foot measures one and one-third inches. The average weight is very close to twelve ounces. The males are heavier, larger, and broader in the shoulders than the females.

Distribution.—The prairie pocket gopher *Geomys bursarius*, is distributed over that part of the upper Mississippi valley which includes the central and eastern parts of the Dakotas, Nebraska and Kansas, the whole of Iowa, and portions of Missouri, Illinois, Wisconsin and Minnesota. On the west—excepting in the Dakotas—its range meets and partly overlaps that of the plains pocket gopher, *G. lutescens*, and on the south that of the Louisiana gopher, *G. breviceps*. In the western part of the Dakotas *Geomys* is

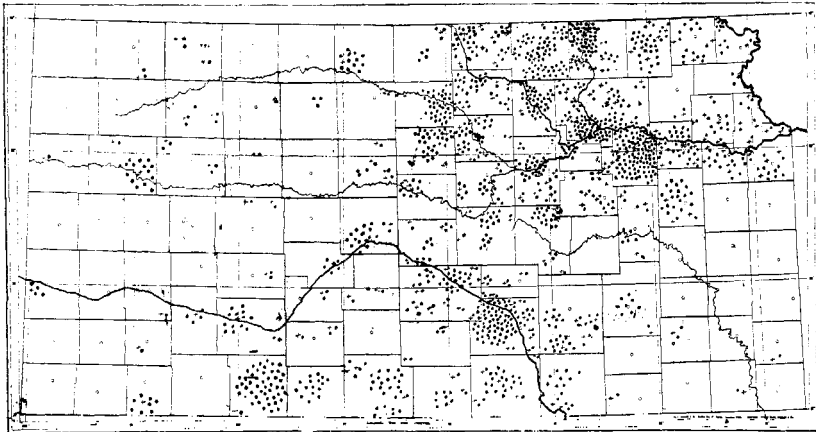


Front foot of prairie pocket gopher.

replaced by a distinct genus—*Thomomys*—inhabiting nearly the whole of the Rocky Mountains and Pacific regions.

Kansas Species.—In Kansas the dominant species of gopher is *G. Bursarius*. It is most abundant in the central and north-eastern parts of the state, and ranges at least as far west as the ninety-ninth meridian. Here it is partly, and a little further west fully, replaced by the paler, sand-colored species, *G. lutescens*. Whether the two species intergrade on the common border of their respective ranges I have not been able to determine. At any rate, a discussion of this matter comes within the province of a technical rather than an economic bulletin. In no part of western Kansas have I found the plains pocket gopher very plentiful. It is more scattering in its distribution than *G. bursarius*, being locally abundant only in the gravel flats along the streams or among the sand-hills. The harder soil of the buffalo-grass tracts has little attraction for this burrowing animal. In the lower Arkansas valley of south-central Kansas the species becomes as abundant, however, as does *G. bursarius* in any quarter of the state.

Distribution Map—If reports of depredations by pocket gophers and demand for measures of repression and extermination can be taken as an index to distribution, it may be seen from the accompanying map that *Geomys bursarius* is most abundant in the region drained by the Kansas river and the lower courses of its main tributaries. The area of greatest



Distribution map. The number of dots represents the number of cans of gopher poison sent out by the Station to various points in the state. The distribution of the dots will thus serve to indicate roughly the local occurrence or absence of the pest in destructive numbers.

infestation is also shown to include that portion of the Arkansas valley east of Great Bend, but here the plains species is the more abundant. A personal survey of the valleys of the Kansas, the Blue, the Republican, the Solomon, the Smoky Hill and the lower Arkansas valley confirms the evidence of the map to which I have referred. Southeastern Kansas seems to be comparatively free from the pest, at least in numbers sufficient to make it troublesome. In this region and along the south-central border of the state the range of *G. bursarius* probably meets that of the Louisiana pocket gopher, *Geomys breviceps*. The evidence of this is shown by specimens from the valley of the Ninescah—now in the zoölogical collection at Washington—having some characteristics of both species.

HABITS.

The pocket gopher is an excellent illustration of an animal adapted to a particular environment. Built short and stocky, like a Hungarian miner, it is able to excavate with ease and dispatch the intricate system of long, branching, subterranean galleries in which it spends practically its entire life. Its shoulders are broad and its fore legs strong and sinewy, ending in stout claws that can rapidly rake a passage through a wall of earth. In mining operations the claws are assisted by a pair of long and sharp incisor teeth curving from the upper jaw. Its eyes are very small and their range of vision quite limited, as has been proven by experiments with animals kept in captivity. In fact the animal can have no possible use for eyes except in the brief moments it spends at the exits of its burrow when throwing out earth. As might be expected, a study of the animal's reactions to stimuli shows that its sense of touch and of smell are exceptionally well developed. The short, stubby tail, nearly devoid of hair, is particularly sensitive to touch.

The greater number of burrowing mammals, like the prairie-dog, the spermophile and the woodchuck, spend most of the daylight hours in fine weather above ground. The interesting little kangaroo rats and their ilk come out at night to thread their tiny pathways in the sand fields or report their errands in delicate tracery on patches of snow. The pocket gopher, on the other hand, cares neither for the enticing warmth of sunshine nor the witchery of moonlight, but sticks to the dark-

ness of his tunnels. In watching gophers push out the earth when extending their burrows I have never seen one expose more of the body than the head, and usually one can catch a glimpse of the nose only, as with a quick upward flirt of this member the animal flings the dirt from the exit. As the earth is sometimes pushed to a considerable distance from the temporary opening, it is likely that the gopher must of necessity emerge entirely from his burrow at times. This he no doubt does under cover of darkness, for it is a matter of common observation that after a busy hour or so in the early morning very little dirt flies again until near sunset, except perhaps on dark, cloudy days. No evidence of tracks or traces of foraging indicates that the animal ordinarily ventures farther than its mound of earth, however, even in the night. At certain seasons, though, particularly when many of the young generation of that year are setting up in business for themselves, the natural instinct of all animals to extend the limits of their range impels the gopher to roam about. This is evidenced by the sudden appearance in late summer and in autumn of new mounds, like pioneer shanties, in fields remote from other gopher habitations. At this season we occasionally encounter a claim seeker abroad even in the daytime. In late autumn and early winter, too, the males no doubt wander about more or less.

The Burrow.—Except where an invader has recently established himself in new territory, it is practically impossible to determine the limits of a gopher's burrow. The work of excavating is usually carried on at a depth of eight to ten inches below the surface of the ground, but the animal sometimes ranges lower in loose, sandy soil where succulent roots penetrate deeper. The average diameter of the burrow of the prairie pocket gopher is about three inches; large enough that one may usually thrust the hand and arm back into it as far as he can reach. These data are easily obtained; but when one undertakes to map out the course of the main runways, the branch tunnels and their intersections, the pockets and the short laterals, he has before him a task that might well appal a military engineer in the wilds of a jungle. In a field that is even fairly well populated by gophers the runways of different individuals must of necessity frequently intersect each other, for it cannot be supposed that all the numerous subway cross-

ings one exposes in digging along the tunnels are parts of one animal's private labyrinth. A prairie-dog or a spermophile digs a burrow very much like that of his neighbor; but it must be borne in mind that these animals are constructing homes, not extending passageways in search of food. The gopher follows his own sweet will in mining. Here a chance for easier digging turns him aside; there a promising lead of succulent roots entices him the other way. Heading everywhere in general and nowhere in particular, he may, in the course of a year, explore the length and breadth of a field of many acres. At irregular intervals he excavates a short lateral obliquely upward to the surface of the ground. Through these the loosened dirt is carried and thrust out in heaps. The presence of a gopher is thus easily detected by the lines of mounds, varying in size from a hatful to one or even several bushels of dirt. A study of a fresh mound reveals the plan of construction. The dirt is carried out of the opening and distributed radially, very much as miners dispose of the useless shale from a coal-pit. Usually the dump extends only part way around the opening, but sometimes the mound has the shape of a cone with a crater at the top. Where surface vegetation hinders the work, the piles of dirt are more irregular.

The Mound.—In removing the excavated earth from the burrow the gopher pushes his load before him in armfuls, so to speak. At the exit it is thrown out with a quick flip of the nose until the enlarging mound compels the animal to come out and dump the material down the slopes. After these become so steep that the material rolls back into the opening much dirt still boils up from beneath under the pressure of a powerful pair of shoulders. A wrinkled ring of earth on the completed mound usually identifies the point of the last out-thrusts. After scraping away a mound from the harder surface of the ground, one may search in vain for the lateral leading to the burrow. The miner has packed it so tightly that the plug is as firm as the surrounding earth. Here and there a gopher burrow enlarges into a chamber of moderate size. Some of these are partly filled with dry grass; others are used for food storage. Not infrequently one finds a pocket extending upward, as though the animal had started to dig an exit but had abandoned the task for some reason or other.

Mole Runways.—The ridges and mounds of earth thrown

up by moles are often incorrectly supposed to be the work of gophers. A little careful scrutiny will soon reveal the difference. The gopher piles up the dirt on the surface of the ground, building a mound by the addition of load after load on top of that already deposited. A mole simply heaves up the dirt from beneath, forming piles which show radiating cracks. Associated with these piles are the surface ridges made by the animal when ranging in search of food. The feeding runways of the gopher never show in surface ridges.

Breeding.—But little information along this line is obtainable in the literature accessible at this Station, and some of the statements therein made are, in the light of our own investigations, found to be more or less erroneous. The pocket gopher lives such a secluded life in its underground burrows that direct observations of its breeding habits require considerable painstaking effort. I have never been able to find a litter of the young myself, although I have explored a great many burrows in studying the animal. Occasionally, though, I have run across a nest of soft, dry grass that had probably been constructed for the purpose of rearing the young.

As might be expected of animals living in such comparative security, the pocket gopher is not a very prolific breeder. It certainly rears but one litter a year in this locality, for I have examined scores of specimens in all months of the year and have found the embryos only in late winter and early spring. The number of young in a litter varies from three to six and averages a little more than four. Very rarely only two embryos are found in the uteri.

Quite early in the spring, before the snows are fairly gone, the male gophers are said to roam about in search of mates. As I have never encountered one on such amorous errands intent I have not been able to verify the statement. It is entirely probable, however, that for reasons of personal safety such excursions are undertaken mainly after nightfall. If the statements concerning the wanderings of the male are correct, the period of gestation is short, for the young are nearly all born, in this locality, in March and April. It seems more probable, though, that mating takes place in late fall as well as in early spring; perhaps also during milder periods of the winter, as fairly well developed embryos are found in the uteri from January to May. The following table gives the results of some

investigations conducted in the spring of 1907 and spring of 1908:

Number of females examined.	Date.	Number of embryos.	Stage of development of embryos, etc.
	1907.		
4.....	Feb. 27	0	No signs of pregnancy.
2.....	Mar. 15	4,5	1 lot nearly fully developed, the other a little less so.
4.....	Mar. 18	5,5,0,0	1 lot only slightly developed; 1 lot about an inch long, thick as one's finger; 1 female evidently pregnant, but foeti not distinguishable; 1 female no signs of pregnancy.
1.....	Mar. 19	0	Uteri congested, but foeti not distinguishable.
2.....	Mar. 25	3,4	1 lot size of thumb; 1 lot size of peanut kernel.
2.....	Mar. 26	1,0	1 lot size of peanut kernel; 1 female gave evidence of having been suckled.
2.....	Apr. 1	3,4	1 lot size of pea; 1 lot size of peanut kernel.
3.....	Apr. 4	4,4,5	2 lots size of end of thumb; 1 lot size of peanut kernel.
3.....	Apr. 5	4,4,5	2 lots size of end of one's finger; 1 lot size of peanut kernel.
1.....	Apr. 8	0	Evidence that young had been born.
3.....	Apr. 9	4,4,4	2 lots foeti in early stages of development; 1 lot size of end of thumb.
3.....	Apr. 15	5,5,0	2 lots foeti size of hulled peanut; no foeti distinguishable in other female.
2.....	Apr. 22	4,4	1 lot size of pea; 1 lot size of hulled peanut.
2.....	Apr. 24	4,3	1 lot in early stage of development; 1 lot size of end of little finger.
2.....	May 3	0,0	Young evidently born; milk in glands of females.
5.....	May 7	3,0,0,0,0	1 lot of foeti size of pea; 2 females showed no signs of pregnancy nor of having had young; 2 females had milk in glands.
10.....	May 13	2,4,0,0,0 0,0,0,0,0	7 females contained no foeti and gave no evidence of suckling young; 1 female had milk in glands; 1 lot of foeti size of pea; 1 lot size of Lima bean.
7.....	May 14	0,0,0,0 0,0,0	No trace of foeti or evidence of suckling young.
10.....	May 20	0,0,0,0,0 0,0,0,0,0	Of the 10 females none carried foeti and only 3 gave evidence of being suckled.
	1908.		
2.....	Jan. 31	0,4	1 female showed no signs of pregnancy; 1 lot of foeti size of peanut kernel.
4.....	Feb. 5	5,0,0,0	1 lot of foeti size of pea; 1 female no traces; 2 females had congested uteri.
5.....	Feb. 7	5,0,0,0,0	1 lot foeti size of peanut kernel; 2 females no traces; 2 females with congested uteri.
3.....	Feb. 8	0,0,0	2 females no traces; 1 female with congested uteri.
9.....	Feb. 10	6,6,5,0,0 0,0,0,0	1 lot size of pea; 1 lot size of peanut kernel; 1 lot size of end of little finger; 2 females no traces; 4 females with congested uteri.
4.....	Feb. 12	4,0,0,0	1 lot size of pea; 1 female no traces; 2 females with congested uteri.

It will be seen that of the ninety-five females examined some showed signs of pregnancy in the latter part of January and all but two or three had given birth to their young before the first week in May. The record for some parts of the season is not so complete, however, as it should be. It should include data for the remainder of January and for the first half of March.

The young are described as being entirely hairless, with transparent skin of a delicate pinky-white. They are blind, their ears are sealed, and in most respects, therefore, they are perfectly helpless. In the fall one may still distinguish the younger specimens by their smaller size, but most of them seem to be fully grown by the advent of cold weather. Long before

this time they have excavated burrows of their own and laid up some stores for the winter.

NATURAL FOOD.

The natural food of the pocket gopher consists of the fleshy roots and underground stems of various plants growing wild on the prairies. To this bill of fare he adds occasionally a small quantity of succulent vegetation drawn down into his burrow from the surface at points where exits are dug for removing earth. When foraging thus above ground he loses no time in cramming supplies into his cheek pockets and hurrying below to eat the stuff at his leisure. The underground stems and roots he encounters in extending his burrows are cut into short pieces of convenient length to carry, provided he does not care to dine upon the spot. The sections thus made are commonly an inch or two in length, sometimes shorter, but I have found stores of alfalfa roots in which dozens of the pieces ranged from four to eight inches long. These, of course, the animal must carry or drag to the storeroom without the aid of his pockets. The same is necessarily true of the large cultivated tubers he often steals from the fields or bins of the unlucky farmer. Observations on the habits of a pocket gopher kept in captivity by Doctor Merriam, of Washington, D. C., seemed to indicate that the animal when thus storing his larder can travel as easily and as readily backward as forward. The writer states that the gopher moved back and forth from food supply to storeroom like a shuttle on its track, rarely turning around after securing a load. In its backward progression the sensitive tail served as an organ of touch.

The underground chamber excavated for the purpose of storing food varies in size according to the supplies in sight and the demands of the season. Sometimes one will find only a handful of roots; in other places a peck or more is packed away. Indeed, when an over-industrious gopher finds his way into a pit stored with potatoes or apples he will sometimes carry away and store several bushels of them. A mound of unusually large size is pretty good evidence of the presence of food stores near by, especially if located in the immediate vicinity of a source of plentiful supplies. In some cases a part of the dirt excavated, however, is used to pack the food supplies. I have uncovered stores in which each separate piece of root was carefully separated from the others by fine dirt, much

as the farmers sometimes pack sweet potatoes in sand when storing them for winter.

The popular idea that the gopher uses his cheek pockets for carrying out the earth from his burrow is certainly erroneous. I have watched many gophers at work, and noted that the process of removing the earth is always the same: the dirt is pushed ahead of the animal in armfuls. Examination of the pockets of gophers shot in the act of removing earth, or trapped at any time, reveals no traces of contained earth. At this point it might be well to state also that no part of a gopher's runway necessarily extends down to a supply of water, as currently supposed. Like many other animals that feed upon more or less succulent vegetation, sufficient water for the tissues of the body is obtained in the food.

ACTIVE SEASON.

The pocket gopher seems to be busy at any season of the year when the ground is not frozen too hard and too deep for mining operations. Not uncommonly we see mounds of fresh earth thrown up from beneath the snows of midwinter. It is unlikely therefore that, strictly speaking, the animal ever hibernates in this part of the country. During the briefer periods of particularly inclement weather in the winter no mounds are thrown up, and if the animal burrows lower then to escape the frost, as some have observed, he must dispose of the earth in tunnels or pockets previously excavated. It is my belief, however, that the gopher spends these stormy periods near the supplies of stored food. Evidence of this habit is given by certain mounds thrown up in the spring that are made up almost wholly of crumbling pellets of excrement and fragments of nest material. October and November is a season of particular activity. Impelled by the instinct that exacts obedience without forecasting the winter, the gophers then extend their runways in all directions in search of food for their underground cellars. At this time of year the best results can usually be obtained in poisoning or trapping the animals. In the spring, again, after the frost has left the ground, this activity is renewed for a time; but when the season for breeding, and rearing the young comes on, extension of the burrows receives less attention.

It has been said that the gopher is a solitary animal; that no two individuals ever occupy the same burrow except in the

mating season. This statement is not in accordance with my observations, for I have on several occasions trapped a second gopher by resetting at the same opening into a burrow. This was in the early fall, too; not in the mating season.

NATURAL ENEMIES.

Since the pocket gopher so seldom shows itself outside of its subterranean galleries, it has little to fear from the natural enemies of the rodent race. It is not entirely safe from attack, however, for a few sharp-eyed and vigilant foes habitually capture numbers of gophers when they come to the mouths of their burrows to push out a load of earth. Hawks and owls take toll at these favorable moments, and many a house cat has learned the trick of capturing a meal then with little difficulty.

The gopher's habit of confining active operations in mining mainly to the hours of twilight particularly favors the owl and the cat. The Great Horned owl, the Long-eared owl, and the Barn owl, particularly the last named, render valuable service in keeping down the numbers of these destructive rodents. A single pair of owls, nesting on the farm, has been known to destroy scores of gophers in a brief season. Sometimes they live on nothing else for a time, as evidenced by the pellets of bones and fur which, like most birds of prey, they invariably disgorge after a meal.

Instances of a house cat becoming addicted to the gopher habit are not uncommon. In a number of cases that were reported directly to me, mother cats brought in several gophers a day, regularly as clockwork, to their families of kittens. In many instances of reported gopher catching, however, the informant has had in mind the little striped "gopher" or ground-squirrel.

Two enemies that, in some localities, are said to hold the pocket gopher in check more than all others are the weasel and the bull-snake. The former is too scarce in most parts of Kansas to be worth considering in this relation; but the bull-snake is common enough on farms whose owners or tenants have had the wisdom and forethought to protect the natural enemies of the destructive rodent tribe. The snake would, of course, be able to gain entrance to the gopher's burrow only when the latter was temporarily left open; but once inside he would probably remain there for some time and make things inter-

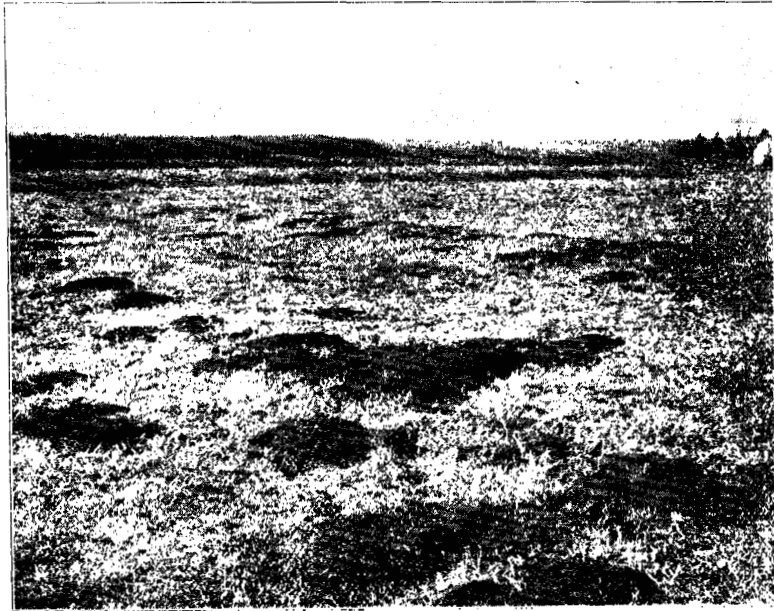
esting for the occupants. When one is trapping gophers he will occasionally surprise a bull-snake in the act of trying to swallow the captured animal, trap and all. I have also found this snake in the burrow of the striped spermophile, helping himself to a nestful of the young of the latter, and have seen him capture and kill the adult spermophile at the mouth of its burrow.

The little striped skunk (*Spilogale interrupta*) should not be left out of account in discussing the natural enemies of the pocket gopher. I had not supposed that these animals could make their way through the burrows of the gopher, and had laid to the charge of weasels a number of cases of killing and feeding on gophers imprisoned in steel traps. Finally I resorted to setting traps a second time in the mouths of the burrows where a gopher had been partly eaten, and in two instances succeeded in capturing a little striped skunk. There was no question in either case but that the skunk had entered the burrow at some point remote from the location of the trap, for the opening through which the trap had been introduced had been carefully covered with a board and loose earth; this covering was undisturbed. In comparing this slender little skunk's body with the diameter of many of the gopher burrows in alfalfa fields, it will be seen at once that it is not a difficult matter for the skunk to make his way through the underground passages. The additional fact that, by digging, he can enter the burrow at any point and corner the occupant in some lateral or pocket tunnel renders the little striped skunk especially valuable as a gopher catcher.

In summary, it may be said that we cannot, except in a few favored localities, depend upon natural forces to keep in check the increase of the pocket gopher. By increasing the acreage of alfalfa we are producing the very conditions that are favorable to the most rapid multiplication of the species, and, on the other hand, by thoughtlessly or wantonly destroying harmless owls, hawks, bull-snakes, and certain mammals, we still further interfere with nature's efforts to preserve the balance of power in the animal world. The worst that can be said of the enemies of the pocket gopher is that the Great Horned owl, the weasel and the skunk sometimes destroy domestic fowls. But a little wise precaution in shutting up coops at night would prevent these inroads on the poultry industry.

CROPS DAMAGED.

The economic status of the pocket gopher has changed in the last few decades. There was a time when their work was of real benefit to the future interests of agriculture. For untold centuries they have been mixing the soil of the prairies, bringing up the subsoil to mellow, and covering up vegetation to molder and add humus to the clays and sand. But now that the virgin soil has been prepared for us we would gladly dispense with their services, for their presence is now seriously detrimental to our interests.



View of a gopher-infested alfalfa field.

Alfalfa—The damage to cultivated plants results not only from the animal's eating roots or stems, but also from its habit of throwing up numerous mounds of earth, which very often cover considerable areas of the growing crops and obstruct the harvesting of the remainder later. Indeed, it would scarcely be worth while, in many instances, to make such vigorous warfare on the gopher if the only issue at stake was the kind or quantity of food he pilfered. This is especially true in the case of alfalfa. No other one of the important

crops of the state has suffered as much from the ravages of the pocket gopher as this valuable plant. From a gopher's standpoint, conditions of life are easy in a field of alfalfa. The ground is not worked for years at a time, at least not deep enough to interfere with the underground runways. Again, the roots of the plant are fleshy and toothsome and penetrate deep into the soil, where they may be encountered in abundance at the usual depth at which the animal ranges. They are there, too, at any time of the year to satisfy the appetite of the hungry rodent. As a result of these favorable conditions gophers have multiplied at an alarming rate in recent years wherever alfalfa is extensively grown. In the river valleys of central Kansas particularly, I have seen fields of thirty or forty acres in which one might walk over the entire tract by stepping from one gopher mound to another. It is safe to say that in these cases not less than one-fourth to one-third of the actual acreage of the field was covered, and therefore a total loss. Much of that which remained is necessarily weakened by the loss of portions of the root system.

Even a few gophers in an alfalfa field become an intolerable nuisance by obstructing the work of mowing the crop. The man who is running the machine must be constantly on the lookout for the mounds, so that he may raise the sickle-bar until the obstruction is passed. Thus much extra work is entailed and a portion of the crop is lost by running the sickle too high. If the operator does not see the mound in time it is very likely to clog the machine, or at least one or more sections of the sickle may be dulled or nicked by encountering gravel or pebbles. If the ground is reasonably mellow the horses drawing the mower stumble frequently, their feet breaking through into the runways of the gopher. Sometimes the holes thus formed are not filled again from below and the rains washing in enlarge the openings to a pit a foot or more in diameter.

Native Meadows.—Meadows of natural prairie-grasses are often invaded by the gopher to such an extent that they have the appearance of having been plowed up over many acres of their surface. The animals apparently find suitable food scarcer there than in the alfalfa field, and are consequently obliged to dig more extensive runways in search of the roots of the native plants. Unless such tracts of meadow can be

freed from the pest and the surface subsequently leveled, they had better be used for pasture, as it is almost impossible to cut the grass for hay.

Orchards and Nurseries.—Young trees in nurseries and orchards or in belts planted for shade, ornament and shelter sometimes suffer seriously from attacks upon their root system. The gopher may gnaw off so many of the roots that the tree readily topples over; or at least it damages the system to the extent that the health of the tree is impaired and its growth stunted. The animal has the habit of following the young hedge or nursery row for some distance, taking everything as it goes, It may then cross over and follow another row in the same manner. Fortunately for the interests of the nurseryman, the gopher never gets the foothold in plantations of young trees that it secures in alfalfa fields, by reason of the fact that the former are cultivated frequently and the ground plowed up every three or four years after the growing stock has been cleaned off. The following are extracts from letters received recently from prominent nurserymen and orchardists of the state :

“There has never been a year since we have planted apple-trees here, thirteen years ago, that we have not been troubled with gophers. They eat the roots of the large trees. Have never noticed that they went straight down the rows.”—E. E. YAGGY, Hutchinson.

“Once I had a large Austrian pine (seven feet) gnawed off at the surface, and in a few hours afterwards the tree fell. I shot the gopher and planted another pine in its place.”—H. F. CECIL, Topeka.

“The gophers have been a serious pest to nurseries or trees near grass or clover. They will sometimes go a long way through the trees if not checked. They eat any kind of wood, even the hard Osage hedge. I do not remember that they have ever eaten any grape-vines for me, but probably because they are not where they could get to them freely.”—A. H. GRIESA, Lawrence.

“Will say, in regard to the pocket gopher, that we are not troubled as much now as we were a number of years ago. When we first commenced planting trees in this locality we had considerable loss from them. They do not seem to be particular as to the kind of tree. As we grew more apple-trees than anything else, our loss was heavy in that line. We found that the best manner of ridding ourselves of the gopher was to poison them.”—J. H. SKINNER, Topeka.

“We have had considerable trouble with the pocket gopher and a great deal of loss. They seem to be worst with our young cherry. They sometimes run along the row for a few trees and then cross over into another

row. They do not often kill more than from six to ten in one spot." — A. L. BROOKE, Topeka.

"The pocket gopher is not a great pest with us, yet does considerable damage. He does not seem to be particular as to what he destroys. The past season he has crossed a block of two-year-old cherry-trees, taking one to three trees in a row and crossing over half the block. In one place he has cut off probably fifty pear trees (Kieffer), and in still another place a half dozen poplars, ten feet high, an inch in diameter. We like to follow with trees where alfalfa has been plowed up, but it is nearly impossible to do so on account of pocket gophers. They seem to congregate in the alfalfa, and it takes a year or two to get the land free from them." —F. W. WATSON, Topeka.

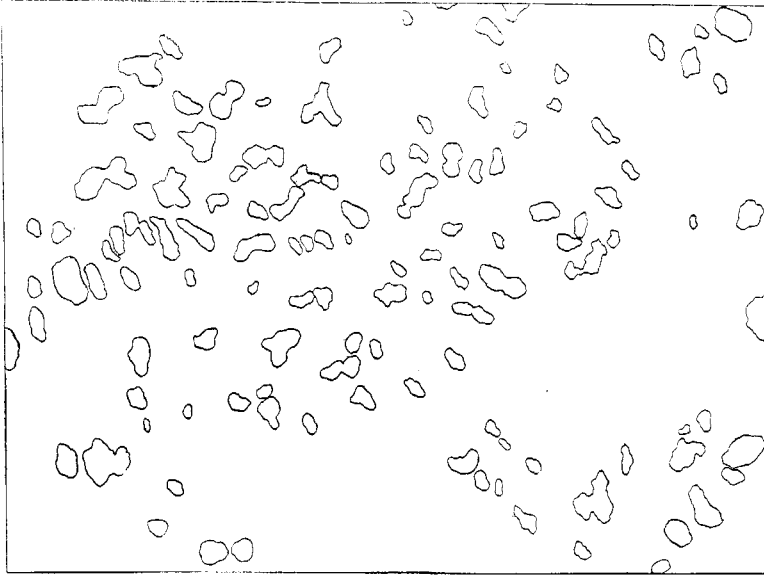
Potatoes.—Potatoes and sweet potatoes sometimes suffer seriously from the depredations of gophers, but of course the animals do not gain a permanent foothold in potato fields as they do in the tracts of ground remaining uncultivated for a period of years. They generally invade the potato ground from the surrounding fence-rows or from adjoining meadows or alfalfa fields. If no effort is made to destroy them, they will often establish themselves for a time in any part of the cultivated field. Here they eat the pieces of potato that are planted in the spring or bite off the roots of the young sweet potato plants. Later they feed upon the newly forming roots or tubers, causing the death of the plant. In the fall they proceed to harvest their share of the crop and store it in their underground root-cellars for winter use. Not content with what they may harvest on their own account, they find their way into the farmer's potato-pit and steal at their leisure. It is surprising to note the heaps of potatoes, sweet potatoes and apples sometimes carried away thus from pits and cellars and stored in chambers in the gopher's runways. In making inquiries of potato growers along the Kansas valley I have learned of several instances where the thefts amounted to five or six bushels. Prof. L. L. Dyche, writing to the Department of Agriculture, reports a case near Lawrence in which thirty-five bushels of sweet potatoes were taken from a cellar dug in rather sandy ground. To make room for their stolen treasures the rodents carry all the excavated earth into the potato cellar and pack it from time to time into the space left vacant by the removal of the tubers. The farmer, therefore, rarely learns of the loss he has sustained until he removes the contents of the cellar in the spring, when he is astonished to find, some dis-

tance below the surface, a huge pile of earth where there should be potatoes or apples. No caving in of the heap in the cellar, no piles of earth on the surface of the ground, have betrayed the gopher's work, which may have been in progress for weeks or months. By making a vigorous search the farmer sometimes recovers a part of his property, however, for the gopher's avarice has prompted him to carry away vastly more than he can possibly ever hope to eat. In the case mentioned above but two gophers could be found to answer to the charge of stealing thirty-five bushels.

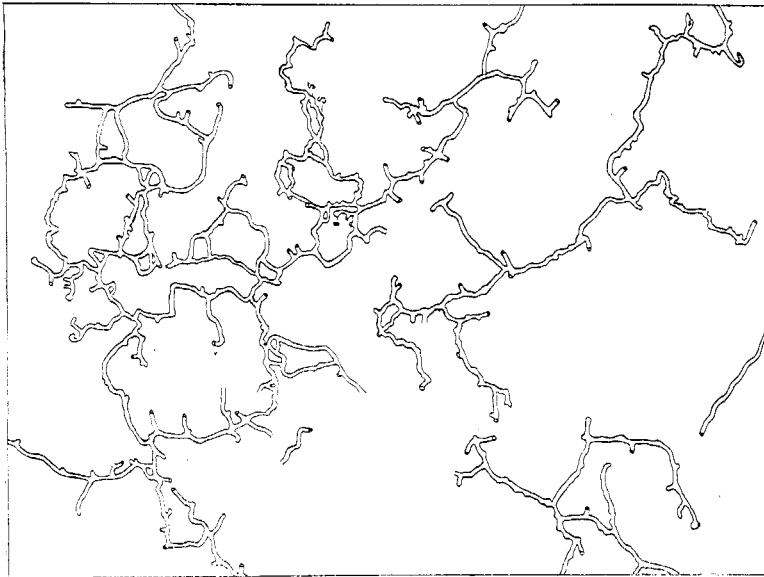
Garden Crops.—There are very few garden crops but that receive occasional attention from the pocket gopher. He does not even draw the line at the odoriferous onion, but prefers, of course, the fleshy roots, such as beet, parsnip, carrot and turnip. He is also said to have a habit of gnawing into the under side of melons and pumpkins and hollowing out the interior, sometimes filling the cavity thus formed by packing it with earth. I have not been able to verify this statement. Peanut growers suffer some loss from the depredations of pocket gophers. One correspondent, writing to the Department of Agriculture from Reeder, Kan., states that twenty-five bushels were taken from the crop grown on an acre of ground.

Small Grains.—Apparently no serious loss results from the work of pocket gophers in fields of small grain. The roots of such plants are not large enough to attract the animals. Sometimes, though, they bite off and drag stems and heads into their burrows below. When grain is in the shock, too, they often come up from beneath and carry down the heads, filling in the spaces between the sheaves with dirt. It is not fair to lay all such work to their charge, however, for they are assisted by field-mice, spermophiles and the common rat.

Irrigated Crops.—Contrary to my expectations, I did not find the gopher a serious problem in the irrigated districts of the southwestern part of the state. The prairie gopher (*Geomys bursarius*) of eastern and central Kansas is there largely replaced by the plains gopher (*Geomys lutescens*). I scarcely think the latter is as aggressive in its habits as the former; at least it has not gained much of a foothold in the extensive fields of alfalfa that have been grown in that section for years. On the other hand, this may be partly or wholly due to the flooding of the fields from the irrigating ditches several



Typical area of a badly infested alfalfa field. This tract (54 ft. x 72 ft.) was carefully mapped after first dividing it into small squares by tightly stretched lines. The small irregular patches show the shape, relative size and location of the mounds thrown up by the gophers.



Same tract as above, with all the runways carefully excavated and mapped.

times a year. Farmers who work land under the ditch tell me that the flooding process frequently drives the gopher to the surface to escape drowning. A few such experiences probably discourage the animals so that they do not establish themselves permanently in the alfalfa and sugar-beet fields. Outside the irrigated tracts there is very little food supply except that provided by nature; hence the numbers of the species remain about the same from year to year. It is interesting to note in this connection that the western agricultural ant (*Pogonomyrmex occidentalis*) is more successful in maintaining a permanent residence on irrigated lands than the pocket gopher. The latter establishes itself permanently only on the uncultivated tracts of wild land and along fences and ditches. It prefers the loose soil of the sand-hills and gravel flats to the harder clayey soils covered by buffalo-grass.

Damage to Ditches.—Of course the gopher causes considerable annoyance in the irrigated districts by its excursions into the fields from its retreats along the fences and ditches. Its habit of burrowing into the banks of the ditches is most exasperating to the farmer who, when he turns the water on, must often spend hours locating and stopping leaks. These leaks, enlarged by erosion of the water, may cause considerable loss to the farmer himself or result in damage suits from his neighbors. The water escaping in this way also softens up stretches of the public roads so as to make them impassable.

Results of Floods.—During the great flood of 1903 in the valleys of the Kansas and its tributaries the flood-plains of many streams were inundated from bluff to bluff. At this time observers noted hundreds of pocket gophers on the higher points of land above water and along railroad embankments. An observer near Manhattan killed 180 of the animals with a club. For a year or so after the floods the lowlands were comparatively free from gophers, but they are fast reoccupying the flats and regaining their original numbers.

GOPHER LEGISLATION.

The sentiment which always looks to legislative enactment for a remedy for all remediable evils has crystallized into two recent gopher laws in Kansas—the one a compulsory extermination law, the other a bounty law. The former was enacted by the session of 1905; the latter is a part of the grist from the mill of our last legislature in its regular session.

The compulsory extermination law—House bill No. 184, Session Laws of 1905—might be made a pretty effective weapon against the pocket gopher, but unfortunately it does not appear that township officers care to avail themselves of its provisions. From correspondence with county officers in nearly all counties of the state, I have not been able to learn of a single case wherein the law has been made operative. The law provides that, on petition of ten resident landowners of any township, the county commissioners may, at their discretion, direct the trustee of the township from which the petition came to appoint the road-overseer, or other suitable person in any road district, to see that the gophers in said district are exterminated. The person so appointed must enter the premises of every resident of his district at least three times a year on a tour of inspection. If any landowner fails to take proper measures to exterminate the gophers on his premises within five days after having been notified in writing to do so, the inspector must attend to the work of destroying the animals. The costs are then charged up in the taxes of the delinquent landowner. Other expenses incurred in the work, including a salary of two dollars per day for the inspector, are paid out of the general fund of the township. A weak point in this law is the clause which leaves it optional with the commissioners to authorize the appointment prayed for or to ignore the petition altogether. Then, too, the provisions of the law make it necessary for one neighbor to interfere in affairs that may seem to another clearly none of the former's business. He may reason that pocket gophers, because of their burrowing habits, are like weeds, practically fixtures of the soil, to be eradicated or allowed to thrive as the owner of the land pleases.

The new bounty law* requires all counties in the state to pay a premium of ten cents per head on pocket gophers. This law will probably result in a considerable diminution of the pest in some localities. The bounty system in general, however has its objectionable features, and in the particular case of the animal under discussion these features are prominent. In the first place, the gopher roams about so little above ground that each individual is practically a permanent resi-

* The attorney-general of Kansas having rendered a decision which practically invalidates the state bounty law, several counties east of the sixth principal meridian are now paying bounty under the old law of 1903.

dent of the farm on which its burrow is located. The justification for placing a price on the scalp of an animal like the coyote or puma, that may take toll from one man's flock to-day and from his neighbor's, miles away, to-morrow, is entirely wanting in the case of the pocket gopher. The principle of allowing the community at large to pay the expense of protecting the careless man's crop, while his thrifty neighbor looks after his own fields, is theoretically wrong. It imposes a double burden upon thrift.

Again, the payment of ten cents for each scalp will put a premium on trapping and tend to discourage poisoning, the more thorough and easily applied method of ridding a badly infested locality of these pests.

Further, the expense of maintaining a bounty system is usually out of all proportion to the benefits gained. Experience in other states, and in a few counties in this state, has demonstrated that bounties on small mammals seldom, if ever, accomplish the desired end—ridding the community of the pests. After the cream of the territory has been skimmed, so to speak, trapping becomes unprofitable and large numbers of the animals are left to again regain their ground. Long before even the skimming process is completed, however, the heavy drain on the public treasuries usually results in the repeal of the law. No state has ever been able to pay a general bounty on small mammals for any considerable length of time.

Finally, the opportunities for fraud in the matter of claiming bounties are much greater in the case of the pocket gopher than with the larger and better known mammals. The majority of county clerks to whom the scalps will be presented have perhaps never seen a pocket gopher. At least they are not trained mammalogists, and only such can, under certain circumstances, distinguish the scalp of a pocket gopher from that of some of the other small mammals. The law requires that the scalp, with the ears, be presented in evidence; but the gopher has practically no external ears. Any ingenious boy with a ticket punch can easily manufacture a half dozen legal scalps from the pelt of a single gopher. Although not specified in the law, it would be well to require the cheek-pockets to be included with the scalp. There could then be little question as to the identity of the animal.

In 1903, four years previous to the enactment of the present

bounty law, an act was passed authorizing county commissioners, in their discretion, to pay a premium of five to twenty-five cents apiece for the scalps of pocket gophers and gray ground-squirrels. The scope of this law was limited, by provision, to counties east of the sixth principal meridian. Under this act eight counties have paid premiums on gopher scalps for periods ranging from three months to four years. The list of these counties follows: Atchison, Brown, Jefferson, Johnson, Leavenworth, Marshall, Morris, and Pottawatomie. Some of them report the payment of only a few dollars per year in bounties, while in other cases the amounts are considerable. Leavenworth county, for example, paid out \$2480, after which the commissioners withdrew the bounty. Marshall county has just withdrawn its bounty, after paying out in the year 1907 \$4200. Township trustees from all parts of the county report that the numbers of pocket gophers are apparently as great in their respective townships as they were when they began paying bounty a year ago. Evidently the trap is slower than the gopher's rate of increase. Wholesale fraud in the matter of manufacturing several scalps from one skin is suspected in a number of cases.

If a few farmer boys in every school district in certain counties of central Kansas should become as active in the extermination of the pocket gopher as the law perhaps contemplates, those counties would soon be stamping their warrants "Not paid for lack of funds." By way of supporting this statement, let me cite two illustrations: Benton county, Iowa, paid out in three years \$18,000 in bounty on gophers, at an average rate of fourteen cents per scalp. Meeker county, Minnesota, withdrew its bounty on pocket and striped gophers, or ground-squirrels, after having cashed bounty warrants to the amount of \$14,056 in five months.

If the destruction of the pests is to be paid for out of the public treasury, better results can be obtained, and at a much less cost, by the plan of distributing a prepared poison free to those landowners who will agree to use it as directed. Counties that have tried this plan in other states prefer it to the bounty system. Why may we not profit also by our own experience in ridding western Kansas of the prairie-dog? Under the provisions of an act passed by the legislature of Kansas in 1903 the purchase and use of poison in all townships in-

fested by prairie-dogs was made compulsory. All expenses were defrayed from the township treasury, the county commissioners having previously made a special levy for the purpose. The vigorous campaign that followed the enactment of this law almost wiped the prairie-dog from the face of the land. A reenactment, therefore, of the prairie-dog law of 1903, so modified as to fit the case of the pocket gopher, is, in our opinion, the wisest measure that could be adopted.

Even though we do not get a compulsory "extermination" law for the pocket gopher, the thrifty farmer would profit much by legal enactment compelling road-overseers to keep down the pest on the roadsides. The same should apply also to the foremen having charge of the various sections on the railroad right of way. It is a matter of common observation that when gophers invade a clean field they usually enter from the roadsides, railroad right of way, or neglected fence-row.

METHODS OF COMBATING.

Poisoning. — Gophers do not possess the shrewdness and cunning that have become instinctive in many other wild creatures because of the constant necessity imposed upon the latter of avoiding and escaping enemies. Later experience in the wiles of man has evidently taught them nothing, for they seldom reject any kind of poisoned food offered them.

As stated before, poisoning is the more thorough and easily applied method of ridding a badly infested farm of the pest. It is also the best method if the territory to be freed from gophers is of considerable extent. In either of the above cases one man can accomplish as much with poisoned bait as a half dozen could in the same time with traps. The danger of killing stock or useful birds and animals, attending the use of poison for prairie-dogs, English sparrows, and the like, is entirely eliminated by the plan of introducing the bait through small openings into the gophers' burrows.

Since the pocket gopher lives naturally on the roots and tubers of native plants, or on succulent vegetation drawn down into the burrow from the surface, it follows that a close substitute for these articles will make the best bait for poisoning. Knowledge gained by personal experiments and by careful inquiry among farmers and fruit growers goes to show that pieces of potato, apple, or sweet potato, poisoned by inserting a few crystals of strychnine into slits made with the point of

a knife, answer the purpose very well. Some correspondents have reported good results from soaking the baits in a solution of arsenic or strychnine. Only a mechanical mixture of either substance can be obtained in water, however, and the presence of particles of the free poison on the surface of the bait would be more likely to cause its rejection than if they were concealed in small slits. Raisins and prunes, treated like the pieces of potato or apple, seem to be very effective baits also. Our experience with specially prepared tablets, sold under patented formulas, does not warrant us in recommending them.

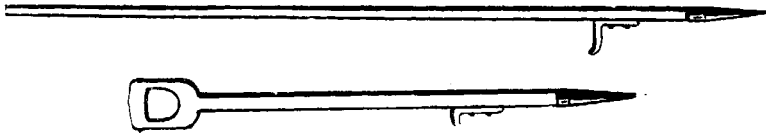
There is some question as to the efficacy of any sort of scent applied to the poisoned bait. We have tried scented and unscented bait at the Station without being able to determine that one was eaten more readily than the other. All claims to superiority in certain proprietary gopher poisons, based on the use of a secret scent, may be set down as lacking the warrant of practical test. It is true that the sense of smell is probably highly developed in the pocket gopher, owing to the necessities of his underground life, but we lack evidence as to what may appeal to his tastes. Anise oil is often put on baits for various animals, but in poisoning gophers as good results are obtainable without its use.

About five years ago the state, through a special agent, Prof. D. E. Lantz, purchased the right to manufacture and distribute within the borders of Kansas a certain proprietary poison, the active principles of which are strychnine and cyanide of potassium. This poison was intended to be used in destroying the prairie-dogs on the cattle ranges of the West, but it was found that by leaving out one ingredient—the cyanide of potassium—a very efficient poison for pocket gophers could be prepared. After the state's contract with the special agent had expired by time limit, the work of manufacturing and distributing this poison was turned over to the Department of Zoology and Entomology in the College. The poison is put up in the form of a syrup and sent out in quart cans to any part of the state. On each can is a printed label giving the formula used in preparing the poison and full directions for its use. The success attending the use of this syrup is evidenced by the fact that in the past four years we have sent out over 1500 cans. Experiments personally con-

ducted on the Station grounds and elsewhere have borne out the uniformly favorable reports from alfalfa growers, particularly, as to the merits of the poison. We therefore recommend this poisoned syrup as the best means we have discovered so far for the destruction of pocket gophers. The syrup is sold by the College at actual cost of manufacture, which at present is \$1.10 per quart can.

The method of using this poison commends itself as a time saver. Pour boiling water over as much shelled corn as you will need—the quart of syrup will poison a half bushel—and let it stand several hours to swell and soften. Drain off the water and pour over the grain enough of the syrup to render it sticky when thoroughly stirred together. Sweeten the mass with a little good table syrup and add a little corn-meal to take up the excess moisture, but not enough to leave any dry meal. Cork up the syrup can tightly and place it out of reach of children and domestic animals. It will keep indefinitely and is ready for use at any time.

The soaked corn, poisoned as above, is introduced into the burrows of the gophers, a few grains at a place, by means of an old spoon. Openings into the burrows must first be made with a sharp stick—a sharpened broom handle will serve the purpose—or a spade handle shod with an iron point and hav-



Two forms of prod for locating runways of the pocket gopher and making openings for the introduction of poisoned bait.

ing an iron foot-bar some distance from the end to aid in making the thrust. Experience will soon enable one to tell when he has struck the burrow, which can be located approximately by getting on a line between two mounds of earth. After dropping in the poisoned grain the hole may be left open, or if closed care should be taken not to allow dirt to fall in and cover up the bait. If the hole is left open the gopher is likely to be attracted by the light and find the bait the sooner.

The same method of introducing the poison into the burrows is employed also when raisins and prunes or pieces of apple

and potato are used. The presence of freshly thrown up mounds indicates that the animal is extending his runways in that quarter, and it is best to confine one's poisoning operations to such places. If the field can be dragged over with a harrow or plank a few days after the poison has been put out, new mounds can be readily detected and fresh poison distributed. If the work was thoroughly done in the first place it usually takes but a few minutes to go over the field a second time. The few remaining gophers, if any, may become wary, and in that case they should be trapped.

The best time of the year to poison gophers is when they are most active in extending their burrows. This is usually in the late fall, for they are then laying in stores of provisions for the winter. Spring is a period of renewed activity, and poison may be successfully used at this time also. In fact, it will pay to make war on pocket gophers at any time when they are seen to be active.

Fumigation. — The use of carbon-bisulfid vapor or the fumes of burning sulfur as agents for destroying the pocket gopher is not recommended by this Station. It is true that fumigation methods are occasionally followed by successful results, but under ordinary conditions the game is not worth the powder. We have other remedies for the pest that can be more easily, more effectively and more cheaply employed. An older bulletin of the United States Department of Agriculture recommends carbon-bisulfid as the simplest agent for the destruction of gophers, but later advices from the same source partially discredit the former recommendations, and experiments at this Station contribute to the same result.

The ordinary method of using carbon-bisulfid for destroying burrowing rodents is to pour the liquid upon a wad of cotton, corn-cob, or other porous substance and then thrust the latter into an opening made into the burrow, closing the opening at once with earth. The bisulfid vaporizes rapidly, forming a heavy gas which is supposed to flow along the runways, smothering the occupants. This it will do in the case of animals whose burrows are short or penetrate deep into the soil. The pocket gopher, however, in his search for food ranges so near the surface of the ground that the introduced gas has plenty of opportunity to escape through the loose earth or to be absorbed. The burrows are long and intricate, branching often

and in places reaching almost the actual surface, especially where the excavated earth has been thrust out or where the animal has started to dig an exit and later abandoned the work. If the ground is dry the gas is dissipated the more rapidly, so that good results might be expected only when the soil is sodden by recent rains.

With us, the plan of forcing the gas into the burrows by means of a bellows gave no better results than the methods described above. The apparatus used for forcing the gas consisted of an ordinary two-gallon kerosene can with a ten-inch hand-bellows connected by a short piece of half-inch hose to the opening at the top of the can. This end of the hose, or a tin tube attached to it, should extend nearly to the bottom of the can, so that the air from the bellows will have to bubble up through the liquid bisulfid on its way to the exit at the spout. The vapor thus formed is led into the burrow by means of another short piece of hose attached to the spout of the can. I have described the apparatus here because some who have used it in localities where there were comparatively few gophers and the burrows simple, claim that they have rid their farms of the pest by this means.

In order to give the gas-pumping method a thorough test, a larger quantity of bisulfid was used in repeated experiments than has been recommended when the liquid is simply to be introduced on a wad of cotton. At each opening made into a burrow the bellows was operated four or five minutes, vaporizing from four to seven ounces of carbon-bisulfid. This variation in the amount of liquid vaporized in equal periods of time was due to difference of quantity put into the can before the series of experiments was begun. The larger the quantity the more gas will be evaporated in a given period. As carbon-bisulfid costs about twenty cents per pound retail, the expense of treating each burrow was therefore from five to eight cents, not counting the time of the operator. A very conservative estimate will place the average cost of attempting to destroy pocket gophers by this method in the alfalfa fields and meadows of central Kansas at one dollar per acre for materials alone. Results do not justify this expense. In a series of thirty experiments personally supervised by the writer during the fall of 1906 and spring of 1907 but four were attended with successful outcome, three of these at a time when the

ground was fairly well soaked by recent rains. The method of determining results in all cases was to open the burrow some hours after the introduction of the gas and then visit the spot a little later to note whether the opening had been closed. As indicated above, in twenty-six out of thirty cases it was found that fresh dirt had been pushed into the opening, showing that the occupant of the burrow was uninjured. In a series of experiments conducted recently at Alden, Kan., with the plains pocket gopher, ten out of twelve openings were promptly closed after the burrows had been thoroughly fumigated.

In one experiment, undertaken with particular care, a line of mounds on a gentle slope of prairie sod was selected as indicating a single, simple burrow. At a point 100 feet down the slope from the last mound in the line an opening was made into the runway and the latter sufficiently enlarged to receive a cat. In four minutes from the time the operator began pumping gas at a second opening—100 feet distant—the cat yielded its nine lives separately and individually to the cause of science. Not so the gopher, however. After pumping gas into two openings made below the point where the cat had been placed, the field was abandoned until the next day, when it was found that the gopher, or gophers, had packed some of the openings and were defiantly throwing up fresh mounds.

No experiments in forcing fumes of burning sulfur into the burrows were undertaken, but in a number of the trials mentioned above the charge of carbon-bisulfid vapor was exploded by dropping a lighted match into the opening of the burrow after removing the can to a safe distance. The gas resulting from the combustion of the carbon-bisulfid vapor is the same as that produced by burning sulfur—sulfur dioxide. Although no disaster to the gopher seemed to follow these explosions, the distance to which the gas had penetrated and the length and intricacies of the burrows was demonstrated by the presence of smoke or loose earth forced out at weak places.

In the case of the experiment with the cat, cited above, the investigator who furnished the apparatus for the trial undertook to increase the efficiency of the gas by adding flowers of sulfur to the liquid in the can. This served only to clog the machine, however, as none of the sulfur can be dissolved in the carbon-bisulfid. A certain manufacturer of a proprietary liquid for destroying pocket gophers by fumigation claims

that he has added something which will increase the volume of gas arising from the bisulfid. More attention might be paid to his claim if efficiency depended upon volume alone.

Trapping.—Although somewhat slow, there is no surer method of ridding one's premises of pocket gophers than by trapping. When you have the animal fast in the jaws of a trap you are certain that his career of uselessness is over. If the gopher were as wise as a rat we would not be permitted to indulge this feeling very often, but a long series of experiments has convinced me that he will blunder into almost any sort of trap that is set for him, no matter how we set it. Long experience in the wiles of man, as a result of living in the nooks and corners of his habitations, has developed by natural selection a race of rats that is proverbial for sagacity. Such shrewdness the pocket gopher will never know, at least not until after many generations of contact with his sworn enemy, man. On the other hand, it is true that a "burned child dreads the fire," and after a gopher has once been nipped by a trap that failed to hold him he becomes more or less wary, and the trap must be set in a different way or poison must be employed to get him.

As stated elsewhere, trapping is a good method of combating gophers if the field to be cleared of the pest is small or if over a large area there are but a few scattered gopher tenants. If the landowner is vigilant, the career of any invader may with little trouble be ended by the use of the trap. The objections to trapping are that it is slower than poisoning and more expensive, particularly the latter if one must hire somebody to do the work. While I have elsewhere in this bulletin presented objections to the bounty system as a public measure, I believe that money paid for gopher scalps by individual landowners is wisely expended. Give your boys or your neighbor's boys a chance to earn a little pocket money, and thus by expending dimes save dollars on your crops. Furthermore, as the number of gophers on your place diminishes raise the price per scalp now and then, so that the boys may be encouraged to complete the extermination. This is strictly a business proposition. No busy farmer need give much of his time to the work, but he will find that the average boy will get as much satisfaction out of earning money by trapping wild animals as he will from expending the same in the various chan-

nels known only to his tribe. Then, too, the farmer will have the satisfaction of knowing that the expense of freeing his premises of the pest has not been borne by the public treasury.

In the course of our experiments, covering a period of three seasons, several makes of special gopher traps have been thoroughly tested for efficiency, and the ordinary steel trap has been set in various ways with the hope of finding a best way. In the latter respect I cannot say that we have succeeded, for it does not seem to make much difference how one sets the steel trap; results will be about the same. These results, obtained by 100 tests of each of four or five different methods, are given in the table further on.

In trapping the location of the runway is determined in one of two ways : by prodding with a sharp stick on a line between two fresh hills of earth, or by digging into the mound itself until one strikes the short lateral. A sharpened broomstick, or a wagon rod, and a spade, are the best tools to use if one follows the first plan. In digging into the mound to the lateral a heavy plant trowel, with a strong shank, serves the purpose very well, and can be carried about in the hip pocket when not



A handy tool for use in setting traps.

in use. A careful scrutiny of the mound will usually reveal the exact spot from which the dirt was thrown out and enable one to locate the lateral with very little digging.

Among the methods of setting the steel trap which suggested themselves to us, or were recommended by others, we tested five. As stated before, the per cent. of catch did not vary greatly. The plan of digging into the lateral at the mound, pushing the trap back a little way and leaving everything open gave the poorest results. More of these traps were packed with earth and fewer caught and held the gopher than when set in any other way. Attracted by the flood of light which enters the burrow at the large opening the animal is pretty sure to come pushing a heavy load of dirt ahead of him. This clogs the trap at once. The plan of admitting a little light through a chink between the sods covering the opening into the burrow, or through a hole bored for that purpose in a board, demonstrated that the admission of any light at all is unnecessary and perhaps operates to reduce the catch. The

gopher is not so likely to be pushing a load of dirt when he encounters the steel trap in the dark. As between covering the trap itself or leaving it uncovered, I should recommend the latter plan. In a series of 100 tests we carefully covered one trap in each case with tissue paper and fine earth and left the other exposed. The per cent. of catch was so nearly the same that the slight difference in favor of the covered trap would not warrant the expense of extra time required to set the traps in this way. In fact, later experiments, performed when the ground was wet from recent rains, gave the poorer results for the covered trap, on account of the jaws clogging. As the gopher in his underground tunnels must be guided entirely by the sense of smell and of feeling, there could be no particular advantage in concealing the trap with a thin covering of earth. This practice has no doubt arisen from similar methods employed in trapping animals that live above ground.

It seems to me, therefore, that the most practical and efficient method of using the steel trap is to simply open the burrow at some point, introduce the trap and completely cover the opening you make with sods, a bunch of hay, or perhaps a board — anything that is convenient and will exclude all light. Vary the method of setting the trap if the animal keeps filling it with earth. Placing the trap vertically in the runway, with jaws down, will sometimes give good results. We have never tried baited traps of any sort. I believe, however, from the evidence of a few experiments, that one may increase the per cent. of catch by covering the opening above the trap with freshly cut alfalfa.

Traps designed especially for the pocket gopher have the advantage, over the steel trap, of being more easily and quickly set and of killing the animals at once instead of holding them by the leg for hours. Some of them also have given us a higher per cent. of catch than the steel trap. Of the five different patterns we have tested, all are built on pretty much the same lines. They are intended to be set at the end of a lateral, and are so constructed as to throw when the gopher pushes a load of earth against the trigger. A choker or a pair of sharp prongs does the rest. In setting any of these traps a ray of light must be admitted to the burrow through a small opening, so as to attract the attention of the gopher and cause him to come with a load of earth to stop up the hole. The trigger in

any such special trap should be about three inches beyond the choker, so that when the former is tripped by pressure of the earth the animal will have his neck well in the noose.

The "California" gopher trap and the "O. K." gopher trap are almost identical in appearance and design. Both are easily and quickly set, and good results are obtainable by the use of either one. Each consists of a small box with one end open for the entrance of the gopher's head. At the opposite end of the box a small hole is bored to admit a ray of light. The box, when the trap is set, practically forms a continuation of the burrow. It should be placed with the open end close up to the opening into the lateral and the line of contact between trap and lateral sealed with a few handfuls of earth so that no light may reach the burrow except through the small hole in the end of the box. The trigger is skeleton in form so as not to obstruct this light, and depends vertically from the center of the box.

The "Out O' Sight" gopher trap is built like the "California," except that the sides and end of the box have been omitted—simply the roof is left for the attachment of the working parts. This trap is to be set in the same manner as the two just described, but one end has to be supported by means of a small stick laid across the opening into the burrow and sods must be used to exclude all light, except the ray which is to attract the attention of the gopher. Plainly the disadvantage in the use of this trap is in the greater length of time required to set it.

The "Newhouse" gopher trap is entirely of steel. It is arranged to trip in the same way as the other, but instead of a choker it has three sharp prongs which strike down into the neck of the animal. It is the least efficient of all of the makes of special gopher traps we have tried. If properly set it must be supported by a stick at one end, and so covered by sods as to leave only a small chink open. It is so light that a gopher coming with his load will upset it oftener than spring it. The small size of the trap also permits it to be drawn back into the burrow if the animal is caught. In this way we lost half of our traps the first week of our experiments. If used at all they should be secured with chain and stake. A few experiments seem to indicate that this trap gives much better results when used in the smaller burrows of the plains pocket gopher.

The best time to trap is in the spring and fall, particularly

STEEL TRAP TESTS.

Conditions under which traps were set.	Number traps set.	Number disturbed.	Number gophers caught.	Per cent. catch.
Entrance to burrow entirely darkened; trap covered with tissue paper and fine earth.....	100	77	28	36+
Entrance to burrow entirely darkened; trap left uncovered.....	100	75	25	33+
Entrance to burrow left wide open; trap not covered.....	100	81	17	21
Entrance to burrow covered by board having a small hole for the admission of light; trap not covered..	100	66	18	27+

In all cases the light No. 0 steel traps were used. They were placed horizontally in the runways and were not baited. The per cent. catch is based on the number of traps disturbed, including those that caught and held the gopher. The tests were made mainly in the spring and fall months.

SPECIAL TRAP TESTS.

Trade name of trap.	Number traps set.	Number disturbed.	Number gophers caught.	Per cent. catch.
California Gopher Trap	100	71	26	36+
Newhouse Gopher Trap	100	72	14	19+
Out O' Sight Gopher Trap	100	82	36	43+
Newhouse trap modified by addition of sheet-iron shield and skeleton trigger.....	100	69	26	37+
Ordinary steel trap set various ways.....	100	75	23	30+

in October and November. At those seasons the gophers are especially active in extending their burrows or storing up food. It will generally pay to run the traps twice a day—in the morning and as late as practicable in the evening. Experience has proven that one may sometimes catch a second gopher by resetting at the same opening where one has already been trapped, but is scarcely worth while to make the attempt unless one notices after trapping the first animal that the opening into the burrow has been filled again from the inside.

Shooting and Trap Guns.—If one has the time and inclination to do a little shooting, he can kill quite a few gophers with the shotgun. The best time for shooting is early in the morning or late in the evening, when the animals are pushing out their loads of earth. Open holes can then usually be found, but if not one can easily open a few burrows and keep watch of those which are being filled up again. It requires quick work on the part of the sportsman to bag his game, for all that can usually be seen is a little spurt of earth and perhaps a nose. In a few cases that came under my notice a bag of ten or a dozen gophers was made in a single evening or morning.

A trap gun so arranged as to be discharged by the act of the gopher in pushing against an obstruction in his burrow has been recommended by at least two of the experiment stations. The objection to this recommendation lies in the first cost of the mechanism and the amount of time required to visit and reset the gun each time it has been discharged.

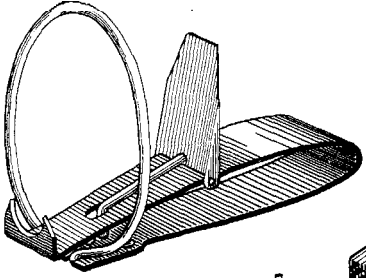


Fig. 1.

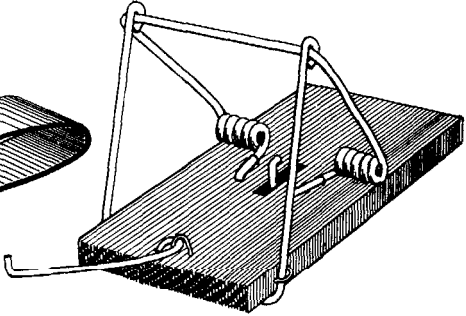


Fig. 2.

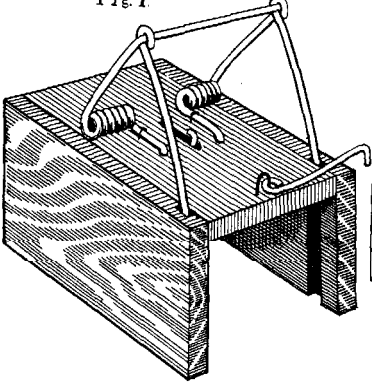


Fig. 3.

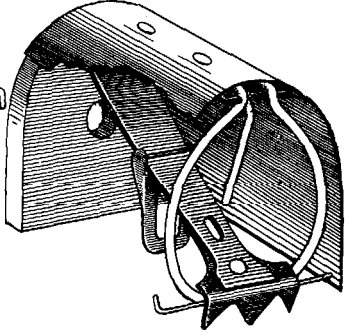


Fig. 4.

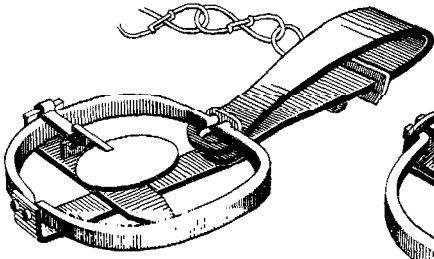


Fig. 5.

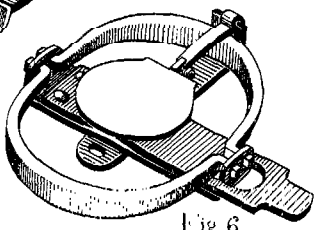


Fig. 6.

Fig. 1, Newhouse gopher trap. Fig. 2, Out O' Sight gopher trap. Fig. 3, California gopher trap. Fig. 4, Newhouse trap as modified for use at this Station. Fig 5, steel trap No. 0. Fig. 6, the steel jump trap.